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Training Course

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PowerMILL 2016 Five Axis Contents

Chapters

Page Number

Day 1

	1	3+2 Axis Machining and Drilling 1.1 - 1.36			
	2	Positional Tool Moves 2.1 - 2			
	3	Five Axis Tool Alignment	3.1 - 3.36		
	4	Surface Projection Finishing	4.1 - 4.16		
Day	2				
	5	Embedded Pattern Finishing	5.1 - 5.8		
	6	Five Axis Swarf Machining 6.1 - 6.26			
	7	Flowline Finishing	7.1 - 7.12		
	8	Auto Collision Avoidance	8.1 - 8.10		
	9	Tool Axis Limits	9.1 - 9.24		
	10	Tool Axis Editing	10.1 - 10.8		
Day					
	11	Machine Tool Simulation	11 1 - 11 14		

Machine Tool Simulation	11.1 - 11.14
Machine Axis Control	12.1 - 12.16
MTD files	13.1 - 13.14
Four Axis Rotary Machining	14.1 - 14.6
Port Machining	15.1 - 15.12
Blisk Machining	16.1 - 16.10
Five-Axis Tutorial	17.1 - 17.12
	Machine Tool Simulation Machine Axis Control MTD files Four Axis Rotary Machining Port Machining Blisk Machining Five-Axis Tutorial

1. 3 + 2 Axis Machining

Introduction

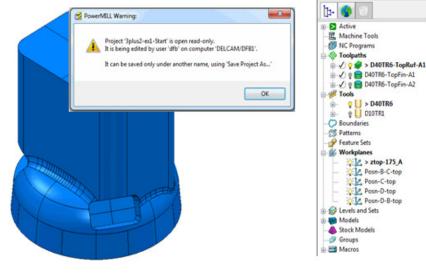
3 + 2 Axis Machining involves indexing the head and\or bed to re-align the tool at a fixed angular, orientation, before performing standard **X Y Z** transitions. This is achieved either by manual adjustment or as part of the CNC control.

The most common method of creating a **3** + **2 Axis** is by using **Workplane** with the **Z-Axis** arranged at an appropriate **Tool Axis** alignment. Standard 3 Axis strategies and their **plunge** and **retract** moves will occur relative to the **Workplane**.

- 3 + 2 Axis machining enables:
 - a All faces of a component (except the base) can be machined in one set-up, relative to a common tool setting datum.
 - **b** Access to deep sidewalls with standard length tooling.
 - c Access to undercut features.

3 + 2 Axis - Machining Example

- 1 **Open** the following **Project**:
 - ...\PowerMILL_Data\five_axis\3plus2_as_5axis\3Plus2-ex1-Start



- 2 Save the Project as:
 - ...\COURSEWORK\PowerMILL-Projects\3Plus2-ex1

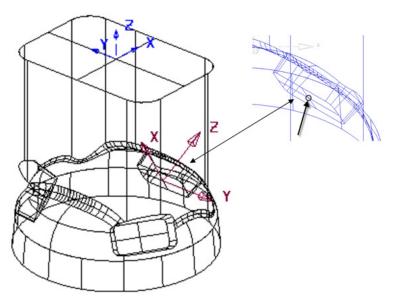
0

A **3-Axis Roughing** and two **Finishing** strategies already exist in the imported **Project**.

Also, a series of **workplanes** are already included in the **Project**, with one just above the top of the model at **Z175** above the **Transform**. This **workplane** will be used as the main machining datum. The other 4 **workplanes** will be used later to control positional movements between multi-axis machining strategies.

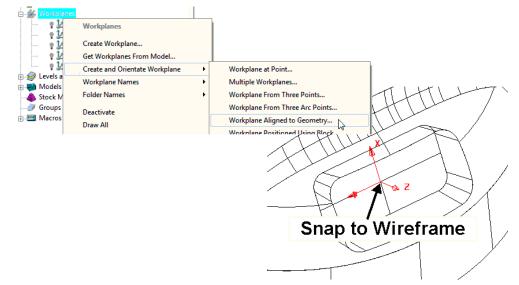
3 Select an **ISO 1** view and consider the machining options.

Note the relatively high sides of the component and the orientation of the three recesses making it impossible to machine as **3** Axis (with the tooling aligned to the **Z-Axis**).



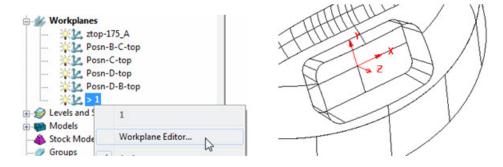
The pocket located along the **X direction** will be the first to be assigned with a new **workplane** to control one of the **3 Plus 2** - **Tool Axis** alignments.

- 4 From the **PowerMILL** *explorer* select **Workplane** > **Create and Orientate Workplane** > **Workplane Aligned to Geometry**.
- 5 Using the left mouse button, snap or box the wireframe crossover at the base of the first pocket (located along X from workplane *ztop-175_A*).



6 Activate the new Workplane 1.

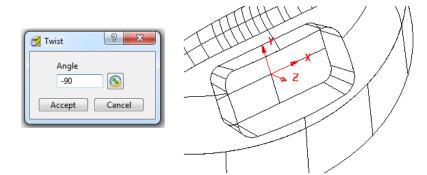
The **workplane** is automatically aligned to the wireframe with the **Z** Axis normal to the **surface**. It still requires further editing as it is advisable for the **X**-Axis to align anticlockwise around the component in reference to the global coordinates.



7 From the **PowerMILL** *explorer*, right-click on **Workplane** 1 and from the local menu, select the *workplane editor* option to open the following toolbar.

Name	1	X Z	X	X	Z	\$¥	¦ ⊒ ∳	1 🤺	闄	9	Gi
					12						

8 Select **Twist about Z** and in the dialog, input an **Angle** of -90 (normal to the base of the recess).



The **X-Axis** of the **workplane** should be pointing anticlockwise relative to the **Transform** (Global Datum) as viewed from the top of the component (If not already the case).

- 9 Select **V** to save the changes and exit the **Workplane Editor** toolbar.
- **10** Rename **Workplane 1** as **Align_B**.
- 11 Activate the Workplane ztop-175_A.
- 12 Right-click on the Workplane, Align_B, and from the local menu select Transform.



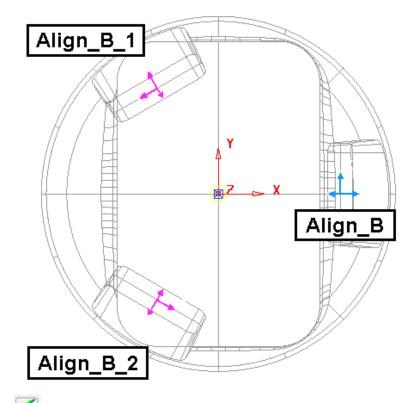
13 Select the Rotate workplane options (shown arrowed below).



- 14 In the Rotate dialog, select Keep original.
- 15 Input **No. of Copies 2**, **Angle 120**, to create two new **workplanes** (Positioned normal to the base of the next pocket in an anticlockwise direction as viewed from the top).

Rotate				
No. of Copies 2	-	Angle 120	- 📳 🕮 🖾	×

16 Select the *small cross* on the right of the toolbar to exit the dialog.



- 17 Select **V** at the end of the **Workplane Editor** toolbar to accept the new **workplanes** (Align_B_1 & Align_B_2).
- 18 Rename the 2 new Workplanes (in anticlockwise order) as Align_C and Align_D respectively.

The component is now ready to have the **3 Plus 2** machining strategies created, relative to the three new workplane alignments. (**Align_B, Align_C,** and **Align_D**).

For each of the 3 Pockets a rectangular material **Block** will be created locally, relative to the aligned **3+2 workplane**. A **Model** *Boundary* will also be created around each pocket to provide even more control of the machining strategy limits.

- 1 Activate the workplane Align_B.
- 2 Select the 2 surfaces that define the pocket around workplane Align_B.
- 3 Create a Block (*Defined by box*) to Type Model (*Model*).

Block	? ×		
Defined by			
Box 🗸	D 🔁 💥		
Coordinate System			
Active Workplane 🗸	~		1 tom
			THE T
Limits Min Max	Length		
	52.947822		z
γ -14.19449 🕤 13.855629	28.050123		
Z -0.0	S 19.368158	\mathbf{X}	
X X X X X X X X X X X X X X X X X X X	6	X	
Estimate limits			
Tolerance Expansion	Туре		
0.1	Model 🗸		
✓ Include reference surfaces	Calculate		

- 4 Ensure that the *pocket surfaces* are still selected so that the **Rapid Move Heights** calculation ignores the de-selected **surfaces**.
- 5 In **Rapid Move Heights** input the operational **Workplane** as **Align_B** and select **Calculate** to create values for **Safe Z** and **Start Z** aligned to the correct coordinate system.

🥳 🛛 Rapid Move	Heights	? ×
Geometry		
Safe area	Plane	~
Workplane	Align_B	~
Normal		
0.0 0.0	1.0	
	Rapid height	29.368158
Ē	Plunge height	24.368158
Calculate dimensions		
Ra	pid clearance	5.0
Plu	nge clearance	5.0
		Calculate



Input the **Workplane** (**Align_B**) to achieve the correct **Rapid Move Heights** alignment.

 $\Box O$

Rapid Move Heights are calculated based on the **Model** or **Block**, whichever has the **maximum Z height**.

If a group of surfaces are selected, the remainder will not be included in the calculation.

- 6 Create a User Defined Model Boundary named Pkt-B1 around the top edge of the pocket (surfaces still selected!) that surrounds the Workplane (Align_B).
- 7 Activate the existing Tiprad tool D10TR1.
- 8 Set Lead In to Ramp with Ramp Options as Zig Angle 4, Follow Circle, and Diameter (TDU) 0.6
- 9 In the **Strategy Selector** dialog in **3D Area Clearance** select **Model Area Clearance** and fill in the options in the pages, exactly as shown below:

di Mo	odel Area Clearance	?	×
Toolpath name	D10TR1-Rgh-B1		
 Workplane Block Tool Machine tool Model area clearance Offset Step cutting Wall finishing Unsafe segment removal Flat machining F High speed Order Approach Automatic verification Cutter compensation Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point Freeds and speeds History Notes and Description 	Model area clearance Style Offset model Cut direction Profile Area Climb Climb Tolerance 0.1 0.1 Thickness 0.5 Stepover Stepover 2.0 Stepdown Automatic Constant stepdown Rest machining Calculate Queue OK Cancel 	· · · · · · · · · · · · · · · · · · ·	
	Career on Concer		

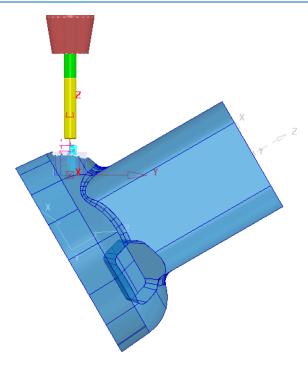
Toolpath name: D10TR1-Rgh-B1

Style: Offset model.

10 In the Limit page input the Boundary Pkt-B1 and set Limit tool periphery to boundary.

Limit
🍲 🖃
<i>%</i>
5 5

11 Select **Calculate** to create the **toolpath** and then **Cancel** the dialog.

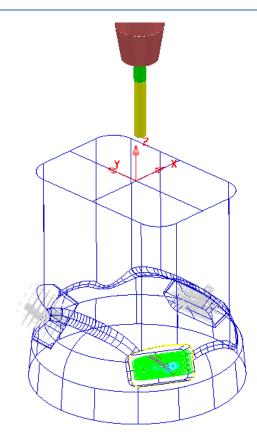


The toolpath plunge moves are aligned to the **Active workplane's**, Z Axis.

- 12 Use Copy to create cloned strategies on the other two recesses, adjusting the values and settings as required to create toolpaths, D10t1-Rgh-C1 and D10t1-Rgh-D1.
 - a **Rapid Move Heights** must be defined separately for each toolpath with the correct **Workplane** selected in the dialog (Remember to include the correct **Workplane** in the dialog).

di Mo	del Area Clearance ? 🗙	
Toolpath name	D10TR1-Ruf-C1	
Workplane Block Group State S	Rapid move heights Geometry Safe area Plane v Workplane Align_C1 Normal 0.0 1.0 0.0 0.0 1.0 Rapid height 29.368158 Plunge height 24.368158 Calculate Dimensions Rapid clearance Sapid clearance 5.0 Plunge clearance 5.0	
Leads and links	Calculate Drawing options Draw rapid surface Opacity 20 Draw plunge surface Opacity 20	

b Don't forget to create and **activate** the appropriate **User defined** - **Model** - **Boundaries** named **Pkt-C1** and **Pkt-D1**.



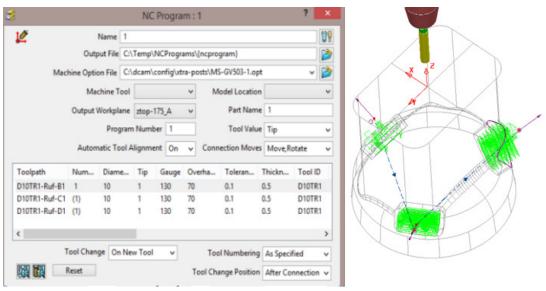
After the creation of **toolpaths** for **3 + 2 Axis** valid ncdata can only be output using a compatible, post-processor. For programs containing multi-alignment toolpaths the **NC Programs** output options create the ncdata from one datum (In this case the **Workplane** - **ztop175_A**). This option is selected in the **NC Preferences** or **NC Program Settings** dialog.

- **13** In the **PowerMILL** *explorer*, right-click on **NC Programs** and select **Preferences**.
- 14 From the Machine Option File select MS-GV503-1.opt as the controller.
- 15 For the Output Workplane select ztop-175_A.

- 31			NC Prefer	rences		? ×
Output	Toolpath	Fixture offset V	/erification			
Chang	ges made he	re will not chang	e existing NC	Programs		
	Use Proj		Output Fo	older C:\Temp\NCPros	grams	
	Мас	hine Option File	C:\dcam\cc	onfig\xtra-posts\MS-GV	′503-1.opt	
	Machine	Tool	~	Model Location		~
0	utput Workp	lane Align_D1	v	Part Name		
				Tool Value	Тір	~
	Automati	c Tool Alignmen	t On 🗸	Connection Moves	Move,Rotate	~
			Close	e		

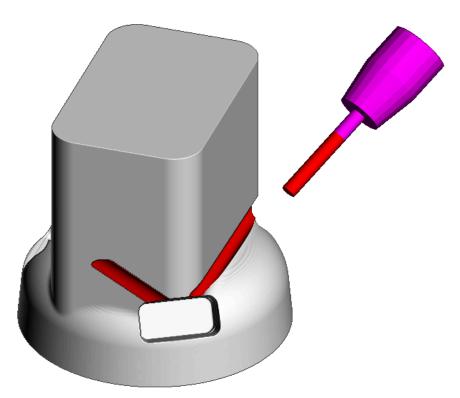
16 Close the dialog.

17 In the PowerMILL explorer, NCPrograms, select Create NC Program and add to it the toolpaths, D10TR1-Rgh-B1, D10TR1-Rgh-C1, and D10TR1-Rgh-D1.





The link moves between the three individual '**3Plus2**' toolpaths are displayed in the **NC Program** and in this case are passing straight through the component!

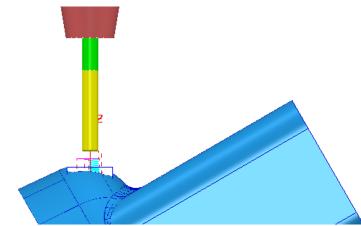


Automatic gouge protection only exists within a toolpath (Between the **Start and End Point**). After inserting the toolpaths into an **NC Program**, it is essential to independently control the **Positional Moves** outside the toolpaths to eliminate any collisions with the component and fixtures.

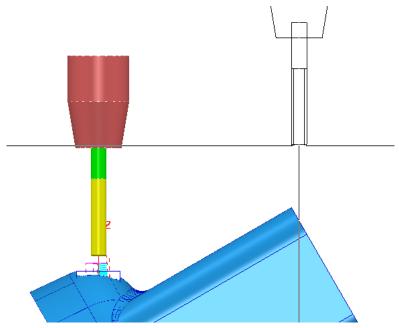
Link moves controlled by Absolute Start and End points

This method of creating safe link moves between separate 3 Plus 2 toolpaths is the most universal and safest method for all types of application and postprocessor. The start and end point for each toolpath is defined as an absolute coordinate position above the maximum Z height of the component.

- 18 Activate the toolpath D10TR1-Rgh-B1.
- **19** Select a **View from right (X)**.



- 20 Switch on both Draw Cursor Crosshair (Ctrl H) and Tool (Ctrl T).
- 21 Move the cursor to a suitable **Start/End** point above the top of the model.



The X, Y, and Z coordinate values are displayed in the *information* toolbar located below the graphics area.

0	130.32	100.049
---	--------	---------

22 Make a note of the individual Y and Z values as integers 130 and 100.

🥳 Rapid Move Heights ? 🗙
Geometry
Safe area Plane 🗸
Workplane Align_B 🗸
Normal
0.0 0.0 1.0
Rapid height 100.0
Plunge height 24.368158
Calculate dimensions
Rapid clearance 5.0
Plunge clearance 5.0
Calculate

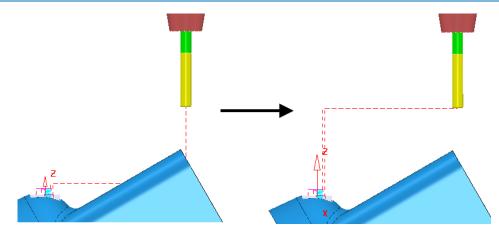
The **Rapid Move** - **Safe Z** value must now be matched to the **Z** value in **Start and End Point** dialog.

23 Open the **Rapid Move Heights** dialog, edit the **Safe Z** value to **100** before selecting **Apply** (to update the toolpath).

24	Open	the	Start	and	End	Point	dialog
----	------	-----	-------	-----	-----	-------	--------

Method	S
	Y
Approach Along Tool Axis <u>Approach Distance</u> 5.0	~
Coordinates	
0.0 130.0 100.0	ž
Tool Axis	
0.0 0.0 1.0	¥7 K
Apply Start Point]
	Use Absolute Override Tool A Approach Along Tool Axis Approach Distance 5.0 Coordinates 0.0 130.0 100.0 Tool Axis 0.0 0.0 1.0

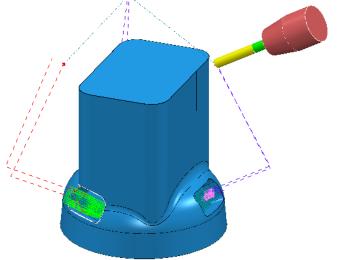
- 25 For the *Method* select *Use* Absolute and input the new Y value (130).
- **26** Select **Apply Start Point** (to update the toolpath).
- 27 Select the End Point tab, repeat stage 25 above, and then select Apply End Point (to update the toolpath).



28 Repeat stages 19 to 27 on toolpaths D10TR1-Rgh-C1 and D10TR1-Rgh-D1 this time using the values 130 and 130.

Note the new values (eg 130 130) will be different due to these pockets being in the corners of the main section.

😚 Start and End Point ? 🗙	
Start Point End Point	
6	
Method Use Absolute	
Override Tool Axis	· · · · · · · · · · · · · · · · · · ·
Approach Along Tool Axis 🗸	
Approach Distance 5.0	
Coordinates	
-0.022823 130.0 130.0	2
Tool Axis 0.0 0.0 1.0	
Apply Start Point	
Apply Accept Cancel	





29 Select **File** > **Save** to update the contents of the previously stored **Project**.

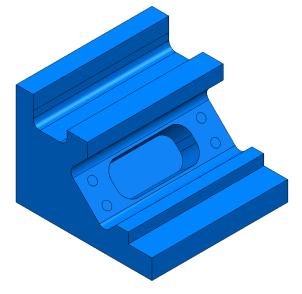
3+2 Axis – Stock Model Application

The **Stock Model** represents the un-machined material at any point in the machining process. An empty Stock Model is created, followed by applying the material **Block** and\or any number toolpaths to be considered in the process. The Stock Model is then updated by selecting Calculate, to display the current 'unmachined' material remaining.

- Select File Delete All and Tools Reset forms. 1
- 2 Import the Model:

...\PowerMILL_Data\five_axis\AnglePad\StockModelRest.dgk

- Save Project As: 3
 - ...\COURSEWORK\PowerMILL Projects\StockModel-3Plus2

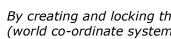


The **model** includes undercut features which for a normal **3-Axis** application, would require the component to be machined in two separate set ups. However, by applying **3+2** with separate **workplanes** controlling the **tool alignments**, the whole project can be completed in one setup. During an initial **3-Axis** operation, the undercut pockets will be partially machined which provides an application for using **Stock Model** to enable the user to optimise the **3+2** machining.

Open the Block dialog and Calculate using Defined by – Box, Type - Model, 4 and the Coordinate System set to Global Transform.

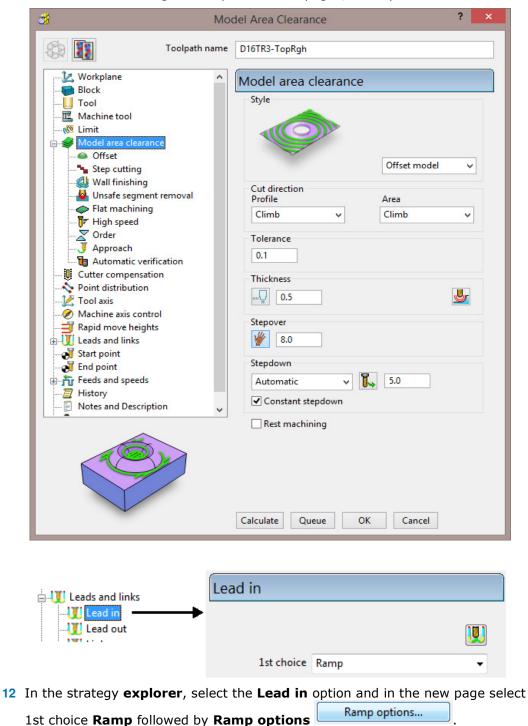
3	Blo	ck
Defined by		
Box	~	
Coordinate System		
Global Transform	~	
Active Workplane		
Global Transform	N	
Named Workplane	13	

Accept the dialog. 5



By creating and locking the material **Block** to the **Global Transform** (world co-ordinate system), the orientation and position will remain unchanged if a Workplane is made Active.

- 6 Create a Dia 16 tip radius 3 tool named D16TR3
- 7 Create a Dia 12 tip radius 1 tool named D12TR1
- 8 Activate the tool D16TR3
- 9 In the **Rapid Move Heights** dialog 🗾 select **Calculate**.
- 10 Use the default settings for both the Start and End Points
- 11 Select the **Strategy Selector Solution** and from **3D Area Clearance** select **Model Area Clearance** filling in the options in the pages, exactly as shown below:



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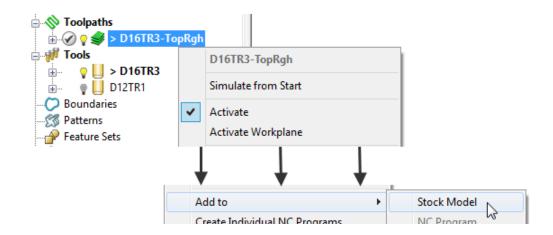
13 In the Ramp Options dialog, Input Max Zig Angle 4 using a Circle with 0.65 (TDU).

i	Lead I	n Ramı	o Options	?	×
1s	t Choice 2nd Choice				
	Follow		Max zig angle		
	Circle	*	4.0		
	Circle diameter (TDU))			
	0.65				
	Closed segments o	only			
	Ramp height				
	Туре		<u>Height</u>		
	Incremental	*	5.0		

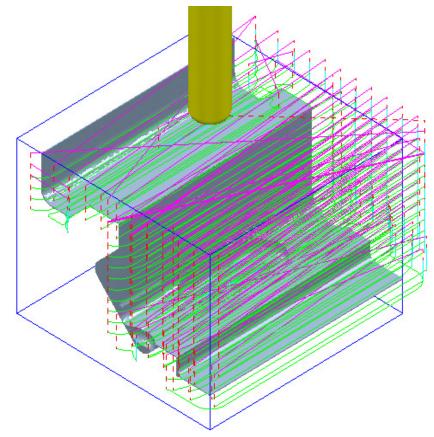
- 14 Accept both the Ramp Options and Leads and Links dialogs.
- 15 Back in the **main** dialog, select **Calculate** to create the toolpath and then **Close**.
- 16 Select an **Iso1** view.
- 17 Activate > Workplane 2 (The Block remains in situ!).
- 18 In the PowerMILL explorer, right-click on Stock Models and from the local menu, select Create Stock Model to open the following dialog.

3	Stock	Model	?	×
Name				
1				S
Tolerance		Stepover		
0.05		1.0		
Rest thickness		Workplane		
0.1	13	2		~
	Accept	Cancel		

- **19** Input the above values and **Accept** the dialog.
- 20 In the **PowerMILL** *explorer*, right-click over the toolpath **D16TR3-TopRgh** and from the local menu select, **Add to Stock Model**.



- 21 In the **PowerMILL** *explorer*, right-click over the new **Stock Model 1** and from the local menu, select **Calculate**.
- 22 With the local *Stock Model* menu still open, select, **Drawing Options** > **Shaded** and **Show Rest Material**.



The **3-Axis Roughing** operation has removed all accessible material leaving a **0.5 thickness** on the component form. This is clearly visible on the displayed **Stock Model**.

- 23 Activate Workplane 2 to change the set up to a 3+2 orientation.
- 24 Activate the tool D12TR1.
- 25 From the main toolbar select Rapid Move Heights and input the correct Workplane (2) into the dialog before selecting Calculate, followed by Accept.

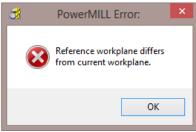
₫	Rapid Move	Heights	?	×	
Geometry					
	Safe area	Plane		~	
	Workplane	2		~	

26 Select the **Strategy Selector** and from **3D Area Clearance** select **Model Rest Area Clearance** and input settings exactly as shown in the following illustration:

Mod	el Rest Area Clearance	? ×	
Toolpath name	D12TR1-AngleRgh]
Workplane Block Tool Machine tool Machine tool Rest Offset Step cutting Wall finishing Unsafe segment removal Flat machining F High speed Order Approach Automatic verification Order Automatic verification Machine axis control Rapid move heights Leads and links Start point End point Feeds and speeds History Notes and Description	Model rest area clearance Style Offset model Cut direction Profile Climb Climb Climb Tolerance 0.1 Thickness 0.5 Stepover 8.0 Stepdown Automatic Stepdown Automatic Rest machining		
·	Calculate Queue OK Cancel		

- 27 In the local explorer select the **Rest** page and input **Rest Machining Toolpath D16t3-TopRgh**.
- 28 Select **Calculate** to request the **toolpath** to be created.

Workplane Block Jool Limit Model rest area clearance Section	Rest Rest machining Toolpath
<i>The strategy fails to calcula box appears!</i>	ate and the following PowerMILL Error message



It is not possible to apply **Area Clearance** - **Rest machining** using a reference toolpath that has been generated relative to a different **Workplane** alignment.



It is however possible to use a **Stock Model** as the reference item for **rest machining**.

29 Select OK to close the PowerMILL Error message and return to the strategy

(that is still in **Recycle** 🕸 mode).

Set the option **Rest machining** as **Stock model** using **1**, and input **Detect material thicker than 0.6** as shown in the following illustration.

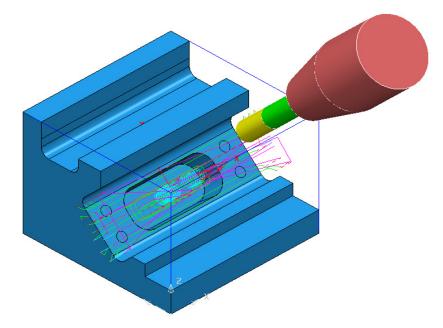
Workplane	Rest
	Rest machining Stock model V 1 V Stock Model state D16TR3-TopRuf V
Construction Construction Construction Construction Construction Construction Construction Construction Construction	Detect material thicker than 0.6 Expand area by 1.2 Minimum gap length 18.849556

30 In the local strategy *explorer*, open the Limit page and select Limit tool

centre to block edge

Limit <u> </u> 🛨

31 Select **Calculate** to create the **toolpath** and then **Close**.



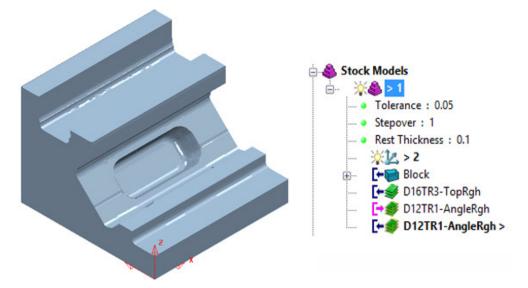
The modified **Rest Roughing** toolpath now successfully operates within the defined **Stock Model** volume (as shown above left).

The material removed by the toolpath, although referenced, is not physically included as part of the **Stock Model** at this stage.

32 In the **PowerMILL** *explorer*, right-click on the **Toolpath D12TR1-AngleRgh** and from the local menu select, **Add to** - **Stock Model**.

Õ

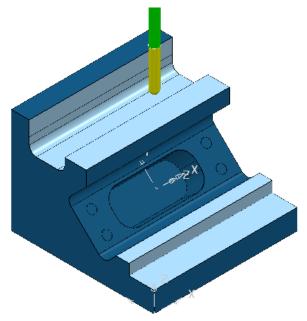
33 In the **PowerMILL** *explorer*, right-click over the new **Stock Model 1** and from the local menu, select **Calculate**.



The **Stock Model** now displays the remaining material after both the **3-Axis Roughing** and **3+2 Roughing** operations.

Unlike **Area Clearance**, **Finishing** strategies cannot be directly **rest** machined to a **Stock Model**. However it is possible to create and apply **Stock Model Rest Boundaries** where required, providing suitable **rest** limits for subsequent finishing operations.

- 34 Activate the toolpath D16TR3-TopRgh to reinstate the settings used.
- 35 Create a Dia 6 Ball Nosed Tool named BN6.
- 36 Un-draw the Stock Model (click the light bulb off).
- **37** Select the **Surfaces** (shown shaded below) required for initial finish machining relative to **Workplane 1**.



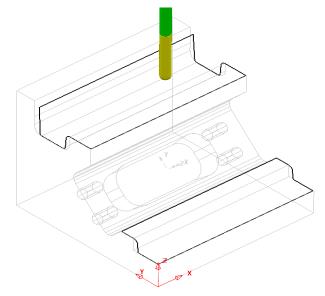
38 In the **PowerMILL** *explorer*, right-click over **Boundaries** and select **Create Boundary** followed by **Selected Surface** to open the following dialog.

Selected Surfa	ace Boundary ?
Top ✔ Roll Over ☐ Tolerances 0.01 Thickness 0.0	Limit Boundary Inside Limiting Boundary Outside
Axial Thickness 0.0 Use Axial Thickness	Automatic Collision Checking
Tool	Holder Clearance 0.0 Shank Clearance 0.0
	Block
Private	

39 Input data in the Selected Surface Boundary dialog exactly (as shown above) with a *tick* in the box named Top and the Limit option set to Limit tool centre to block edge.



40 Select **Apply** and when processed, **Cancel** the dialog.

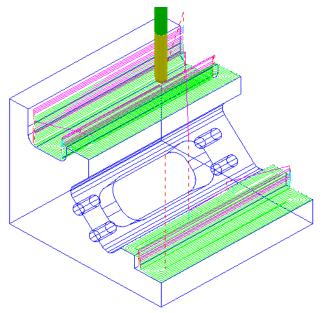


When created, the new **Boundary** will be **Active** and by default included as the **limits** (keep inside) in the following finishing strategy.

- 41 Select the **Strategy Selector** and from the **Finishing** dialog select the **Steep and Shallow** finishing option.
- 42 Enter the name **BN6-TopFin** along with the remaining values and settings exactly as shown below before selecting **Apply**.

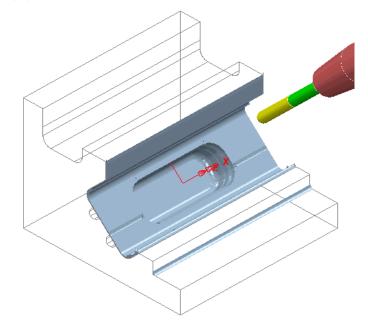
🕉 Steep	and Shallow Finishing	? 🗙
Toolpath name	BN6-TopFin	
 Workplane Block Tool Machine tool Limit Stock engagement Stock engagement Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start Point Feeds and speeds Notes User defined settings 	Steep and shallow fini Order Top first V Threshold angle 30.0 Steep Spiral Cut direction Climb V Stepdown Stepdown Q.3 Cut direction Climb V Stepdown Climb V Stepdown Climb V Stepdown	shing Additional stock 0.3 Steep shallow overlap 0.0 Shallow ♥ Spiral Cut direction Climb ♥ Stepover ♥ 0.3 ↓ 0.007509 Type 3D offset ♥ Smoothing
	Tolerance 0.01 Thickness 	K Cancel

- 43 Set both Lead In and Lead Out to Surface normal arc (Angle 90, Radius 3).
- 44 Select **Calculate** to create the toolpath and then **Close** the dialog.



All of the features accessible from the top have now been finish machined. This finishing strategy will be added to the **Stock Model** ready for a **Stock Model Rest Boundary** to be created and applied to a 3+2 finishing strategy along **Workplane 2**.

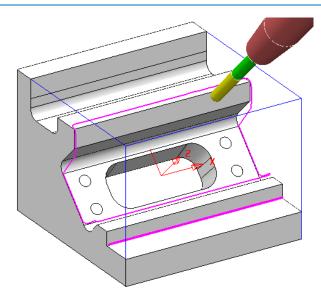
- **45** In the **PowerMILL** *explorer*, right-click on the **Toolpath BN6-TopFin** and from the local menu select, **Add to Stock Model**.
- **46** In the **PowerMILL** *explorer*, right-click over the new **Stock Model 1** and from the local menu, select **Calculate**.
- 47 With the local Stock Model menu still open, select Show Rest Material, followed by Drawing Options Shaded, and finally Calculate.
- 48 Select an **ISO 1**.
- 49 Activate Workplane 2.
- 50 From the **main** toolbar select **Rapid Move Heights** and input the correct **workplane** (2) in the dialog before selecting **Calculate**.



51 In the **PowerMILL** *explorer*, right-click **Boundaries** and select **Create Boundary** followed by **Stock Model Rest** to open the following dialog.

3	Stock Model F	Rest Boundary ? ×	<
<u>8</u>	🔪 Name 🛛	2	
Stock Model Stock Model State	1 v BN6-TopFin v	Limit Boundary Inside Limiting Boundary Outside]
<u>Detect Material Thick</u> <u>E</u> Tolerances	xpand Area By 0.0		
0.4	Tolerance 0.01 Thickness 0.0 I Thickness 0.0	Automatic Collision Checking Holder Clearance 0.0]
	Use Axial Thickness	Shank Clearance 0.0 Block	
€ .	BN6 ¥	Limit 💆 🗸	
Private	to be private	0	

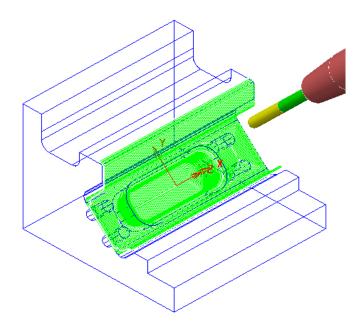
52 Input data in the **Stock Model Rest** *Boundary* dialog exactly as shown above.



- 53 Apply and when processed, Cancel.
- 54 Select and **Delete** the narrow segment at the base of the lower vertical wall.
- 55 Ensure that new **Boundary 2** is **Active**.
- 56 Select the *Strategy Selector* 2 and from the **Finishing** dialog, select the **Steep and Shallow** finishing option.
- 57 Enter the name **BN6-AngFin** along with the remaining values and settings exactly as shown below.

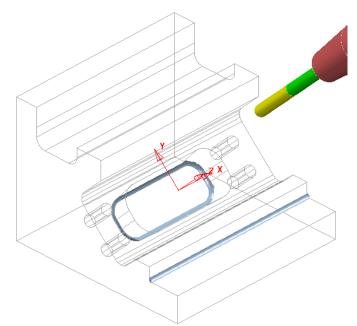
🥳 Steep	o and Shallow Finishing	? ×
Toolpath name	BN6-AngleFin	
 Workplane Block Tool Machine tool Limit Stock engagement Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point Start point Freeds and speeds History Notes and Description User defined settings 	Steep and shallow fini Order Top first v Threshold angle 30.0 Steep Spiral Cut direction Climb v Stepdown Stepdown Climb climb v Claculate using cusp	shing Additional stock 0.3 Steep shallow overlap 0.0 Shallow Spiral Cut direction Climb Stepover 0.3 0.007509 Type 3D offset Smoothing
	Tolerance 0.01 Thickness 0.0 Calculate Oueue O	K Cancel

58 Select **Calculate** to create the **toolpath** and then **Close** the dialog.



The resultant **toolpath** will be added to the **Stock Model** mainly to confirm whether machining is now complete.

- 59 In the **PowerMILL** *explorer*, right-click on the **Toolpath BN6-AngleFin** and from the local menu select, **Add to Stock Model**.
- 60 In the **PowerMILL** *explorer*, right-click over the new **Stock Model 1** and from the local menu, select **Calculate**.

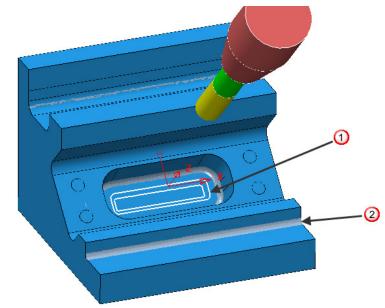


There are now 2 areas remaining as part of the **Stock Model**. As both include sharp internal corners they will need to be finished off using an End Mill.

- 61 Create a Dia 12 End Mill named EM12.
- 62 In the **PowerMILL** *explorer*, right-click over **Boundaries** and select **Create Boundary** followed by **Stock Model Rest** to open the following dialog.

📆 Stock Model Rest Bo	oundary	? ×
11 🗧 🧳	🕽 Name [3
Stock Model Stock Model State	1 ~ BN6-AngleFin ~	Limit Boundary Inside Limiting Boundary Outside
Detect Material Thicke	r Than 0.2 pand Area By 0.0	
Avial	Tolerance 0.01 Thickness 0.0 Thickness 0.0	Automatic Collision Checking Holder Clearance 0.0 Shank Clearance 0.0
Tool	se Axial Thickness 🗌	Block Limit 🙍 🗸
Private	o be private	0
Edit History Apply edit history	on calculation	0
Ap	ply Queue	Accept Cancel

- 63 Input data in the **Stock Model Rest Boundary** dialog exactly as shown above.
- 64 Apply and when processed, Cancel the dialog.



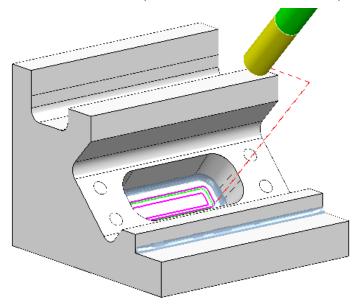
① A new **Stock Model Rest** *Boundary* has appeared where the remaining material is accessible to the **EM12** tool.

② This area is not accessible to the **EM12** tool, and as a result **Boundary** segments will not be created.

- 65 Ensure that the new **Boundary** (3) is Active.
- 66 Select **Toolpath Strategies** and from the **Finishing** dialog, select the **Constant Z** option.
- 67 Enter the name **EM12-AngleFin** along with the remaining values and settings exactly as shown on the following page before selecting **Apply**.

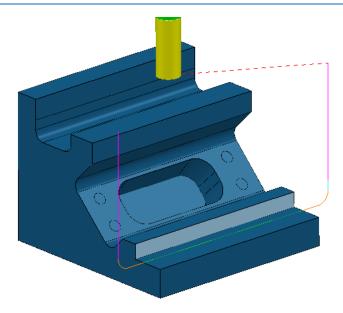
Co	nstant Z Finishing		?	×
Toolpath name	EM12-AngleFin			
 Workplane Block Tool Machine tool Limit Stock engagement Constant Z finishing Unsafe segment removal Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point Start point Feeds and speeds History Notes and Description User defined settings 	Constant Z finishing Order by Region	Additional stock 0.6 Undercut Flat tolerance 0.1		
	Tolerance 0.01 Thickness 0.0 Stepdown <u>Minimum s</u>	Cut direction Climb tepdown Lepdown 1.0 Calculate using c	v Usp	

68 Select **Calculate** to create the toolpath and then **Close** the dialoq.



The angled pocket is now fully machined and the latest toolpath will now be added to the **Stock Model**.

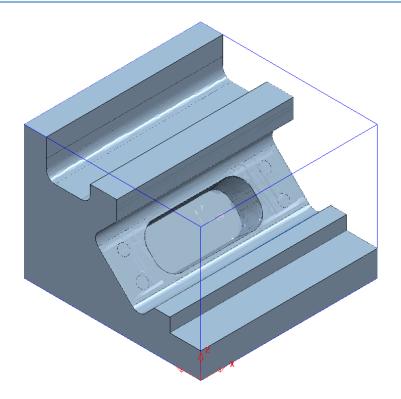
- 69 In the **PowerMILL** *explorer*, right-click on the **Toolpath EM12-AngleFin** and from the local menu select, **Add to Stock Model**.
- 70 In the PowerMILL explorer, right-click over the new Stock Model 1 and from the local menu, select Calculate.
- 71 Activate the toolpath D16TR3-TopRgh to reinstate the settings used.
- 72 De-activate the toolpath D16TR3-TopRgh and activate the EM12 tool.



73 Create a **Swarf Finishing** strategy named **EM12-TopFin** on the selected, vertical **surface** (shown shaded above).

<u>.</u>	Swarf Finishing ? ×
Toolpath name	EM12-TopFin
Workplane Block Jool Machine tool With Limit Stock engagement	Swarf finishing Drive curve Surface side Qutside Radial offset 0.0
 Swarf fnishing Position Gouge avoidance Multiple cuts High Speed Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start Point Start Point Feeds and speeds Notes User defined settings 	Minimum fanning distance 0.0 Fan at end on planes ✔ Reverse axis Follow surface laterals
	Surface joining tolerance 0.3 Gouge avoidance Gouge check Degouge tolerance 0.3
	Tolerance Cut direction 0.01 Climb Thickness 0.0
THE P	Preview Draw Calculate Queue OK Cancel

- 74 Set both Lead In and Lead Out to Vertical arc with Distance 6, Angle 90, and Radius 4.
- 75 *Add* the new toolpath **EM12-TopFin** to the **Stock Model** and **Calculate** to visually confirm that all excess material has now been removed.





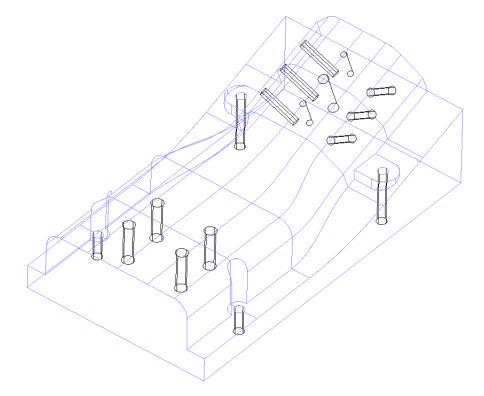
The **Stock Model** is only visible when the **Show Rest Material** option is unticked.

76 Select **File** > **Save** to update the contents of the previously stored **Project**.

3+2 Axis - Drilling Example

The **PowerMILL** - **Drilling** options operate on **Hole Features** and not directly on the **Model**. This enables drilling to take place without the need to modify or trim back the existing surface data. When the **Multi-Axis** option is ticked the **Hole Features** at different alignments will be created to a common workplane.

- 1 Select File Delete All and Tools Reset Forms.
- 2 Import the Model:
 - ...\PowerMILL_Data\five_axis\drill_5axis\drill5ax_ex1.dgk



3 Select File - Save Project As:

...\COURSEWORK\PowerMILL-Projects\MultiAxisDrill-ex1

The first stage is to create a **Feature Set** into which all cylindrical surfaces in the selected model are inserted as **Hole** features.

Any cylindrical surfaces within the selection will automatically be recognised as a **Hole Feature**. It is important that no **Block** exists to ensure that the **Hole Features** are arranged with the top at the **maximum Z height**.



The existence of a **Block** will affect the orientation of individual **Hole Features** in that they are more likely to be created to an **unsuitable alignment**.

- 4 Use the left mouse to select all of the **surfaces**.
- 5 In the **PowerMILL** *explorer*, right mouse click on **Feature Sets**, and from the local menu select **Create Holes**.
- 6 Enter data into the **Feature** form exactly as shown.

🕉 Create Holes ? 🗙		
Name root		
Н		
Create from Tolerance		
Model V 0.1		
Create compound holes		
Use active workplane only		
Find holes in both directions		
Find holes going down		
O Find holes going up		
Group holes by axis		
Try to recognise partial holes		
Minimum arc angle for partial holes		
300.0		
Ignore capped cylinders		
Edit after creation		
Apply Close		

The **Group holes by axis** option must be un-ticked for a **Multi Axis Hole** > **Feature Set** to be created (All of the *Hole Features* including those at different orientations will be input into a single **Feature Set**).

7 Apply and Close the dialog.

-

All cylindrical surfaces within the selection will automatically be recognised as **Multiaxis Hole Features**.

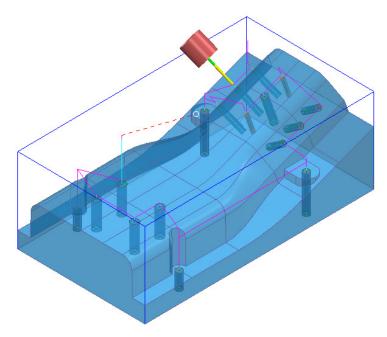
8 Undraw the **model** to view the newly created **Features**.

All 17 **Holes** in the **Feature Set** are correctly aligned, with the cross at the base representing the bottom of the hole.

- 9 Create a material Block using **Defined by** Box and **Type Model**.
- 10 In the **Rapid Move Heights** idalog, select **Calculate**.
- 11 Create a Dia 3 Drill named Drill3 of Length 40.
- 12 Add a Shank component Upper\Lower Dia 3 Length 40.
- 13 Add a Holder component Upper Dia 30 Lower Dia 30 Length 30 Overhang 60.
- 14 Select Toolpath Strategies Sand in the Strategy Selector dialog, select Drilling.
- **15** In the **Drilling** dialog, select the option **Drilling**.
- 16 Rename the toolpath CentreDrill-Dia3.

3	Drilling ? ×
Toolpath name	CentreDrill-Dia3
Holes Ho	Drilling Cycle type Break chip Define top by Hole top Operation Centre drill Clearance 5.0 Peck Depth 1.5 Dwell time 0.0 Tolerance
	0.1 Thickness 0.0 Drilling cycle output Select Calculate Queue OK Cancel

- 17 Back in the main **Drilling** page select **Calculate** to create the **Centre Drilling** toolpath, and then **Cancel** the dialog.
- **18 Simulate** the toolpath.



The **Multiaxis** option has created all of the **Hole Features** aligned at different elevations in a single **Feature Set**.

The two **Dia 6 Hole Features** are to be drilled to depth with a **Dia 5 Drill** and then **Tapped**. To allow for the inevitable point angle at the bottom of the blind holes the **Tapping** operation needs to stop short of the full depth by applying a suitable **Axial Thickness** value.

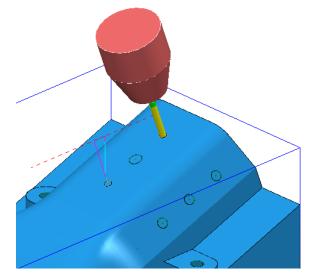
- 19 Create a Dia 5 Drill named DRILL5 of Length 60
- 20 Add a Shank, Upper Dia 5, Lower Dia 5, Length 30.
- 21 Add a Holder, Upper Dia 30, Lower Dia 30, Length 30, Overhang 50.
- 22 Select Toolpath Strategies and in the Strategy Selector dialog select Drilling.
- 23 In the **Drilling** dialog select the option **Break Chip**.
- 24 Rename the toolpath as **Drill5**.

- 3 4	Drilling	?	×
Toolpath name	Drill5		
Holes Workplane Block Machine tool Machine tool Machine tool Automatic verification Automatic verification Automatic verification Machine axis control Automatic verification Col axis Machine axis control Start point End point Start point Feeds and Inks History Notes and Description User defined settings	Drilling Cycle type Break chip Define top by Hole top Operation Drill to hole depth V Clearance 5.0 Peck Depth V 5.0 Depth V Doepth V Depth Doepth Duell time 0.0		
600	Select		

25 Select the two **Dia 6** Hole Features (shown coloured orange below).

Diameter 8.00 10.00 12.00 ►	Selection Filter	
< > Tolerance 0.01 Select	Component Largest V	

- 26 Close the Feature Selection dialog.
- 27 Select **Calculate** to create the **Drilling** toolpath, then **Cancel** the dialog.
- 28 Simulate the toolpath.



The two **Dia 6 Holes** have now been drilled to full depth using a **Dia 5 Drill**.

They will now be **Tapped** to a depth of **5** (*Axial thickness*) from the base of each *Dia 6 Hole* using a *Dia 6 Tap* with a **1mm** *Pitch*.

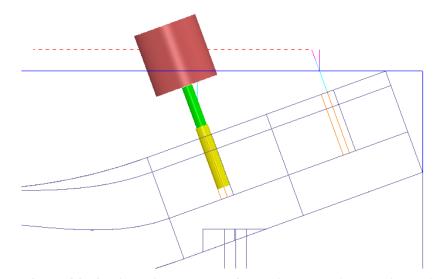
- 29 Create a Dia 6 Tap (Named M6Coarse-TAP) with Pitch 1 and Length 25.
- 30 Add a Shank, Upper Dia 4, Lower Dia 4, Length 30.
- 31 Add a Holder, Upper Dia 30, Lower Dia 30, Length 30, Overhang 50
- 32 Select Toolpath Strategies and in the Strategy Selector dialog select Drilling.
- **33** In the **Drilling** dialog select the option **Tap**.
- 34 Rename the toolpath as M6-Tap.

đ	Drilling	? ×
Toolpath name	M6-Tap	
Holes	Drilling Cycle type	
	Tapping v Define top by	
	Hole top v Operation Drill to hole depth v	
Ø Machine axis control Rapid move heights ⊡∭ Leads and links Start point	5.0 1	Start 0.0
End point Feds and speeds Fit Feeds and speeds History Fit Notes and Description Sources and Settings	<u>Pitch</u>	Depth 24.999999 Dwell time 0.0
	Tolerance 0.1	Left hand
	Thickness	5.0
	✓ Drilling cycle output	raw

35 Select the two **Dia 6** Hole Features.

36 In the **Drilling** dialog select the option **Tapping**.

- 37 Rename the toolpath as M6-Tap.
- 38 Set Cycle Type Tapping, Operation Drill to hole Depth, and Pitch 1.
- 39 Input an Axial Thickness value of 5.
- 40 Select the two **Dia 6** Hole Features.
- 41 Select **Calculate** to create the toolpath and then **Close** the dialog.
- 42 Select a View from front (-Y).



The *selected holes* have been **Tapped** to a distance of 5mm short of the full depth.

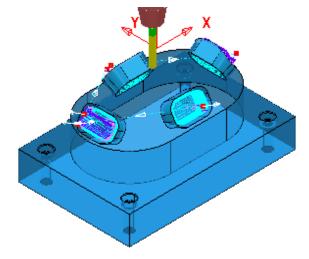
43 From the main pulldown menus, select File > Save to update the contents of the previously stored Project.

2. Positional Tool Moves

Positional Tool Moves – Essential Information

When performing multi-axis, **Positional Tool Moves**, it is the user's responsibility to pay careful attention and take appropriate action to prevent collisions.

- All individual toolpaths should be created such that the Start and End Points are clear of any <u>undercut</u> features in the CAD model.
- PowerMILL <u>does not</u> gouge check positional moves before and after an individual toolpath. These Pale Blue dashed connection moves are only visible if the NCProgram is drawn (as shown below).



- Neither, PowerMILL, or a Postprocessor will be aware of any obstructions within the confines of a machine tool.
- The **Positional** moves displayed in a **PowerMILL** toolpath **simulation** will not necessarily match all moves performed by the actual machine tool.
- For a more accurate simulation a Machine Tool Model along with an associated mtd file can be created. It must be stressed that a machine tool simulation is essentially a visual animation and <u>not</u> an ncprogram, verification.

Three suggested methods in **PowerMILL** to create **Positional Tool Moves** include:

- a Use of **Absolute** coordinates in the toolpath **Start** and **End Point** dialog.
- **b** The insertion of a *Drive Curve* **Pattern Finishing** strategy suitably positioned in 3D space.
- c The insertion of strategically placed **Workplanes** into an **NC Program**.

Postprocessor option file – Safe Z Positional Moves

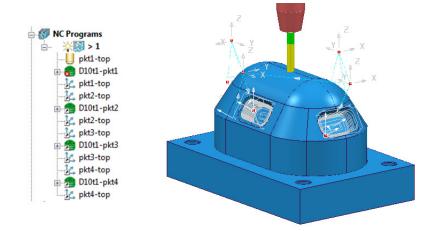
There are two different ways that a specific **Postprocessor Option file** can be created to deal with positional moves (Method 1 is the default).

a Method 1 – The Postprocessor Option file automatically outputs moves from/to the Machine Tool, maximum Z height (Home) at the start and end of each Toolpath. Note! In this case any Workplanes inserted into the NC Program (Item c on the previous page) are completely ignored.

The name for a typical **Postprocessor Option file** using Method 1 includes **ZMAX** at the end of the name:- **DMG_DMU10p_H530_ZMAX.pmopt**

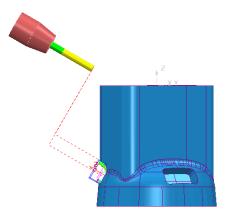
b Method 2 – The Postprocessor Option file does not automatically output Machine Tool Safe Z moves. All additional, safe positional, moves must be added by the user in PowerMILL (In this case a network of workplanes can be used as shown in the illustration below).

The name for a typical **Postprocessor Option file** using Method 2 will <u>not</u> include **ZMAX** at the end of the name:- **DMG_DMU10p_H530.pmopt**



Tool Move with Start and End Point

Positional Tool Moves can be controlled in the **Start and End Point** dialog by use of **Absolute** (along with specific XYZ coordinates).



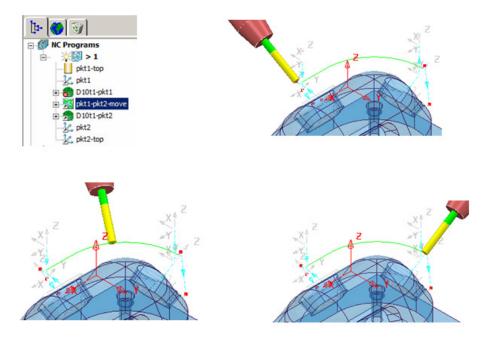
Start and End Points input as **Absolute** coordinates, above the component where it is safe to re-align the tool and/or perform rapid XY moves.

Tool Moves using a Pattern Finishing in 3D Space

Positional Tool Moves can be controlled by running the tool along a **Pattern Finishing** strategy used as a *Drive Curve* in 3D space.



A *lean* angle can be applied to maintain an angular **tool alignment** during transit.

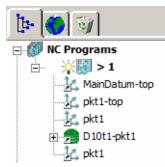


Tool Move via Workplanes in an NC Program

Positional Tool Moves can be controlled by strategically placed **Workplanes** inserted between the **Toolpaths** in the **NC Program** list. A **Workplane** in the **ncprogram** list can also be registered as a **Toolchange Point** if required.

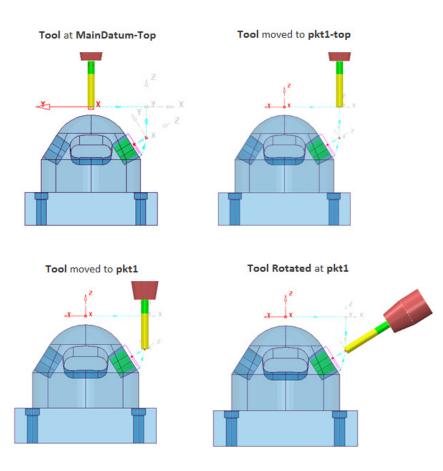


This method is only applicable to non-**ZMAX post-processor** applications.



While a **tool** moves to a **Workplane**, it will simultaneously re-align to align to the **Workplane - Z Axis (Simultaneous** is the **NC Preferences** - *default* setting).

The following 4 illustrations show the tool movements to 3 workplanes including a rotational move prior to performing the machining strategy.



Example

An existing **Project** will be opened that contains 4 separate **3 Plus 2**, finishing toolpaths ready to be added to an **NC Program**. Once included in the **NC Program**, appropriate positional moves must be added to prevent the tool from passing through the component form while moving between toolpaths.

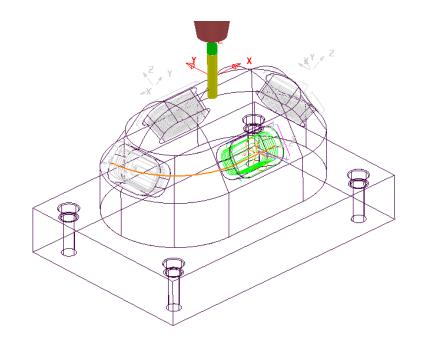
- 1 Select File Open Project:-
 -\PowerMILL_Data\FiveAxis\PositionalMoves\AngledPockets-Start



2 Select File - Save Project As:-

....\COURSEWORK\PowerMILL_Projects\AngledPockets

Connection moves using a Safe Z calculated to a 3-Axis Workplane



3 In the **PowerMILL** *explorer*, right-click on **NC Programs** and from the local menu, select **Preferences**.

3			NC Pre	ferer	nces		?	×
Output	Toolpath	Fixture offset	Verification					
Chang	ges made he	ere will not char	nge existing N	NC Pro	ograms			
	Use Pro	ject Off ↓	Output	t Fold	er C:\Temp\NCPro	grams		2
		Outpu	t File {ncpro	gram	}			
	Ma	chine Option Fi	le C:\dcam	\conf	ig\xtra-posts\MS-G\	/503-1.opt		
	Machine	Tool	~		Model Location	pkt4		~
0	utput Work	plane MainDat	um-top 🗸	S	Part Name			
					Tool Value	Тір		~
	Automat	ic Tool Alignm	ent On 🗸		Connection Moves	Simultaneou	JS	~
			C	lose				

4 Select a suitable *Five Axis*, Post-Processor *Option File*:

C:\dcam\config\xtra-posts\MS-GV503-1.opt

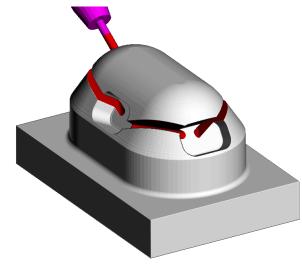
- 5 Select **Close** (The **NC Preferences** settings will be updated).
- 6 Create a new NC Program (It will be Active on creation).
- 7 Select the four *3plus2* Toolpaths (*D10t1-pkt....*) then right-click over them and in the local menu select Add to > NC Progam.

🖶 👹 NC Programs			
🖃 🚫 Toolpaths			🖃 👹 NC Programs
i🔗 🥊 🕩 d40t6-rgh1			🖃 💡 🐺 > 1
🖅 🕢 🖉 😂 BN16-sem1			🕀 📻 D10t1-pkt1
🖽 🔗 🥊 😂 D10t1-pkt1			🕀 🔧 D10t1-pkt2
🖶 🔗 🥊 😂 D10t1-pkt2	Toolpaths	(4)	🚽 🕞 🔂 🔒 🔒 🕞
👜 🛷 🗬 😂 D10t1-pkt3			🗼 💼 🚘 D10t1-pkt4
🗄 🛷 🔮 😫 D10t1-pkt4	Draw Selected		
Tools	Undraw Selected		
🕀 🖓 🔛 D40T6	Add to		Stock Model
	Create Individual NC Programs		NC Program
Boundaries	Load Tool Cutting Data		Group
🕀 🕅 Patterns	Edit	•	Folder
workplanes	Delete Toolpaths		
the second se			J

- 8 Select an **ISO 4** view.
- 9 Run a ViewMILL simulation on the first two, 3 Axis toolpaths; d40t6-rgh1, BN16-sem1, followed by the NC Program containing the four 3plus2 toolpaths.

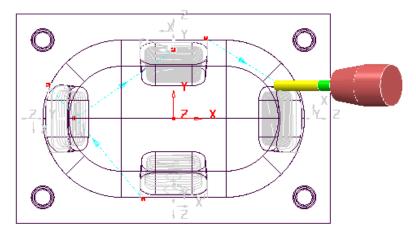


On closer inspection it will be observed that the **3plus2** - **Positional Tool Moves** have ploughed through the component between the individual machining strategies.





If the **Model** is displayed as **wireframe** then the displayed **NC Program** will also include the **link** moves (Pale Blue dashed lines) between the 4 stored **Toolpaths**.



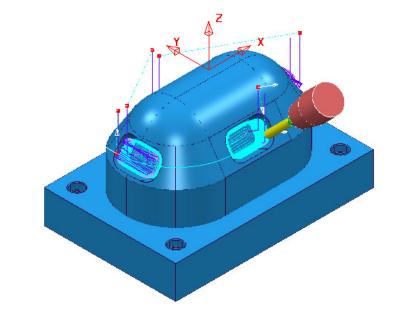
- **10** Activate the workplane MainDatum-top.
- 11 Calculate a Block using *Defined by* Box to the Model dimensions.
- 12 Open the Rapid Move Heights dialog.

🥳 Rapid Move Heights ? 🗙
Geometry
Safe area Plane 🗸
Workplane MainDatum-top 🗸
Normal
0.0 0.0 1.0
Safe Z -2.287618
Start Z -7.287618
Calculate dimensions
Rapid clearance 5.0
Plunge clearance 5.0
Calculate
Apply Accept Cancel
1

- 13 Input *Workplane* MainDatum-top and Calculate before selecting Accept.
- 14 In the **PowerMILL explorer** use the **Shift** key to multi-select the four, 3+2 **toolpaths**.

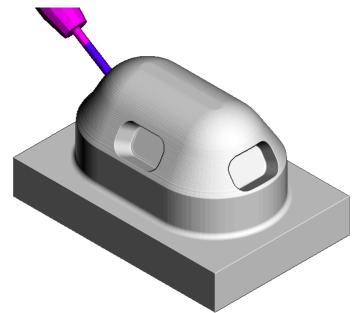
···· Noolpaths ···· Noolpath			
🖽 🗸 🥊 🚭 D10t1-pkt	Toolpaths	(4)	
	Draw Selected Undraw Selected Add to Create Individual NC Progr	rams	
⊕ 🗘 Boundaries	Edit	•	Transform
⊕ Matterns → Peature Sets	Delete Toolpaths		Invalidate Toolpaths Set Named Parameter
→ Workplanes → ☆ 2 > MainDatun → 2 Base-centre	n-top		Set Start Point Set End Point
🥊 🛵 pkt1			Set Rapid Moves
🦞 🛴 pkt2			Set Feed Rates

15 Right mouse click anywhere on the four selected **toolpaths**, and from the local menu select **Edit** – **Set Rapid Moves**.



The **Tool** will now perform rapid moves above the top of the **model**, relative to **workplane MainDatum-top**.

16 Run a ViewMILL simulation on the first two, 3 Axis toolpaths; D40t6-rgh1, Bn16-sem1, followed by the NC Program containing the four 3plus2 toolpaths.



The toolpath connection moves no longer collide with the model.

Connection moves using (Drive Curve) Pattern toolpaths

17 From the **Strategy Selector** - **Finishing** select the **Pattern** finishing strategy and enter data exactly as shown below.

3	Pattern Finishing ? ×
Toolpath name	ToolMove_Pkt1-Pkt2
Workplane Block Block Clock C	Pattern finishing Drive curve Use toolpath Image: Second structure Pkt1-Pkt2 Lower limit Base position Drive curve Axial offset 0.0 Gouge avoidance Gouge check
	Tolerance Ordering 0.1 Pattern Thickness

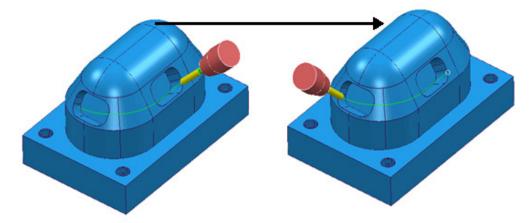
18 Select the **Tool Axis** page, and input a **Tool axis Lead/Lean** with **Mode Vertical** selected and a <u>Lean</u> value of **60**.

3	Pattern Finishing	? ×
Toolpath name	ToolMove_Pkt1-Pkt2	
Workplane	Tool axis	
	Lead/Lean V	
Stock engagement	Lead 0.0	60.0
Point distribution	Mode	Vertical 🗸
Machine axis control 	Fixed angle	Vertical Tangent normal
Leads and links Start point	None	PowerMILL 2012 R2

Workplane	Start point
Block	
Machine tool	Method
	Use First point 🗸 🗸
	Override tool axis
Pattern finishing	
Multiple cuts	Approach along Tool axis 🗸 🗸
Automatic verification	Approach distance 0.0
Point distribution	Approach distance 0.0
Tool axis	Coordinates
Machine axis control	
Rapid move heights	-2.866873 -95.402107 -39.356716
Eads and links	Testuis
Start point	Tool axis
End point	0.0 -0.866025 0.5

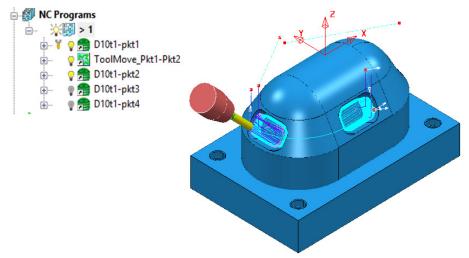
19 Select the **Start point** page, and **Use First point** with **Approach distance 0**.

- 20 Select the End point page and Use Last Point with Approach distance 0.
- 21 In Leads and links set both Lead in and Lead out to None.
- 22 Calculate the Pattern finishing toolpath.



The **Tool** 'winds' along the **Pattern Finishing** strategy creating a collision safe, transition around the component.

23 Insert the **Pattern Finishing** strategy (**ToolMove-Pkt1-Pkt2**) between the toolpaths, **D10t1-pkt1** and **D10t1-pkt2**.

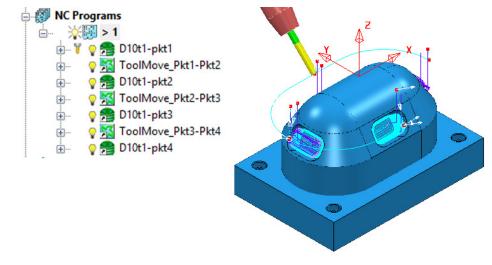


Exercise

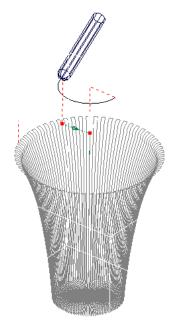
- 24 Create 2 more suitably positioned, tool move **Pattern Finishing** toolpaths named **ToolMove_Pkt2-Pkt3** and **ToolMove_Pkt3-Pkt4**.

Check the direction of each new Pattern Strategy and if necessary, reverse.

25 Insert the new Pattern Finishing toolpaths into the NC Program.



Tool Axis 'Rewind' Move





A useful application for using a **Pattern** as a **Positional Tool Move** is in cases where a **rotary axis limit** has been reached. A circular, **Pattern Finishing** strategy can be use to '**Rewind**' the **tool** in 3D space, back to the start of its rotary travel limits.

3. Five Axis Tool Alignment

Introduction

For **5-Axis** applications where the machine tool head and\or table, are required to perform both *linear* and *rotational* axis moves simultaneously, **PowerMILL** provides a range of appropriate **Tool Axis Alignments** and **Machining Strategies**.

Five Axis Tool Alignment and Machining Options

By default the **Tool Axis** alignment in **PowerMILL** is set to **Vertical** for **3-Axis** applications and other options will only be available to users with a multiaxis licence.



Some strategies only support multiaxis **Tool Axis** alignments when operating with **Ballnose** or **Spherical** tools.

The **Tool Axis Direction** dialog is accessed via the **Tool Axis** icon kiele located in the **Main** toolbar or directly from supported **Machining Strategy** forms.

The dialog provides a list of basic **Tool Axis** alignment options which are further controlled by a *Strategy* dependent selection of **Mode** options.

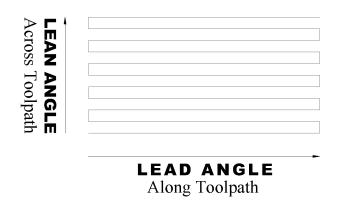
4	Tool A	xis	? ×
Smoothing		Machine axis co	ontrol
Definition	Limits	Collision av	voidance
Tool axis			
Lead/Lean	~		
Lead/Lean angles			
Lead		<u>Lean</u>	
0.0		0.0	
	Mode	Contact normal	~
		Contact normal	N
		/ertical	6
Fixed Angle	٦	langent normal	
None	F	owerMILL 2012	R2
	•	1010	

Tool Axis alignment - Mode options

- a **Contact Normal** This measures a **Lead** angle relative to the toolpath contact normal.
- **b** Vertical This measures a Lead angle relative to the Z Axis.
- c **PowerMILL 2012 R2** Reverts back to this version that did not offer a choice of **Mode** options (The actual **Mode** options used is strategy specific).
- d Preview frame normal This measures a Lead angle relative to the projection direction to or from the normal to the Projection Strategy, Preview pattern.
- Reference tool axis This measures the Lead angle form the tool axis used in a reference toolpath used as the Drive curve in a Pattern Finishing strategy.
- f Tangent Normal This measures the Lead angle relative to the perpendicular to the tangent direction of a Pattern used as the Drive curve in a Pattern Finishing strategy.
- g Undercut angle This measures the Lead angle from the projection direction corresponding to the specified undercut angle in a Parametric Spiral strategy.
- h Toolpath For a basic Tool Axis of From or Towards the actual alignment is relative to the model surface instead of the Preview pattern.
- i **Preview frame** For a basic **Tool Axis** of **From** or **Towards** the actual alignment is relative to the **Projection Strategy**, **Preview** pattern.

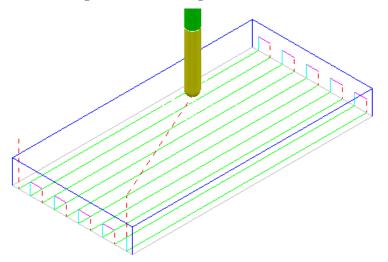
Lead/Lean - Example1

Lead allows the tool to be aligned to a specified angle <u>along</u> the **toolpath direction** and **Lean** a specified angle <u>across</u> the **toolpath direction**. If both angles are zero the **tool** will be aligned along the direction that a **toolpath** is projected onto the model during creation. For **Pattern** finishing this will always be vertical and for **Projection Finishing** it will vary depending on the defined strategy projection options.



1 From the **main** pull down menus select **File - Delete all** and **Tools** - **Reset forms**.

- 2 Open the (Read Only) Project:-
 -\Five_Axis\ToolAlignments\PlaneAlignments_Start



3 Save Project As:-

....\COURSEWORK\PowerMILL_Projects\PlaneAlignments_Demo

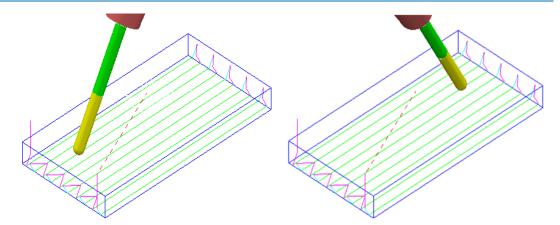
4 Simulate the Toolpath BN5-Vertical.

The above **Raster** toolpath is machined with the tool aligned to the **vertical** axis.

- 5 Right-click the Toolpath Raster Vertical in the PowerMILL explorer and select Settings to open the original Raster Finishing dialog.
- 6 Make a Copy of the Toolpath and rename it as BN5-Lead30.
- 7 Select the **Tool axis** page, with the **Tool axis** as **Lead\Lean**, with **Lead -30**, and use **Mode Vertical**.

3	Raster Finishing	?	×
Toolpath name	BN5-Lead30		
	Tool axis		
	Tool axis		
	Lead/Lean v		
🕅 Limit	Lead/Lean angles		-10
	Lead	Lean	
🚊 🚍 Raster finishing	-30.0	0.0	
🖥 🖬 High Speed			
Automatic verification			
	Mode	Vertical 🗸	
Tool axis		Contact normal	
wachine axis control		Vertical	
	Fixed angle	PowerMILL 2012 R2	
🗄 🛄 Leads and links	None 🗸	90.0	-
Start Doint			

- 8 Calculate the Toolpath and then Close the dialog.
- 9 Simulate the Toolpath (BN5-Lead30).



A Raster toolpath has been created with the **Tool axis** direction set to **Lead** at -30 degrees relative to the *vertical axis* (Z).

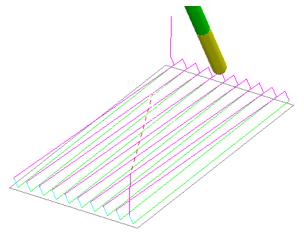


With the Two Way option, the Tool Axis direction will switch on opposing passes. This is due to the **Lead** angle being dependant on the tool track direction.

10 In the **PowerMILL** explorer, right-click on the toolpath **BN5-Lead30** and select Settings to open the Raster Finishing dialog.



- 11 Select *Re-cycle* and change *Style* to **One Way**.
- 12 Calculate the Toolpath and then Close the dialog.



With the Style set to One Way the Tool Axis direction remains fixed.

13 Right-click the toolpath BN5-Lead30 in the PowerMILL explorer and then select **Settings** to open the toolpath dialog.

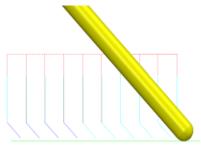


15 Select the **Tool Axis** icon **15** to open the **Tool Axis Direction** dialog.

16 In the Tool Axis page, change the Lead angle to 0, and input Lean 45.

Workplane	Tool axis
	Tool axis
	Lead/Lean V
	Lead/Lean angles
	Lead Lean
🚊 🛁 Raster finishing	0.0 45.0
🖥 🗐 High Speed	
🔚 Automatic verification	
	Mode Vertical 🗸
Tool axis	Contact normal
wiacrime axis control	Vertical
	Fixed angle PowerMILL 2012 R2
🗄 🛄 Leads and links	None v 90.0

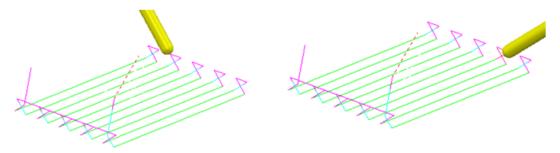
- 17 Calculate the Toolpath and then select Cancel to close the dialog.
- 18 Simulate the Toolpath.





A **Raster** toolpath has been created with the **Tool Axis Direction** set to **Lean 45** degrees across the **toolpath**.

If a **Two Way** had been directly applied in the strategy dialog, the tool axis would lean in the opposite direction across alternate tool tracks.



It is possible to create a **Two Way** strategy with a constant **Lean** direction by retrospectively editing a *one way* - **Toolpath**.

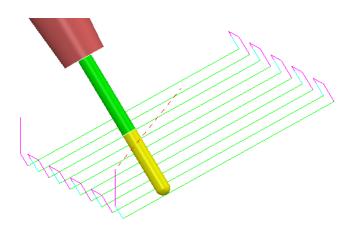
19 Right-click on the (One Way) Toolpath BN5-Lean45 and from the local menu, select Edit > Reorder to open the Reorder Toolpath Segments dialog.

20 Select the **Alternate directions** option (All tool tracks will be edited).

3	Reorder Tool	path Segments	?	×
#	Start point	End point	Length	Poi
0	-50.00, -22.50, -9.27	50.00, -22.50, -9.27	100.00	2
1	-50.00, -17.50, -9.27	50.00, -17.50, -9.27	100.00	2
2	-50.00, -12.50, -9.27	50.00, -12.50, -9.27	100.00	2
3	-50.00, -7.50, -9.27	50.00, -7.50, -9.27	100.00	2
⊻ 4	-50.00, -2.50, -9.27	50.00, -2.50, -9.27	100.00	2
5	-50.00, 2.50, -9.27	50.00, 2.50, -9.27	100.00	2
6	-50.00, 7.50, -9.27	50.00, 7.50, -9.27	100.00	2
7	-50.00, 12.50, -9.27	50.00, 12.50, -9.27	100.00	2
8	-50.00, 17.50, -9.27	50.00, 17.50, -9.27	100.00	2
9	-50.00, 22.50, -9.27	50.00, 22.50, -9.27	100.00	2



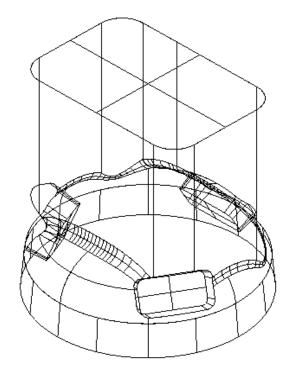
21 Select **OK** to close the above **PowerMILL Warning** dialog.



- 22 Save Project to update:-
 -\COURSEWORK\PowerMILL_Projects\PlaneAlignments_Demo

Lead/Lean - Example2

- 1 Select File Delete all and Tools Reset Forms.
- 2 Open the Project (saved earlier during Chapter 1) from:\COURSEWORK\PowerMILL-Projects\3Plus2-EX1



- 3 Define a Dia 15mm Ball Nose cutter named BN15.
- 4 Activate the Workplane ztop175_A.
- 5 Create a material Block defined by Box to the Max\Min Limits of the Model and then edit the following values as shown below:

Xmin -70 Xmax-52.5 Ymin -50 Ymax 50

- 6 Open the **Rapid Move Heights** dialog and select **Calculate**, then **Accept**.
- 7 In the Start and End Point dialog in *Start Point* set First Point Safe and in *End Point* set Last Point Safe.

8 Set Leads\Links 🛄 as follows:

Z heights: Skim 15, Plunge 5

Lead In\Out: Vertical Arc: Angle 90, Radius 6

Links: Short\Long Skim and Default Incremental

9 Ensure that no **Boundary** is **Active**.

An area of the component will be machined using **Raster Finishing**. The **Tool Axis** will be aligned to a fixed *Lean angle* of **40** degrees relative to the **Vertical** axis.

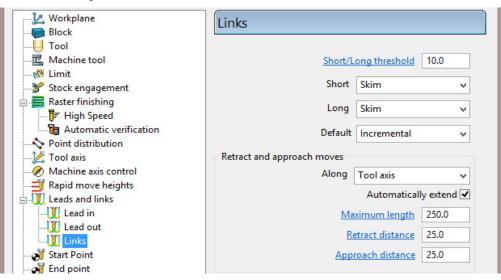
- 10 Select the **Toolpath Strategies** icon and in the **Strategy Selector** dialog, select the **Finishing** tab.
- **11** Select the **Raster Finishing** dialog and enter data exactly as shown below:

- <u></u>	Raster Finishing ? ×
Toolpath name	BN15-Raster-Lean40
Workplane	Raster finishing
U Tool 	✓ Fixed direction Angle 90.0
Raster finishing	Start corner Upper left 🗸 🗸
Automatic verification	Perpendicular pass Perpendicular pass
	Shallow angle 30.0
Rapid move heights	Optimise parallel pass
	Style One way
	Arc radius 0.0
	0.03
	Thickness
	Stepover
(1990)	1.0 🙏 0.033408
	Preview Draw
	Calculate Queue OK Cancel

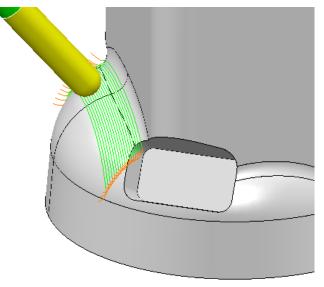
12 Select the **Tool axis** page and enter data into the dialog exactly as shown in the following illustration.

H	Raster Finishing ?	×
Toolpath name	BN15-Raster-Lean40	
Workplane	Tool axis	
Tool	Tool axis	
	Lead/Lean V Lead/Lean angles	
	Lead Lean 0.0 40.0	
High Speed	40.0	
Point distribution	Mode Vertical 🗸	

13 From **Leads and links** select the **Links** dialog and enter data exactly as shown in the following illustration.



14 Calculate the Toolpath and then Cancel to close the dialog.



The resultant toolpath starts at the lower corner and progresses towards the centre using a climb milling action (**One Way**). If it is required for the strategy to be **Two Way** then it can only be retrospectively changed using **Edit** > **Reorder** > **Alternate Direction**.

To compare the effect of applying a different machining strategy, the same area of the component will be machined using **Projection Plane Finishing**. This time the **Tool Axis** will be aligned using a **Lean** of **0** degrees relative to the *projection direction* of the strategy.

- 15 Calculate a Block, Defined by Cylinder using Type Model, to the Coordinate System - Named Workplane - ztop175_A.
- 16 Select the **Toolpath Strategies** icon and in the **Strategy Selector** dialog select the **Finishing** tab.
- 17 In the Finishing options select **Projection Plane Finishing**.

18 Enter data into the following 3 pages of the **Plane Projection Finishing** dialog, exactly as shown below:

🥳 Plane	Projection Finishing ? 🗙
Toolpath name	BN15-ProjPlane-Lean0
Workplane Block Tool Kachine tool Stock engagement Stock engagement Plane projection Automatic verification Point distribution Point distribution Notes Start Point End point Start Point	Plane projection Location -110.0 0.0 -75.0 Image: Constraint of the second s
ITTO	Preview 🗹 Draw

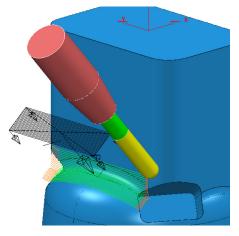
- Set Azimuth to 270
- Set Elevation to 50

Workplane	Pattern
Tool Tool Machine tool Machine projection Plane projection Pattern Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Action and links Start Point Start Point Feeds and speeds	Pattern Pattern direction U v Ordering One way v Sequence None v
	Limits Height Start 0.0 End 25.0 Width Start 50.0 End -50.0



Workplane	Tool axis
Tool	Tool axis
	Lead/Lean 🗸
🔞 Limit	Lead/Lean angles
	Lead Lean
🚊 🤣 Plane projection	0.0 0.0
🔚 Automatic verification	
	Mode Preview frame normal 🗸
🗄 🖆 Tool axis	Contact normal
Machine axis control	Vertical
	Fixed angle Preview frame normal
🗄 🖳 🚺 Leads and links	None v PowerMILL 2012 R2 ゆ
Start Point	

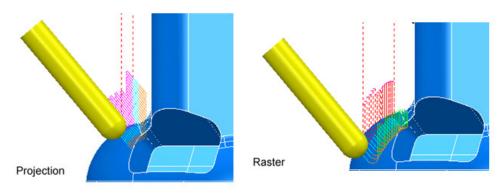
- 20 Calculate the toolpath and then Close the dialog.
- 21 Simulate the toolpath and observe the associated tool alignment.



The resultant toolpath starts at the lower corner and progresses towards the centre with a **Lead in** and **Lean out** both set to **0** creating tool alignment relative to the projection direction. Due to **Lead** and **Lean** being **0** a directly calculated **Two way** strategy is a feasible option.

22 Select a view along the **Y** Axis and then **Simulate** both toolpaths in turn to visually, compare both strategies.

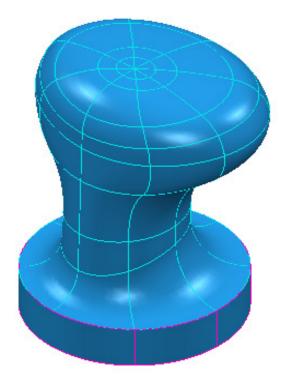
The tool alignment is the same for both toolpaths due to a suitable **Lean** value of **40** being applied to the **Raster** strategy.



23 Select File - Save Project.

Lead/Lean - Example 3

- 1 Select File Delete all and Tools Reset forms.
- 2 Import the model:
 - ...\PowerMILL_Data\five_axis\joint_5axismc\joint5axis.dgk



- 3 Save the Project As:-
 - ...\COURSEWORK\PowerMILL_Projects\Joint-EX1
- 4 Create the material **Block** using **Defined by Box** to the **Model** dimensions and then **expand** it by **15** in **X** and **Y** only.
- 5 Create a **Dia 25 Ball Nosed** cutter (**BN25**).
- 6 Select Calculate in the Rapid Move Heights dialog.
- 7 Use the **Start and End Point** default settings.
- 8 Modify the settings in **Leads and Links** 🔛 as follows:
 - For Z heights use Skim 45 and Plunge 10
 - For *Links* set both *Short* and *Long* Links to Skim.

- 9 Select the Toolpath Strategies icon and in the New Strategies dialog, select the Finishing tab.
- **10** Select **Projection Line Finishing** and enter data exactly as shown in the following 3 pages of the dialog.

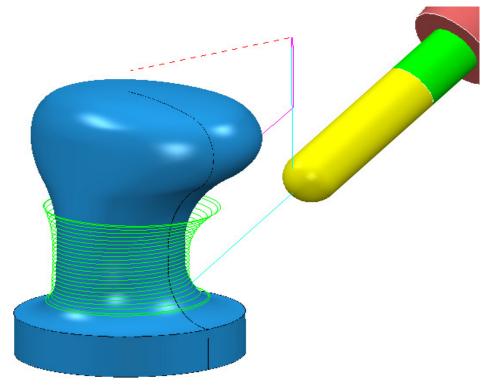
🛃 Line	Projection Finishing ? ×
Toolpath name	BN25-LinrProj-1
Workplane	Line projection
	Pattern Style Spiral V
¥ Stock engagement □	Location 0.0 0.0 22.0
→ Hatomatic verification → Point distribution → Tool axis	Azimuth 0.0
⊘ Machine axis control ⊒ Rapid move heights ⊕-₩ Leads and links	Elevation 0.0
	Projection Direction Inwards
	Tolerance 0.1
	Thickness 0.0
	Stepover
The start	Preview Draw
	Calculate Queue OK Cancel

- Set Azimuth to 0
- Set Elevation to 0

Workplane	Pattern
Block	
Machine tool	Pattern
	Style Spiral 🗸
→	
🚊 🍫 Line projection	Direction Clockwise V
Pattern	
Automatic verification	Limits
	Linits
	Height
Machine axis control	Start 5.0 End 50.0
🗄 🛄 Leads and links	
	Preview 🗹 Draw

Workplane	Tool axis
Tool	Tool axis
	Lead/Lean v
	Lead/Lean angles
	Lead Lean
🚊 🧄 🎪 Line projection	0.0 -30.0
🔚 🔚 Automatic verification	
	Mode Preview frame normal 🗸
Tool axis	
Machine axis control	

11 Calculate the **Toolpath** and then **Cancel** to close the dialog.



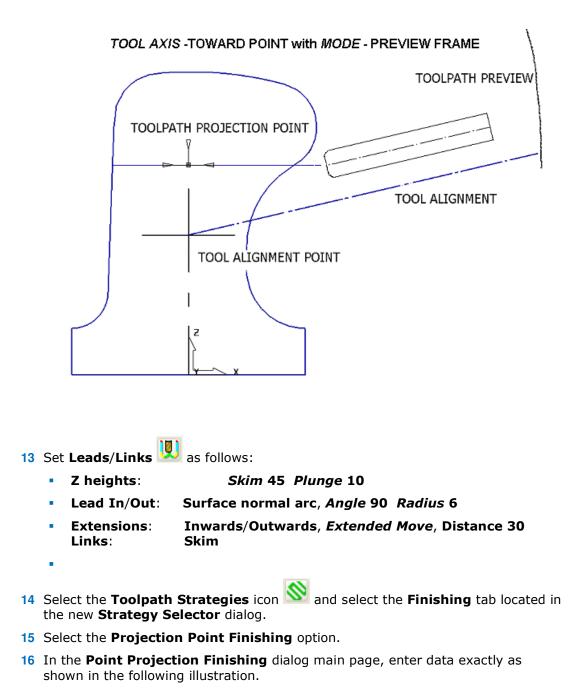


The next section continues with the machining of the upper part of this component.

12 Save the Project (but do not close it down).

Toward \ From Point

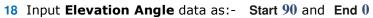
These options allow the **Tool Axis** alignment to be based on a user-defined point during the generation of toolpaths (In this case **Towards Point**). If **Mode** - **Preview frame normal** is used then the actual alignment is taken relative to the **Preview** pattern for the strategy and not the final toolpath.



🥳 Point	: Projection Finishing ? ×
Toolpath name	BN2-PointProj-2
Workplane Block Machine tool Kachine tool Kachine tool Kachine action Point projection Point projection Point projection Point distribution Point distribution Point distribution Machine axis control Rapid move heights Machine axis control Start point End point End point Feeds and speeds History Notes and Description Viser defined settings	Point projection Pattern Style Spiral Location 0.0 0.0 Projection Direction Inwards Tolerance 0.1 Thickness 0.0 0.0 Angular stepover 1.5 Preview Draw
	Calculate Queue OK Cancel

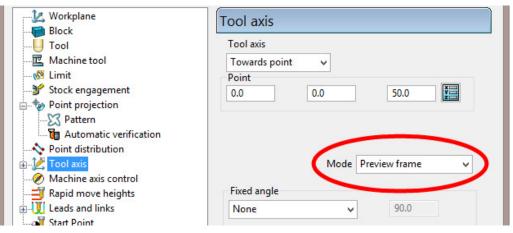
17 Select the **Pattern** page and enter data into the dialog exactly as shown in the following illustration.

Workplane	Pattern
U Tool 	Pattern Style Spiral V Direction Clockwise V
Pattern Automatic verification Point distribution Yool axis Machine axis control Rapid move heights Hendy Leads and links	Limits Elevation angle <u>Start</u> 90.0 <u>End</u> 0.0
Start Point	Preview Draw

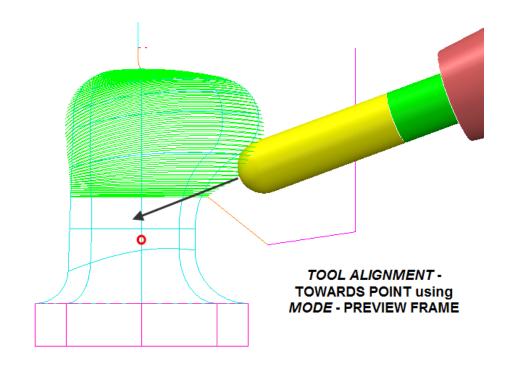


Copyright © Delcam Ltd

19 Select the **Tool Axis** page and enter data into the dialog exactly as shown in the following illustration.



20 **Calculate** the **Toolpath** but <u>do not</u> close the dialog.





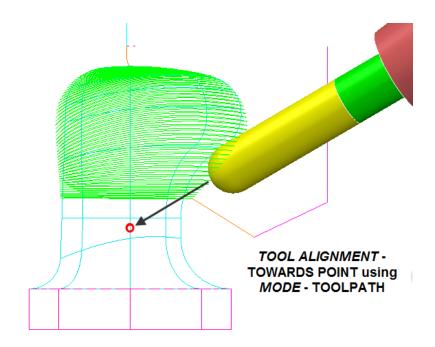
The **Tool Alignment** point is approximately **20mm** below the **Projection Finishing** focal point to ensure that the spindle axis remains at an elevation angle to the machine tool table during machining hence avoiding collision.

Mode – Preview Plane:- The actual **Tool** alignment occurs on the **Projection Point Finishing - Preview** pattern, after which the tool is then projected on to the model (towards the **strategy - focal point**).

- 21 In the **Point Projection** dialog select *Re-cycle* and then open the **Tool Axis** page.
- 22 Change the *Tool axis* Mode to Toolpath.

🥶 Point	Projection Finishing	?	×
Toolpath name	BN25-PointProj-2		
Workplane Block Jool Kachine tool Kachine tool Machine tool Machine agement Point projection Point projection Automatic verification Point distribution Point distribution Machine axis control Rapid move heights Leads and links Start Point	Tool axis Tool axis Towards point Point 0.0 50.0	Y	
	Fixed angle None 90.0		\supset

23 Calculate the Toolpath and then Cancel to close the dialog.



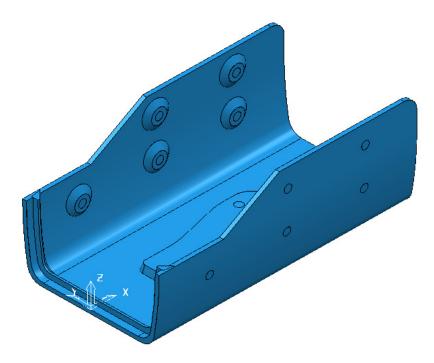
Mode – Toolpath:- The **Tool** alignment is applied directly on to the finished toolpath (towards the **strategy focal point**).

24 Select File - Save Project.

Toward\From Line

These options allow **tool axis alignment** to be **towards** or **from** a user-defined line, specified by a **Vector** direction through a suitably positioned **XYZ** coordinate.

- 1 Select File Delete all and Tools Reset forms.
- 2 Import the Model:-
 - ...\PowerMILL_Data\five_axis\Casing\from-line-model.dgk



3 Save the **Project** As:

...\COURSEWORK\PowerMILL_Projects\CameraCasing

- 4 Create a Dia 12 Ball Nose cutter named BN12 of Length 55 with:-
 - Shank of *Dia* 12 *Length* 40.
 - 1st Holder Lower Dia 25 Upper Dia 40 Length 40.
 - 2nd Holder Upper/Lower Dia 40 Length 60 Overhang 90.
- 5 Define the **Block** (use **Box**) to the **Model** limits.
- 6 Select **Calculate** in the **Rapid Move Heights** dialog.
- 7 Set Leads\Links 🛄 as follows:
 - Z heights: Skim 5, Plunge 5
 - Lead In/Out: 1st Choice Surface normal arc, Angle 45, Radius 5.0
 - Links: Threshold 3, Short Circular Arc, and Long Skim.

- 8 Select the **Toolpath Strategies** icon and in the new **Strategy Selector** dialog, select the **Finishing** tab.
- 9 Select the **Projection Line Finishing** option.
- **10** In the **Line Projection Finishing, Pattern**, and **Tool Axis** pages enter data exactly as shown in the following illustrations.

📸 Line	Projection Finishing ? ×	
Toolpath name	BN12-LineProj-FIN1	
Workplane	Line projection	
 Tool Machine tool Limit Stock engagement Pattern Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point End point Feeds and speeds History Notes and Description User defined settings 	Pattern Style Circular v	
	Location 0.0 75.0	
	Azimuth 0.0	
	Elevation 90.0	
	Projection Direction Outwards	
	Tolerance 0.02	
	Thickness	
	Stepover 1.0	
	Preview 🗹 Draw	
	Calculate Queue OK Cancel	

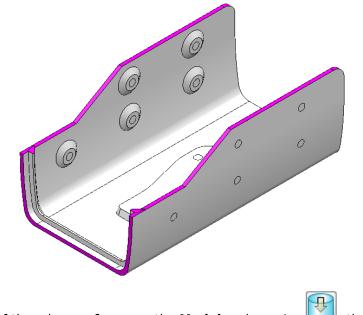
- Set Style to Circular
- Input Location as 0 0 75
- Set Azimuth to 0
- Set Elevation to 90
- Set Direction Outwards
- Use *Tolerance* 0.01
- Use Stepover 1

ی

	Pattern
	Pattern Style Circular v Ordering Two way v Sequence None v
Point distribution Tool axis Machine axis control Rapid move heights Leads and links	Limits Azimuth angle <u>Start</u> 90.0 <u>End</u> -90.0
, Start point , End point ⊒, Freeds and speeds , History	Height <u>End</u> 200.0
 Potes and Description User defined settings 	Preview 🔽 Draw

- 11 Back in the main Line projection page, select Component Thickness
- **12** Select any one of the 8 rows in the **Component Thickness** dialog.

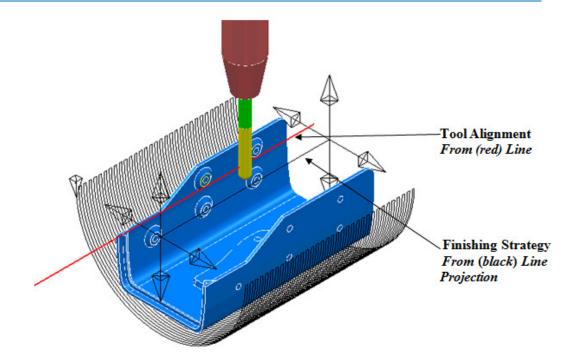
3			Com	ponent Thickne	ess		?	×
Surfaces	Verification	Surface Det	faults					
Entity		eProj-FIN1	♥ Use Axial T	hickness	ne V		2	
Collisi	ning Mode on v	Thistophy	A	Thickness 0.0	T-1-1 A-1-1	-		W
Set	0.00000	Thickness	Axial	Total Thickness	Total Axial	#		
0	Machine	0	-	0	-	0		
1	Machine	0	100	0	2012/1	0		
\$2	Machine	0	-	0	00	0		
3	Machine	0	-	0		0		
4	Collision	0	-	0	-	12		
₫5	Machine	0	-	0		0		
6	Machine	0	_	0		0		
<₿7	Machine	0		0	-	0		
×	Machine	-		0	-	87		
		4	Apply	Accept	Cancel			



- **13** Select all of the edge **surfaces** on the **Model** and acquire them to the selected row in the **Component Thickness** dialog.
- 14 Set the Machining Mode to Collision.
- 15 Apply and Accept the Component Thickness dialog.
- **16** Back in the **Line Projection** dialog select the **Tool Axis** page and enter data exactly as shown below.

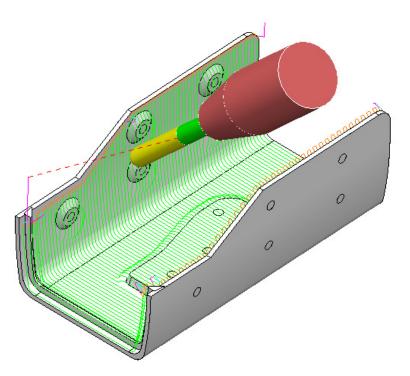
Line Line	Projection Finishing ? ×
Toolpath name	BN12-LineProj-FIN1
 Workplane Block Tool Machine tool Limit Stock engagement Line projection Pattern Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point Feeds and speeds History Notes and Description User defined settings 	Tool axis Tool axis From line Point 0.0 0.0 Direction 1.0 0.0 Direction 1.0 0.0 Mode Preview frame Fixed angle None 90.0 Rotary axis configuration Tool axis limits Automatic collision avoidance Tool axis smoothing \checkmark Draw tool axis

17 Tick the Draw Tool Axis boxIne relative to the Model (as shown in the following image).



- **18** Click the **Preview** tab to view the strategy before selecting **Calculate** to create the **Toolpath**.
- **19** Close the **Line Projection Finishing** dialog.

The end result (with a larger stepover) is as shown in the following illustration:



The use of **Tool Axis – From line** with **Mode – Preview frame** has ensured that the whole of the internal form, including the undercut areas, is fully accessible. Note that in this case it gives a better result than if **Mode – Toolpath** had been used.

20 Save the Project.

Toward\From Curve

These options allow the **tool axis alignment** to be through a user-defined curve (**Pattern**).

The following example will use the **Surface Finishing** strategy. This is possible due to each of the two different blade areas to be machined being *smooth*, *single surfaces* with the edges aligned to the *surface curves* (The resultant tool tracks will be aligned to these curves).

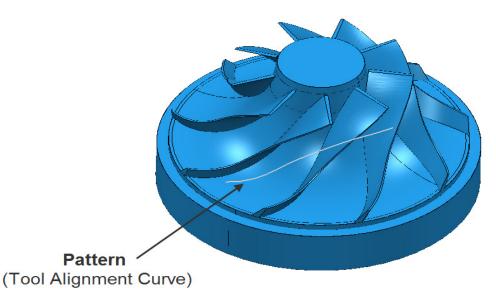
- 1 Select File Delete all and Tools Reset forms.
- 2 Import the Model:

....\PowerMILL_Data\five_axis\Impeller\ impeller+Curve.dgk

3 Save the Project as:

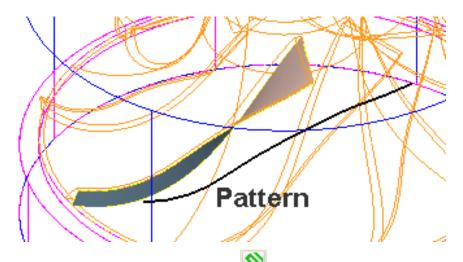
....\COURSEWORK\PowerMILL_Projects\ Impeller+Curve-EX1

- 4 Create an empty **Pattern** and rename it as **Align2Curve**.
- 5 In the graphics area, select the **wireframe**, *alignment curve* that has been imported with the **Model** (Ensure that both the **Plain Shade** and **Wireframe** views are switched on!).
- 6 Right mouse click on the Pattern (*Align2Curve*) and from the local menu, select Insert > Model to copy the selected *alignment curve* as a Pattern segment.



- 7 Create a **Dia 3 Ball Nosed** cutter (named **BN3-LR**) of **Length 35** with the following **Shank** and **Holder** dimensions:
 - Shank Upper\Lower Dia 3 Length 25
 - Holder 1 Upper Dia 15 Lower Dia 10 Length 50
 - Holder 2 Upper\Lower Dia 15 Length 35
 - Overhang 50
- 8 Create a **Block** defined by **Cylinder** to the **Model** dimensions.
- 9 Set Links as *Short/Long* to Skim and *Default* to Incremental.
- 10 In the Rapid Move Heights dialog select Calculate.

11 Select the underside face of the blade (nearest to the **Pattern)** to be used in the 1st **Surface Finishing** strategy.



- 12 Select the **Toolpath Strategies** icon and in the **Strategy Selector** dialog select the **Finishing** tab.
- **13** Select **Surface Finishing** and fill in the pages of the dialog exactly as shown in the following illustration.

🥳 Surface Finishing		?	×
State Too	path name BN3-LwrBlade-FIN		
 Workplane Block Tool Machine tool Stock engagement Stock engagement Stock engagement Pattern Automatic verification Tool axis Machine axis control Rapid move heights U Leads and links Start point Freds and speeds History Notes and Description User defined settings 	Surface finishing Surface side Outside Surface units Distance Degouge tolerance 0.3 Tolerance 0.02 Thickness 0.0 Stepover (Distance) 0.3 Output Draw Draw	~	
	Calculate Queue OK Cancel]	
Surface side - Out	side		

Workplane	Pattern
	Pattern
¥ Stock engagement ₩ Surface finishing ₩ Pattern	Pattern direction V - Spiral 🕅
Hattomatic verification	Ordering One way 🗸
	Start corner Max U min V 👻
✓ Machine axis control ✓ Rapid move heights	Sequence None -

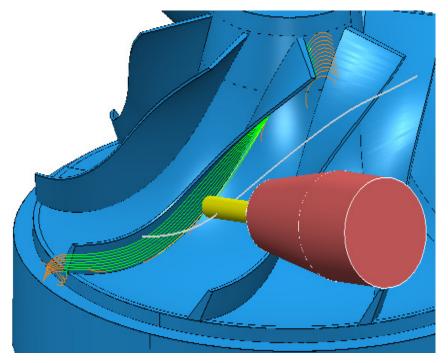
- Pattern direction V
- Ordering One way
- Start corner Max U min V

Workplane Block Tool Machine tool Limit Stock engagement Surface finishing Automatic verification	Tool axis Tool axis From curve
Point distribution Col axis Machine axis control	Mode Toolpath

14 For both Lead in and Lead out use the following for *1st* and *2nd* choice.

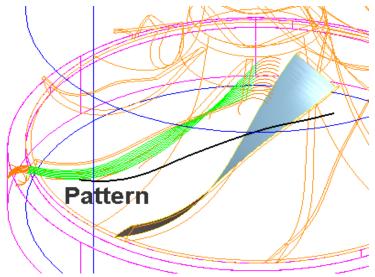
3		L	eads a	nd Linl	s	?	×
Extension	ns		Links		Point	distribution	
Z heights	First lea	id in	Lead	d in	Lead out	Last lead out	
1st choice				2nd c	hoice		
Surface normal	arc		~	Verti	cal arc		~
	Distanc	<u>e</u> 0.0			I	Distance 0.0	
	Ang	<u>le</u> 90.0)			Angle 90.	0
	Radiu	<u>us</u> 3.0				Radius 3.0	

- **15** Click the **Preview** tab and view the strategy before selecting **Calculate** to create the **Toolpath**.
- **16** Close the **Surface Finishing** dialog.



The **Tool Axis** is always aligned through the specified **Pattern** (Curve) while performing the **Surface Finishing** strategy.

- 17 Right-click on the existing **Surface Finishing** strategy and from the local menu, select **Settings** to re-open the dialog.
- 18 In the dialog, select Make a copy of the Toolpath
 19 Select the
- Select the upper side, blade surface (nearest to the **Pattern**) to be used as the **Reference Surface** in the 2nd **Surface Finishing** strategy.

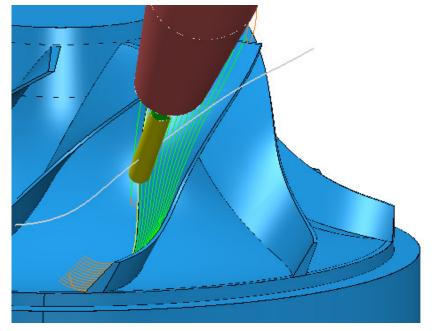


20 Open the **Surface Finishing** and **Tool Axis** dialogs, entering the data exactly as shown on the next page and select **Calculate**.

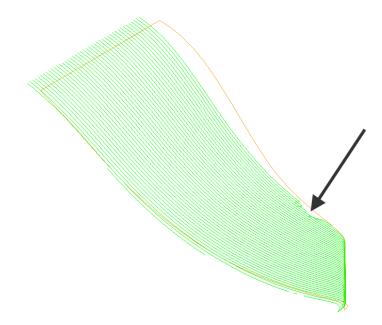
🥳 Surface Finishing				?	×
🕸 🚺	Toolpath name	BN3-UprBlade-	FIN		
 Workplane Block Tool Kachine tool Stock engageme Surface finishing Pattern Automatic ve Point distribution Tool axis Machine axis cor Rapid move heig Leads and links Start point End point Feeds and speed History Notes and Descri User defined sett 	rification htrol hts s	Surface fini Surface Degouge tok 0.3 Tolerance 0.02 Thickness 0.0 Stepover (Dis ¥ 0.3	Surface side Outside Surface units Distance erance		

	Pattern
U Tool 	Pattern Pattern direction
Surface finishing	Spiral 🥅
Automatic verification	Ordering One way 👻
	Start corner Min U max V 👻
Machine axis control	Sequence None -

- Pattern direction V
- Start corner Min U max V
- 21 Click the **Preview** tab to view the strategy before selecting **Calculate** to create the **Toolpath**.
- **22** Close the Surface Finishing dialog.



The *Tool Axis* is always aligned through the specified **Pattern** (Tool Alignment Curve) while performing the chosen machining strategy (**Surface Finishing**).



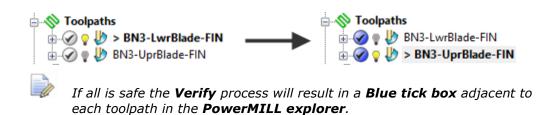
A small area on the latest toolpath is fragmenting along the top edge as arrowed above. This is caused by one of the other blades getting in the way of the projection process at this point. In this instance an easy fix can be applied by using a copy of the existing **Pattern** and moving it upwards by **1.5**.

- 23 Create a copy of **Pattern Align2Curve** which will automatically be named as **Align2Curve-1**.
- 24 Move the new Pattern upwards by 1.5mm.
- 25 Recycle the toolpath **BN3-UprBlade-FIN** with the **Tool axis from curve** options using **Pattern Align2Curve-1**.



The toolpath fragmentation on the upper edge has now been fixed.

26 Activate and Verify each toolpath in turn, checking both the Gouge and Collision status (Use a Shank Clearance of 1 and a Holder Clearance of 2).



27 Save the Project.

Fixed Direction

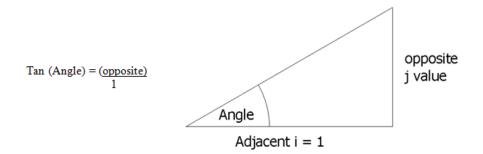
This allows the **Tool Axis** to be set to a fixed angle, specified as a user defined, **Vector**. In this case it is applied to the finishing of an angled recess on the supplied **Model**.

Angle to Vector conversion table

Fixed Direction Tool Alignment - Vectors\Angular equivalents

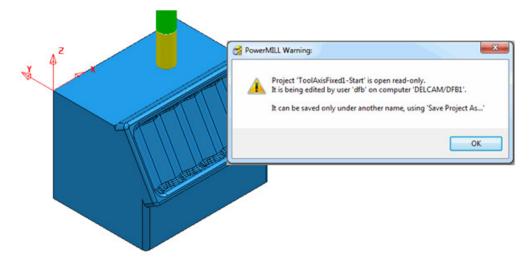
The table represents angular directions and vectors on the XY plane (Z=0).

ANGLE		VECTORS	
(Degrees)	(I	J	K)
0	1	0.0000	0
5	1	0.0875	0
10	1	0.1760	0
15	1	0.2680	0
20	1	0.3640	0
25	1	0.4660	0
30	1	0.5770	0
35	1	0.7000	0
40	1	0.8390	0
45	1	1.0000	0
50	1	1.1920	0
55	1	1.4280	0
60	1	1.7320	0
65	1	2.1450	0
70	1	2.7470	0
75	1	3.7320	0
80	1	5.6710	0
85	1	11.4300	0
90	0	1.0000	0

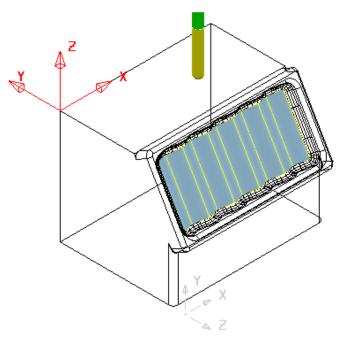


The **Tool Alignment** is set to a **Fixed Direction** relative to the currently active **Workplane** by inputting suitable values as an **I J K vector** along the **Tool Axis** (towards the spindle). Although the correct values for a **vector** may require the user to exercise their trigonometry skills, this method does provide full flexibility for defining compound angles.

- 1 From the **main** pull down menus, select **File Delete All** and **Tools Reset Forms**.
- 2 **Open the (read only) Project:**
 - ...\PowerMILL_Data\five_axis\AngledFrame\ToolAxisFixed1-Start



- **3 Save the Project As:**
 - ...\COURSEWORK\PowerMILL_Projects\ToolAxisFixed-EX1
- 4 Activate and then *de-activate* the Toolpath D12t1-ruf-TOP.
- 5 This will restore the settings (**Workplane**, **Rapid Move Heights**, **etc**) ready to apply a finishing strategy on the corrugated angled form.
- 6 Activate the BN6 tool.
- 7 Select the undulating **Surface** on the base of the angled recess.



- 8 Select the **Toolpath Strategies** icon and in the **Strategy Selector** dialog select the **Finishing** tab.
- **9** Select the **Surface Finishing** option and fill in the pages of the dialog exactly as shown in the following illustrations.

- 🛃 - S	Surface Finishing ? ×
Toolpath name	BN6-fin-ANGLE
 Workplane Block Tool Machine tool Limit Stock engagement Surface finishing Pattern Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point Freds and speeds History Notes and Description User defined settings 	Surface finishing Surface side Outside Surface units Distance Degouge tolerance O.3 Tolerance O.02 Thickness O.0 Stepover (Distance) Preview Draw
	Calculate Queue OK Cancel

- Surface Side Outside
- Stepover 0.5

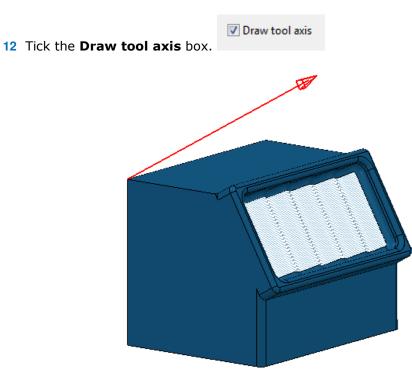
8	Surface Finishing			? >
Toolpath r	BN6-Fin-ANGLE			
	Pattern			
	Pattern			
		Patterr	n direction V	iral 🗌
Pattern Automatic verification		Ordering	Two way	~
		Start corner	Min U min V	¥
Machine axis control		Sequence	None	~
attern direction - V				

Ordering - Two way

🤹 s	urface Finishing ? ×
Toolpath name	BN6-Fin-ANGLE
Workplane ➡ Block ➡ Tool ➡ Machine tool ➡ Ø Limit	Tool axis Tool axis Fixed direction
Stock engagement Surface finishing Pattern Automatic verification Point distribution Col axis Machine axis control	Direction 0.0 -1.0 0.577

10 Set the **Tool Axis** to **Fixed direction**.

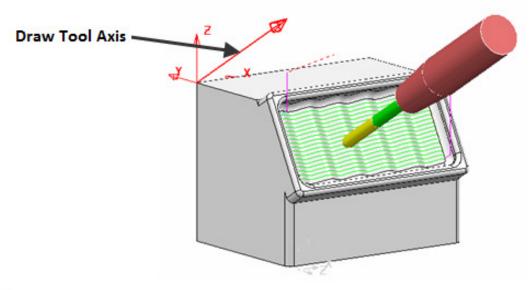
11 Input the vector *Direction* values: **I** 0 J -1 K 0.577



13 From **Leads and links** select the **Links** dialog and enter data exactly as shown in the following illustration.

Workplane	Links
Tool	Short/Long threshold 2.0
Stock engagement ⊡	Short On surface 🗸
Pattern	Long Skim -
Point distribution	Default Incremental -

- 14 Click the **Preview** tab to view the strategy before selecting **Calculate** to create the **Toolpath**.
- **15** Close the Surface Finishing dialog.





For viewing purposes, the toolpath shown in the illustration has been created using a 2mm Stepover.

16 From the main pulldown menu, select File - Save to update the stored Project: ...\COURSEWORK\PowerMILL_Projects\ToolAxisFixed-EX1

4. Projection Surface Finishing

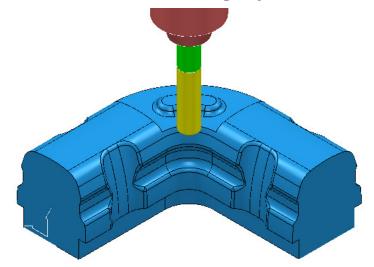
Introduction

In a **Projection Surface Finishing** the strategy is projected **Inwards** or **Outwards** along the normals of a single **Reference Surface**. For five axis applications an appropriate **tool alignmen**t is used. The toolpath runs either across or along the natural **Reference Surface** directions (U or V) with the **Stepover** being defined by unit **Distance** or **Parametric** division between **Surface Curves**. In some cases the **Reference Surface** may form part or all, of the component to be machined.

To create a **Reference Surface** the user will require the services of a suitable **Surface Modeller**, ideally **PowerSHAPE**. For the following example the **Reference Surface** has already been created and stored as a separate *dgk* file to be imported as required. A **reference surface** should be as smooth and simple as possible. It should also be as close as possible to the actual *surfaces* that are to be machined.

1 Open the (Read Only) Project:-

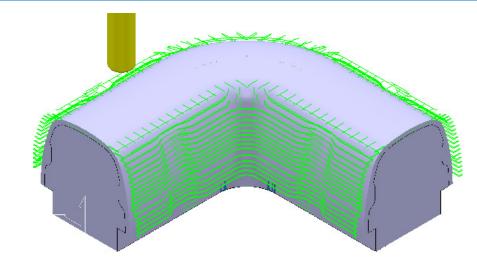
...\PowerMILL_Data\five_axis\CornerFixing\ProjectionSurfaceEX1-Start



2 Save the Project as:

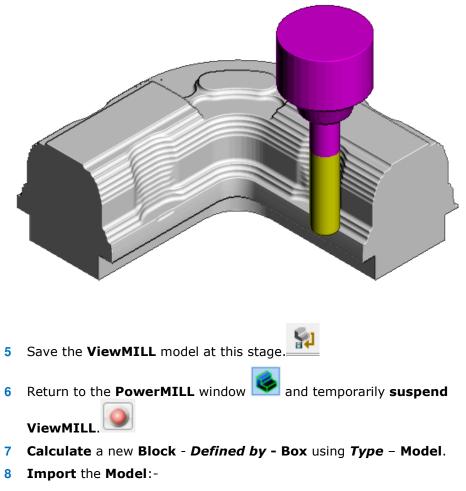
...\COURSEWORK\PowerMILL_Projects\ProjectionSurface-Example1

3 Activate the toolpath D25TR3-RGH1 to reinstate the settings.



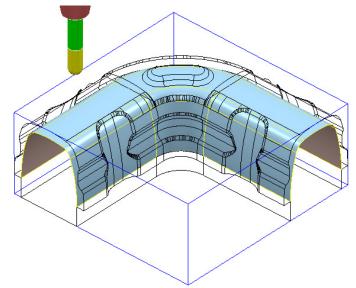
The **Block** used in the toolpath D25TR3-RGH1 is defined from an imported **Triangle** model (**dmt** file) of a Casting.

4 Run a ViewMILL simulation on the toolpath D25TR3-RGH1.



.....\PowerMILL_Data\five_axis\CornerFixing\CornerFixingRefSurf1.dgk

- 9 In the **PowerMILL** explorer, Activate the BN16 tool.
- 10 In the **PowerMILL explorer** right mouse click on the **model** named **CornerFixingRefSurf1** and from the local menu select **Select All**.



The newly *imported* (reference) **surface** (shown shaded above) is fully located inside the original component **model**.

- 11 From the main toolbar select the Toolpath Strategies
- 12 From the dialog select the **Finishing** tab followed by the **Projection Surface Finishing** option.
- **13** Enter the values into the *main* page of the **Surface Projection Finishing** exactly as shown below.

🥳 Surfac	e Projection Finishing ?	×
Toolpath name	BN16-FIN1	
 Workplane Block Tool Machine tool Limit Stock engagement Pattern Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point Start point Feeds and speeds History Notes and Description User defined settings 	Surface projection Surface Surface units Distance Smoothing tolerance 0.02 Angular smoothing tolerance 0.015535 Projection Direction Inwards Tolerance 0.1 Thickness 0.1 Stepover (Distance) 2.0 Preview Draw	

14 Enter the values into the **Pattern** page of the **Surface Projection Finishing** exactly as shown below.

🕉 Surface	e Projection Finishing ? 🗙
Toolpath name	BN16-FIN1
Workplane Block Glock Glock	Pattern Pattern Pattern Pattern direction U v Spiral Ordering One way v Start corner Min U max V v Sequence None v
Rapid move heights Rapid move heights Leads and links Lead out Lead out Links Rapid End point Feeds and speeds History Notes and Description	Limits (Distance) UVV Start 0.0 0.0 End 1.0 95.0 Preview VDraw

- Pattern direction U
- Start corner Min U max V
- Limits (Distance) V (ticked):- Start 0 End 95
- 15 Enter the values into the **Tool axis** page of the **Surface Projection Finishing** exactly as shown below.

😸 Surfac	e Projection Finishing	?	×
Toolpath name	BN16-FIN1		
Workplane Block Tool Machine tool Workplane Stock engagement Stock engagement Surface projection W Pattern	Tool axis Tool axis Lead/Lean Lead/Lean angles Lead 0.0		
Automatic verification Point distribution Coloratis Machine axis control Rapid move heights Coloration Start Point Coloration Col	Mode Preview frame nor Contact normal Vertical Fixed angle Preview frame nor None PowerMILL 2012 R2 Rotary axis configuration Preview frame nor	mal	8

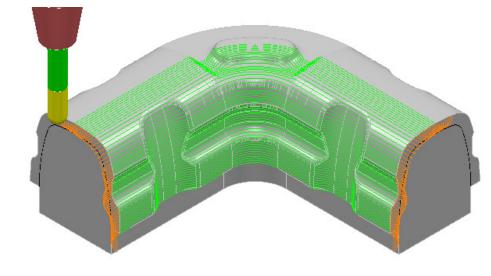
16 In the **Tool Axis** page select **Lead/Lean** with both values set to **0**.

17 Enter the values into the Tool axis page of the Surface Projection Finishing exactly as shown below.

🕉 Surfac	e Projection Finish	ing	? ×
Toolpath name	BN16-FIN1		
Workplane	Lead in		
Block			1811
Machine tool			
🔞 Limit	1st choice	Vertical arc	~
Stock engagement		Distance	3.0
Surface projection			
Automatic verification		Angle	90.0
		Radius	8.0
		Ramp opt	ions
Machine axis control		Kamp opt	ions
E-U Leads and links	Overlap dist	ance (tool diameter units)	0.0
Lead in		Allow start points to b	e moved 🖌
Lead out			
Links		Add leads to sl	nort links 🗹

18 In the Leads and Links pages set:-

- Set both Lead in and Lead out Vertical Arc Distance 3, Angle 90, Radius 8.
- 19 Select **Calculate** to create the **toolpath**, but do not close the dialog.



For visual reasons a larger **Stepover** has been used on the **Toolpath** shown in the illustration

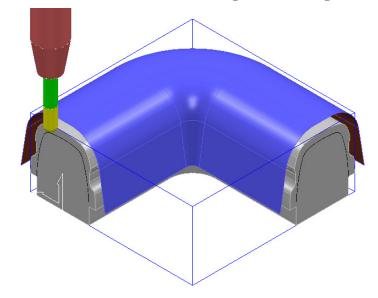


to re-activate 20 In the Surface Projection dialog select *Make a Copy* the Settings.

It is possible for all or part, of the **Reference Surface** to exist outside of the component to be machined. In this case the option, **Import Reference Surface** will be used as it is not a part of the component model to be machined.

- 21 Right-click on Models in the PowerMILL *explorer* and select Import Reference Surfaces.
- 22 In the Reference Surface dialog, select the Model:

...\PowerMILL_Data\five_axis\ CornerFixing\CornerFixingRefSurf3.dgk



The new **Reference Surface** exists outside the component to be machined. As a result of using the command **Import Reference Surfaces**, the **Machining Mode** is permanently set to **Ignore** for the **Reference Surface**.

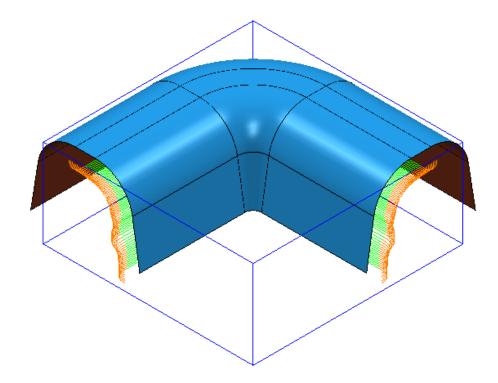


The imported **Reference Surface** is displayed in the **PowerMILL** *explorer* with a different colour (grey).

- 23 Select the *Reference Surface* CornerFixingRefSurf3.
- 24 Rename the Toolpath as BN16-FIN2.
- 25 In the **Pattern** page change the *Limits (Distance)* **V** as shown in the image below.

Limits (Distan	ice)	
	🔲 U	V
Start	0.0	0.0
End	1.0	130.0
	Preview	Draw

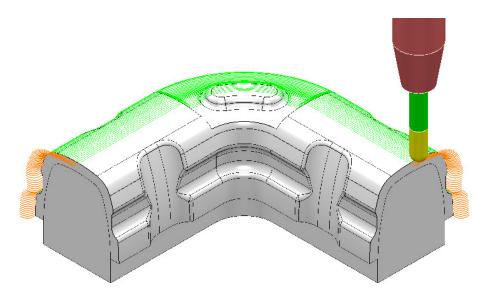
26 Calculate the copied, Projection Surface Strategy.



27 To update the stored Project, select File > Save Project: ...\COURSEWORK\PowerMILL_Projects\ProjectionSurface-Example1

Exercise

28 Create a new **Projection Surface Finishing** (named **BN16-FIN3**) starting at the centre of the top face to complete the other side of the component model (as shown below).



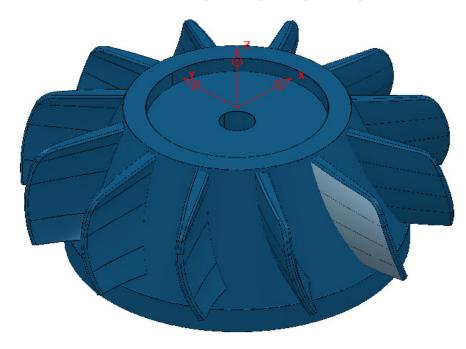
29 To update the stored **Project**, select **File > Save Project**:

Surface Projection Range.

Depending on the application, it may be necesary to limit the infinite *projection range* while applying the **Surface Projection** strategy. This situation occurs where the part of the model to be machined is shielded by other surfaces that are in the projection path. This command is, at present, only available via typed input into the **PowerMILL Command Window**. A more efficient way would be to store the command lines for a range of different distances in a series of **macros**, which in turn could be accessed via a **user defined menu**.

- 1 Select File Delete all and Tools Reset forms.
- 2 **Open** the (Read Only) **Project**:

...\PowerMILL_Data\five_axis\ImpellerType2\ImpellerType2-Start



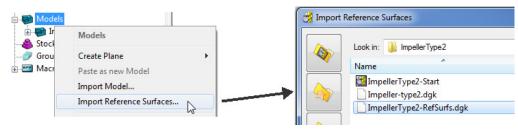
3 Save the **Project** as:-

....\COURSEWORK\PowerMILL_Projects\ImpellerType2-EX1

The imported **Project** already contains 3 Roughing **Toolpaths**, and a **Stock Model**.

4 Select an **ISO 1** view.

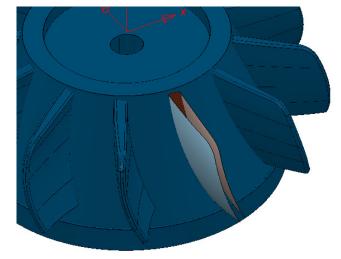
The next stage is to finish machine the 2 main faces of the blade positioned along the **-Y** direction (Shown shaded light blue in the above image). If the 2 main faces were single surfaces then it would be possible to directly apply the **Surface Machining** strategy (which is not affected by **Projection Range**). This option is not practical in this case as the main faces of the blade consist of several surfaces. As a result it is necessary to obtain 2 suitable single, reference surfaces created using CAD (ideally PowerSHAPE). These will purely be used as **reference surfaces** in the **Projection Surface Finishing** strategy and will not be physically machined. 5 In the **PowerMILL** *explorer* right mouse click on **Models** and from the local menu select **Import Reference Surfaces**.



6 In the dialog browse to:-

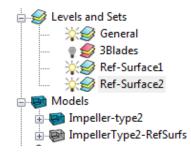
...\PowerMILL_Data\five_axis\ImpellerType2\ImpellerType2-RefSurfs.dgk

7 In the dialog select **Open** to import 2 *reference surfaces* (shown below).





By using this import method the 2 **reference surfaces** will always be ignored by a machining strategy during the calculation of a toolpath.



The **reference surfaces** are already acquired to appropriate **levels** (**Ref-Surface1** and **Ref-Surface2**) this being inherited from the CAD process.

- 8 **Calculate** a **Block** using a **Cylinder** to the full **Model** dimensions.
- 9 **Calculate** the **Rapid Move Heights** using the default settings.
- 10 Switch off the Level, Ref-Surface2.
- 11 Select the reference **Surface** stored on the **level**, **Ref-Surface1**.
- 12 Activate the Workplane TopFace.
- 13 From the **PowerMILL** explorer, Activate the BN16 tool.

14 Set Lead In and Out to use Surface normal arc.

3		Le	eads ai	nd Link	S		?	×
Extensio	ns	,	Links		P	oint distribu	ution	
Z heights	First lea	d in	Lead	d in	Lead out	t Las	t lead o	out
1st choice				2nd ch	noice			
Surface normal	arc		~	Verti	cal arc			~
	Distanc	<u>e</u> 0.0				Distance	<u>e</u> 0.0	
	Angl	<u>e</u> 90.0				Angle	90.0)
	<u>Radiu</u>	<u>IS</u> 8.0				<u>Radiu</u>	<u>s</u> 5.0	
0.0 Overlap	p distance (t	tool dia	meter ur	' nits)		Ramp op	tions	

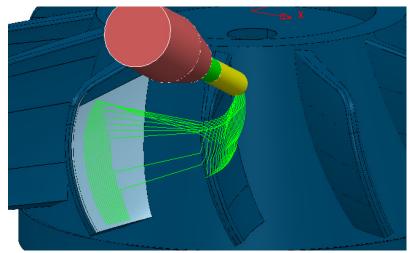
- 15 From the main toolbar select the Toolpath Strategies
- **16** From the dialog select the **Finishing** tab followed by the **Projection Surface Finishing** option.
- **17** Enter data into the following 3 pages of the **Surface Projection** dialog exactly as shown below.

💏 Surfac	e Projection Finishing ? ×
Toolpath name	BN16-Blade1A-FIN
Workplane Block Kock Kock Kock Kock Kock Kock Kock	Surface projection Surface Surface units Distance Smoothing tolerance 0.002042 Projection Direction Inwards Tolerance 0.02 Thickness Image:
Notes and Description	Stepover (Distance) Image: Stepover (Distance) Image: Stepover (Distepover (Distance)
	Calculate Queue OK Cancel

di	Surface Projection	Finishing		? >
Toolp	th name BN16-Blade1/	A-FIN		
Workplane Block	Pattern			
Machine tool	Pattern	Patterr	direction U	¥
Surface projection		Ordering	Sr One way	oiral
→ Point distribution		Start corner Sequence	Min U min V None	* *

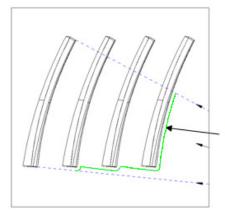
🥳 Surfac	e Projection Finishing	?	×
Toolpath name	BN16-Blade1A-FIN		
🗽 Workplane	Tool axis		
	Tool axis		
	Lead/Lean angles		
Stock engagement	Lead Lean 0.0 -70.0		
Automatic verification			1
Point distribution	Mode Preview frame norm	al ∨	

18 Select **Calculate** in the **Surface Projection Finishing** dialog to produce the following toolpath, and then **Close** the dialog.



With the **Projection Range** set to **OFF** (default), ie. No limit, the toolpath is projected inwards towards the surface to be machined from outside the model limits. As the strategy is projected some of it will appear on neighbouring surfaces instead of those intended to be machined and create the toolpath as shown.

Ò



Projection Range (Unlimited)

Tool tracks are created on the first face of the model, in line with the projection direction.

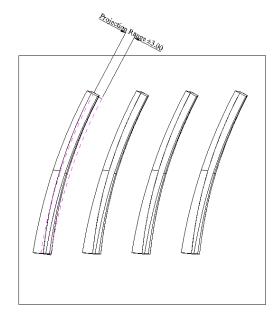
This problem can be resolved by switching to the **Projection Range ON** option and assigning suitable **+** and **-** distance values.

19 Right mouse click on the toolpath **BN16-Blade1A-FIN** and from the local menu select **Settings** to re-open the strategy dialog.



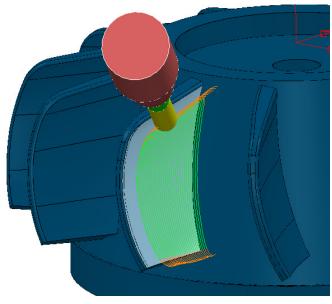
- 21 From the main pull down menus select: **View** > **Toolbar** > **Command**.
- 22 Enter the following commands into the **Command Window** that has appeared at the below of the graphics area:

EDIT SURFPROJ AUTORANGE OFF EDIT SURFPROJ RANGEMIN -3 EDIT SURFPROJ RANGEMAX 3

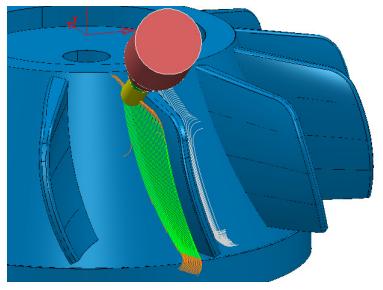


The above command input limits the **Surface Projection** Range to **+** and **- 3mm**.

23 Select **Calculate** to create the new toolpath.



- 24 **Simulate** the toolpath to observe the effect of the *limited Projection* **Range**.
- 25 Create a Copy of this Surface Projection strategy on the other side of the blade (Use the reference Surface stored on Level, Ref-Surface2).



26 In the **Command Window** type the following to restore the default, *infinite* **Projection Range**:

EDIT SURFPROJ AUTORANGE ON

This command returns to the default infinite limit for the Surface Projection distance range.

27 select File > Save Project to update the stored Project: ...\COURSEWORK\PowerMILL_Projects\Ref-Surfs-Blades

Surface Finishing and Surface Projection - Spiral

Both the **Surface Finishing** and **Surface Projection Finishing** strategies include the option to create a spiral toolpath:

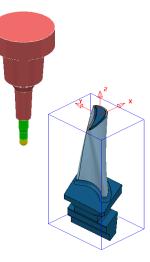
 The stepover is automatically adjusted so that the final cut finishes exactly on the Surface edge at the end of the toolpath.

If you select a **Surface Units** of **Distance**, then the first and last passes will match the edges of the surface. To achieve this, the intermediate passes will adjust to less than or equal to the specified **stepover**.

Projection Surface - Spiral Example

- 1 Select File Delete All and Tools Reset Forms.
- 2 **Open** the (read-only) **Project**:

...\PowerMILL_Data\five_axis\ProjSurf-Blade\SurfProjSpiral-Start



3 Save the Project as:

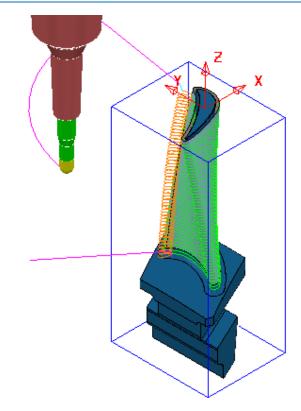
...\COURSEWORK\PowerMILL_Projects\SurfMachine-Spiral



The Strategy in the above **Project** is unprocessed (indicated by the Calculator icon).

4 In the **PowerMILL** *explorer*, right-click on **Toolpaths** to open the local menu and select **Batch Process** to create the toolpath.



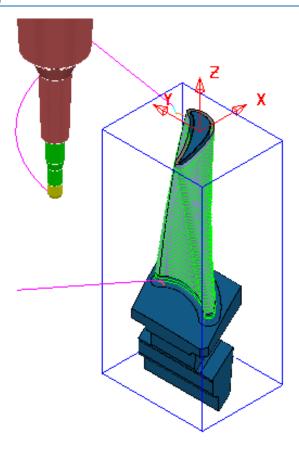


The strategy automatically reinstates the original selected **surface** used on a previous occasion. The resultant Toolpath contains independent, stacked tool tracks and Surface Normal Arcs for Lead In/Out. For this strategy it, would be both possible and more appropriate to use the **Spiral** option.

- 5 Right-click on the **Active** toolpath to open the local menu and select Settings to open the original Surface Projection Finishing dialog.
- 6 Select *Make a Copy* to re-activate the **Settings**.
- 7 Select the **Pattern** page in the **Surface Projection Finishing** dialog.

🛃 Surfac	e Projection Finishing		? ×
Toolpath name	SurfaceProjectionSPIRAL		
Korkplane 	Pattern		
	Pattern Pattern	n direction V	~
Surface projection	Ordering	One way	biral 🗸
Point distribution	Start corner	Min U min V	~
Machine axis control	Sequence	None	~

8 Rename the strategy as SurfaceProjectionSPIRAL, tick the Spiral box, and check that the *reference surface* is selected, before selecting Calculate.



This time the **Projection Surface** strategy consists of a single **Spiral** tool track, providing optimum efficiency and a smooth, consistent material removal.

- 9 Close the dialog.
- 10 Select File Save Project to update the stored Project:-

...\COURSEWORK\PowerMILL_Projects\SurfMachine-Spiral

5. Embedded Pattern Finishing

Introduction

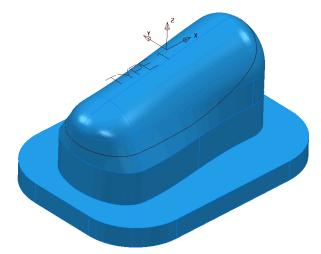
This **Five Axis** strategy not only tracks along the **Embedded Pattern** but automatically applies a **Tool Axis** alignment relative to the **Surface Normals**.

An **Embedded Pattern** is created as a projection of an ordinary **Pattern** using the **Edit** - **Embed** option. The **Pattern** projection can be performed down the active **Z Axis** or towards the **closest point** on the **model**.

Embedded Pattern Finishing - Engraving

1 Open the (Read only) Project:

...\PowerMILL_Data\five_axis\ 5axis_Embedded_Pattern\TrimPart-Start



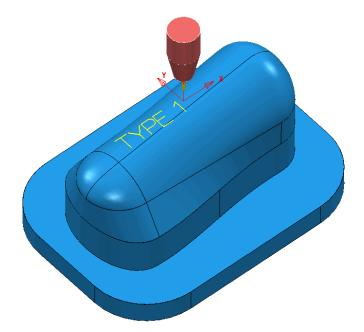
The **model** includes some wireframe *Text* and a 'scribe line' **curve** running around the form.

These will each be used create separate **Patterns**. The corresponding **Embedded Patterns** can then created from the 2 new **Patterns**.

2 Select File > Save Project As:

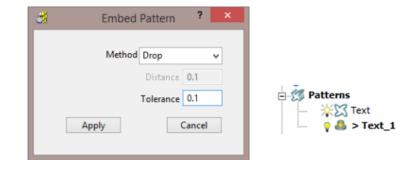
...\COURSEWORK\PowerMILL-Projects\Trim-Part

- 3 Activate the toolpath, BN16-Form-FIN to reinstate suitable *Parameters* and *Settings* for the Embedded Pattern.
- 4 Activate the *Tool* BN2.
- 5 Ensure that none of the stored **Boundaries** are *active*.
- 6 In the graphics area, select the part of the model named **`TYPE 1**'.
- 7 In the **PowerMILL** *explorer*, right-click on **Patterns** and from the local menu, select **Create Pattern**.
- 8 Right-click on the new (empty) **Pattern** and from the local menu, select **Insert Model** to inherit the selected **wireframe text**, **`TYPE 1**'.



The first **Pattern** contains the text **`TYPE 1**' and is positioned above the **Model**. This **Pattern** is then used to create an **Embedded Pattern** which projects down **Z** onto the **model**. The **Embedded Pattern** will also pick up and store the **Surface Normals**.

- 9 Rename the Pattern as 'Text'.
- 10 In the **PowerMILL** *explorer*, right-click on the **Pattern** and from the local menu select **Edit > Embed**.
- 11 From the local menu, select *Method* Drop and Apply the dialog.



An Embedded Pattern called **Text_1** is created as projected down Z and is identified by the icon ⁴ in the explorer. The original Pattern is retained.

- 12 Select **Toolpath Strategies** and from the **Strategy Selector** dialog sect the **Finishing** tab.
- **13** From the **Finishing** options, select the **Embedded Pattern Finishing**.
- 14 Enter the values into the following pages of the **Embedded Pattern Finishing** dialog exactly as shown.

- 🛃	Embec	Ided Pattern Finishing ? 🛛 🗙
222344444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444<l< th=""><th>Toolpath name</th><th>BN2-Text-FIN</th></l<>	Toolpath name	BN2-Text-FIN
Workplane Block Jool Tool Machine tool Stock engagement Stock engagement Multiple cuts Multiple cuts More distribution Stock engagement Multiple cuts Machine axis contr Rapid move height Leads and links Start point Feeds and speeds History Notes and Descript Viser defined setting	finishing fication ol s	Embedded pattern finishing
		Calculate Queue OK Cancel

- Drive curve Text_1
- Axial offset -3
- Untick Gouge Check

Embe		dded Pattern Finishing		?
\$? !!	Toolpath name	BN2-Text-FIN		
		Multiple cuts		
		Ме	Offset down	~
Stock engagen	nent	Order	by Region	~
Embedded pattern finishing Multiple cuts Automatic verification Point distribution Tool axis Machine axis control Rapid move heights		Maximum number of cuts		
		 ✓ Upper limit -1.0 		
U Leads and link Start Point End point Eeds and spect		Maximum stepdown		

15 Tick **Upper limit** with a value of **-1**

🛃 Embe	dded Pattern Finishing	?	×
Toolpath name Vorkplane Vorkplane Block Tool Kuinit Stock engagement Multiple cuts Multiple cuts Multiple cuts Point distribution Volume Tool axis		~	
Machine axis control			

16 Set the **Tool Axis** to **Lead/Lean** both with **0** angles.

It is necessary to ensure that the tool plunges and retracts along the Tool axis during Embedded Pattern finishing (Retract and Approach distance 5).

17 Under Leads and Links, select the Links page.

Workplane	Links
	Linko
Tool	
	Short/Long threshold 4.0
Limit	
	Short Skim 🗸
🖃 📎 Embedded pattern finishing	Lana Clin
	Long Skim 🗸
🔚 Automatic verification	Default Incremental
- 🖉 Tool axis	Retract and approach moves
Machine axis control	Along Tool axis
🖃 👿 Leads and links	Automatically extend 🗹
🔣 Lead in	Maximum length 250.0
U Lead out	
Links	Retract distance 5.0
	Approach distance 5.0
- End point	

18 In both **Retract** and **Approach distance**, enter **5** (as shown above).

- 19 Accept the Leads and Links dialog.
- 20 Back in the main dialog select **Calculate** to create the **Toolpath**.



The text **`TYPE 1**' is machined to a total depth of **-3** with the tool aligned to the *Surface Normals*.

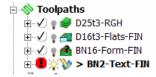
21 Perform a ViewMILL Simulation on all of the Toolpaths.

The **Embedded Pattern** toolpath has been produced with the **tool aligned normal** to the **surface model**.

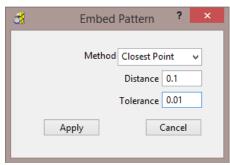


If the toolpath is **verified** for **gouges** it will take on a **Red** `gouge' warning. It is not possible to create a toolpath using a -ve thickness value that is higher than the tool tip radius while **Gouge check** is switched on.

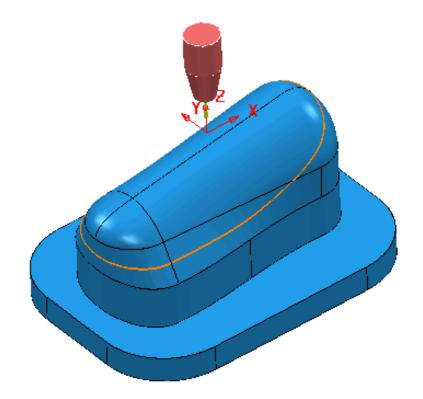
This is in technical terms a 'deliberate gouge' and will be ignored.



- 22 Create a new **Pattern** named **ScribeLine** and **Insert** the wireframe **Curve**, running around the upper wall of the **model**.
- 23 Create an Embedded Pattern from the Pattern (ScribeLine) but this time select Closest Point in the dialog.



This time the **Embedded Pattern** results from a projection towards the nearest point on the **Model** (Normals) from the original **Pattern**.



24 Open a new Embedded Pattern strategy named BN2-ScribeLine-FIN using Drive curve - ScribeLine_1.

🕺 Embed	ded Pattern Finishing ? 🗙
Toolpath name	Bn2-ScribeLine-FIN
Workplane Block U Tool Machine tool C Embedded pattern finishing Gouge avoidance Multiple cuts Automatic verification Point distribution C Tool axis Machine axis control Rapid move heights Leads and links	Embedded pattern finishing Drive curve ScribeLine_1 Lower limit Gouge avoidance Gouge check Degouge Degouge tolerance 0.3
Start point Start point Start point Start point History Start point Start poi	Tolerance 0.02 Thickness

- Axial offset: 0
- Gouge check: Ticked
- Thickness: -0.75

This time the required **Depth Of Cut** is less than the **Tool Tip Radius** allowing the **Thickness** option to be used instead of **Axial offset**.

\$2 III	Toolpath name	Bn2-ScribeLine-FIN		
- 💯 Workplane 		Multiple cuts		
		Mode	Off	~
Stock engagement		Order by	Region	~
W Embedded pattern Gouge avoidan Multiple cuts Automatic verif	ce	Maximum number of cuts		
	ol	Upper limit		
	5	Maximum stepdown		
- 🛃 End point				

Upper Limit: Un-ticked

25 Select Calculate to create the Embedded Pattern toolpath.

26 Continue the ViewMILL Simulation on the new toolpath.



27 Select File > Save Project.

6. Five Axis Swarf Machining

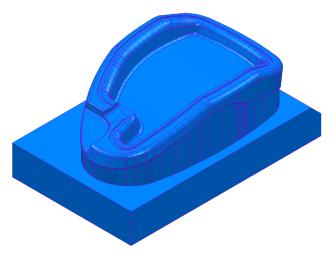
Introduction

Five Axis - Swarf Finishing is designed to create a toolpath where the selected surfaces are machined with the side of the tool (the default **Tool Alignment** option is **Automatic**). A **Swarf Finishing** toolpath will only exist where the tool is able to remain in full contact with the selected **surfaces** along the whole cutting depth. In other words, the tool must always be able to find a *Linear* path across the **surfaces**. It is possible for the user to apply a different tool alignment (For example, **Vertical** or **Lead\Lean**) but the selected **surfaces** must still be *Swarfable* for machining to occur.

In cases where imported **surfaces** are supposed to be **Swarfable** but are not of a suitable quality, the upper and lower edges can be created as separate (wireframe) **Patterns** to be used with **Wireframe Swarf Finishing**.

Swarf Finishing - example 1

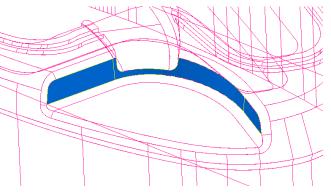
- 1 Select File > Delete All followed by Tools > Reset Forms.
- 2 **Import** the **model**:
 - ...\PowerMILL_Data\five_axis\swarf_mc\swarf_model.dgk



- 3 Create a **Block** using **Type Box** and **Defined by Model**.
- 4 Create a *Dia* 12, *tiprad* 1, tool named D12TR1.

5 Calculate the Rapid Move Heights.

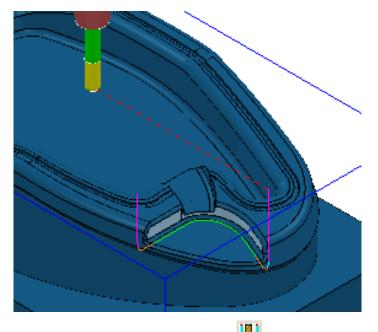
6 Change the **View** to **ISO 4** and select the local surfaces to be **Swarf** machined (as shown below shaded).



- 7 Select **Toolpath Strategies** and from the **Finishing** dialog select the **Swarf Finishing** option.
- 8 Enter the values into the main page of the dialog exactly as shown below and **Calculate**.

The default Tool Alignment is **Automatic** for this strategy.

đ	Swarf Finishing ? ×
Toolpath name	D12TR1-Swarf.1
Workplane Block Machine tool Kimit Stock engagement Stock engagement Stock engagement Gouge avoidance Multiple cuts High speed	Swarf finishing Drive curve Surface side Qutside Radial offset 0.0 Minimum fanning distance 0.0 Fan at end on planes Reverse axis Follow surface laterals
Automatic verification Point distribution Color axis Machine axis control Rapid move heights Leads and links Start point Feeds and speeds Rest of the point Feeds and peeds Rest of the point Rest of the point Re	Follow surface laterals Surface joining tolerance 0.3 Gouge avoidance Gouge check ✔ Degouge tolerance Tolerance 0.1
User defined settings	Thickness Draw Calculate Queue OK Cancel

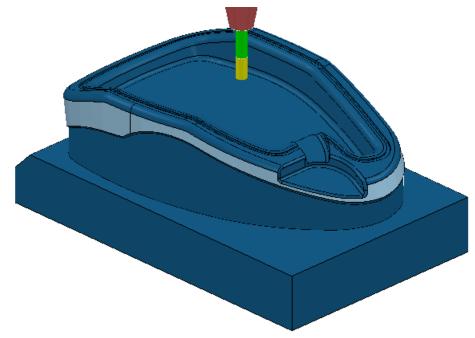


9 Open the **Leads and links** dialog via the icon **I** and **Apply** the following settings:

Lead In/Out:	Vertical Arc - Distan	ce 10 - Angle 90 - Radius 5.0
Links:	<i>Short\Long</i> – Skim	<i>Default</i> – Incremental

- 10 Deselect the local surfaces, **Simulate** the resultant toolpath, and observe the changing **tool alignment** as it **Swarf** machines the selected **surfaces**.
- 11 Select **Settings** to reopen the existing (active) **Swarf Finishing** strategy and

then create a **Copy D12TR1-Swarf2**.



12 Select the, upper sidewall, **surface** (as shown above).

13 Select the **Position** page and set **Base position - Bottom** with **Offset -2**.

đ	Swarf Finishing			?	×
Toolpath name	D12TR1-Swarf2				
Workplane Block United Tool	Position				
歴 Machine tool ® Limit ∳ Stock engagement	Lower limit	Base position	Bottom	~	·
Swarf finishing Position Gouge avoidance Multiple cuts		Workplane	Offset -2.0		>

14 Select the Multiple cuts page, with the Mode set to Merge with Maximum stepdown 1.

d	9	Swarf Finishing		3		×
Toolpath	n name	D12TR1-Swarf2				
Workplane		Multiple cuts				
Tool Machine tool Limit		Mode	Merge		¥	
Stock engagement		Order by	Region		~	
Swarf finishing		Upper limit	Тор		*	
Gouge avoidance		Workplane			Y	
····· <mark>]</mark> ₹ High Speed			<u>Offset</u>	0.0		
Automatic verification		Maximum number of cuts				
1 Tool axis				10		
 Rapid move heights Rapid move heights Leads and links Rapid Start Point		Maximum stepdown				

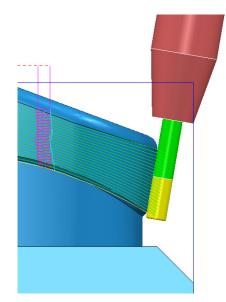
15 Select the **Tool Axis** page and use the default, **Tool Axis** - **Automatic**.

3	Swarf Finishing	?	×
Toolpath name	D12TR1-Swarf2		
Workplane Block Jool Kachine tool Kachine tool Swarf finishing Swarf finishing Swarf finishing Multiple cuts High Speed High Speed Point distribution Machine axis control	Tool axis Tool axis Automatic		

16 Select **Calculate** at the bottom of the dialog to create the toolpath.

17 Open the **Leads and links** dialog via the icon **W** and **Apply** the following settings:

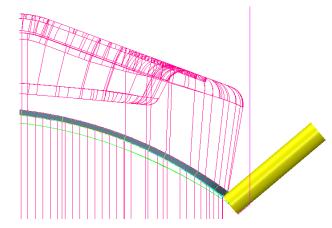
Lead In/Out: Surface normal arc – Distance 0 – Angle 90 – Radius 5.0 Links: Short\Long – Skim Default – Incremental



The new **Swarf Finishing** strategy steps down the selected **surfaces** while merging the **stepover** between the **Upper** and **Lower contours**.

Exercise

- 1 Create a Dia 10 End Mill (EM10).
- 2 Create a Copy of the original, single pass, Swarf Finishing strategy to create a machining path, this time using the Dia 10 End Mill and aligned to the underside of the undercut selected, recess surface on the outer sidewall.



- 3 Deselect the local surfaces, **Simulate** the resultant toolpath and observe the changing angle of the tool as it **Swarf** machines the selected surface.
- 4 Select File > Save Project As:

...\COURSEWORK\PowerMILL-Projects\Swarf-Example

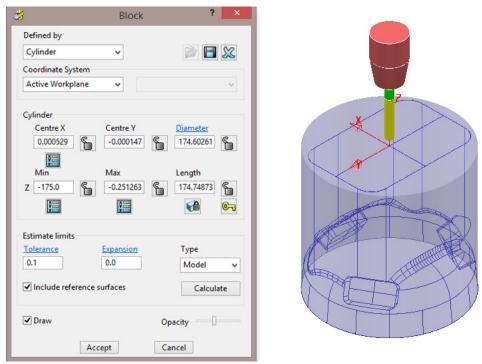
5 Select File > Delete All and Tools > Reset Forms.

Swarf Finishing - Example 2

1 Open the **Project** (created earlier):

...\COURSEWORK\PowerMILL-Projects\3Plus2-EX1

- 2 Activate the Dia 10 tiprad 1 tool (D10T1).
- 3 Activate the workplane ztop175_A.
- 4 Make sure that no **Boundary** is **Active**.
- 5 Open the **Block** dialog and select the option **Defined by Cylinder** before selecting **Calculate** (A cylindrical **Block** to the **Model** dimensions will be created).



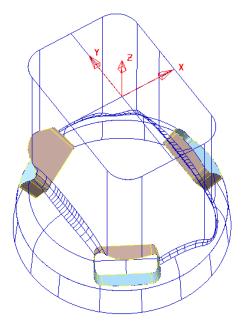
6 Open the **Rapid Move Heights** dialog and set **Safe area Cylinder** and enter data into the dialog exactly as shown below, before selecting **Calculate**.

3 4	Rapid	Move	Heig	hts	?	×
Geom	netry					
	Sa	fe area	Cylin	der		~
	Wo	rkplane	ztop-	175_A		~
Pos	ition					
0.0	00529	-0.000	0006	-87.62	5631	Y Z
Dire	ection					
0.0		0.0		1.0		2
				<u>Radius</u>	133.4	6307
		E	lunge	Radius	128.4	6307

Input the Workplane ztop-175_A and set a Direction (vector) 0 0 1

The use of **Safe area - Cylinder** will produce smoother **link** moves around the cylindrical form instead of point to point, linear moves.

- 7 Set both Lead in/out to Surface normal arc with Angle 90 and Radius 4.
- 8 Select all three *sidewall surfaces* for the three pockets.



- 9 Select **Toolpath Strategies** and select the **Finishing** option located in the **Strategy Selector** dialog.
- 10 Enter the values into the pages of the **Swarf Finishing** dialog exactly as shown.

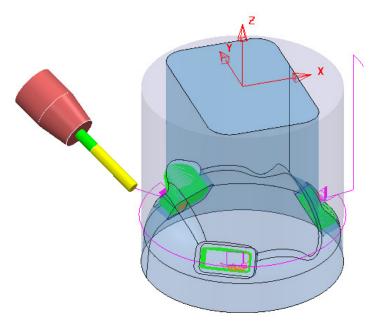
Workplane Block Toolpath name D10TR1-FinPkts Surface side Outside Machine tool Stock engagement Souge avoidance Multiple cuts Point distribution Coll axis Multiple cuts High speed Automatic verification Machine axis control Rapid move heights Machine axis control Start point Start point Start point Start point Start point Start point History Notes and Description Notes and Description User defined settings		Swarf Finishing ? ×
Block Tool Machine tool Limit Stock engagement Swarf finishing Position Gouge avoidance Multiple cuts F High speed Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point Feeds and speeds History Notes and Description User defined settings Swarf finishing Drive curve Multiple cuts F High speed Mutople cuts F High speed Outomatic verification Point distribution Start point Feeds and speeds History Notes and Description User defined settings Tolerance Cut direction 0.02 Climb	Toolpath name	D10TR1-FinPkts
	Block Tool Machine tool Stock engagement Stock engagement Sto	Drive curve Surface side Outside Radial offset O Radial offset O Minimum fanning distance O Fan at end on planes Reverse axis Follow surface laterals Surface joining tolerance O Gouge avoidance Gouge check Degouge tolerance O Tolerance O Cut direction O O Climb V Thickness

³	Swarf Finishing		?
Toolpath	name D10TR1-FinPkts		
	Multiple cuts		
	Mode	Merge	~
	Order by	Region	~
Swarf finishing	Upper limit	Тор	~
	Workplane		~
<mark>F</mark> High Speed		<u>Offset</u>	0.0
Automatic verification	Maximum number of cuts		
Point distribution			10
Machine axis control Machine axis control Rapid move heights Leads and links Start Point Fod point	Maximum stepdown		

- Mode Merge provides continuous tool tracks as variable offsets between the upper and lower edges of the swarfable, surfaces.
- Use: Maximum stepdown 1.0

The default **Tool Axis** setting for **Swarf Finishing** is **Automatic**.

11 Select **Calculate** to process the **Toolpath**.



Note the **link** moves follow a *cylindrical path* as defined in the **Rapid Move Heights** dialog. This will provide both smoother tool *link* and **re-orientation** moves between separate machining areas.

- 12 Simulate the toolpath (D10TR1-FinPkts) and observe the changing angle of the tool as it Swarf machines the selected surfaces.
- **13** Select **File > Save Project** to update:

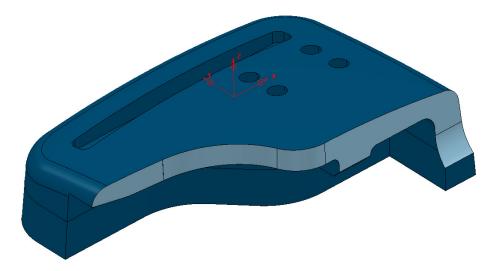
...\COURSEWORK\PowerMILL-Projects\3+2example

Swarf Finishing - Example 3

There are situations where **swarfable surfaces** do not provide an acceptable **tool alignment** around the component form. In these cases the only obvious solution is to use a separate CAD package (eg **PowerSHAPE**) to re-model the affected **surfaces**.

In the following example a **Swarf Finishing** strategy will be applied on 5 selected **surfaces** (As shown, shaded **pale blue** in the following illustration). Due to the way the **Surfaces** have been designed the resultant toolpath will not produce an acceptable tool track along the existing form. To fix this a new 'fit for purpose' **surface model** of the swarfable face will be **imported** and used to produce a much improved **Swarf Finishing** toolpath.

- 1 Select File > Delete All and Tools > Reset forms.
- 2 Select File > Import Model:
 - ...\PowerMILL_Data\five_axis\swarf_mc\SwarfSurfModel-A.dgk



3 Select File > Save Project As:

...\COURSEWORK\PowerMILL-Projects\SwarfSurf-EX3

- 4 Activate the Workplane TopCentre.
- 5 Calculate a Block, *Defined by* Box and using *Type* model.
- 6 In the **Block** dialog, *Lock* the **Z** *values*, input an **expansion 10**, and **Calculate** again,
- 7 Create a Dia 12 End Mill (named EM12).
- 8 Calculate the Rapid Move Heights.
- 9 Set the *Start Point* to First Point Safe and *End Point* to Last Point Safe.
- 10 Set both the Lead in and Lead out to Surface normal arc with Angle 90 and radius 6.
- 11 **Select** the 5 **Surfaces** required to be **Swarf** machined as shown **pale blue** in the above illustration.

12 Select **Toolpath Strategies** and select the **Finishing** option located in the **Strategy Selector** dialog.

0

13 Enter the values into the main page of the **Swarf Finishing** dialog exactly as shown.

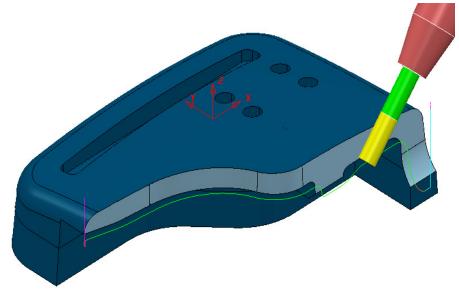
- 31	Swarf Finishing ? ×
Toolpath nam	e EM12-Swarf-1
Workplane	Swarf finishing
Tool	Drive curve
Machine tool	Surface side Outside 🗸
Limit	Radial offset 0.0
Stock engagement	
Swarf finishing	Minimum fanning distance 0.0
Gouge avoidance	Fan at end on planes 🗸
Multiple cuts	Reverse axis
High Speed ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓	Follow surface laterals
Point distribution	Surface joining tolerance
	0.3
Rapid move heights	Gouge avoidance
Leads and links Start Point	Gouge check 🗹
End point	Degouge tolerance 0.3
Notes	Tolerance Cut direction
User defined settings	0.02 Climb v
	Thickness
	Preview Draw
THAN	
_	Calculate Queue OK Cancel

14 Select the **Position** page and input **Offset** -1.0

- 3	:	Swarf Finishing			?	×
	Toolpath name	EM12-Swarf-1				
Workplane		Position				
Block		· obition				
Tool						
		Lower limit				
			Base position	Bottom	~	1
🚽 Stock engagement						
Swarf finishing			Workplane		\sim	
Position				Offset -1.0		1
Gouge avoidance					, 	
Multiple cuts						

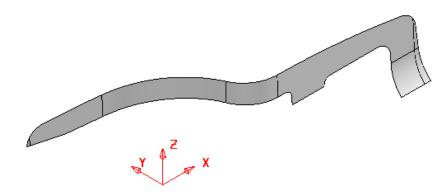
15 Select **Calculate** to process the toolpath.

16 Run a slow, *Point to Point*, **Simulation** and observe the changes in **tool alignment** as it runs along the tool track.



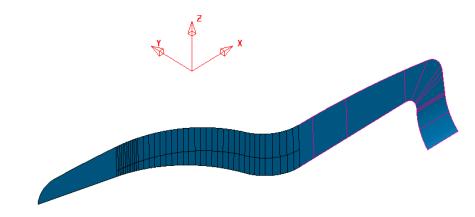
The **Swarf Finishing** toolpath visually looks okay at first until it is run through a **simulation**. This reveals that the **Tool** (**EM12**) is running at an acute angle relative to the **swarfable surfaces** in some areas (as shown in the above illustration). Also, the cutter closely follows the lower edge, causing it to suddenly drop and lift while running around the step.

This strategy can be improved by using different **Surfaces** that are specifically designed to provide a better tool alignment during **Swarf Finishing**.



The original 5 **reference Surfaces** used in the **toolpath EM12-Swarf-1** are as shown above. These will be replaced by new **Surfaces** of exactly the same shape within the original model area, but designed specifically to work more effectively with the **Swarf Finishing** strategy.

- 17 Select File > Import Model:
- 18 ...\PowerMILL_Data\five_axis\Swarf_mc\NewSwarfSurf-B.dgk



The new **Surfaces** are designed with *surface curves* aligned to match the required **tool alignment**. It is also exactly the same shape as the *5 surfaces* used in the original **Swarf Finishing** toolpath. Compared with the original 5 surfaces, the lower edge has been extended with a smooth transition constructed along the lower edge of the form.



<u>Do Not Delete</u> the **5** surfaces used in the original **Swarf Finishing** strategy. They are still required for accurate gouge checking.

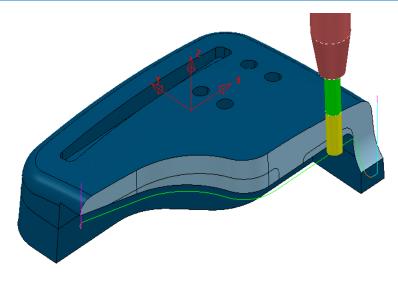
- 19 Right mouse click on the toolpath **EM12-Swarf-1** and from the local menu select **Settings** to open the strategy dialog.
- 20 In the Swarf Finishing dialog select the option, make a Copy



- 21 Select the new, imported reference Surfaces.
- 22 In the main page select **Follow surface laterals** to make the **tool** to align to the **surface curves** wherever possible.

3	Swarf Finishing ? ×
Toolpath na	EM12-Swarf-1_1
Workplane	Swarf finishing
····· <mark>L</mark> Tool ····· I Machine tool ······ ® Limit	Drive curve Surface side Outside V
Stock engagement	Radial offset 0.0
Source Action	Fan at end on planes
	Reverse axis Follow surface laterals
Point distribution	

- 23 Select Calculate to process the new toolpath (EM12-Swarf-1_1).
- 24 Run a slow, *Point to Point*, **Simulation** and observe the changes in **tool alignment** as it runs along the tool track.



This time the **Tool** is more suitably aligned to the **swarfable surface** as it runs along the **Toolpath** (**EM12-Swarf-1_1**).

25 Select File > Save Project to update:

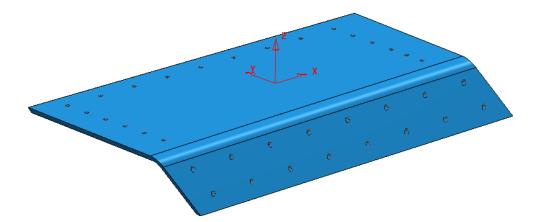
...\COURSEWORK\PowerMILL-Projects\SwarfSurf-EX3

Swarf Finishing - Example 4

In the following example a **Swarf Finishing** strategy will be applied to trim the edges of an angled plate. Due to the way the original edge **Surfaces** have been designed the tool is unable to maintain a suitable alignment to the model form. To fix this a different set of swarfable edges will be used instead to produce a much improved **Swarf Finishing** toolpath. These surfaces have been created using **PowerSHAPE**.

- 1 Select File > Delete All and Tools > Reset forms.
- 2 Select File > Open Project:-

....\PowerMILL_Data\five_axis\swarf_mc\AnglePlate4-Swarf-Start



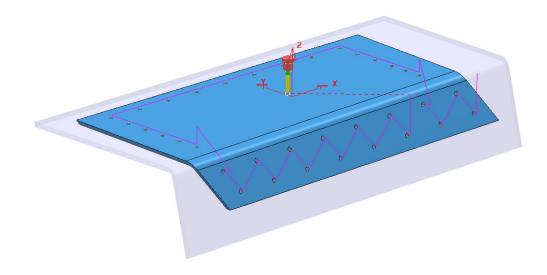
3 Select **File > Save Project As**:

...\COURSEWORK\PowerMILL-Projects\ AnglePlate4-Swarf-EX1

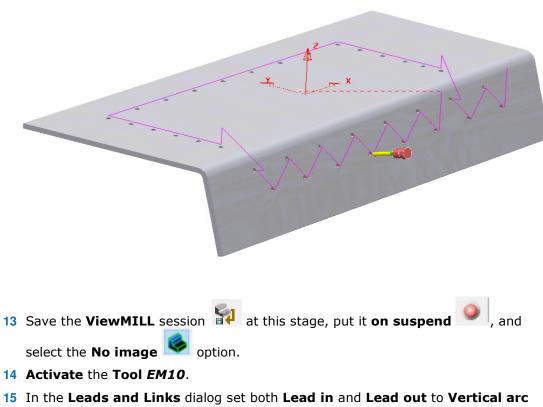
- 4 Activate the existing drilling Toolpath Drill20-Thro.
- 5 From the **Main** toolbar select **Block**.
- 6 In the **Block** dialog select **Defined by Triangles** with the **Coordinate System** set to **Global Transform**.

		?	\times
~	(🔌 🖪	22
~			
	~	✓ (? ~

- 7 Select the *Load block from file* option.
- 8 In the **Open Block from Triangles** dialog and select the file:-....\PowerMILL_Data\five_axis\swarf_mc\AnglePlate4-Material.dmt
- 9 Select **Accept** to close the dialog.



- 10 Right mouse click on the Toolpath **Drill20** and from the local menu select **Simulate from Start**.
- 11 Ensure that the **ViewMILL** toolbar is displayed and click the **Red** button to connect it to the simulation.
- 12 Run a ViewMILL simulation on the 2 existing drilling *toolpaths* Drill20-Thro and EM16-Dia24_Helical.



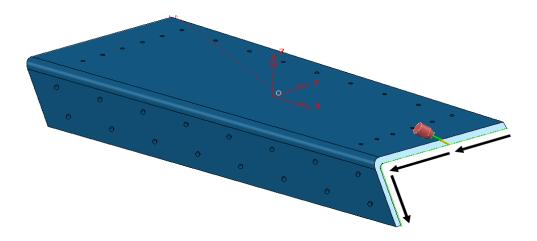
- with Angle 90 and Radius 5.16 In the PowerMILL explorer, Levels and Sets folder, right mouse click on the
- Set OriginalEdges and from the local menu click on Select Surfaces.

- 17 Select **Toolpath Strategies** and select the **Finishing** option located in the **Strategy Selector** dialog.
- **18** Enter the values into the pages of the **Swarf Finishing** dialog exactly as shown below.

🥳 Swarf Finishing		? ×
	Toolpath name	EM10-TrimEdges-FIN1
 Workplane Block Tool Machine tool Limit Stock engagement Stock engagement Swarf finishing Position Gouge avoidance Multiple cuts High speed Automatic verifice Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point Start point Feeds and speeds History Notes and Description User defined settings 	n	Swarf finishing Drive curve Surface side Radial offset 0.0 Minimum fanning distance 0.0 Fan at end on planes Reverse axis Follow surface laterals Surface joining tolerance 0.3 Gouge avoidance Gouge check Degouge tolerance 0.2 Climb Thickness 0.0

🥳 Swarf Finishing					?	\times
	Toolpath name	EM10-TrimEdges-	-FIN1			
		Position				
Block						
Tool						
		Lower limit				
			Base position	Bottom	~	
🖕 📶 Swarf finishing			Workplane			
Position				Offset -2	.0	
- Couge avoidance	E E					
Multiple cuts						

- **19** Select **Calculate** to process the toolpath and then **Close** the dialog.
- 20 Run a **Toolpath** *simulation* and observe the alignment of the **Tool** as it tracks along the selected surfaces.

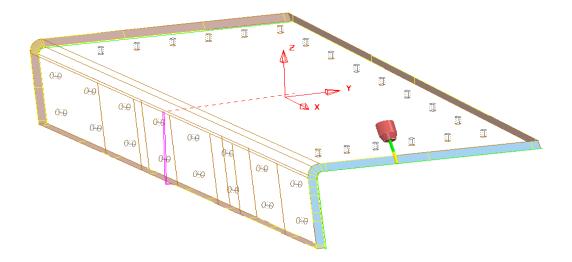


Due to the component edges being planer the alignment of the **EM12** tool is not compelled to remain *Normal* to the main *Angle Plate* surfaces. In the above image the tool has remained cranked over after tracking around a curve in the edge form. There are too many choices for the cutter to use a linear alignment across the swarfable surfaces.

- 21 Right mouse click on the toolpath and from the local menu select **Settings**.
- 22 Select the option to **Recycle** the toolpath.
- **23** In the **Swarf finishing** page *tick* the box **Follow surface laterals**.

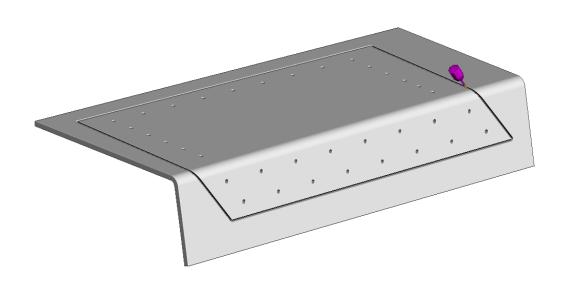
🥳 Swarf Finishing		? ×	2
Toolpath na	EM10-TrimEdges-FIN1		
	Swarf finishing		
<mark> </mark> Tool 型. Machine tool	Drive curve Surface side Outside	~	
	Radial offset 0.0)	
Swarf finishing	Minimum fanning distance 0.0		
Gouge avoidance		e axis	
High speed High speed Automatic verification	Follow surface lat	terals 🗹)

- 24 In the PowerMILL explorer, Levels and Sets folder, right mouse click on the Level NewEdges and from the local menu click on Select Surfaces.
- 25 Calculate the updated Swarf finishing strategy.



This time the tool is aligned to the *laterals* of the replacement swarfable surfaces. These have been re-designed using **PowerSHAPE** surface modelling and have been designed with *laterals* that produce the above tool alignment.

26 Reconnect the existing **ViewMILL** session and **simulate** the latest **Swarf Finishing** strategy.



27 Select File - Save Project to update the stored Project.

Wireframe Swarf Finishing

In some cases imported **surfaces** to be used in **Swarf Machining** could be of a poor quality. This would typically include such problems as *mis-matching edges* and/or *un-intentional curves* across the **surfaces**. These problems will undoubtedly result in part or complete failure to create a **Swarf Finishing** strategy.

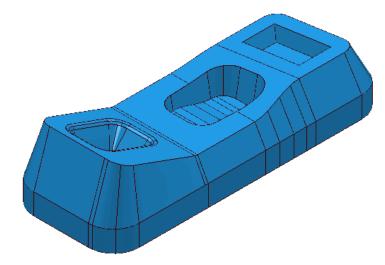
One solution is to re-model the affected **Surfaces** (assuming the user has access to a suitable CAD system (eg **PowerSHAPE**)).

The other alternative is to create 2 separate **Patterns** that define both edges running along the area to be *swarf machined*. The user can then use the **Wireframe Swarf Finishing** strategy.

The **model** used in the following example contains a pocket in which part of the sidewall is **un-swarfable** due to being slightly convex between the top and bottom edges.

- 1 Select File > Delete All and Tools > Reset Forms.
- 2 Import the Model:

...\PowerMILL_Data\five_axis\Swarf_mc\Wfrm-Swarf.dgk

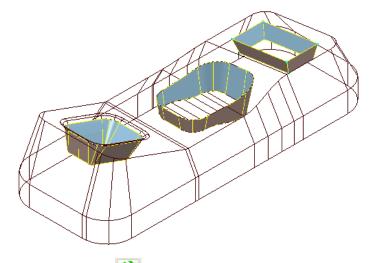


- 3 Select File > Save Project As: ...\COURSEWORK\PowerMILL-Projects\Wframe-Swarf
- 4 Activate the Workplane Datum.
- 5 Calculate a Block using *Defined by* Box to the model dimensions.
- 6 Create a **Dia 5 End Mill** (EM5) using the following dimensions:

ToolDia 5Length 35ShankLower Dia 5Upper Dia 5Length 15Holder-1Lower Dia 15Upper Dia 25Length 15Holder-2Lower Dia 25Upper Dia 25Length 15Overhang 50

7 Calculate the Rapid Move Heights.

8 Select the *sidewall surfaces* on each of the 3 pockets in the component.

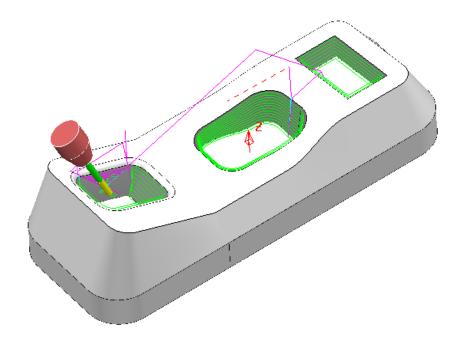


- 9 Select Toolpath Strategies and from the Finishing tab select the Swarf Finishing option.
- **10** Enter the values into the 2 pages of the **Swarf Finishing** dialog exactly as shown.

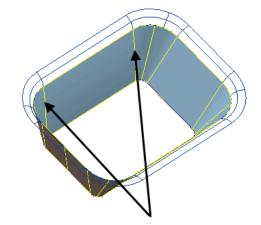
3	Swarf Finishing ? ×
Toolpath name	EM5-SwarfPkts
Workplane Block Tool Col Kathine tool Kathine tool Kathine tool Kathine Stock engagement Stock engagement Col Kathine Col Kat	Swarf finishing Drive curve Surface side Outside Radial offset 0.0 Minimum fanning distance 0.0 Fan at end on planes Reverse axis
	Follow surface laterals Surface joining tolerance 0.3 Gouge avoidance Gouge check Degouge tolerance 0.3
History Notes and Description User defined settings	Tolerance Cut direction 0.02 Climb Thickness Image 0.0
	Preview Draw Calculate Queue OK Cancel

d i	:	Swarf Finishing		?
	Toolpath name	EM5-SwarfPkts		
Workplane		Multiple cuts		
Tool 		Mode	Merge	~
	ent	Order by	Region	~
⊡ ⓓ Swarf finishing		Upper limit	Тор	~
- 🚠 Gouge avoid		Workplane		\sim
<mark> Multiple cut</mark>] F High Speed	s		<u>Offset</u>	0.0
🔚 Automatic v		Maximum number of cuts		
Point distributio	n			10
Machine axis co Rapid move hei U Leads and links		Maximum stepdown		
		3.0		

- Mode Merge and Max Stepdown 3.0
- **11 Calculate** the **toolpath**.



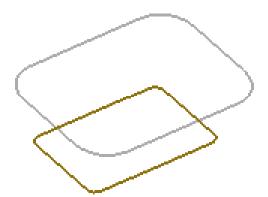
The **Swarf Finishing** strategy has failed to machine one of the *selected surfaces* due to part of the sidewall being un-swarfable.



On closer inspection it is evident that some of the curves linking across the **sidewall surface** are convex and as a result make this area un-swarfable.

This problem will be fixed by creating separate **Patterns** along the upper and lower edges of the *sidewall surface* of the affected pocket. The 2 **Patterns** will then be used in a **Wireframe Swarf Finishing** strategy.

- 12 Select the **Surface** defining the angled sidewall of the left hand pocket (shown above).
- 13 Create a **Pattern** named **Upper** and right-click over it in the **PowerMILL** *explorer* selecting **Insert > Model** from the local menu.
- 14 Select the lower **Pattern** segment.



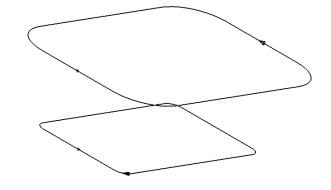
- 15 Right-click on the *Pattern* named **Upper** and from the local menu, select the option **Edit Copy Pattern (selected only)**.
- 16 *Rename* the new, copied **Pattern** as **Lower**.
- 17 Select and **Delete** the *lower segment* from the **Pattern** named **Upper**.



For **Wireframe Swarf Finishing** to function correctly the two **Patterns** must travel in the same direction.

It is not compulsory to align the **start points** on the upper and lower **Patterns**. It is the **first point** on the lower **Pattern** that defines the start position of the resultant toolpath.

18 To identify whether the two patterns are suitable for use, right click each one in turn and select **Instrument** to display the start point and direction.





As can be clearly seen the two **segments** travel in opposite directions creating the need for one to be reversed.

In this case, to create a Climb milling strategy, the lower segment must <i>be reversed.

- 19 Select the lower **Pattern** *segment* and *right mouse click* on it to open the local menu.
- 20 From the local menu, select **Edit > Reverse Selected**.
- 21 Select the **Toolpath Strategies** and from the **Strategy Selector** > **Finishing** options, select **Wireframe Swarf Finishing**.
- **22** Enter the values into the dialog exactly as shown below:

🥳 Wiret	frame Swarf Finishing ? 🛛 🗙
Toolpath name	EM5-WireframeSwarfPkt1
 Workplane Block Tool Kachine tool Stock engagement Stock engagement Stock engagement Stock engagement Mireframe swarf finishing Position Gouge avoidance Multiple cuts F High speed Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point 	Wireframe swarf finishing Drive curve Top pattern Upper Bottom pattern Lower Vireframe side Left Vireframe side Left Angular rulings tolerance 2.0 Radial offset 0.0 Minimum fanning distance 0.0 Fan at end on planes V
End point End point Freeds and speeds Freeds and Description Super defined settings	Gouge avoidance Gouge check Degouge tolerance 0.3 Tolerance 0.02 Climb Thickness 0.0 OL

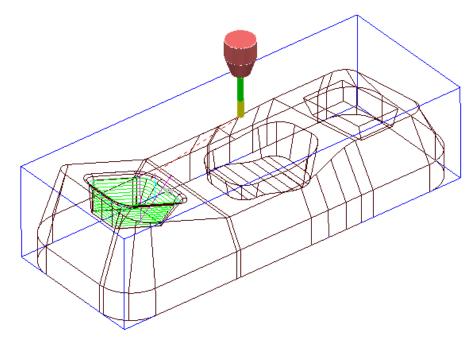
- 23 Select **Component Thickness** to open the following dialog.
- 24 Select both the *sidewall* and *fillet* surface (flanked by the **Patterns**) and *acquire* them to a selected **row** (with the **Machining Mode** set to **Ignore**) in the **Component Thickness** dialog.

X			Co	omponent	Thickne	ess			?	×
Surfaces	Verification	Surface Def	faults							
Entity	EM5-Wirefr	rameSwarfF	v		Clor			~	2	
*	7		Use Axi	al Thickness					E.	3
Machini	ing Mode			Thick	(ness					~
Machini Ignore	ing Mode v			Thick 0.0	(ness				F	
Ignore		Thickness	Axial	0.0		Total Axial	#	_	Ę	
Ignore Set	~	Thickness 0	Axial	0.0		Total Axial	#		¥	
lgnore Set ⊗0	۲ Mode			0.0 Total Th					¥	
Ignore Set	V Mode Machine	0		0.0 Total Th 0			0		¥	

25 Apply the Component Thickness dialog.

ž.	Wiref	rame Swarf Finishing		?	2
	Toolpath name	EM5-WireframeSwarfPkt1			
🗽 Workplane 🍯 Block		Multiple cuts			
Tool 🔣 Machine tool		Mode	Merge		¥
	nt	Order by	Region		v
Wireframe swarf	finishing	Upper limit	Тор		Y
	ince	Workplane			~
🖟 High speed			<u>Offset</u>	0.0	
Point distribution		Maximum number of cuts		10	
→ Ø Machine axis con → I Rapid move heig → U Leads and links → Ø Start point		Maximum stepdown 3.0			

26 Calculate the Wireframe Swarf Finishing strategy.

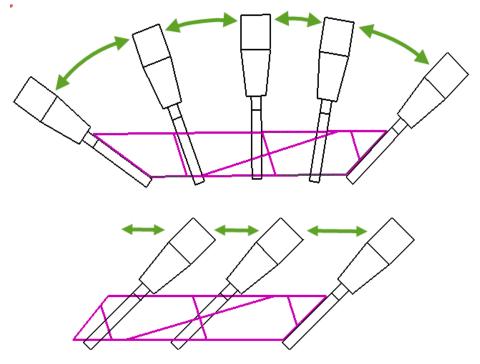


The new **Wireframe swarf finishing** strategy has successfully been applied between the **Upper** and **Lower Patterns**.

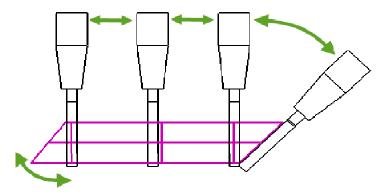
- 27 Select File > Save Project to update the Project:
 - ...\COURSEWORK\PowerMILL-Projects\Wframe-Swarf

Swarfable Surface Design

When designing a component certain factors will dictate how successfully a **Swarf finishing** strategy can be applied to what appear to be visibly suitable **surfaces**. The fundamental rule is that **Swarf finishing** will only occur where the side of the tool can be in full contact from one side of a surface to the other (Linear). This works fine if the swarfable surfaces are twisting and turning and the tool is able to find a specific linear alignment at all times. If however a **surface** is totally planer then the linear tool alignment can occur at any angle across the swarfable edges.



A tick box option exists in the strategy to force the tool to **Follow surface laterals** (natural surface curves). For this to work it is likely that the existing planer swarfable surfaces will need to be re-modelled. This task has to be done using a suitable CAD software such as **PowerSHAPE**.



The above planer **surface** has been designed with the **laterals** aligned to match the required tool axis. The initial angular move is the required transition to or from the end of another selected swarfable **surface**.

7. Flowline Finishing

Flowline Finishing

Flowline Finishing is designed to machine multiple surfaces. The strategy uses 2 *drive curves* and either 1 (closed form) or 2 (open form) *end curves* to define a virtual surface area. Intermediate drive curves can be added to further control the flowline shape. This strategy provides evenly spaced tool passes, irrespective of the underlying geometry.

Advantages over existing toolpaths include:

- Multiple surfaces can be machined.
- Machining of undercut regions is possible.
- The toolpath passes are not determined by the surface parameterisation.
- The region being machined is not forced to be an entire surface or parametric box.
- The stepover is defined in 3D, giving total control over the maximum value.

Flowline Finishing Example

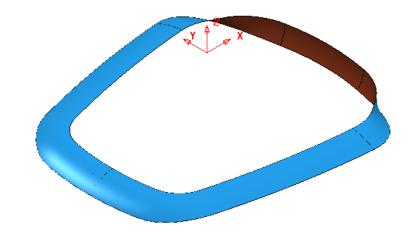
- 1 Select File > Delete All followed by Tools > Reset Forms.
- 2 Open the Project:

....\PowerMILL_Data\five_axis\Flowline\Flowline_EX4-Start



- 3 Select File > Save Project As:
 - ...\COURSEWORK\PowerMILL-Projects\Flowline-EX4

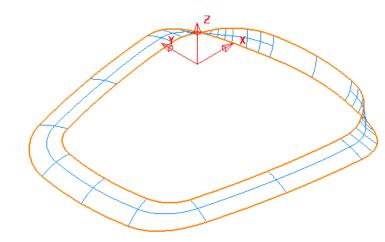
- 4 Activate the Workplane MC-Datum.
- 5 Activate the BN12 tool.
- 6 Calculate a Block Using Defined by Box and Type Model.
- 7 Calculate the Rapid Move Heights using the default settings.
- 8 Select the following 5 **Surfaces** and **Blank** the rest (Ctrl K).



- 9 Display the **Model** as **Wireframe** only.
- 10 Create a new (empty) Pattern 1.



11 With the above **Surfaces** selected, Right click on the **Pattern** and from the local menu select **Insert** – **Model**.





A Pattern extracted from a selection of surfaces will automatically become Embedded (Inherits the surface normals etc).



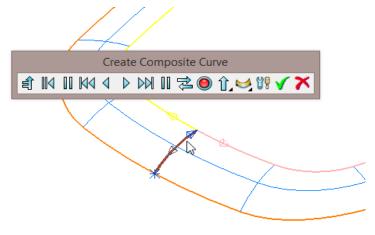


The Pattern symbol changes to identify it as being Embedded.

- 12 Right click on the **Pattern** and from the local menu select **Curve Editor**.
- **13** Select the **Composite Curve** option from the **Curve Editor** toolbar.

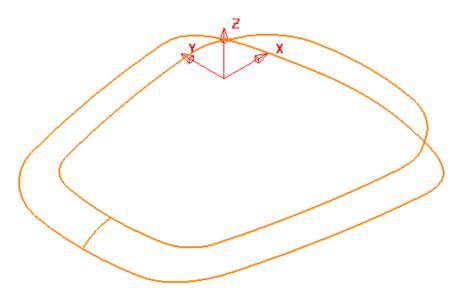


14 With the **Create Composite Curve** toolbar open click near to the upper end of the first surface lateral (As shown arrowed below).



15 In the toolbar select the **red disc** followed by the **green tick** to both accept the new segment and close the toolbar.

The new **Embedded Pattern** (1) is now made up of 3 *segments* (2 closed and 1 open).

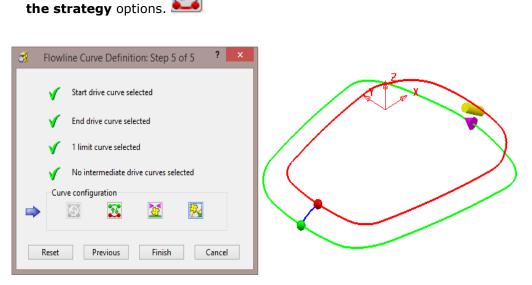




- **16** From **Toolpath Strategies** open the **Finishing** options and from the dialog select Flowline Finishing.
- 17 Enter data into the **main** page exactly as shown below.

- 📆	F	Iowline Finishing	? ×
	Toolpath name	BN12-Flowline-FIN1	
Workplane Block Glock G	ment <mark>hing</mark> c verification tion	Status Valid	
Machine axis Apid move I Rapid move I Rapid move I Constant III Constant IIII	neights ks eeds escription	Sequence Ordering Surface joining tolerance Tolerance	None V Two way V 0.3 0.02
		Thickness 0.0 Stepover 0.5	<u>U</u>

18 Still on the main page select the Interactively select pattern segments for



The options in the above form enable the toolpath ordering, directions, etc to be controlled before the toolpath is calculated. However, no changes are required in this instance.

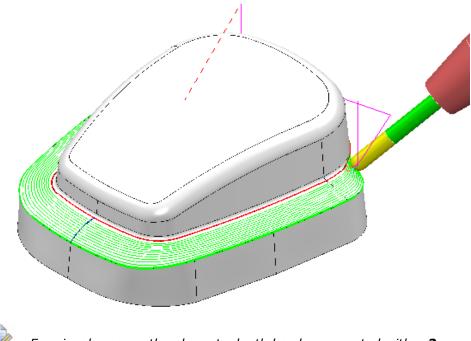
19 Select the **Tool axis** page and select the **Lead/Lean** option with both the **Lead** and **Lean** angles as **0**.

Si F	Iowline Finishing	?	×
Toolpath name	BN12-Flowline-FIN1		
 Workplane Block Tool Machine tool Limit Stock engagement Flowline finishing Automatic verification Point distribution Tool axis Machine axis control 	Tool axis Lead/Lean Lead/Lean angles Lean 0.0 0.0 Mode Contact normal	~	

20 Select Calculate to create the following Flowline Finishing toolpath.



If the Flowline Finishing toolpath should fail to calculate try to **Embed** *the* **Pattern** *again using* **Closest point** *with* **Distance 0.1** *and* **Tolerance 0.01**



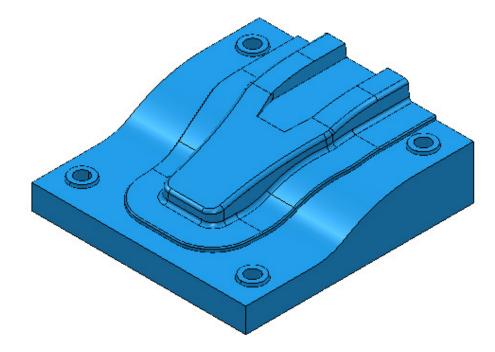
For visual reasons the above toolpath has been created with a **2mm** *stepover*.

- 21 Right mouse click on the *toolpath* BN12-Flowline-FIN1 and from the local menu select Simulate from Start.
- 22 From the Simulation toolbar select *Play* and observe the Flowline Finishing process.
- 23 Select File Save Project.
- 24 Select File Delete All and Tools Reset Forms.

Exercise

The purpose of this exercise is to create a suitable **Embedded Pattern** and use *Five Axis* - **Flowline Finishing** to machine the *fillet surfaces* running around the upper edge of a component model form.

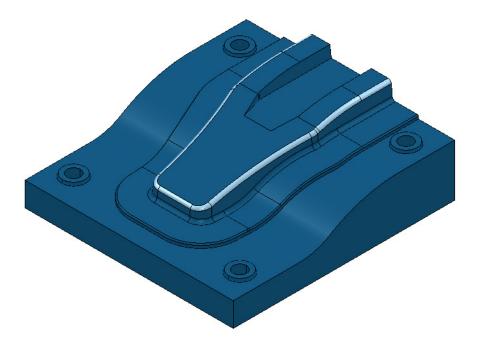
- a A single segment, **Embedded Pattern** will be directly created along the edges of the *fillet surfaces*.
- **b** The **Embedded Pattern** will then be split into 4 suitable segments using the **Curve Editor** options.
- **c** The user will then be asked to create a suitable **Flowline Finishing** strategy using the **Embedded Pattern**.
- 1 Import the Model:-
 -\PowerMILL_Data\Models\Vortex2.dgk



2 Select File > Save Project As:

...\COURSEWORK\PowerMILL-Projects\FlowLineFillet-EX1

- **3** Select the whole of the **Model** and the select **Create and Orientate Workplane – Workplane at Top of Selection**.
- 4 Activate the new Workplane.
- 5 Create a **Dia 8 Ball Nose Tool**, named **BN8**.
- 6 Create a **Block** using **Defined by Box** and **Type Model**.
- 7 Calculate the Rapid Move Heights using the default settings.
- 8 Select all of the **Surfaces** that define the fillet along the upper edge of the main 3D form (As shown below).



- 9 In the **PowerMILL explorer** right mouse click on **Patterns** and from the local menu select **Create Pattern**.
- 10 From the same menu select Insert Model.



This will automatically become an **Embedded Pattern** as it inherits the required data from the edges of the selected **Surfaces**.



- 11 Select and Blank the whole of the Model and Un-draw the Tool and Block.
- 12 Right mouse click on the **Embedded Pattern** and from the local menu select **Curve Editor**.
- 13 Use Cut item to break the Pattern into separate segments at the four corners of the fillet form.





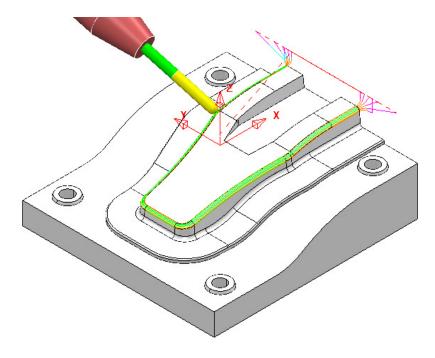
In this example the Embedded Pattern must consist of 4 segments that specifically define the 2 ends and 2 sides of the enclosed fillet.

14 Select any multiple segments that define a single, *drive* or *end* curve and then use Merge selected to reduce these to a single segment.



- **15** Accept the changes (*Green tick*) and return the **Embedded Pattern** from the **Curve Editor**.
- 16 Use the (4 segment) Embedded Pattern in a Flowline Finishing strategy to five axis machine (Tool Axis Lead/Lean 0 using Mode Contact normal) the enclosed surfaces of the fillet form.
- **17** Use the options in **Interactively select pattern segments for the strategy** to control the required toolpath order and direction.

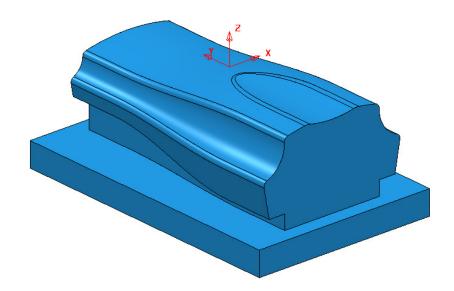
Curves definition	ern
Embedded patte	V III III
1	S
 Flowline Curve Definition: Step 5 of 5 Start drive curve selected End drive curve selected 2 limit curves selected No intermediate drive curves selected Curve configuration Example Selected Reset Previous Finish Cancel 	



18 Select File > Save Project As: ...\COURSEWORK\PowerMILL-Projects\FlowLineFillet-EX1

Flowline with intermediate drive curves Example

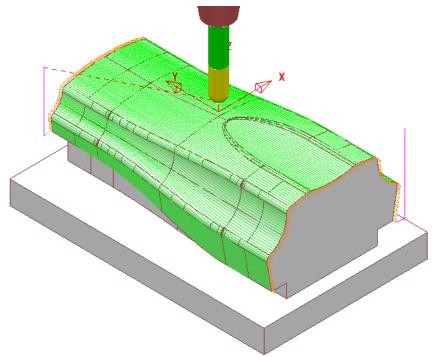
- 1 Select File > Delete All followed by Tools > Reset Forms.
- 2 Open the Project:
 -\PowerMILL_Data\five_axis\Flowline\FlowLine-ExtraDriveCurves-Start

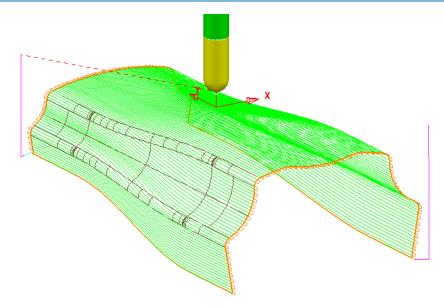


3 Select **File > Save Project As**:

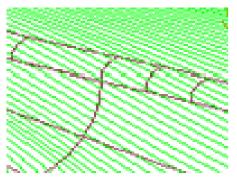
...\COURSEWORK\PowerMILL-Projects\FlowlineWithExtraDriveCurve

- 4 Select an **ISO 1** view.
- 5 Activate the toolpath BN16-Flowline-4Curves-All.



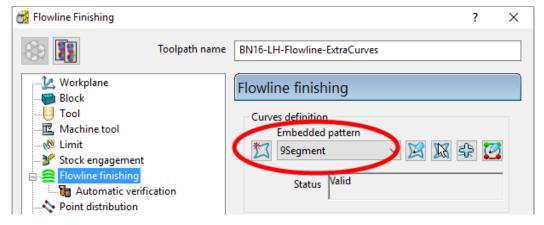


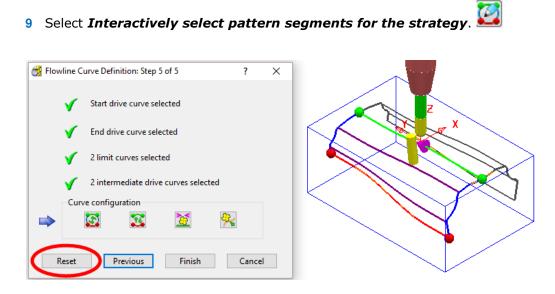
Note that this basic 4 segment, **Flowline** toolpath does not follow the intermediate flowlines of the variable fillet within the model form.

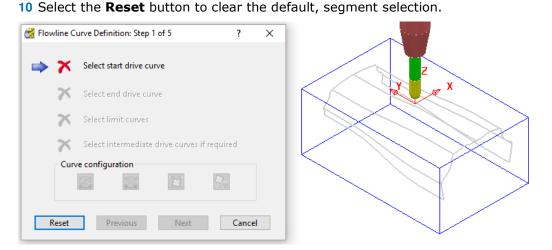


This can be changed if *intermediate drive curves* are included in the **Embedded Pattern**.

- 6 Right mouse click on the active toolpath **BN16-Flowline-4Curves-All** and from the local menu select **Settings** to open the **Flowline Finishing** dialog.
- 7 Select the *Copy* toolpath option and then rename the new toolpath as BN16-LH-Flowline-ExtraCurves.
- 8 In *Curves definition*, change the selected **Embedded pattern** to **9Segment**.

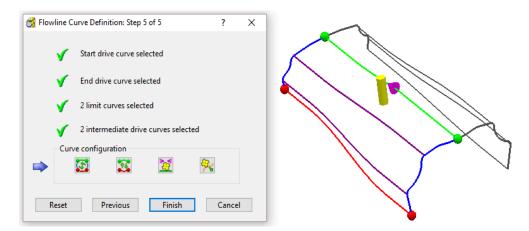






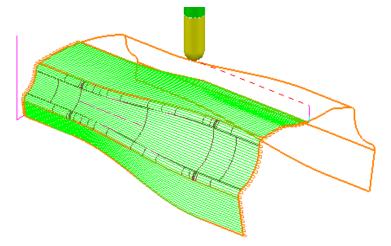
- 11 Select the upper central curve as the *start drive curve* (green)
- 12 Select the bottom left curve as the *end drive curve* (red).
- 13 Shift select the 2 end curves (blue).
- 14 Shift select the 2 nearest intermediate curves (purple).

15 Select the **Next** button to return to the full preview stage.



16 Select the Finish button to return to the main Flowline finishing dialog.

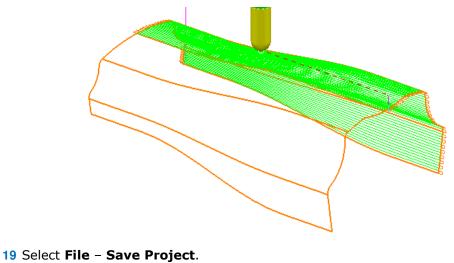
17 Select **Calculate** to generate the new toolpath then select **Close**.



Note that this 6 segment, **Flowline** toolpath follows the intermediate flowlines of the variable fillet within the model form.

Exercise

18 Create a *Copy* of the above toolpath named **BN16-RH-Flowline-ExtraCurves** and modify to machine the RH side of the component form.



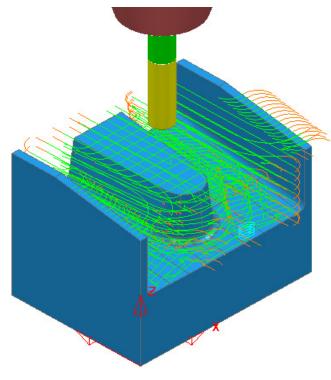
20 Select File - Delete All and Tools - Reset Forms.

8. Auto Collision Avoidance

Introduction

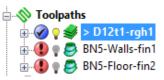
Automatic Collision Avoidance can be applied to Vertical alignment operations in cases where the Shank would otherwise be rubbing on a sidewall and\or the Holder would clash with the component. If parts of the component still cannot be machined without a tool collision occurring then these areas will not be included as part of the toolpath. Note: Automatic Collision Avoidance is not applicable to Swarf Finishing.

- 1 Open the Project:
 - ...\PowerMILL_Data\five_axis\CollisionAvoidance\AutoCollisionAvoid1_Start



- 2 Select File > Save Project as:
 - ...\COURSEWORK\PowerMILL-Projects\AutoCollisionAvoid_1

The **Project** contains 3 toolpaths all of which have had **Collision Checking** applied with **Shank** and **Holder** clearances values of **1** and **2** respectively.



The Area Clearance strategy is Gouge and Collision safe while the two 3D

Offset finishing strategies although **Gouge** free are not **Collision** safe relative to the **Shank** and **Holder**.

- 3 In the **PowerMILL** explorer, activate the toolpath **BN5-Walls-fin1**.
- 4 Right mouse click on the toolpath BN5-Walls-fin1 and from the local menu select Settings.
- 5 Select **Recycle** in the **3D Offset Finishing** dialog and select the **Tool Axis** page.



Note that the selected **Tool Axis** option is **Vertical**.

- 3 3	D Offset Finishing ? ×
Toolpath name	BN5-Walls-fin1
 Workplane Block Tool Machine tool Limit Stock engagement O offset finishing Automatic verification Point distribution Point distribution Point distribution Rapid move heights Start point Start point Feeds and speeds History Notes and Description O ser defined settings 	Tool axis Tool axis Vertical Vertical Image: Second and the second and the second axis Fixed angle None 90.0 Rotary axis configuration Tool axis finite Image: Second axis Image: Second axis Image: Draw tool axis
	Calculate Queue OK Cancel

6 Select the newly available **Collision Avoidance** page (Below **Tool axis**).

31	O Offset Finishing	?	x
Toolpath name Workplane Block	BN5-Walls-fin1 Collision Avoidance Tilt method Lean		
 	Tool clearances Shank clearance 1.0 Holder clearance 2.0		
 Point distribution □ 2 Tool axis □ 2 Collision Avoidance □ 0 Machine axis control 	Smoothing distance 10.0		

- Input the *Tilt method* as Lean.
- Input Shank and Holder clearances of 1 and 2 along with a smoothing distance of 10.
- 7 Calculate the 3D offset Finishing toolpath.
- 8 Apply Lead In and Lead Out with the same 1st/2nd choice Surface normal arc as shown in the following dialog.

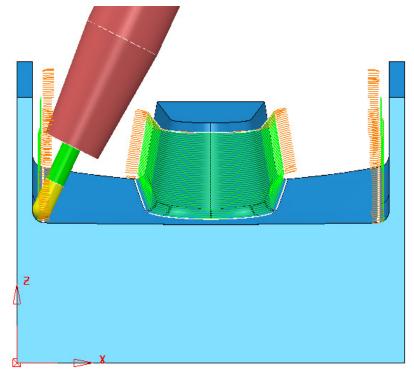
3 8		Le	eads a	nd Linl	ks			?	×
Extensio	ns		Links			Point	nt distribution		
Z heights	First lea	id in	Lea	d in	Lead	out	Last I	ead o	out
1st choice				2nd c	hoice				
Surface normal	arc		~	Surfa	ace norm	nal arc			~
	Distanc	<u>e</u> 0.0				[Distance	0.0	
	Ang	<u>le</u> 90.0					Angle	90.0)
	Radiu	<u>us</u> 3.0					<u>Radius</u>	1.0	
0.0 Overlap Allow start p Add leads to Add leads at	short links	moved scontinu	iities —	nits) threshol	<u>d</u> 90.0	Ra	amp opti	ons	
Gouge check	5					Д	opply lead	d ins	
·	Ар	ply	Acc	cept	Car	ncel			

This recycled **3D Offset Finishing** toolpath will need to be retrospectively edited to make the strategy ordering start at the top of the walls.

9 Right mouse click on the toolpath and from the local menu select Edit – Reorder.

3		Reord	er Toolp	ath Segments	?	×
22	#	Start point		End point	Length	^
	0	5.42, 74.17, 4	19.34	6.04, -1.03, 35.50	76.87	
	1	5.41, 74.33, 4	19.83	5.42, -0.02, 35.68	75.75	1
	2	5.41, 74.33, 5	60.33	5.41, 0.07, 36.25	75.63	5 - E
$\mathbf{\nabla}$	3	5.41, 74.33, 5	50.83	5.41, 0.07, 36.77	75.62	1
$\mathbf{\Sigma}$	4	5.41, 74.33, 5	51.33	5.41, 0.07, 37.29	75.62	
$\mathbf{\nabla}$	5	5.41, 74.33, 5	51.83	5.41, 0.07, 37.80	75.61	1
	6	5.41, 74.33, 5	52.33	5.41, 0.07, 38.30	75.61	1 I I
~	Reverse	order	52.83	5.41, 0.07, 38.81	75.61	1 I I
	8	5.41, 74.33, 5	53.33	5.41, 0.07, 39.32	75.60	1 I I
	9	5.41, 74.33, 5	53.83	5.41, 0.07, 39.83	75.60	1
	10	5.41, 74.33, 5	64.33	5.41, 0.23, 40.36	75.43	1 I I I
	11	5.41, 74.33, 5	64.83	5.41, 0.08, 40.83	75.59	

- 10 In the *Reorder Toolpath Segments* dialog select Reverse Order.
- 11 Select a **View from front** and **Simulate** the toolpath to observe the **Automatic Collision Avoidance** in action.



- 12 In the **PowerMILL** *explorer*, activate the toolpath **BN5-Floor-fin2**.
- **13** Right mouse click on the **toolpath BN5-Floor-fin2** and from the local menu select **Settings**.
- 14 Select **Recycle** in the **3D Offset Finishing** dialog and select the **Tool Axis** page.

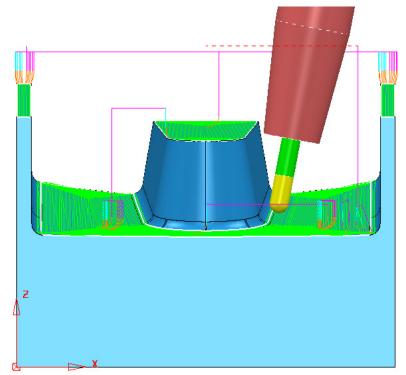
3	3D Offset Finishing ? ×
Toolpath name Workplane Block Tool Machine tool Machine tool Limit Stock engagement 3D offset finishing Automatic verification Point distribution Collision Avoidance	e BN5-Floor-fin2 Tool axis Tool axis Vertical v
Machine axis control Rapid move heights Leads and links Start Point Feeds and speeds Notes User defined settings	Fixed angle None Poly Poly Rotary axis configuration Toolpath Tool axis limits ✓ Automatic collision avoidance Tool axis smoothing Draw tool axis

15 Select the **Collision Avoidance** page.

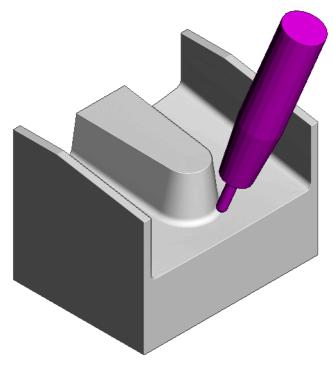
30	D Offset Finishing	?	×
Toolpath name	BN5-Floor-fin2		
Workplane Block Tool Machine tool Stock engagement Stock engagement Stock engagement Automatic verification Point distribution Tool axis	Collision Avoidance Tilt method Lean Tool clearances Shank clearance Shank clearance 1.0 Holder clearance 2.0 Smoothing distance 5.0		
Machine axis control			

- Input the *Tilt method* as Lean.
- Input Shank and Holder clearances of 1 and 2 along with a smoothing distance of 5.
- **16** Calculate the **3D Offset Finishing** toolpath.
- 17 Apply Lead In and Lead Out as 1st choice Surface normal Arc as used in the previous toolpath (BN5-Walls-fin1).

18 Select a **View from front** and **Simulate** the toolpath to observe the **Automatic Collision Avoidance** in action.



Vertical tool alignment is applied as default and the **Lean** angle is progressively changed as required in areas where a collision would otherwise occur.

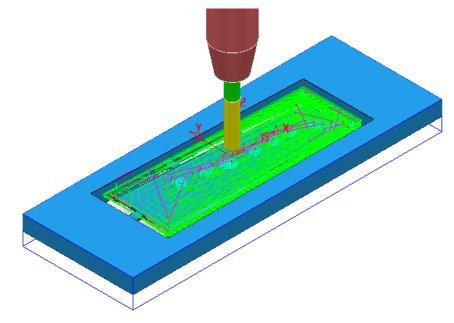


19 Select **File > Save Project**.

EXAMPLE 2

- 1 Select File Delete All and Tools Reset Forms.
- 2 **Open** the (read only) **Project**:

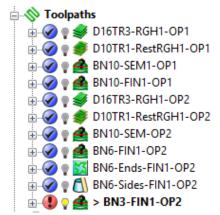
....\PowerMILL_Data\five_axis\CollisionAvoidance\DashboardPanel-A1_Start



3 Select **File > Save Project as**:

....\COURSEWORK\PowerMILL-Projects\Dashboard-A1_EX1

The **Project** contains 11 toolpaths all of which have had **Collision Checking** applied with **Shank** and **Holder** clearances values of **1** and **2** respectively.

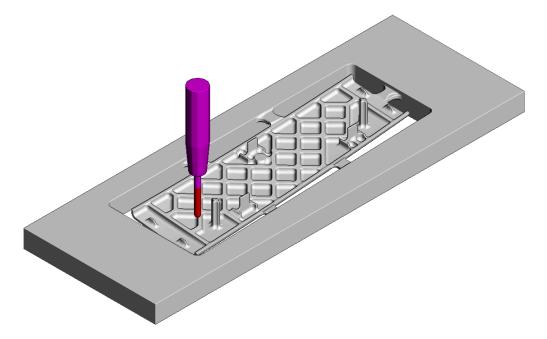


All have been confirmed to be safe with the exception of **BN3-FIN1-OP2**.

The toolpath is *gouge free* relative to the flutes but not *collision safe* relative to the **Shank** and **Holder**.

- 4 Activate the 5th toolpath, **D16TR3-RGH1-OP2** to reinstate the **OP2** setup.
- 5 Select an **ISO1** view.

6 Run a full **ViewMILL** simulation on both *NCPrograms* **OP1** and **OP2**.



The final toolpath **BN3-FIN1-OP2** is not currently included in the **OP2** *ncprogram*. The above **ViewMILL** simulation displays the result of all toolpaths except **BN3-FIN1-OP2**.

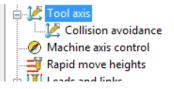
7 Put ViewMILL on suspend and return the graphics area to the **PowerMILL**

page.

- 8 Activate the toolpath BN3-FIN1-OP2 and from the local menu select Settings.
- 9 In the **Tool axis** page *tick* the box named **Automatic collision avoidance**.



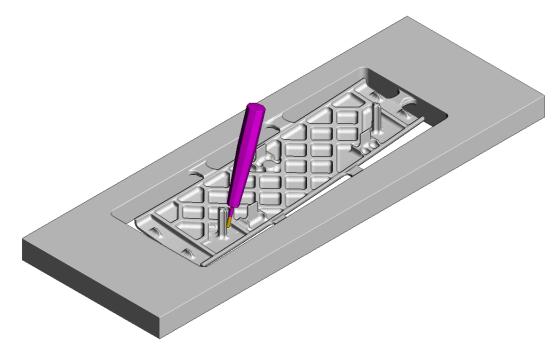
The **Collision avoidance** page appears in the local **explorer**.



- **10** Select the **Collision avoidance** page.
- 11 Set *Tilt Method* to Lean with a *Holder clearance* of **2.0**, *Shank clearance* of **1.0**, and *Smoothing distance* **3.0**.

😸 Steep	and Shallow Finishing	?	×
Toolpath name	BN3-FIN1-OP2		
Workplane Workplane Block Jool Kachine tool Kachine tool Kachine tool Automatic verification Point distribution Collision Avoidance Machine axis control	Collision Avoidance Tilt method Lean Tool clearances Shank clearance 1.0 Holder clearance 2.0 Smoothing distance 3.0		

12 Select **Calculate** and note that the collision status of the toolpath **BN3-FIN1-OP2** (as displayed in the local explorer) changes from a **Red** to **Blue**.



13 Run a **ViewMILL** simulation on the toolpath **BN3-FIN1-OP2**.

If a potential collision situation is encountered the tool automatically *leans* away from the wall (as shown in the above image).

14 Save the **Project**.

9. Tool Axis Limits

Introduction

It is possible to control the **Tool axis limits** of the machine tool within **PowerMILL**. This enables the rotary working envelope of a specific machine not to be exceeded when creating multi-axis toolpaths. The angular limits are defined in terms of **Azimuth** and **Elevation** angles in **PowerMILL**.

Azimuth and Elevation

The **Azimuth** is the angle from X 0° anticlockwise around the **XY** plane. The **Elevation** is the angle that is lifted upwards (+90°) or downwards (-90°) from the **XY** plane.



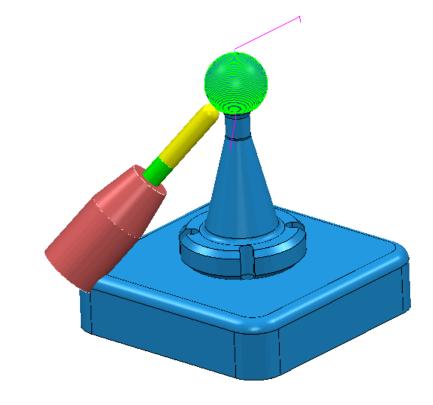
The **Tool Axis Limits** dialog is accessed from within the **Tool Axis** direction dialog. **Tool Axis Limits** are accessible if the **Tool Axis** box is ticked. This *tick box* will not be available if the **Tool axis** is set to **Vertical** or **Fixed Direction**.

T B	Fool Axis 🛛 ? 🗙	3		Tool Axis
Smoothing	Machine axis control		Smoothing	Machine axis c
Definition Lin	nits Collision avoidance		Definition	Limits Collision a
Tool axis		M	ode	Workplane
Lead/Lean 🗸			emove toolpath	~
Lead/Lean angles	Lean	Ar	ngle limits	
Lead 0.0	0.0		Azimuth angle	
0.0	0.0	5	Start	End
N	1ode Contact normal 🗸		0.0	360.0
		-F	levation angle	
			Start	End
Fixed Angle	00.0		-90.0	90.0
None	♥ 90.0			
Rotary axis configuratio	n		Damping angle	
Toolpath			3.0	
Tool axis limits				
Automatic collision av	voidance		Project to plane	
Tool axis smoothing			Draw limits	
Draw tool axis			anslucency (percen	itage)
		0.	.0	

- 1 Select File Delete all and Tools Reset Forms.
- 2 **Open** the 'read only' **Project**:

...\PowerMILL_Data\five_axis\Tool_Limit\JoyStick_Start

- 3 Select File > Save Project As:
 - ...\COURSEWORK\PowerMILL-Projects\JoyStick-Example
- 4 In the graphics area, right-click on the **toolpath** at the underside of the sphere, and from the local menu select, **Simulate** from **Nearest Point**.





Note that the **tool** is cranked over way beyond the **rotational limits** of the machine tool and the **tool holder** is visibly colliding with the base form.

To further illustrate the machining process exceeding the rotary limits, the strategy will be **simulated** using a **DMU50 Evolution** machine tool.

5 In the PowerMILL explorer, right mouse click on the Toolpath BN16-NoToolAxisLimits and from the local menu select Simulate from Start.

This command will raise the **Simulation** toolbar (if it is not already open).

	BN16-NoToolAxisLi ♥	😽 BN16	~	\triangleright		4	angle	44 DD			A	×	
--	---------------------	--------	---	------------------	--	---	-------	-------	--	--	---	---	--

6 In the **PowerMILL** *explorer* right mouse click on **Machine Tools** and from the local menu select **Toolbar**.

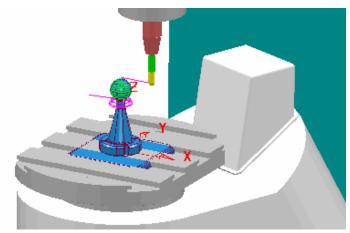


7 Select **Import the Machine Tool Model** and select the file:

....\PowerMILL Data\Machine Data\DMU\dmu50v.mtd

		ort Machine Tool			
Look in: 🧻	MachineData	v 🎯 🤌 📂 🖽 •			
Name	^	Date modified	Туре	Size	
CMS Ar	es48-18	08/07/2014 14:18	File folder		
🔪 🔰 dmu50	/	08/07/2014 14:18	File folder		
📃 🔒 fidiaK21	1	08/07/2014 14:18	File folder		
🔰 machin	e_parts	08/07/2014 14:18	File folder		
Mazak_	Variaxis_630	08/07/2014 14:18	File folder		
📃 🛛 🐌 RotaryN	/lachine	08/07/2014 14:18	File folder		
📗 Rye		10/11/2014 10:41	File folder		
dmu50	/.mtd	07/11/2003 15:20	MTD File	4 KB	
fidiaK2	1.mtd	05/07/2012 07:59	MTD File	3 KB	
head-h	ead.mtd	05/07/2012 07:59	MTD File	3 KB	
head-ta	ble.mtd	05/07/2012 07:59	MTD File	2 KB	
PMPOS	T-CMS_Ares48-18.mtd	09/01/2012 11:10	MTD File	6 KB	
PMPOS	T-Mazak_Variaxis_630PSA.mtd	09/01/2012 12:23	MTD File	5 KB	
Rotary	/lachine.mtd	21/11/2006 11:05	MTD File	3 KB	
Rye.mt	ł	27/08/2014 15:30	MTD File	4 KB	
table-ta	ble.mtd	05/07/2012 07:59	MTD File	3 KB	
File name:	dmu50v.mtd			~	Open
Files of type:	MTD (*.mtd)			~ (Cancel

8 Ensure the **Draw\Undraw** machine tool icon is on to display the machine tool model.

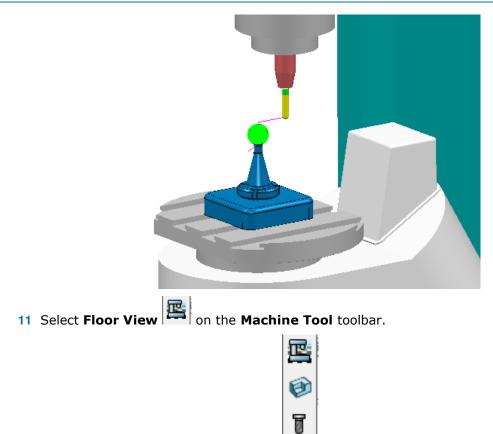


The current component datum (**Transform**) is matched to that of the Machine Tool model (Top - Centre of Table). As a result, the base of the component is currently embedded into the machine tool bed. To compensate for this, a new, suitably positioned Workplane is created. This new **Workplane** is then used in the **Machine Tool definition** toolbar.

- 9 Create a new Workplane named MTD-datum and move it by Z-50.
- **10** Input the new **Workplane**, **MTD-datum** into the **Machine Tool definition** dialog.

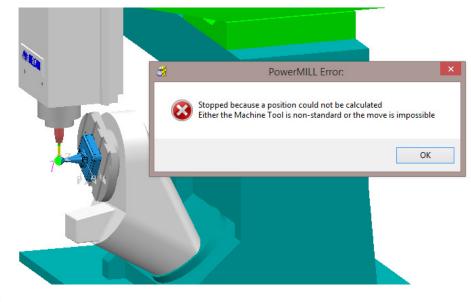


The component will immediately be repositioned, relative to the new **Workplane**.



12 Start the **Simulation** to observe the virtual machining of the component.

The **DMU50** angular limits are **X** \pm **90 Y** \pm **360** and this information is stored in the **MTD** file. This translates to **Azimuth** angle limits of **0** to **360** and **Elevation** angle limits of **0** to **90**. When the toolpath **simulation** attempts to go beyond this range an error message will be displayed indicating that the machine, **Tool Axis Limits** will be exceeded.



To allow for this appropriate **Tool Axis Limits** will be applied to the toolpath during calculation.

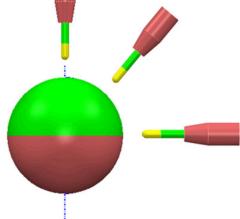
Õ

13 In the PowerMILL explorer, Machine Tools folder right mouse click on dmu50v and from the local menu select Go Home to return the machine tool model to the home position.

14 Make a **Copy** IIII of the original toolpath and rename it as **BN16-LimitsSet**.

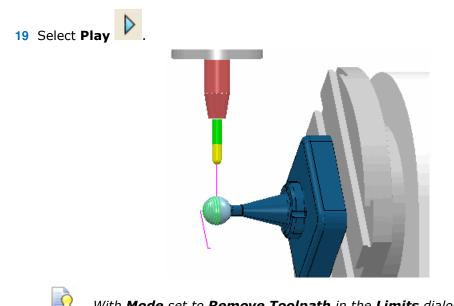
- 15 In the local *explorer* below **Tool Axis**, select the **Tool Axis Limits** option to activate the **Tool Axis Limits** page.
- **16** Enter the values into the dialog exactly as shown (select **Mode Remove toolpath** and tick the **Draw limits** box).

🛃 Surfac	e Projection Finishing ? ×
Toolpath name	BN16-LimitsSet
 Workplane Block Tool Machine tool Limit Stock engagement Surface projection Pattern Pattern Automatic verification Point distribution Tool axis Tool axis limits Machine axis control Rapid move heights 	Mode Remove toolpath Mode Remove toolpath Workplane MTD-datum Angle limits Azimuth angle Start Start 0.0 End 360.0 Elevation angle Start 0.0 End 90.0 Damping angle 3.0
 ↓↓ Leads and links ↓↓ Leads and links ↓↓ Start point ↓↓ Feeds and speeds ↓↓ History 	Project to plane Project to plane Translucency (percentage) 0.0
V	



The green area of the sphere represents the permissible angular alignment of the **Tool Axis**.

- 17 With the same Reference Surface selected, Calculate and Close the dialog.
- 18 Right-click the *Toolpath*, BN16-LimitsSet, in the PowerMILL explorer and select Simulate from Start.

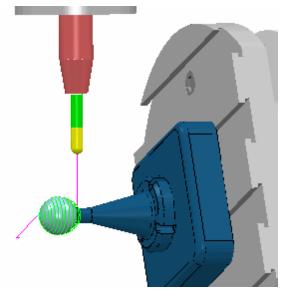


With **Mode** set to **Remove Toolpath** in the **Limits** dialog, only the portion of the surface within the rotary **Tool Axis Limit** range is machined.

- 20 Right-click on the toolpath, **BN16-LimitsSet**, and select **Settings** to access the **Surface Projection Finishing** dialog.
- 21 Select recycle and from the **Tool Axis** dialog select the **Limits** page and enter the values into the form exactly as shown below (select **Mode Move tool axis**).

Surface	e Projection Finishing	3	?	×
Toolpath name	BN16-LimitsSet			
	Tool axis limits			
 Tool Machine tool Limit Stock engagement Surface projection Pattern Point distribution Tool axis Tool axis Tool axis limits Machine axis control Rapid move heights Leads and links Start point Start point Feeds and speeds History 	Mode Workplane Angle limits Azimuth angle <u>Start</u> 0.0 Elevation angle <u>Start</u> 0.0	End 360.0		
	✓ Draw limits	Project to plane		

- 22 With the original reference **surface** selected, **Calculate** the toolpath.
- 23 Right-click the Toolpath BN16-LimitsSet, in the PowerMILL explorer and select Simulate from Start.
- 24 Select Play



With **Mode** set to **Move tool axis** in the **Limits** dialog, the **surface** is fully machined with the **Tool Axis** becoming fixed when it reaches the maximum, **Tool Axis Limit**.

25 Select File > Save Project to update the stored data.

Defining Limits for a Multi-Axis Machine

The **Tool Axis Limits** option allows the user to control the angular limits of a tool while creating a multi-axis toolpath. The specified limits will differ in format depending on the type of rotary axis configuration. As a result they will have to be translated as universal **Azimuth** and **Elevation** angles to be compatible with **PowerMILL**.

The configuration of the rotary axes varies widely, however the differences between many of these are relatively minor and there are really only three fundamentally different machine configurations:

Table – **Table**Both rotary axes move the table.

Head – **Head** Both rotary axes move the head.

Head – **Table** One rotary axis moves the head, the other moves the table.

The next examples will show how to transpose angular limits of a machine tool into **Azimuth** and **Elevation** angles.

- 1 Select File **Delete all** and tools **Reset Forms**.
- 2 Select the **Tool Axis** icon **1** from the **main** toolbar.
- 3 Define **Tool Axis** as **Lead****Lean** and set both **Lead** and **Lean** angles to **0**.
 - Select the **Tool axis limits** option

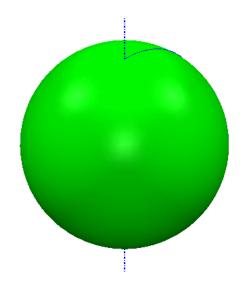
to activate the Limits tab.

- 5 Open the Limits tab.
- 6 Select the **Draw Limits** option from the dialog.

☑ Draw limits Translucency (percentage) 0.0

4

7 Select view ISO 1.

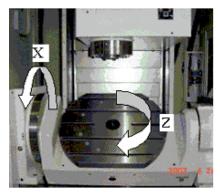


With the **Draw Limits** option selected a sphere will be displayed in the graphics window representing the angular machining limits available.

Green indicates a machinable portion and Red a non-machinable portion. With the default settings selected the total machining range is covered so the whole sphere will be Green.

Table – Table

Both rotary axes operate on a table.



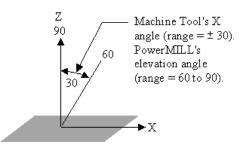
With the above Table-Table machine tool the angular limits are specified as:

X ± 30

Z ± 360

The machine tool **Y** limits are equivalent to the Azimuth angle or the angular limits normal to the **XY** plane. The **Y** limit of \pm **360** translates to **Azimuth** angle limits of **0** to **360**.

The machine tool **X** limits are equivalent to the **Elevation** angle above the **XY** plane. However they are not the same angle. This is best described using the diagram below. The machine tool measures the angular range relative to the **Z** Axis and **PowerMILL** measures it relative to the **XY** plane, therefore the angle required for the limit in PowerMILL is the complementary angle to the one given for the machine tool.



This means that the X limit of ±30 translates to Elevation angle limits of 60 to 90.

1 Retain the default **Azimuth Angle** and modify the **Elevation Angle** values in the form as shown below to update the machining limits.

Angle limits	
Azimuth angle	
Start	End
0.0	360.0
Elevation angle	
Start	End
60.0	90.0

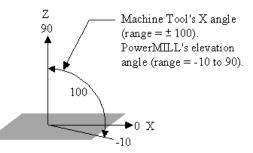
The Tool Axis Limits sphere has been visually updated with the modified values.

An Alternative **Table -Table** machine tool has the following angular limits:

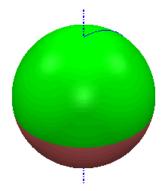
X ± 100

Y ± 360

This translates to **Azimuth Angle** limits of **0** to **360** and **Elevation Angle** limits of **-10** to **90**.



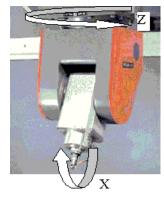
2 Modify the **Elevation Angle** values (-10 to 90) in the **Angle Limits** dialog to update the machining limits (as shown).



The **Tool Axis Limits** sphere has been visually updated with the modified values.

Head – Head

Both rotary axes move the head.



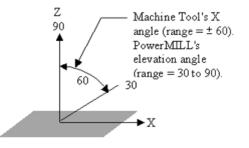
With the above **Head-Head** machine tool the angular limits are specified as:

X ± 60

Z ± 360

The machine tool **Z** limits are equivalent to the **Azimuth Angle** or the angular limits normal to the **XY** plane. In PowerMILL the Z limit of \pm 360 translates to Azimuth angle limits of 0 to 360.

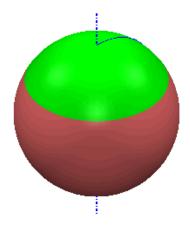
The machine tool X limits are equivalent to the **Elevation Angle** above the XY plane. The angular range of the machine tool is relative to the Z axis, however **PowerMILL** measures it relative to the XY plane. Therefore the angle required for the limit in **PowerMILL** is the complementary angle to the one given for the machine tool. The X limit of \pm 60 translates to **Elevation** Angle limits of 30 to 90.



Alternative **Head-Head** machine tool angular limits:

X -50 to +60 Z ± 360 This translates to **Azimuth Angle** limits of **0** to **360** and **Elevation Angle** limits of **30** to **90**. In this case the machine tool limits across the **XZ** plane differ. **PowerMILL** will use the largest rotational value (+60). This is allowed by rotating the head **180°** about **Z** to provide access to the maximum range **+60** (which otherwise would be **-50**).

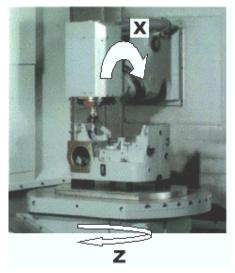
1 Modify the **Elevation Angle** values (**30** to **90**) in the dialog to update the machining limits as shown.



The **Tool Axis Limits** sphere has been visually updated with the modified values.

Head – Table

One rotary axis moves the head, and the other moves the table.



With the above **Head-Table** machine tool, the angular limits are specified as:

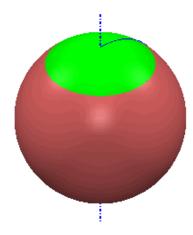
X ± 40

Z ± 360

The machine tool **Z** limits are equivalent to the **Azimuth Angle** or the angular limits in the **XY** plane. The **Z** limit of **±360** translates to **Azimuth Angle** limits of **0** to **360**.

The machine tool **X** limits are equivalent to the **Elevation Angle** above the **XY** plane. It is the complimentary angle to the **Elevation** Angle. The X limit of \pm **40** translates to **Elevation Angle** limits of **50** to **90**.

1 Modify the **Elevation Angle** values (**50** to **90**) in the dialog to update the machining limits as shown below.

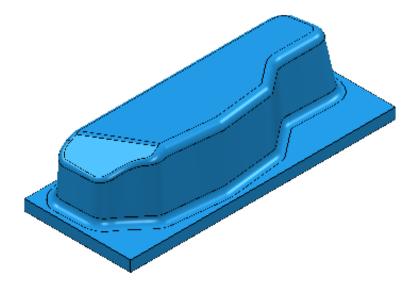


The **Tool Axis Limits** sphere has been visually updated with the modified values.

Applying tool Axis limits on a Steep Sidewall base Fillet

- 1 Select File Delete all and Tools Reset Forms.
- 2 Import the Model:

...\PowerMILL_Data\five-axis\punch2\punch2_insert.dgk

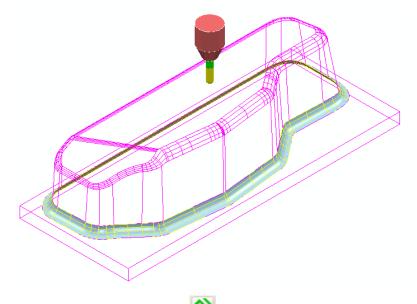


3 Select File > Save Project As:

...\COURSEWORK\PowerMILL-Projects\Punch2-ToolAxisLimits

- 4 Create a Diameter 20 Ballnose tool Length 50 named BN20.
- 5 Add a Shank component Upper Dia 20 Lower Dia 20 Length 40
- 6 Add a Holder component Upper Dia 70 Lower Dia 40 Length 40
- 7 Add a Holder component Upper Dia 70 Lower Dia 70 Length 60 Overhang
 80
- 8 Calculate a Block using *Defined by* Box and *Type* Model.
- 9 Calculate the Rapid Move Heights using the default settings.

10 Select the fillet running around the base of the main component sidewalls.



- 11 Select the **Toolpath Strategies** icon and in the **Strategy Selector Finishing** options select the **Surface Finishing**.
- 12 Input data into the **Surface Finishing** dialog exactly as shown:

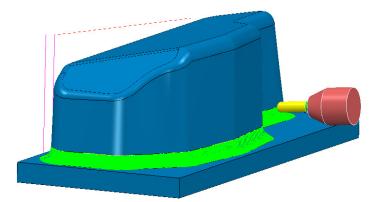
3	Surface Finishing ? ×
Toolpath name	BN20-Fillet-FIN
 Workplane Block Tool Machine tool Machine tool Machine tool Machine tool Machine tool Machine tool Pattern Pattern Point distribution Tool axis Machine axis control Rapid move heights I Leads and links Start point Start point Feeds and speeds History Notes and Description User defined settings 	Surface finishing Surface Surface Surface units Degouge tolerance 0.3 Tolerance 0.02 Thickness 0.0 Stepover (Distance) Stepover (Distance) Preview

- Toolpath name: BN20-Fillet-FIN
- Stepover: **0.5**

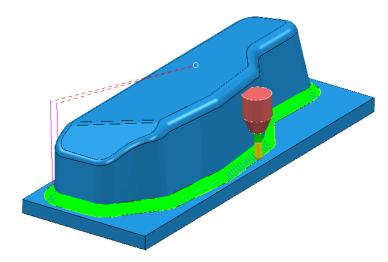
đ	Surface Finishing		? >	×
Toolpath r	BN20-Fillet-FIN			
Workplane	Pattern			
	Pattern Pattern	direction U Sp	✓ iral ✔	
Pattern	Ordering	One way	~	
Point distribution	Start corner	Min U min V	~	
Machine axis control	Sequence	None	~	
Pattern Direction: U				
Spiral: <i>Ticked</i>				
3	Surface Finishing		?	×

- 3 8	Surface Finishing
Toolpath name	BN20-Fillet-FIN
Workplane	Tool axis
	Tool axis
	Lead/Lean V
Stock engagement	Lead/Lean angles Lead
Surface finishing	0.0
Pattern	
	Mode Contact normal 🗸
Machine axis control	
widenine axis control	

13 Select **Calculate** to create the **Surface Finishing** toolpath.



- The **Tool Holder** is in Collision with the Base.
- 14 From the local toolpath menu, select **Verify Toolpath** to open the **Toolpath** Verification dialog.
- 15 Un-tick both Split Toolpath and Adjust Tool.
- **16** Then check for **Collisions** using a **Shank Clearance** of **1** and a **Holder Clearance** of **2**.



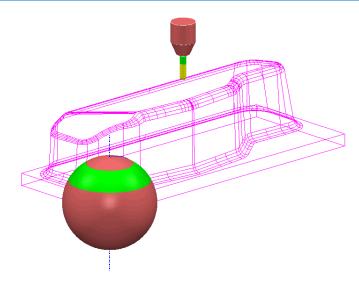
- The Tool Holder is also in collision with the Sidewall.
- During **Projection Surface Finishing** the tool (**BN20**) is aligned normal to the Fillet Surface (if default Lead Lean 0 is applied). This is creating a Collision situation with both the sidewall and the base. Tool Axis limits will be applied to prevent this immediate problem as well as to keep the tool alignment within the machine tool rotary limits.
- 17 In the PowerMILL explorer, right-click the toolpath, BN20-Fillet-FIN, and select **Settings** to re-open the **Surface Finishing** dialog.



18 In the **Surface Finishing** dialog select **1** to create a 'copy' and enter the toolpath name BN20-Fillet-FIN-LIM30.

đ	Surface Finishing		?	×
Toolpath name	BN20-Fillet-FIN_LIM30			
- 🗽 Workplane - 🖶 Block	Tool axis limits			
<mark>U</mark> Tool E Machine tool	Mode	Move tool axis 🗸 🗸		
Stock engagement Stock engagement Surface finishing	Workplane Angle limits Azimuth angle	~		
 Point distribution 10 Tool axis 	Start 0.0 Elevation angle Start 30.0	End 360.0		
 Machine axis limits Machine axis control Rapid move heights 		amping angle 3.0		
Eads and links	✓ Draw limits	Project to plane		
Feeds and speeds Image: Boost State	Translucency	(percentage) 0.0		

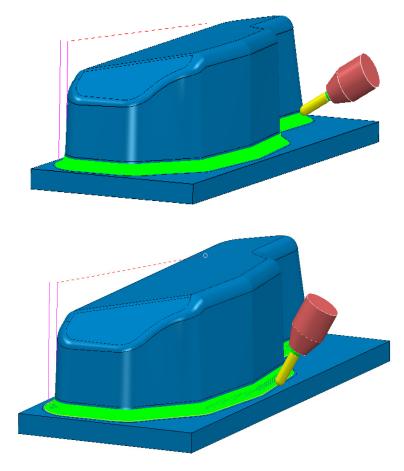
- **19** Tick **Tool Axis limits** and move to the **Tool axis limits** page.
- 20 In Mode, select Move tool axis and for Elevation angle input:- Start 30 and End 60.
- 21 Select **Calculate** to create the new toolpath.



With the **Tool Axis Limits** applied the alignment will be restricted to operate between **30** and **60** degrees (**Elevation Angle**) relative to the **XY** plane. The sphere displaying the **Tool Axis** alignment limits (shaded green and pink) becomes visible when the box labelled **Draw Limits** is ticked.



The two illustrations below show the toolpath with the tool attached on the upper and lower tracks and the effect of the specified limits.

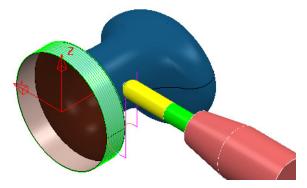


• The **Tool Holder** is no longer in collision with the Base or Sidewalls.

22 Save the Project.

Applying Tool Axis limits to maintain a 4-Axis toolpath.

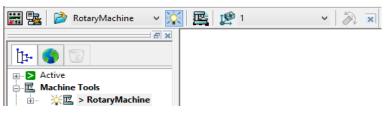
- 1 Select File Delete all and Tools Reset Forms.
- 2 **Open** the 'read only' **Project**:
 -\PowerMILL_Data\five_axis\Tool_Limit\FixTo4Axis_Start



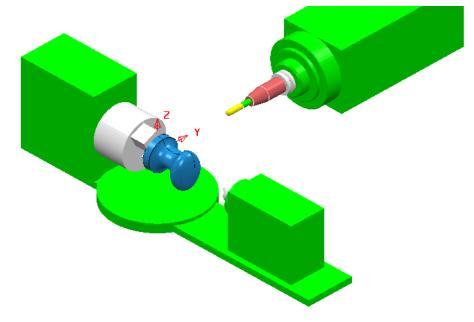
3 Select File > Save Project As:

....\COURSEWORK\PowerMILL-Projects\FixTo4Axis-example1

- 4 If not already displayed, from the main **pull down** menus select **View Toolbar** and tick **Machine Tool**.
- 5 In the **PowerMILL** *explorer* open the **Machine Tools** folder and **activate** the **RotaryMachine** (double left click the icon ^{IIII}).



- 6 Input workplane 1 as the Machine Tool output datum.
- 7 Select an **ISO 2** view.

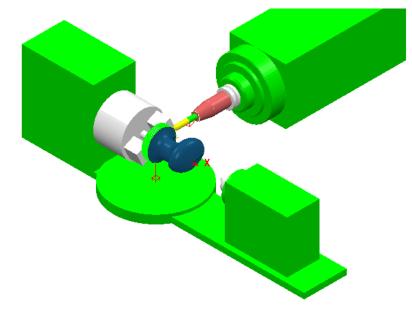


The **Project** contains a model of a 4-Axis Rotary Machine and two toolpaths.

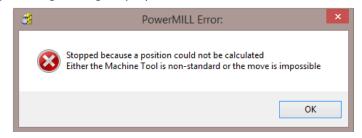
The first **toolpath** is inherently 4 Axis while the second **toolpath** is 5 Axis.

The Rotary Machine is unable to produce the **Tool Axis** moves required by the second *Five Axis* **toolpath**. This **toolpath** can however easily be converted to *4-Axis* using the **Tool Axis Limits** options.

- 8 In the PowerMILL explorer, right mouse click on the toolpath BN16-Base-SEM1 and select Activate followed by Simulate from Start.
- 9 Click the **Play** button and the **simulation** successfully runs all the way to the end.



- 10 In the **PowerMILL** *explorer*, right mouse click on the **toolpath BN16-Form-SEM2** and select **Simulate from Start**.
- 11 Click the **Play** button and the **simulation** immediately fails to proceed with the following message being displayed.



As the toolpath is fully *Five Axis* it impossible for the **Rotary Machine** to perform a **simulation**.

- **12** Abandon the **simulation**.
- 13 Right mouse click on the toolpath BN16-Form-SEM2 and from the local menu select Activate it before selecting Settings to open the Projection Surface dialog.



14 In the **Projection Surface** dialog select the Recycle toolpath option

15 In the local *explorer* select **Tool axis** and *tick* the **Tool axis limits** box.

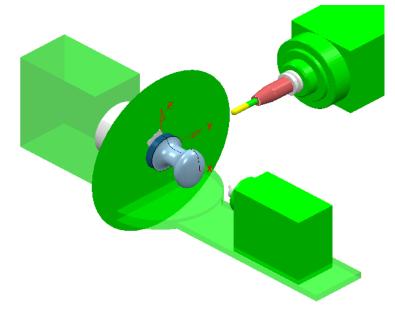


The Tool axis limits page will become available in the local explorer.

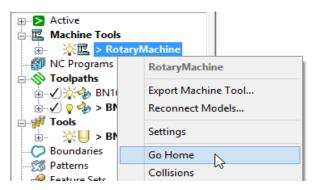
16 Select the **Tool axis limits** page and enter data exactly as shown below.

😚 Surfac	Surface Projection Finishing ? ×			
Toolpath name	BN16-Form-SEM2			
	Tool axis limits			
	Mode	Move tool axis 🛛 🗸		
₩ Limit ¥ Stock engagement	Workplane Angle limits	¥		
- → Surface projection 	Azimuth angle <u>Start</u> 0.0	End 360.0		
	Elevation angle			
⊡… ¹ Tool axis	Start 0.0	<u>End</u> 65.0		
─Ø Machine axis control ── ■ Rapid move heights		amping angle 0.0	Ő	
	\frown	Project to plane 🗸	>	
	✓ Draw limits			
Intersection of the sector	Translucency	(percentage) 0.0		

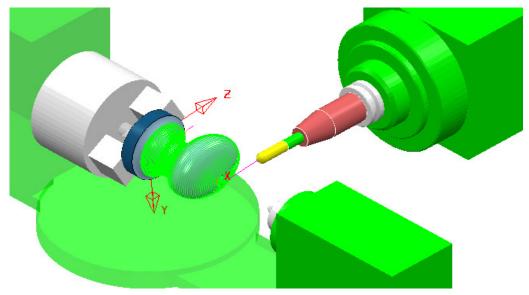
With **Project to plane** ticked the **Tool axis limits** are flattened to create a 4 axis limit (about the global transform in this case). A zero **Damping angle** will ensure that the 4 axis alignment is fully maintained.



- 17 In the **Tool axis limits** page, un-tick **Draw limits**.
- **18** With the 3D form, **surface** selected **Calculate** the new 4-Axis toolpath.



- **19** In the local **explorer**, right mouse click on **Rotary Machine** and from the local menu select **Go Home**.
- 20 From the PowerMILL explorer, right mouse click on the new toolpath BN16-Form-SEM2 and from the local menu select Simulate from Start.
- 21 Click the **Play** button and the 4-Axis toolpath simulation successfully runs all the way to the end.

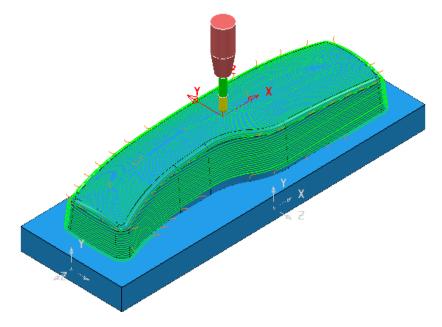


22 Save the Project.

Exercise 1

- 1 Select File Delete all and Tools Reset forms.
- 2 Open the 'read only' Project:

...\PowerMILL_Data\five_axis\Punch3\Punch3_Start



- 3 Save the Project As:-
 - ...\COURSEWORK\PowerMILL_Projects\Punch3_EX1

The **Project** contains a **Steep and Shallow Finishing** toolpath **BN16-StpShlw** with a **Tool Axis** set to **Vertical**. The **Tool** is too short to safely machine some areas of the sidewalls. These potential collisions are avoided by the using **Automatic verification** (*Shank clearance* **1** and *Holder clearance* **5**).

The upper base surface is set with *Machining Mode* as **Collision** with a **Thickness** value of **0.5**.

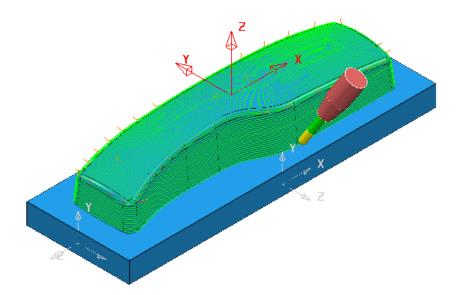
💰 Steep	and Shallow Finishing ? ×
Toolpath name	BN16-StpShlw
 Workplane Block Tool Machine tool Limit Stock engagement Steep and shallow finishing Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leade and links 	Automatic verification Head clearance 600.0 Automatic collision checking Collision checking against Model Holder clearance 5.0 Shank clearance 1.0 Machine maximum stock

The object of the exercise is to create 2 copies of the existing toolpath the first with a suitable **Toward Point** - **Tool Axis alignment** applied and the second that is further limited to being **4 Axis** only (applied about the X axis).

- 4 Activate the toolpath BN16-StpShlw and from the local menu select Settings to re-open the strategy dialog.
- 5 Create a *Copy* of the toolpath and rename it as **BN16-StpShlw_TwdPt**
- 6 Select the **Tool Axis** page and select the option, **Towards Point** with the **X Y Z** positional values as **0 50 350**.

🛃 Steep	and Shallow Finishing ? ×
Toolpath name	BN16-StpShlw_TwdPt
···· ¹ / ₂ , Workplane ···· ¹ / ₂ Block ····· ¹ / ₂ Tool ···· ¹ / ₂ Machine tool ···· ¹ / ₂ Limit ···· ³ / ₂ Stock engagement	Tool axis Tool axis Towards point v Point 0.0 50.0 -350.0
Steep and shallow finishing Automatic verification Point distribution Yool axis Machine axis control Rapid move heights Henvil Leads and links	Mode Toolpath
Start point End point ⊞ The Feeds and speeds History	None 90.0 Rotary axis configuration 700lpath
 B Notes and Description User defined settings 	 Tool axis limits Automatic collision avoidance Tool axis smoothing Draw tool axis

7 **Calculate** the new toolpath.

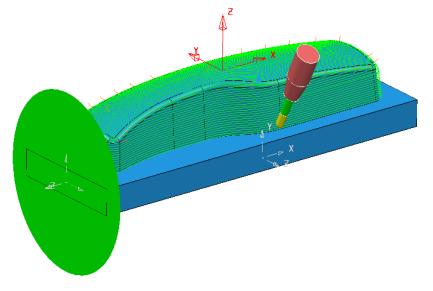


With a suitable **Toward Point** - **Tool Axis alignment** applied the **Tool** is now angled away from the sidewalls providing collision free access to the deeper areas.

- 8 Activate the toolpath BN16-StpShlw_TwdPt and from the local menu select Settings to re-open the strategy dialog.
- 9 Create a Copy of the toolpath and rename it as BN16-StpShlw_TwdPt_4Axis
- 10 Select the **Tool Axis** page and tick the **Tool axis limits** box.
- 11 Select the newly appeared **Tool axis limits** page in the *local explorer* and input the data into the dialog exactly as shown below.

😚 Steep	and Shallow Finishin	g	?	×
Toolpath name	BN16-StpShlw_TwdPt_4	Axis		
Workplane	Tool axis limits			
Block	Angle limits Azimuth angle <u>Start</u> 0.0 Elevation angle <u>Start</u> -90.0 Draw limits	Move tool axis X-Direction End 360.0 End 90.0 amping angle 3.0 Project to plane (percentage) 0.0		

12 Calculate the new toolpath.

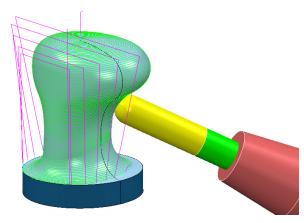


This strategy is limited to operate as 4 Axis only.

13 Save the **Project**.

Exercise 2

- 14 Select File Delete all and Tools Reset forms.
- 15 Open the 'read only' Project:
 - ...\PowerMILL_Data\five_axis\joint_5axismc\JointAxisLimits_Start

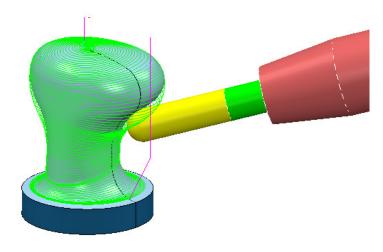


16 Save Project As:-

...\COURSEWORK\PowerMILL_Projects\JointAxisLimits-EX1

The **Project** contains a **Surface Finishing** toolpath with a **Tool Axis** setting of **Lead 0** and **Lean 0**. This causes the **Tool** to be aligned to the *surface normals* at all points on the toolpath adjacent to the selected **surface**. The tool alignment is not prevented from exceeding the machine tool, *rotary limits* or to clear overhanging areas of the model.

- 17 Recycle the **Surface finishing** on the selected **Surface** using **Tool axis limits** between *Elevation Angles* of **15** and **65** degrees using **Mode Move tool axis**.
- 18 Perform a toolpath Simulation followed by a full Gouge and Collision (Shank Clearance 2 Holder Clearance 3) check on the modified Surfacing Finishing toolpath.



19 Save the **Project**.

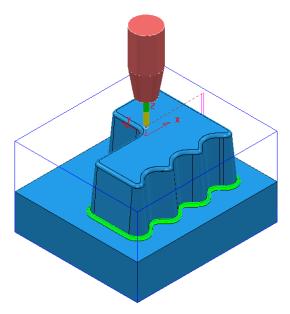
10. Tool Axis Editing

Introduction.

In some applications the type of **Tool Alignment** option applied to a **Five Axis** strategy can result in unnecessary, exaggerated rotary movements while the cutter runs along a toolpath.

In some cases, these exaggerated movements can result in **Tool Holder** or **Machine Tool** collisions. To reduce this, it is possible to edit the toolpath to have an alternative **Tool Alignment** within a user defined, area.

- 1 **Open** 'read only' the **Project**:
 -\PowerMILL_Data \five_axis\ToolAxisEditing\EditToolAxis_Start



The **Project** contains a **Corner Along** strategy created using a **Dia 5 Ball Nosed** tool with a **Lean Angle** of **45** Degrees applied.

2 From the **main** pulldown menus select **File** > **Save Project as**:

....\COURSEWORK\PowerMILL-Projects\EditToolAxis

3 In the **main** pull down menus select **View** > **Toolbars** > **Machine Tool** to raise the **Machine Tool** definition toolbar.

📰 🛃 🔌	v 🔀 🖳 🧟	 > 🔊 ×
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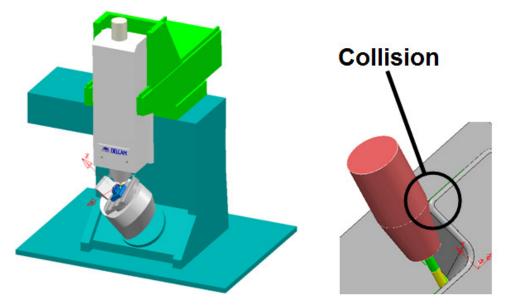
4 Click on the **Import Machine Tool Model** icon and from the **....YowerMILL_Data\MachineData** directory, select the file **dmu50v.mtd**.



- 5 Input the workplane Base as the datum for the Machine Tool Simulation.
- 6 Ensure the **Draw\Undraw** machine tool icon is selected to display the machine tool.
- 7 Select an **ISO 1** view and zoom the machining area.
- 8 Select Floor View From the Simulation toolbar.
- 9 Right-click on the toolpath BN5-Rest-Lean45 and from the local menu, select Simulate from Start.



10 Move the simulation speed, *slider* to a slow setting and then click the *Play* icon and observe the machine tool movement.



In addition to there being an excessive amount of table rotation while the undulating sidewall is machined there is also a **Tool Holder collision** on the sidewall internal corner (see above right graphic).

- 11 From the local **BN5-Rest-Lean5** toolpath menu, select **Verify Toolpath** and in the dialog, un-tick both **Split Toolpath** and **Adjust Tool**.
- 12 Select *Check* Collisions, with a Shank Clearance 1 and Holder Clearance 2 and Apply the dialog.

The **Toolpath** is now displayed red in the **PowerMILL explorer** confirming that the **Shank** and/or **Holder** are colliding with the model.



0 The 2 issues will be fixed by applying localised Tool Axis alignment modifications on the toolpath. To enable normal viewing while the changes are made, the Machine Tool model will temporarily be removed from the Machine Tool Simulation toolbar. 13 In the Machine Tool Simulation toolbar select None to remove dmu50v.mtd from the selection input box leaving it blank. B æ, 😥 Base 🛱 😼 V -0-X 14 Select a **View from top** ready for snapping the corners of a **polygon** to define the first area of the toolpath to undergo Tool Axis Editing. 15 On the keyboard select **Ctrl H** to display the **Cross Hair** on the cursor position. 16 In the PowerMILL explorer, right-click on the toolpath BN5-Rest-Lean45 and select Edit > Edit Within Region from the local menus to access the following dialogs. 17 In the (default) Select Region dialog set Define Region By - Polygon and Side - Inner (as shown below left). 🥳 Edit Toolpath Within Region ? 🥳 Edit Toolpath Within Region Select Regions Specify Changes Select Regions Specify Changes Define Region 🚺 Polygon Type of Editing Plane New Axis Definition ¥ Type Plane X **Rotary Axis Configuration** Point R Toolpath 0.0 0.0 -32.5 Normal **Tool Axis** 0.0 0.0 1.0 Tool Axi **Fixed Direction** 1 🖉 Boundary Boundary Orientation 10 Free Projection Plane Active Workplane Y ✓ Point Distribution Side ¥ Inner Type Tolerance And Keep Arcs • Save Selection Blend Distance 5.0 **Clear Selection** Undo 🧐 Cancel Apply Cancel Apply

18 Select the Specify Changes tab, and set Tool Axis as Fixed Direction and input a Blend Distance of 5, before selecting the Tool Axis icon

3	Tool Axis	?	×
Smoothing	Mac	hine axis control	
Definition	Limits	Collision avoidan	ce
Tool axis			
Fixed direction	~		
Tool axis smoo	ision avoidance thing	1.0 P	
	Accept Ca	ncel	

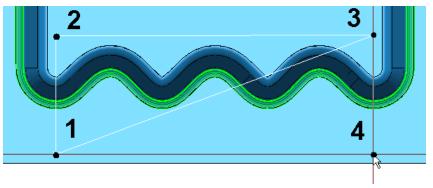
19 Input values into the Direction vector (Along the tool axis) as:-

I 0.0 J -1.0 K 1.0

- 20 In the **Tool Axis** dialog, tick the **Draw Tool Axis** box before selecting **Accept** (to return to the **Edit Toolpath Within Region** dialog).
- **21** From the **main** pulldown menus select **Draw** > **Cursor** > **Cross Hair**.

This will display **cross hairs** running through the **cursor position**, to assist visual alignment when 'snapping' points.

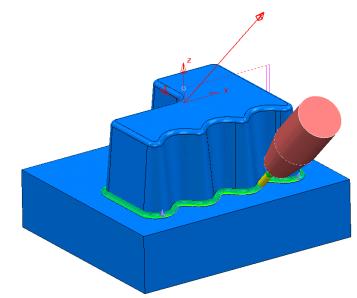
- 22 Click on the **Select Regions** tab to access the original options.
- 23 Left-click to snap 4 corners of the **Polygon** inside where the **Tool Axis Edit** is to occur, and click **Apply**.



The above illustration is at the stage where the user is ready to **snap** the **4th** and final point on the **Polygon** (Cross hairs are mid grey).

⁰

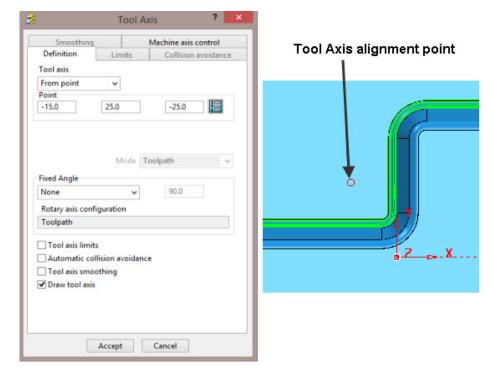
24 Select an ISO 1 view and simulate the toolpath to observe that the Tool Axis Alignment is no longer performing a series of rotary movements along the undulating sidewall.



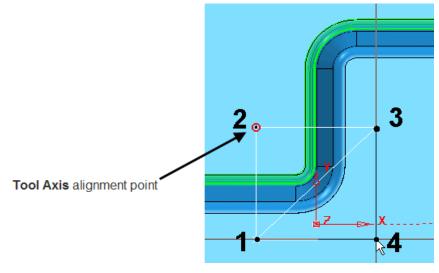
- 25 Select a View from top.
- 26 In the PowerMILL explorer, right-click on the toolpath BN5-Rest-Lean45 and select Edit > Edit Within Region to open the Edit Toolpath Within Region dialog again.
- 27 In Select Regions select Polygon with Side Inner, and then click the Specify Changes tab.

ect Regions	Specify Cl	hanges		Select Regions Specify Changes
Define	Region By	Polygon	~	Type of Editing
Plane				New Axis Definition
Point	Туре	Plane X	×	Rotary Axis Configuration
0.0	0.0	-32.5	N N N N N N N N N N N N N N N N N N N	Toolpath
Normal			(Amazaniti	
1.0	0.0	0.0	X Z	Tool Axis
				Tool Axis
Boundary				From Point
B	oundary		\sim	Orientation
Projectio	on Plane 🗛	ctive Workp	lane 🗸	Free
	Side In	iner	~	Point Distribution
			Ť	Туре
				Tolerance And Keep Arcs
	Save Sel	ection		Blend Distance 5.0
	Clear Sel	lection		Undo

28 Set *Tool Axis* - From Point with the coordinate values X-15 Y 25 Z-25, and then tick the box labelled Draw Tool Axis before selecting Accept.



29 This time snap 4 corners of the polygon to form a square, aligned as close as possible to the **Tool Axis Alignment** point, and click **Apply**.

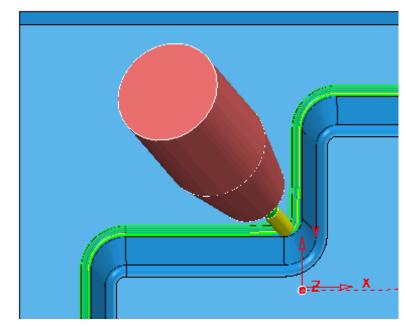


- **30** Select an **ISO 1** view.
- 31 From the local **BN5-Rest-Lean5** *toolpath* menu, select **Verify Toolpath** and in the dialog, un-tick both **Split Toolpath** and **Adjust Tool**.
- 32 Select *Check* Collisions, with a Shank Clearance 1 and Holder Clearance 2 and Apply the dialog.
- 33 Select *Check* Gouges and Apply the dialog.

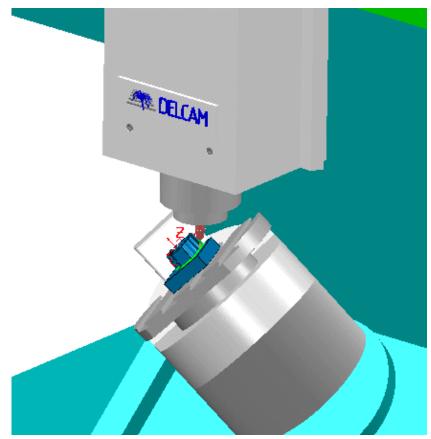
The **Toolpath** is now displayed green in the **PowerMILL explorer** confirming that the toolpath is free of both **Gouges** and **Collisions**.



34 Simulate the toolpath to observe that with the new **Tool Axis Alignment** the tool holder is no longer in a *collision* condition with the sidewall internal corners.



35 Perform a **Machine Tool Simulation** again using the **DMU50V** with the **Floor View** selected.



This time the unnecessary, 'rocking' movements about the rotary axis are minimised and the **Tool Holder collision** removed.

36 Select **File - Save Project**.

11. Machine Tool Simulation and Verification

Introduction

The ability to check for potential **Machine Tool** - **Component collisions** is an essential requirement for **Five Axis** applications. To provide this capability **PowerMILL** contains an additional **Machine Tool** toolbar for use with the toolpath **Simulation** options.



The standard **Machine Tool Simulation** is purely visual and it is the user's responsibility to identify collisions. An additional, 'cost option' is available where the **Machine Tool Simulation** will stop if a collision situation is identified. At this point a warning box will be displayed. The tool along with the affected parts of the **Machine Tool model** will turn red, and once acknowledged (by clicking **OK**) all moves in a collision condition will be registered in a list.

The individual component parts of a **machine tool** (eg; Main Body, Head, Rotary Table, Cradle, etc) are stored as a set of individual triangle models. These are registered within an **mtd** file that controls the **orientation** and **position** of the individual triangle models during a **simulation**.

Three basic, multi-axis **Machine Tool Simulation** (.mtd) files are supplied within the **PowerMILL** installation data. A typical location for a **C** drive install:

C:\Program Files\Delcam\PowerMILL13.0.06\file\examples\MachineData

A further selection of sample **mtd** files, based on actual **machine tools** are located on the training PCs in:

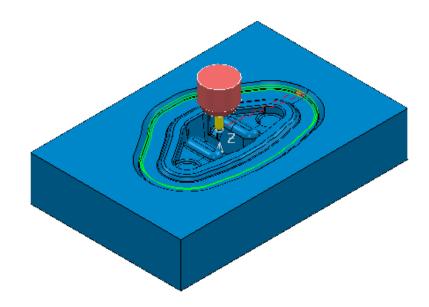
....\PowerMILL_Data\MachineData

It is essential that all models along with controlling moves and limits used in a **Machine Tool Simulation** (.mtd) file are an accurate copy of the actual Post-Processor and machine tool in use. Due to design variations, different set up criteria, and tolerance issues, each **Machine Tool Simulation** (.mtd) file and associated models must be tailor made and fine-tuned for each individual application.

1 Select File - Delete all and Tools - Reset forms.

2 **Open** the read only **Project**:

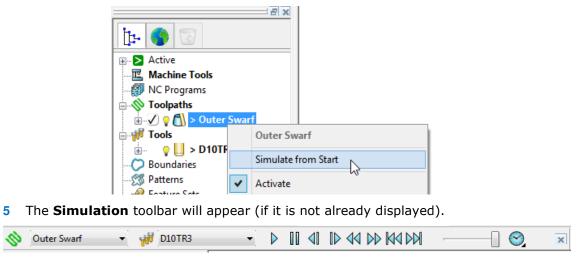
....\PowerMILL_Data\five_axis\Collision_Simulation\Swarf_check



3 Select File - Save Project As:

```
....\COURSEWORK\PowerMILL-Projects\MCTool-simulation
```

4 In the **PowerMILL** *explorer*, right mouse click the toolpath **Outer Swarf** and select **Simulate from Start**.

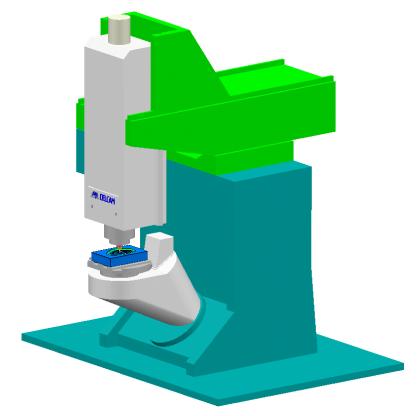


6 In the **PowerMILL** *explorer* right mouse click on **Machine Tools** and from the local menu select **Toolbar**.



7 Select the *Import the Machine Tool Model* icon and select the file dmu50v.mtd from:

....\PowerMILL_Data\Machine Data\DMU\dmu50.mtd



The **MTD** file contains the **Positional** and **Rotational** details for the individual, **Machine Tool**.

It is normal practice to create the **machine tool model**, with the global datum (Transform) positioned at the Top - Centre of the table.

The active cutting **Tool** is automatically positioned in the machine tool head.

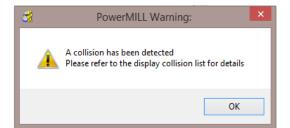
- 8 Ensure the **Draw\Undraw** machine tool icon is selected to display the machine tool.
- 9 Select an **ISO 1** view and zoom into the machining area.
- 10 Select the Floor View icon from the Simulation toolbar.
- 11 Select **Display the machine tool issues** If from the **Simulation** toolbar.

During a toolpath **Simulation**, the **Machine Tool Simulation Issues** dialog will display information on collision positions.

With the **Position** tab selected machine tool positions will be displayed. The values on the left hand side refer to the **Axis Address Letters** and their associated values.

This machine tool has five axes, **A** and **B** are rotary with **X**, **Y** and **Z** as linear.

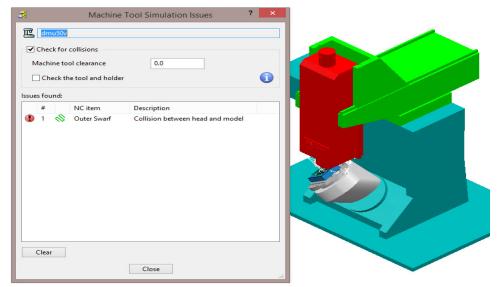
12 Start the **Simulation** \triangleright to observe the virtual machining of the component.



A collision has been detected and a **PowerMILL Warning** message displayed.

The warning message is only displayed for the first collision.

13 Select **OK** to close the **PowerMILL Warning** dialog.



The first collision move is registered and displayed in the **Issues found** pane. At present only the first collision is displayed until the **Simulation** is continued.

14 Continue the **Simulation**.

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ues f	ound	l:			
#	¢	N	C item	Description	
1	Ċ	S 01	ter Swarf	Collision between head and model	
2		S 01	uter Swarf	Collision between head and model	
Ď 3		0	uter Swarf	Collision between head and model	
1 4		\$ 01	uter Swarf	Collision between head and model	100 000
5		Š 0.	uter Swarf	Collision between head and model	- Mar
. 6		\$ OI	uter Swarf	Collision between head and model	
2 7	0	S 01	uter Swarf	Collision between head and model	
9 8	0	δ Οι	uter Swarf	Collision between head and model	
9	0	S 01	uter Swarf	Collision between head and model	
1	0 0	S 01	uter Swarf	Collision between head and model	
1	1 0	ο 🖇	uter Swarf	Collision between head and model	
1	2 9	\$ Oi	uter Swarf	Collision between head and model	

On completion of the simulation the machine tool is displayed in the normal colour scheme.

15 Select a *Collision Move* from the list.

			collisions ol clearance ne tool and holde	0.0	1	
sue	s fou	ind:				
	#		NC item	Description		
2	1	Co	Outer Swarf	Collision between head and model		
1	2	20	Outer Swarf	Collision between head and model		
	3	Co	Outer Swarf	Collision between head and model		
2	4	Co	Outer Swarf	Collision between head and model		
	5		Outer Swarf	Collision between head and model		
	6	0	Outer Swarf	Collision between head and model		
	7	20	Outer Swarf	Collision between head and model		
:	8	20	Outer Swarf	Collision between head and model		
	9	20	Outer Swarf	Collision between head and model		
	10	20	Outer Swarf	Collision between head and model		
!	11	20	Outer Swarf	Collision between head and model		
	12	20	Outer Swarf	Collision between head and model		

The **simulation** will move directly to the selected position in the form so that the collision (top right corner of component) can be viewed.

16 Select *View and adjust the Machine Tool position* from the **Simulation** toolbar.



The current positional values are displayed in the **Machine Tool Position** dialog.

With a clear view of the collision, the user can assess how best to make the appropriate changes to avoid it. In this case, substituting the cutter with one with increased Tool Length would be the easiest solution.

17 In the **PowerMILL** *explorer* right mouse click on the tool **D10TR3** and select **Settings**.

Ē

1 Tools				
	rr3			
🗘 Boundaries		D10TR3		
Patterns				
📲 Feature Sets	\checkmark	Activate		
- 🕍 Workplanes				
📜 💡 🛵 Main		Settings		
A Levels and Sets		_	15	

18 Select the **Holder** tab on the tool dialog and modify the **Overhang** to **50**.

📸 Tip radiused tool	?	×
Tip Shank Holder Holder profile Cutting data Description		
Components Holder name dummy toolholder name Will a sembly Will a security of a securi		
	s 🕺	
Close		

19 Close the dialog and in the **PowerMILL** *explorer* select **Simulate from Start** on the **toolpath** named **'Outer Swarf**'.

te 🌖 🕝		
🖽 🔁 Active		
🚊 🔣 Machine Tool	5	
🛓 👾 🔆 🚾 > dn	1u50	v
- 👘 NC Programs		
🛓 🚫 Toolpaths		
🛓 🗸 🖓 🔁 🖓 🔁	iter S	Swarf
🗄 🖓 Tools		Outer Swarf
🛓 🤉 📙 > D1		
O Boundaries		Simulate from Start
然 Patterns Feature Sets	✓	Activate

- 20 Select *Switch on the Machine Tool Display* From the Simulation toolbar.
- 21 Select the **Collisions** tab on the dialog.
- 22 Select **Clear** on the dialog to clear any existing collisions.

23 Start the Si	mulatior							
	∰		Machine Tool Collisions				?	×
	dmu50v							
	x	Y	Z	А	В	Distance		
	Clear		Ilision Che	ecking	Cla	arance value	0.0	
	Clear	v	Un		Cle	arance value	0.0	
			[Close				

The Machine Tool Collisions dialog remains blank indicating that no collisions have been detected.

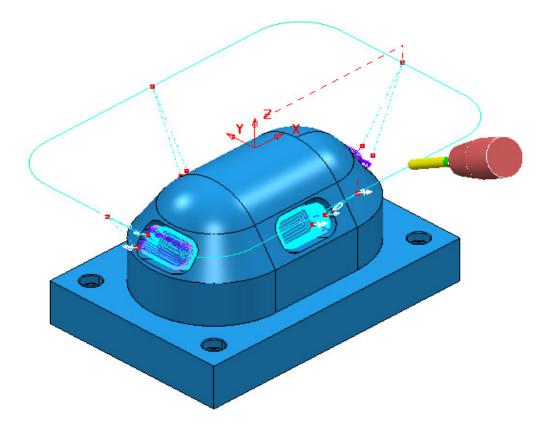
- 24 Select File > Save Project.
- 25 Select File Delete All and Tools Reset Forms.

NCProgram Verification (Including a Machine Tool Model)

It is possible to **Verify** the whole contents of an **NC Program** including an option to collision check a *Machine Tool Model*.

1 **Open** the read only **Project**:

....\PowerMILL_Data\five_axis\Collision_Simulation\AnglePockets-FullVerify_Start

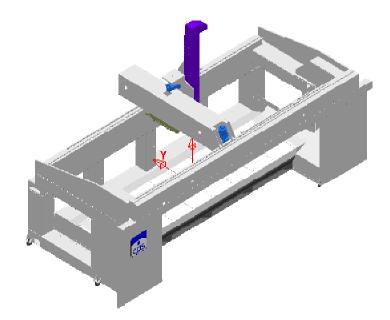


Select File - Save Project As:

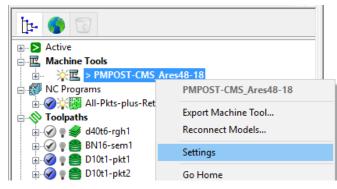
....\COURSEWORK\PowerMILL-Projects\AnglePockets-FullVerify

2 In the **PowerMILL** *explorer* right mouse click on **Machine Tools** and from the local menu select **Toolbar**.

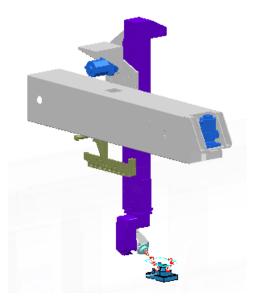




4 In the **PowerMILL** *explorer* right mouse click on the **Machine Tool** *PMPOST-CMS_Ares48-18* and fro the local menu select **Settings**.



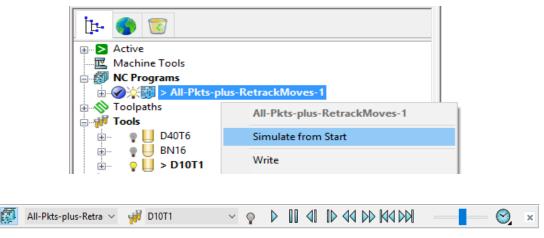
- 5 In the dialog, select **Part** and move the **Opacity** slider fully to the left to make the static machine tool parts almost invisible.
- 6 Apply and Accept the dialog.



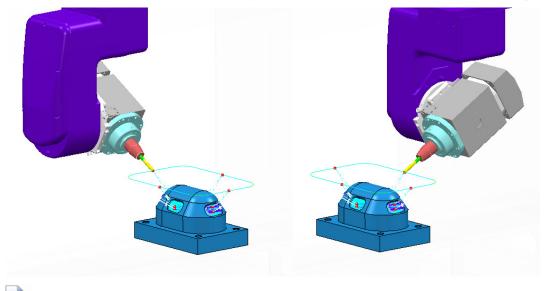
7 In the Machine Tool toolbar select the Workplane MC-Table-location.



8 In the **PowerMILL** *explorer*, right mouse click the **NC Program** named **All-Pkts-plus-RetrackMoves-1** and from the local menu select **Simulate** from Start.



9 In the **simulation** toolbar set the speed slider to medium before selecting **Play**.



Observe that the total CMS machine's Head rotation (C Axis) is currently 450 degrees (This CMS has a maximum C axis rotation limit of 360 degrees).

- 10 Right mouse click on the NC Program *All-Pkts-plus-RetrackMoves-1* and from the local menu select **Settings** to open the NC Program dialog.
- 11 In the *Machine Tool* box select the **PMPOST-CMS_Ares48-18** and for *Model Location* select **MC-Table-location**.

🖁 NC Program : A	All-Pkts-plu	us-RetrackN	loves	-1					?	Х
1 <u>2</u>	Name All-	Pkts-	Pkts-plus-RetrackMoves-1						89	
Output File C:\T			Temp	\NCProg	rams\{r	ncprogram}				0
Machine Option File C:\				cam\config\PMPOST\CMS_Head-Head_Fanuc31i_5ax 🗸					5ax ~	0
	Ma	chine Tool	PMP	OST-CM	5 <u> </u>	Model Location	M	C-Tabl	e-locatio	• ~
	Output \	Norkolane		🖏 <non< th=""><th>e></th><th></th><th></th><th></th><th></th><th></th></non<>	e>					
Output Workplane			PMPOST-CMS_Ares48-18							
		Program					ip	0		\sim
	Autom	natic Tool A					40	ove,Ro	otate	~
Toolpath	Num	Diame					ic	kn	Axial T	• ^
Pkt4-Pkt1-C	1	10								
D10t1-pkt1	(1)	10	1	130	70	0.01	0			
Pkt1-Pkt2	(1)	10	1	130	70	0.01	0			
D10t1-pkt2	(1)	10	1	130	70	0.01	0			¥
<									>	

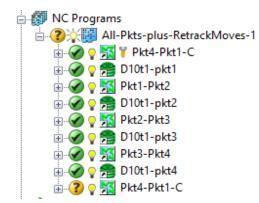
- 12 At the base of the dialog select **Apply** followed by **Accept**.
- **13** In the **PowerMILL** *explorer* right mouse click on the **NC Program**

All-Pkts-plus-RetracMoves-1 and from the local menu select Verify.

14 In the NC program verification dialog input the Machine Tool, Holder, Shank clearances as 5 2 and 1 respectively before selecting the Verify tab.

💏 NC program verification	?	×
All-Pkts-plus-RetrackMov 🗸		
PMPOST-CMS_Ares48-18		
Verify the machine tool Verify toolpaths 🗹		
Verify connection moves 🗹		
Machine tool clearance 5.0		
Verify the tool against the model Verify toolpaths 🗹		
Keep existing toolpath clearances		
Verify connection moves 🗹		
Holder clearance 2.0		
Shank clearance 1.0		
Verified. Potential issues found.		
# NC item Description		
2 1 N Pkt4-Pkt1-C A retract and reconfigure is required		
Load issue		
Verify Close		.::

In the above **NC Program** dialog it has been reported that one of the toolpaths is causing the rotary limits to be exceeded. This CMS machine tool can only perform a total of one 360 Degrees rotation about the C axis. The total of C Axis rotation currently required by the **NC Program** is 450 Deg.

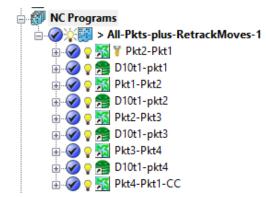


This can be fixed by using a different positional move toolpath at the ends of the NC Program that will start well within the main machining areas and re-track the tool back to the original start position.

15 In the PowerMILL explorer right mouse click on the NC Program

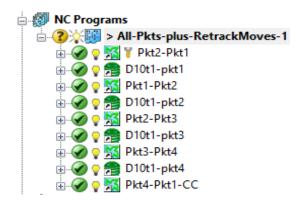
All-Pkts-plus-RetracMoves-1 and from the local menu select Clear Verification.

16 In the NC Program All-Pkts-plus-RetracMoves-1 replace the common first and last positioning toolpath (Pkt4-Pkt1-C) with Pkt2-Pkt1 and Pkt4-Pkt1-CC respectively.



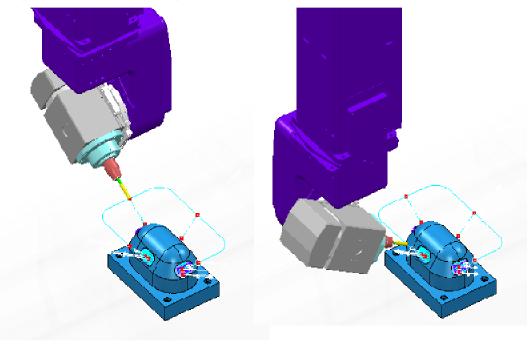
The replacement toolpaths preform repositioning with counter clockwise rotation about the C axis. This will keep the total C rotation moves well within the CMS machine limits.

17 In the **PowerMILL** *explorer* right mouse click on the updated **NC Program** *All-Pkts-plus-RetracMoves-1* and from the local menu select **Verify**.



This time all toolpaths are displayed with a green verification status 'S and no issues are reported in the **NC program verification** dialog. The green status also confirms that within the **NC Program** the **Machine Tool** is collision safe in addition to the included, gouge free **toolpaths**.

18 Run another **NC Program** simulation and observe that this time the whole process is now contained within a total C axis rotation of 270 degrees (max permissible 360 degrees).



- **19** Select **File > Save Project**.
- 20 Select File Delete All and Tools Reset Forms.

12. Machine Axis Control

Introduction.

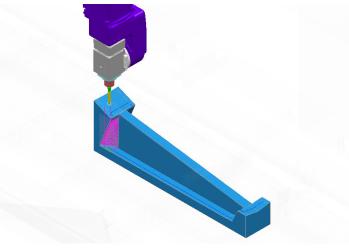
The **PowerMILL** *verification* options will ensure collision safe, toolpaths relative to the **Tooling components**. However, In 5 Axis applications it is also essential to check that the actual moving parts of the **Machine Tool** are also collision safe. For this to work effectively, a suitable machine tool model (**MTD** file) is required in the **simulation** process. If a collision between the component part and machine tool model is detected then the user can **recycle** the strategy with appropriate **Machine Axis Control** options applied.

Machine Axis Control options allow the user to avoid collisions by controlling the *orientation/movement* of the independent parts of a machine tool within the machining strategy.

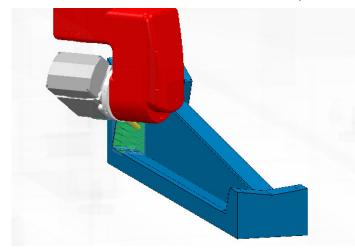
Machine Axis Control is not just used for collision avoidance but can also be used to enable an oversized component to be machined by applying **Polar** to force the use of a *rotary axis* in preference to a *linear axis*. This option can also used in cases where it is simply more efficient for a specific machine tool to use a rotary axis in place of a linear axis.

Tool Axis Control - Re-Orientation - Example

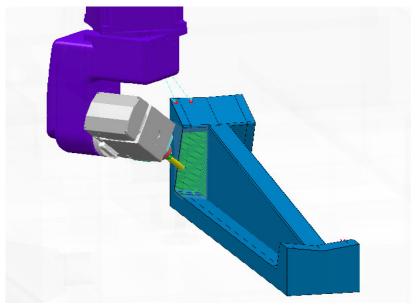
- 1 Open 'read only' the **Project**:
 -\PowerMILL_Data \five_axis\MachineAxisCtrl\CMS-AxisControl_Start



2 From the main pull down menus select File > Save Project as:\COURSEWORK\PowerMILL-Projects\ CMS-AxisControl-ex1 The **Project** contains 2 **NC Programs** that contain the same machining toolpaths. If the **NCProgram** *No-OrientationMoves* is run in a *machine tool simulation* the Machine Tool Head clashes with the component.



If the **NCProgram** *With-External-OrientationMoves* is run in a *machine tool simulation* there are no collisions between the machine tool parts and component. This is due to the addition of repositioning toolpaths inserted as necessary to provide machine tool head **re-orientation**.



Although the last **NC program** provides an acceptable collision free solution the method is labour intensive and dependant on the user correctly creating and inserting positional move toolpaths in the correct order.

- 3 Select an **ISO 2** view.
- 4 In the **PowerMILL** *explorer* right mouse click on **Machine Tools** and from the local menu select **Toolbar**.
- 5 Input **Base-Centre** in the *workplane* input box of the **Machine Tool** toolbar.
- 6 In the Machine Tool toolbar input the machine tool model:-

....\PowerMILL_Data\MachineData\CMS\PMPOST-CMS_Ares48-18.mtd



- 7 In the **PowerMILL** *explorer*, right mouse click **Machine Tools** > **PMPOST-CMS_Ares48-18**, to open the local menu.
- 8 In the local menu select **Settings**.

⊟ <mark>Machine Tools</mark> → ☆ 	res48-18			
Image: Image	PMPOST-CMS_Ares48-18			
😥 🕴 👰 🛐 WithExternal-Orien	Export Machine Tool			
	Reconnect Models			
⊡	Settings			

9 In the dialog select the item, named **Part** and then move the **Opacity** slider to make the static part of the machine tool model, translucent.

් Ma	chine Tool	? 🗙	
Machine Tool PMPOST-CMS_Ares48-18	Axis MachineDNA Part name Movement Statis Filename Iogobianco Iogobiu piedini2 piedini carena base <	c Colour Black White Blue DarkSlateGrey Gainsboro DimGrey	
Apply	Accept Cancel		

- 10 Accept the Machine Tool dialog.
- 11 In the **PowerMILL** *explorer*, right mouse click on the **NC Program** *No-Orientation Moves* and from the local menu select **Simulate from Start**.
- 12 Select the **Play** button in the **simulation** toolbar.

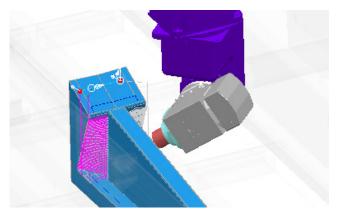


After several passes the machine tool head is in collision with the component. The machine tool head changes colour to **red** and a **PowerMILL Warning** box appears as soon as the first collision is detected.

13 Select **OK** and the **simulation** will continue even though the head is still colliding (The head will change colour to *red* during each collision).

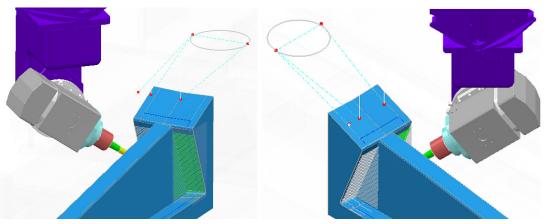


Collision checking and reporting to a Machine Tool Model simulation is a cost option. Otherwise the checking process is purely visual.

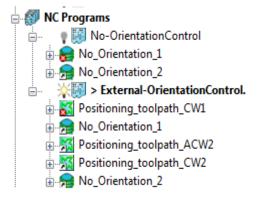


When the **NC Program simulation** moves to the other side of rib, the machine tool head happens to be in a collision safe, orientation relative to the component. This is not easily predictable and could easily change to a collision situation on switching the order or inserting new toolpaths into the **NC Program**.

14 In the **PowerMILL** *explorer*, right mouse click on the **NC Program** *WithExternal-OrientationMoves* and from the local menu select **Simulate** from Start.



This time the machine tool head is collision safe throughout the simulation.



In this case, drive curve toolpaths have been inserted as required into the **NC Program** to force appropriate re-orientation moves to occur.

The only problem is that these moves are added retrospectively and as mentioned earlier, will be unpredictable if the toolpath order is changed or additional toolpaths are inserted into the **NC Program**.

A more efficient and direct method to apply machine tool head alignment within an individual strategy is to use the **Machine axis control** dialog.

💶 and rename the

- 15 Ensure that neither **NC Program** is active.
- 16 Activate and then select Settings from the local menu for toolpath No_Orientation_1.
- 17 In the **Constant Z** strategy dialog, select *Make a Copy* new **toolpath** as **Orientation_AZ180**.
- 18 Select the Machine axis control page in the dialog and select the Orientation type as Orientation vector, Orientation vector as Fixed direction, and input a Direction Azimuth 180.

1	Co	nstant Z Finishing		?	×
£2 II	Toolpath name	Orientation_AZ180			
Workplane		Machine axis contro	ol		
Tool		Orientation type			
Machine tool		Orientation vector 🗸			
🚽 Stock engageme	nt	Orientation vector	Offset angle		
Constant Z finish	ning	Fixed direction 🗸	0.0		
🔚 Automatic ve	erification	Direction			
Point distribution	n	Azimuth	Elevation		
<u>12</u> Tool axis Ø Machine axis co	ntrol	180.0	0.0		
🚽 Rapid move heig	hts	Components			
		-1.0 -0.0	0.0	~	

By changing the default **Orientation type** from **Free** to **Orientation vector** the machine head alignment will now be controlled directly within the strategy. The **Machine axis control** will cause the head to be rotated by **180** Degrees about the **Z** axis compared with the original toolpath.

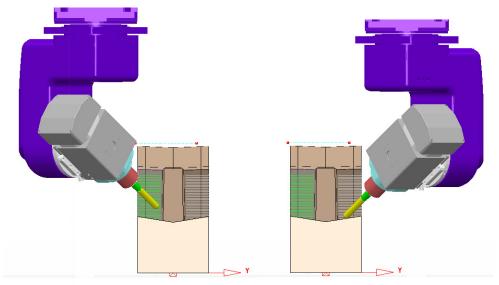
- 19 Select **Calculate** to create the new toolpath and close the dialog.
- 20 Activate and then select Settings from the local menu for toolpath *No_Orientation_2*.
- 21 In the **Constant Z** strategy dialog, select **Make a Copy** and rename the new **toolpath** as **Orientation_AZO**.
- 22 Select the **Machine axis control** page in the dialog and enter data exactly as shown below but this time with **Direction Azimuth 0**.

💰 Co	onstant Z Finishing ? ×
Toolpath name	Orientation_AZ0
Workplane	Machine axis control
	Orientation type
	Orientation vector 🗸 🚺
	Orientation vector Offset angle
Constant Z finishing	Fixed direction V 0.0
Automatic verification	Direction
	Azimuth Elevation
Machine axis control	0.0
	Components
Useds and links Start point	1.0 0.0 0.0

The Machine axis control will use the default values for an Orientation Vector of Azimuth 0 and Elevation 0.

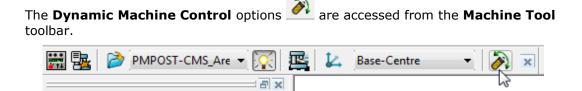
23 Select **Calculate** to create the new toolpath and close the dialog.

- 24 Create a new NC Program named Internal-OrientationControl containing the 2 new toolpaths Orientation_A180 and Orientation_A0.
- 25 With the machine tool model, PMPOST-CMS_Ares48-18 still active, run a full simulation on the new NC Program and check that the head movement is collision free throughout.
- 26 Reverse the order of the toolpaths in the NC-Program named Internal-OrientationControl and run the full simulation again and check that the head movement is collision free throughout.



The application of **Machine axis control** directly in the strategies has eliminated the need for the additional positioning toolpaths. As shown in the above illustration, the **machine axis control** is now independently controlled within the 2 new strategies.

Dynamic Machine Control (Requires the Advanced Simulation cost option)



It is possible to apply machine axis control dynamically using options from the **Dynamic machine control** toolbar (shown below).

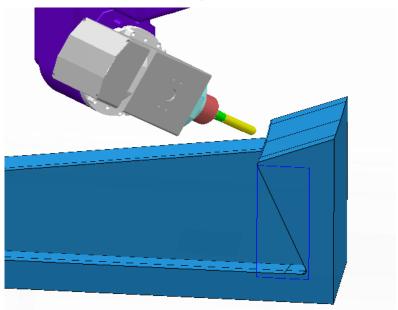
🕡 20bn	~ "	t 😰 🕉	🖕 📑	FR 🖳	ቶ 📈 🙀	SS 19	🕞 🦎 🤊
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Visual checking for Machine Tool accessibility

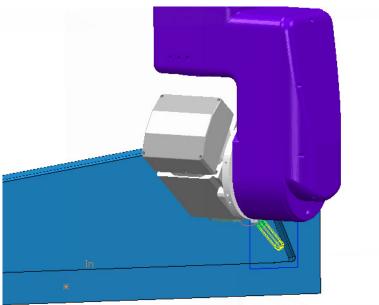
The active **Tool** and **Machine Tool** head can be dynamically moved around the part to visually check for accessibility relative to the current orientation

- 1 In the **PowerMILL explorer** right mouse click on the **Toolpath** *No_Orientation_2* and select **Simulate** from start.
- 2 **Jog** the tool to the start of the fixed machining alignment position and then from

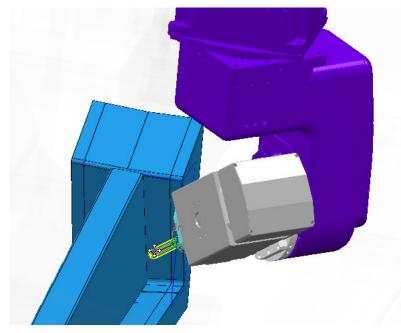
the Machine Tool toolbar select The Dynamic Machine Control. 🌌



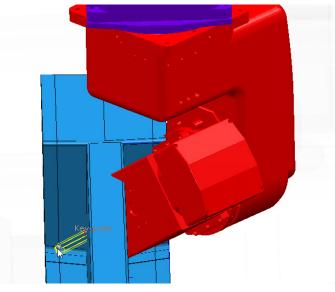
- 3 In the Dynamic machine control toolbar select use tool positioning graphics.
- 4 Left click on the tip of the **Tool** and then dynamically move it down the angled model, undercut towards the base of the recess.



5 Rotate the view to observe the new position from different angles.



6 Dynamically drag the **Tool** to a 'key point' on the opposite side of the model.



If any part clashes with the model the $\ensuremath{\textbf{machine tool head}}$ will change colour to red.

7 Select the **green tick v** at the end of the **Dynamic machine control** toolbar to exit with the tool still displayed in the final position.



The above final **Tool** position is cancelled if a new **Toolpath simulation** is selected, or if **Go Home** is selected in the **Machine Tool** menu.



If the **red cross** ⁽¹⁾ is selected then the tool will be positioned as it was before the **Dynamic machine control** toolbar was opened.

Dymamic Machine Tool re-orientation applied to a Toolpath.

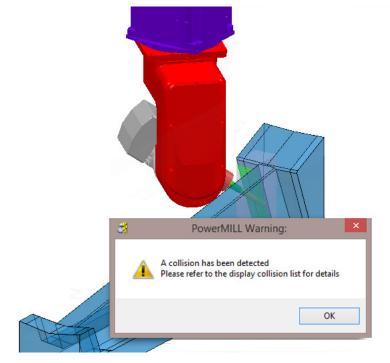


The default setting in the **Dynamic machine control** toolbar is **Use machine tool graphics**.

The rotary axis components of the machine tool can be dynamically reorientated and applied retrospectively to the active toolpath.

Other options include:-

- a **Use machine tool graphics** I Applies dynamic rotation and linear moves relative to the Machine Tool model datum (Default).
- **b** Active workplane graphics mode 2 Applies dynamic rotation and linear moves relative to the active workplane.
- c Lock tool axis direction This locks the current rotary axis orientation, allowing only dynamic linear axis, moves to take place when used with a or b above.
- From the local PowerMILL explorer Toolpaths, right mouse click on No_Orientation_1 and from the local menu select Edit - Copy Toolpath.
- 2 Rename the new Toolpath as Dynamic_Orientation_1.
- 3 Activate the new toolpath and run a Machine Tool simulation until the collision with the *Head* is first detected.

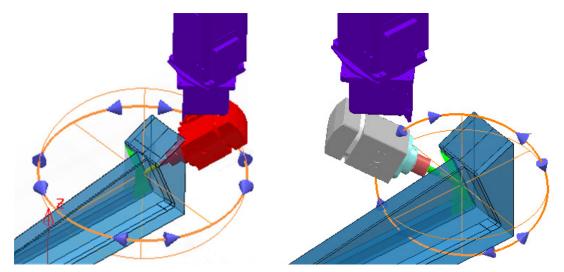


4 Select **OK** in the **PowerMILL Warning** dialog.

5 On the Machine Tool, toolbar select Dynamic machine control



6 Use the default **Use machine tool graphics** option



- 7 Use the upper circular handle to rotate the head to the above left, alignment, followed by the lower circular handle to re-orientate the tool to the above right alignment.
- 8 Once a suitable *Machine Tool Orientation* has been achieved select the

Update Toolpath <u></u> option.

9 Select the *green tick* to accept the changes and close the **Dynamic machine** control toolbar.



The toolpath is now displaying **gouge** and **collision** status as **Unknown**.



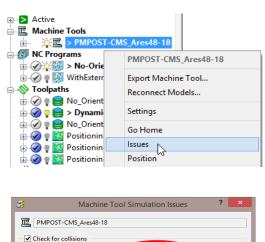
10 Verify the modified Toolpath *Dynamic_Orientation_1* for both Gouges and Collisions (Clearances:- *Holder* 2 and *Shank* 1).



The **Toolpath** is now confirmed to be both **Gouge** and **Collision** safe relative to the **Tool** assembly.

12 - 10

Collisions.

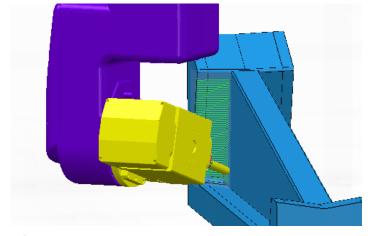


11 Right mouse click on the machine tool model and from the local menu select

- Check for collisions Machine tool clearance 5.0 1 Check the tool and holder es found NC item Description 1
 No_Orientatio...
 Collision between head and model
 Dynamic_Orie...
 Collision between head and model
 12 Dynamic_Orie...
 Collision between head and model
 13 Dynamic_Orie...
 Collision between head and model
 13 Dynamic_Orie...
 Collision between head and model
 13 1 No Orientatio... Collision between head and model ŏ 13 🛞 Dynamic_Orie... Collision between head and model 14 Normal Dynamic_Orie... Collision between head and model Clear Close
- **12** In the dialog input a suitable clearance value for the Machine Tool head.
- **13 Clear** the issues found, list and perform further *machine tool* simulation to confirm that the **Head** assembly also collision safe.



During a simulation the machine tool Head will change colour yellow if a collision situation is identified.



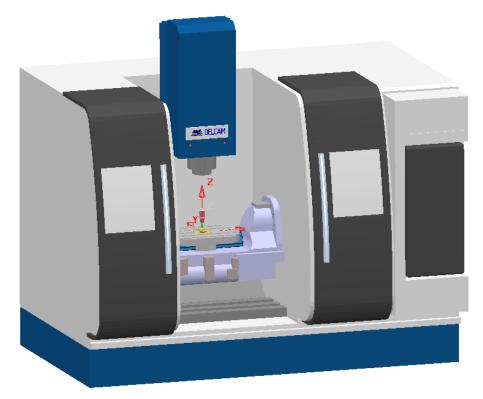
- 14 Save the Project.
- 15 Select File Delete All and Tools Reset Forms.

Tool Axis Control - Polar - Example

The start up **Project** contains a **BN16** tool, 3 Axis **toolpath**, Mazak Variaxis **Machine Tool** model, and component **model**. The component model has a length dimension that exceeds the **X axis** and **maximum Y**, travel limits for the Mazak machine. However the model could be machined in 4 stages if the longest dimension, is controlled to align within the **minimum Y** axis travel limits. This will be achieved by applying the **Tool Axis Control** – **Polar** options to convert all **X** linear moves to **C Axis**, rotary moves (about the Z Axis).

1 **Open** 'read only' the **Project**:

...\PowerMILL_Data \five_axis\MachineAxisCtrl\Mazak-OversizeCompt_Start



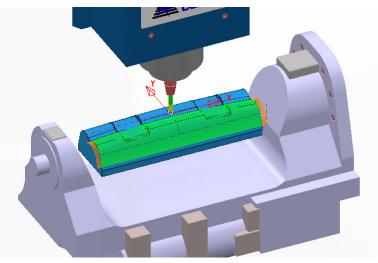
- 2 From the main pull down menus select File > Save Project as: ...\COURSEWORK\PowerMILL-Projects\ Mazak-OversizeCompt-ex1
- 3 In the **PowerMILL explorer Machine Tools** area, *activate* the machine tool model, **PMPOST-Mazak_Variaxis_630PSA**.
- 4 From the **main** pull down menus select **View Toolbar** and from the resultant menu ensure that the **Simulation**, and **Machine Tool** options are all ticked.
- 5 In the Machine Tool toolbar, input the *machine tool* named PMPOST-Mazak_Variaxis_630PSA and the *workplane* named TableDatum.



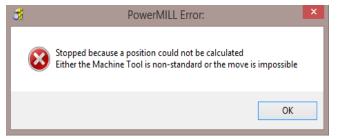
6 In the PowerMILL explorer right mouse click on the Machine Tool -PMPOST-Mazak_Variaxis_630PSA and from the local menu select Settings.

Ma Ma	chine Tool	? ×	
Machine Tool PMPOST-Mazak_Variaxis_6: Part A C X V C X V C X A PAPIy	Avis MachineDNA Part name Movement Static Filename swarf-gutter door-handles doors main-casing base	Colour DarkGrey Lavender DarkSlateGrey White Teal	

- 7 In the dialog, select A and move the *Opacity* slider to the left until the moving parts can be clearly seen behind the opaque, static parts of the **Machine Tool Model**.
- 8 From the **PowerMILL** *explorer*, right mouse click on the existing *toolpath* and from the local menu, select **Simulate from Start**.



9 In the Simulation toolbar, select the Play button and the following PowerMILL Error dialog will open.



The **X** co-ordinates at the ends of the above **toolpath** are outside the **X** axis, travel limits. Note, the travel limits are included in the **machine tool model** definition.

- 10 In the **PowerMILL explorer**, right mouse click on the existing *toolpath* and from the local menu select **Activate** followed by **Settings** to open the dialog.
- 11 In the *Line Projection Finishing* dialog select the 'make a copy' option
- 12 In the dialog, *Rename* the new toolpath as **BN16-Vert-Orientation-Polar_A**.
- **13** In the local dialog explorer, select the **Machine axis control** page and input data as shown below.

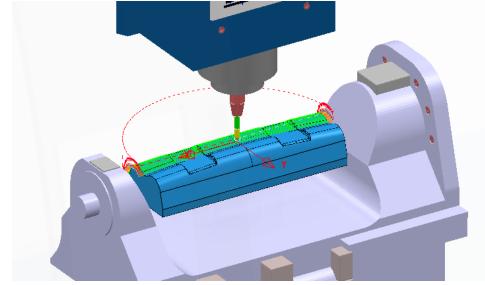
🕉 Line	Projection Finishing	?	×
Toolpath name	BN16-Vert-Orientation-Polar_A		
Workplane Block Block Unit Stock engagement Stock engagem	Machine axis control Orientation type Polar Rotation centre ✓ Lock Axis ✓ Lock Axis ✓ Use complementary angle ✓ You have not chosen polar links.		

14 Select the icon vito change to the **links** page and input data with **Use polar links** - ticked as shown below.

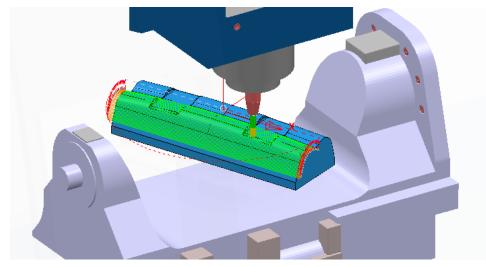
Toolpath name BN16-Vert-Orientation-Polar_A Workplane Block Tool Machine tool Machine tool Short Skim Short Skim Short Skim Pattern Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Lead out Retract and approach moves Automatically extend Maximum length 50.0 Retract distance
Block Tool Machine tool Short/Long threshold 4.0 Short Skim Short Skim Short Skim Short Skim Short Skim Short Skim Short Skim Cong Skim Short Short Skim Short Short Sh
Inits Approach distance 30.0 Inits Approach distance 30.0 Inits Inits Approach distance 30.0 Inits Inits Arc fit rapid moves Inits Arc radius (tool diameter units) 0.25 Inits Inits Inits Inits Inits Inits Inits Inits Inits Inits Inits Inits Inits Inits Inits

15 Calculate the dialog to create the new toolpath.

16 From the **PowerMILL** explorer, right mouse click on the new toolpath and from the local menu, select **Simulate from Start**.



17 In the **Simulation** toolbar, select the **Play** button and this time the strategy will successfully run from start to end.



All the **X-Axis** cutting moves in the original toolpath have been converted to **C-Axis** rotary moves in the new toolpath. This has resulted in tool moves being confined to the area from the *table centre* towards the **min Y** travel limit.

18 Select File - Save Project.

Exercise

- 1 Create a copy of the above **toolpath** named **BN16-Vert-Orientation-Polar-B**.
- 2 Calculate after inputting the appropriate data to finish machine the other half of the component model keeping within the Tool Axis limits for the Mazak machine tool.
- 3 Select File Save Project.

13. Machine Tool Models

Introduction.

The **PowerMILL** toolpath **simulation** process can be expanded to include a **Machine Tool Model**. This capability becomes extremely important for multi-axis applications.

First of all **triangle** models (eg **dmt** or **stl** format) need to be obtained of all the independent moving parts of the machine tool. It is essential that the user obtains accurate dimensions along with any other details relating to the set up of a specific machine tool.

These separate **Triangle** files are stored in a folder adjacent to a *Machine Tool Simulation* schema file (mtd)

To create a new **mtd** file it is easier to modify a copy of an existing one based on a machine tool of similar configuration.

It is essential that the kinematics of a **Machine Tool Simulation model**, is the same as the relevant **Post-Processor** output.

How to configure a Machine Tool for simulation

The first stage is to create the separate component models (ideally in **PowerSHAPE**) for each moveable axis for the machine tool. These must be exported as individual **triangle** models to be compatible for use in an **mtd** file. For the following example the models have already been created and are ready to be registered to a new **mtd** file.

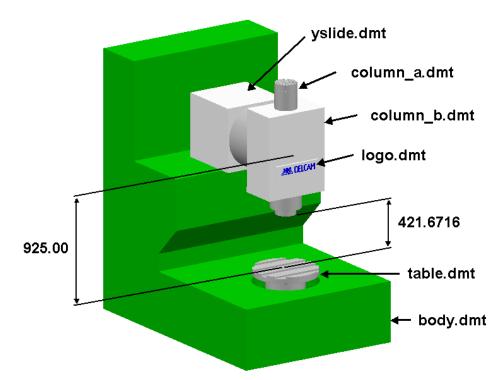
An **mtd** file contains information that describes the kinematics of a particular machine.

For **mtd** files to work, they must be accompanied in the same folder by the *schema* file, **pmillmt.xsd**.

In the same location, a *sub-folder* must exist that contains separate **triangle** models **dmt** of all the necessary *static* and *moving* machine tool components.



Machine Tool Model for a dmu80t Five Axis



The above illustration identifies 6 separate **triangle** models that form a **dmu80t** five axis machine tool. Also shown are the vertical distances from the top of the **table** to the base of the **head** (**421.6716**), and the centre of the **rotational axes** (**925.00**).

machine_part

The **mtd** file is made up of objects called **machine_part**. There are 2 compulsory **machine_part** objects which must be identified as "**head**" and "**table**". Note; their names in the **mtd** file must be in lower case.

In the above machine tool the **X**, **Y**, and **A** axis (rotation about Y) are controlled on the "**head**", and the **Z** and **B** axis (rotation about Z) are controlled on the "**table**".

Linear Axis Controls

X, Y, and Z must exist and only right handed axis systems are supported.

These can be in any orientation as long as they are orthogonal.

Type of axis that can be configured is:-

Simple_linear:- The definition requires *direction*.

Rotary Axis Controls

Rotary controls are typically defined by **A**, **B**, or **C** and ideally should be selected to match the same output as output in the associated *Post-Processor*. Note; where applicable, angular limits can be assigned to an individual rotary axis.

Type of axis that can be configured is:-

simple_rotary:- The definition requires *position* and *direction*.

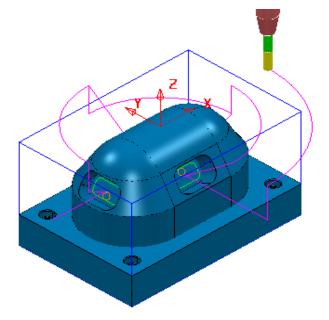
MTD file initial state

Although all the separate **triangle** models are correctly positioned relative to the assembled machine tool model, it is still required to input key dimensions into the mtd file. In this example, these include the 'gauge' distance from the top of the table (**0 0 0**) to the base of the head (**0 0 421.6716**), and the coordinates of the centre of the rotary axes (**0 0 925**).

EXAMPLE:- MTD file for a Mazak five axis machine

1 Select File - Open Project:-

....\PowerMILL_Data\five_axis\MachineToolModels\MTD-Mazak-Ex1_Start



2 Select File - Save Project As:-

....\COURSEWORK\PowerMILL_Projects\MTD-Example1

A **Machine Tool Model** will be loaded into the above **Project** that correctly defines:-

- a The position of all the separate machine tool components.
- b The direction of rotation for the 2 rotary and +/- movement for the 3 linear axes.
- c The max/min travel limits for each of the 5 axes.
- 3 From the main pull down menus select View Toolbar Machine Tool to open the Machine Tool toolbar (Or alternatively right click on Machine Tools in the PowerMILL explorer and from the local menu select Toolbar).



In the Machine Tool toolbar select the Import Machine Tool Model 🔛 option.

4 In the dialog select the Machine Tool Model file:-

....\PowerMILL_Data\five_axis\MachineToolModels\PMPOST-Mazak_Variaxis_630PSA.mtd



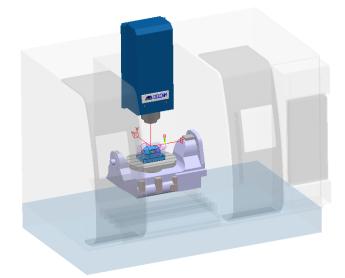
5 In the PowerMILL explorer right mouse click on the Machine Tool Model name PMPOST-Mazak_Variaxis_630PSA and from the local menu select Activate followed by Settings.

🖃 🖳 Machine Tools	
🛓 👾 🔆 🚾 > PMPOS	T-Mazak_V
	PMPOST-Mazak Variaxis 630PSA
🖃 🚫 Toolpaths	
🗄 🕢 🔗 🏹 🗄 🗄 🗄	Export Machine Tool
🖃 👘 Tools	Reconnect Models
🛓 💡 📙 > EM1	
🗉 💭 Boundaries	Settings
Patterns	Go Home

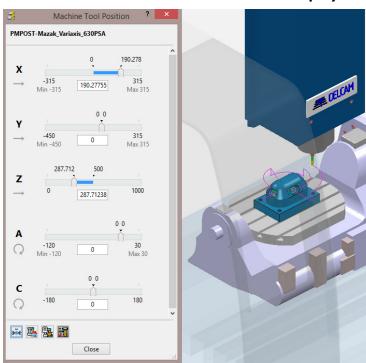
6 In the **Machine Tool** dialog select **Part**.

💰 Ma	chine Tool	? ×
Machine Tool PMPOST-Mazak_Variaxis_6:	Axis MachineDNA Part name Movement Static	
	Filename file file file file file	Colour DarkGrey Lavender DarkSlateGrey White Teal
Apply	Accept Cancel	

7 Move the **Opacity** slider to the left until the **Machine Tool Body** is almost invisible.



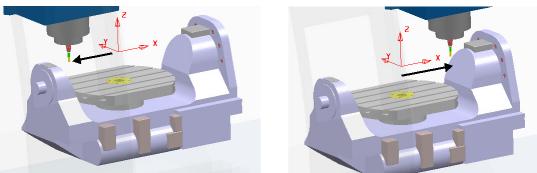
- 8 Right mouse click on the toolpath **EM12-FinPkts** and from the local menu select **Simulate from Start**.
- 9 In the Machine Tool toolbar select the Machine Tool Display 🔤 options.



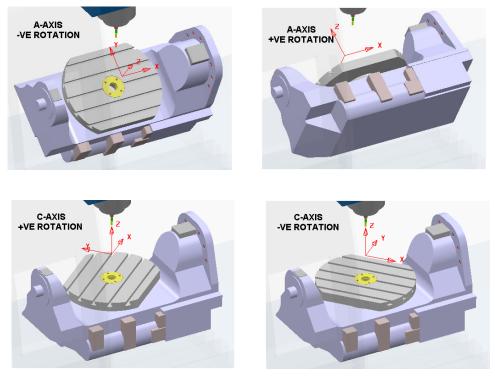
10 Select the **Cursor** on the **X** row slider and drag it to the required position, and/or use the keyboard arrow keys for exact **0.5** incremental moves.



11 On the keyboard hold while holding down the Shift key, press the left hand Arrow key to perform continuous, incremental -ve X moves on the machine tool model.

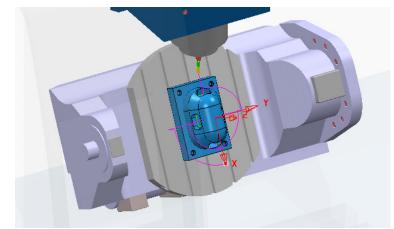


- 12 Repeat 8, but this time, while holding down the **Shift** key, press the *right hand* **Arrow** key to perform a **+ve X** move on the **machine Tool Model**.
- 13 On the keyboard press the downward, **Arrow** key to move down to the next row (or simply click on the **Y** row, cursor).
- 14 As in 8 and 9 above check the **-ve** and **+ve Y** moves on the **Machine Tool Model**.
- **15** Systematically move down the rows and check out the movement of the remaining 3 axes on the **Machine Tool Model**.



The above movements are exactly the same as on the actual **Mazak** machine tool to which the **MTD** file relates.

A full **simulation** will provide a visual confirmation of the all moves performed on the toolpath. It is also possible to check for **Machine Tool** component collisions (if an additional <u>cost option</u> is purchased). 16 Close the *Machine Tool Position* dialog and then perform a full Simulation on the toolpath EM12-FinPkts.



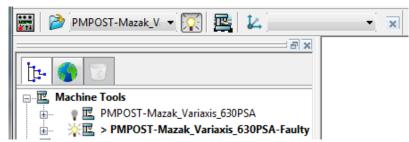
17 In the **PowerMILL** *explorer* right mouse click on the machine tool, *PMPOST-Mazak_Variaxis_630PSA* and from the local menu select **Go Home**.

Correcting a faulty MTD File:-

- 18 In the Machine Tool toolbar select the Import Machine Tool Model option.
- 19 In the dialog select the Machine Tool Model file:-

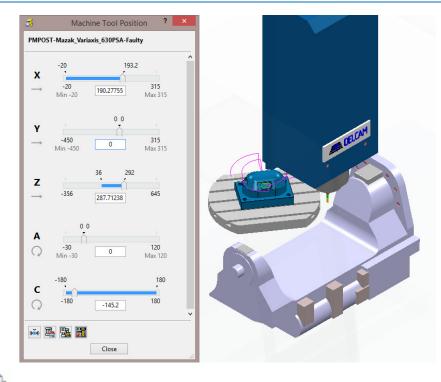
....\PowerMILL_Data\five_axis\MachineToolModels\PMPOST-Mazak_Variaxis_630PSA-Faulty.mtd

- 20 As before open the **Settings** dialog from the local menu and turn down the **Opacity** of the non-moving parts of the **Machine Tool Model**.
- 21 In the dialog select **Open** to import the new **Machine Tool Model**.



The newly imported **Machine Tool Model** file should perform exactly as the existing one. However the **MTD** file contains some incorrect values which need to identified and fixed. The user will need to systematically check the linear and rotary axis movements and the relative location of the trunnion and rotary table.

- 22 In the Machine Tool toolbar select the Machine Tool Display III option.
- 23 Use the Jog options to check the +ve and -ve movement of all 5 axes (They should be the same as the Machine Tool Model imported with the original Project).



The following C-Axis faults are exposed in the currently active MTD file:-

- a The +ve/-ve rotational moves for the Rotary Table C-Axis are reversed compared with the Machine Tool Model imported with the original Project.
- **b** The **Rotary Table** rotational centre (**C-Axis**) is incorrectly aligned at some point along the active **Workplane**, **Y** direction.
- 24 From the Desktop open a File Explorer dialog and browse to the folder:-

....\PowerMILL_Data\five_axis\MachineToolModels

25 Create a copy of the **mtd** file:- PMPOST-Mazak_Variaxis_630PSA-Faulty.mtd and rename it as:- PMPOST-Mbazak_Variaxis_630PSA-Update.mtd



If an MTD file of the same name already exists overwrite it.

26 Open the new copy of the mtd file in Wordpad and look for incorrect data in the section of the mtd file that defines the Rotary Table – C-Axis.

```
<machine_part>
<axis>
<control_info ADDRESS="C" />
<simple_rotary X="0" Y="250" Z="0" I="0" J="0" K="-1" />
</axis>
<model_list>
<dmt_file>
<path FILE="Mazak_Variaxis_630/table.dmt" />
<rgb R="200" G="200" B="200" />
```

The previous row that defines the C-Axis requires the XYZ position to be in the centre of the table, and the +ve/-ve rotation directions to be reversed.

27 Modify the above incorrect values to those shown below:-

<simple_rotary X="0" Y="0" Z="0" I="0" J="0" K="1" />

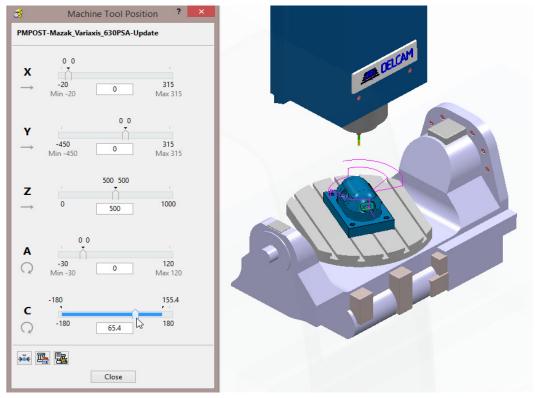
28 Save the updated mtd file (but do not close it).

This latest update will now be tested in the **PowerMILL Project**.

- 29 In the Machine Tool toolbar select the Import Machine Tool Model Le option.
- 30 In the dialog select the Machine Tool Model file:-

....\PowerMILL_Data\five_axis\MachineToolModels\PMPOST-Mazak_Variaxis_630PSA-Update.mtd

- 31 Turn down the **Opacity** on the static parts of the **Machine Tool model**.
- 32 In the Machine Tool toolbar select the Machine Tool Display 🔤 option.
- 33 Use the Jog options to check the +ve and -ve movement of the Rotary Table -C-Axis.

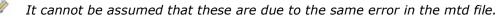


The updated **Rotary Table** – **C-Axis** movement is now exactly the same as in the original **Machine Tool Model** (*PMPOST-Mazak_Variaxis_630PSA*).

The next stage is to use a **Simulation** to check that all of the *linear* and *rotary* travel limits on the **Machine Tool Model** are correct.

- 34 Right mouse click on the toolpath **EM12-FinPkts** and from the local menu select **Simulate from Start**.
- 35 On the Simulation toolbar select the Play button.

Not only has the *Trunnion* unexpectedly rotated towards the back of the machine but the **Simulation** has also stalled due to one of the travel limits being exceeded.



- **36** Return to the file in **Wordpad** and look for incorrect data in the section of the **mtd** file that defines the **Table A-Axis**.
 - <!-- The table -->
 <machine_part>
 <axis>
 <control_info ADDRESS="A" MIN="-30" MAX="120" />
 <simple_rotary X="0" Y="0" Z="50" I="-1" J="0" K="0" />
 </axis>
 <model_list>
 <dmt_file>
 <path FILE="Mazak_Variaxis_630/Trunion1.dmt" />
 <rgb R="210 " G="210" B="255" />

The above row that defines the A-Axis rotational travel limits and simply requires the MIN and MAX numbers to be swapped (The correct movement for +ve and - ve rotation has already been checked and confirmed to be okay).

37 Modify the above incorrect values to those shown below:-

<control_info ADDRESS="A" MIN="-120" MAX="30" />

38 Save the updated mtd file (but do not close it).



This latest update will now be tested in the **PowerMILL Project**.

39 In the PowerMILL explorer right mouse click on the Machine Tool PMPOST-Mazak_Variaxis_630PSA-Update and from the local menu select Delete.

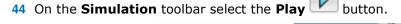


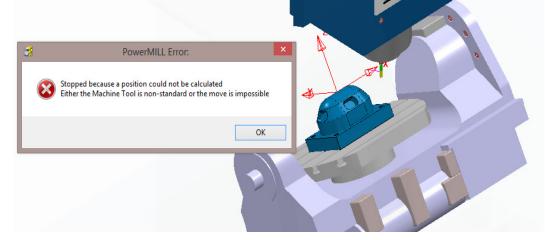
It is necessary to re-import the updated **MTD** file into the **Project**.

- 40 In the Machine Tool toolbar select the Import Machine Tool Model
- 41 In the dialog select the Machine Tool Model file:-

....\PowerMILL_Data\five_axis\MachineToolModels\PMPOST-Mazak_Variaxis_630PSA-Update.mtd

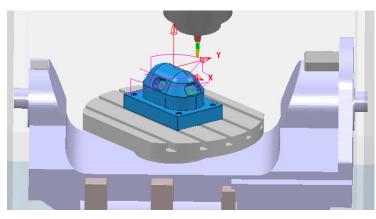
- 42 Turn down the **Opacity** on the static parts of the **Machine Tool model**.
- 43 Right mouse click on the toolpath EM12-FinPkts and from the local menu select Simulate from Start.





The **Simulation** immediately stalls and the **PowerMILL Error** dialog is displayed.

45 Select OK in the PowerMILL Error box and keep clicking on the Step Forward
 button and keep by-passing (OK) the warnings until they are no longer being displayed.



Note that the head is currently positioned along the +ve Y direction.

- 46 Continue to Step Forward and observe that all moves in the -ve X direction are stalling the Simulation while moves in +ve X and -ve/+ve Y are all okay.
- 47 Return to the file in Wordpad and look for incorrect data in 'The head' section of the mtd file that defines the X axis travel limits.

```
<!-- The head -->
<machine_part>
<axis>
<control_info ADDRESS="X" MIN="-20" MAX="315" />
<simple_linear I="1" J="0" K="0" />
</axis>
<machine_part>
<axis>
<control_info ADDRESS="Y" MIN="-450" MAX="315" />
<simple_linear I="0" J="1" K="0" />
</axis>
<machine_part>
```

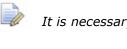
The above row defining the MIN **X** travel limits contains an incorrect value of "-20". This value must be changed to "-315".

```
48 Modify the above incorrect value to that shown below:-
<control_info ADDRESS="X" MIN="-315" MAX="315" />
```

49 Save the file.

This final update will now be tested in the **PowerMILL Project**.

50 In the PowerMILL explorer right mouse click on the Machine Tool -PMPOST-Mazak_Variaxis_630PSA-Update and from the local menu select Delete.

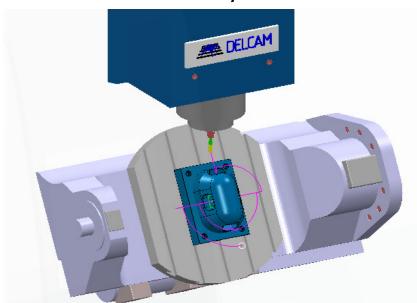


It is necessary to re-import the updated **MTD** file into the **Project**.

- 51 In the Machine Tool toolbar select the Import Machine Tool Model
- 52 In the dialog select the Machine Tool Model file:-

....\PowerMILL_Data\five_axis\MachineToolModels\PMPOST-Mazak_Variaxis_630PSA-Update.mtd

- 53 Turn down the **Opacity** on the static parts of the **Machine Tool model**.
- 54 Right mouse click on the toolpath **EM12-FinPkts** and from the local menu select **Simulate from Start**.



55 On the **Simulation** toolbar select the **Play** whether the **Play** whether the **Play** whether the **Simulation** is the **Simulation** of the **Simulation** is the **Simulation** of the **Simulation** is the **Simulation** of the **Simula**

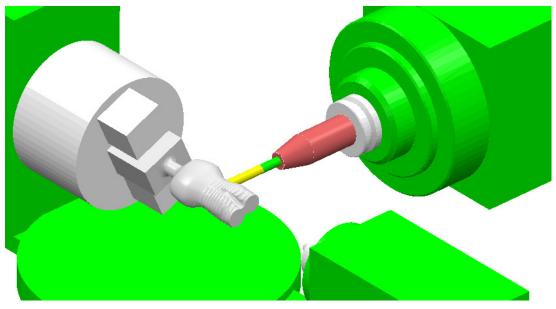
The **simulation** will now successfully run from start to finish without stalling. All linear and rotary moves should be an exact match comaperd with the original **mtd** file, **PMPOST-Mazak_Variaxis_630PSA**.

56 Select File - Save Project

14. Four Axis Rotary Finishing

Introduction.

This **Finishing** strategy is designed for machining a component mounted on a single, programmable **Rotary Axis**. During milling, the component rotates around the rotational **X-axis** while the cutter performs simultaneous **3-Axis** movements.



The main options are summarised below.

X Limits

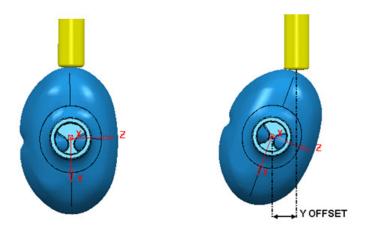
The **X Limits** define the absolute limits of the finishing path along the rotational, X-axis. These can be manually defined, or automatically set to the limits of the block.

Pattern

This enables the cutting method to be specified for rotary milling either **Circular**, **Line**, or **Spiral**.

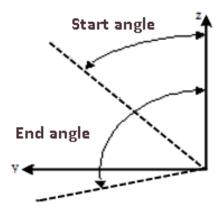
Y Offset

A **Y Offset** distance can be specified to avoid cutting with the tip of the tool. This view along the X-axis shows how the **Y Offset** (if active) is applied to the Rotary form:



Angular Limits

The **Angular Limits** section of the dialog is only available when using the **Style** as **Circular** or **Line**. The **Angular limits** are defined between a **Start** and **End** angle.



The angular limits are measured in an anti-clockwise direction when viewed along the positive X-axis. The area machined is between the start and end angles.

Cut Direction

This option determines whether **Climb**, **Conventional**, or **Any** milling directions are used.

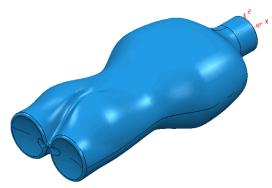
Stepover

In the case of **Circular** and **Spiral** this is defined as the pitch for each programmed revolution of the component. For **Line** this is defined as the angular, stepover between adjacent tool tracks.

Circular Rotary Machining

In this example a model of a bottle with its centre along the X-axis will be used. Using the **Style** as **Circular**, the job rotates with the tool aligned to a fixed direction. While the component rotates, the tool moves back and forth along its axis to generate the sectional form. The tool then steps over by the **Pitch** value and the rotational machining process is repeated.

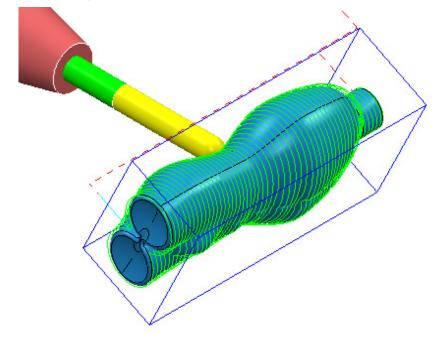
- 1 Select **Delete All** and **Reset forms**.
- 2 Import the Model:
 - ...\PowerMILL_Data\Models\rotary_bottle.dgk



- 3 Calculate the Block using *Defined by* Box and Type model.
- 4 Create a Dia 10 Ball nosed tool named BN10.
- 5 In the **Rapid Move Heights** dialog select **Calculate**.
- In the Start and End Point dialog Use Absolute using the coordinates 20 0 40.
- 7 Set the *Short/Long* Links to Skim and *Default* Links to Incremental.
- 8 In the Strategy Selector \bigotimes select Finishing > Rotary Finishing.

3	Rotary Finishing	?	×
Toolpath name	BN10-Rotary-Circular		
Workplane Block Tool Machine tool Stock engagement Automatic verification Point distribution Machine axis control	Rotary finishing X limits Start -115.067 End 0.0 Pattern Style Circular Y offset 0.0	Ø	
 Machine axis control Rapid move heights Leads and links Start point End point Feeds and speeds History Notes and Description User defined settings 	Angular limits Start 0.0 Tolerance Cut direction 0.02 Climb Thickness	✓ </td <td></td>	

- Enter Name: BN10-Rotary-Circular
- Click on Defines X limits as block limits.
- Set Style: Circular
- Select Cut Direction: Climb
- Input Stepover: 2
- 9 Select **Calculate** to create the toolpath then **Cancel** the dialog.
- 10 In the **PowerMILL** *explorer* right mouse click the toolpath **Rotary1_BN10** and select **Simulate from Start** to open the **Simulation** Toolbar.
- 11 On the **Simulation** toolbar select the **Tool View** icon
- 12 Select the Play button on the Simulation toolbar





By applying **Tool view** point the rotation of the component is simulated (As if viewing the actual machine tool).

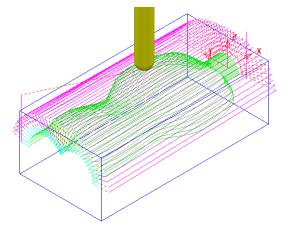
In the above example each section is machined in the same **Climb** milling direction. The entire length of the job is machined since the **X Limits** are set to the **Block** limits. Selecting **Conventional** will produce tool tracks travelling in the reverse direction and **Any** will produce alternate **Climb** and **Conventional** tool tracks along the job.

- **13 Recycle** the toolpath, select **Any** for the **Cut direction** and select **Calculate** to create the toolpath before selecting **Cance**I to close the dialog.
- **14 Simulate** the **toolpath** as before to observe the effect of the toolpath reversing direction with every new section machined.

Line Rotary Machining

Using the **Style** as **Line**, the tool feeds in the X direction following the component form. At the end of each pass the tool retracts and moves above the start of the next pass. At the same time the rotary axis indexes by the angular stepover and the tool then leads onto the next machining move.

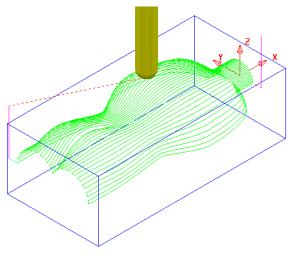
- 15 Make a Copy of the previous toolpath named BN10-Rotary-Line and select Style - Line using Cut Direction > Climb milling.
- 16 For Angular Limits Start Angle, enter 90 and End Angle, enter -90.
- 17 In the Leads and Links dialog set the Z Heights Skim distance to 20 and all of the Links to Skim.
- 18 Click on **Calculate** and **Close** the dialog.



- **19 Simulate** the new, uni-directional toolpath (shown above with a larger step over).
- 20 Make a Copy of the previous toolpath and name it as:-

BN10-Rotary-Line-2way.

- 21 Change the **Cut Direction** to **Any**.
- 22 Apply the dialog and **Simulate** the new, bi-directional toolpath.



Spiral Rotary Machining

Using the **Spiral** technique, a continuous toolpath is generated around the form as the tool advances along the X-axis. To ensure a clean finish the toolpath starts and finishes with a constant X position, sectional pass. Due to a **Spiral** toolpath being a single, continuous track the cutting direction will be either **Climb** or **Conventional** milling. For the same reason the **Angular Limits** option is not viable and as a result is blanked out.

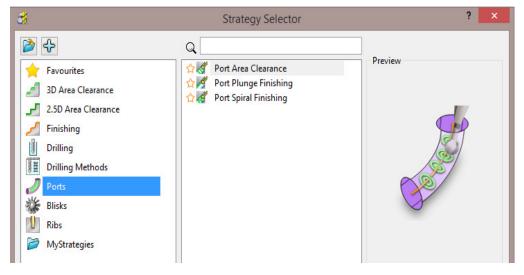
- 23 Make a Copy of the previous toolpath and name it as BN10-Rotary-Spiral and select Style Spiral using Cut Direction > Climb milling.
- 24 Click on **Calculate** to produce the toolpath shown below.

- 25 **Simulate** the new toolpath.
- 26 Save the Project as:-
 - ...\COURSEWORK\PowerMILL_Projects\ Rotary_Bottle-EX1

15. Port Machining

Introduction

In the **Strategy Selector** the **Ports** option provides 3 specialist strategies, designed for machining cylinder head, inlet/outlet ports.

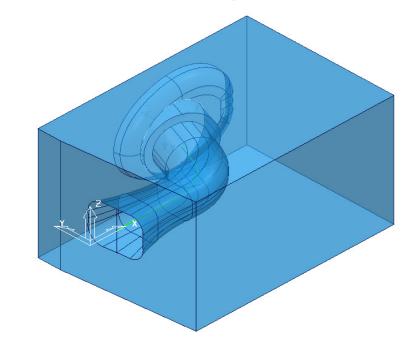


The **Port Machining** options automatically provide multi-axis, **Tool Alignments** where this is possible. A *warning* will be displayed if impossible alignment limits are reached and the port is not fully machined.

<u> </u>	PowerMILL Warning:	×
À	Some unmachined material remains.	
	ОК	

Basic Single Port Example

- 1 Open the 'read-only' **Project**:
 - ...\PowerMILL_Data\five_axis\Ports\SinglePort2-Start



2 Save Project As:-

...\COURSEWORK\PowerMILL-Projects\SinglePort2-ex1



The **Project** already contains all required cutting **Tools**, and preliminary **3Plus2 Toolpaths**.

The following section will take the user through the specialist **Port Area Clearance** and **Port Spiral Finishing** options.

A **Pattern** (4) is included running down the centre of the **Port**. This is required to control the extent and alignment of the **Port Machining** strategies.

- **3** Activate the existing **Toolpath** 1 to reinstate all the settings.
- 4 Activate the BN10 tool.
- 5 In **Toolpath Strategies** select **Ports** > **Port Area Clearance** and fill in the 3 pages of the dialog exactly as shown below.

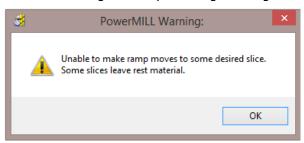
💰 Pc	ort Area Clearance ? ×
Toolpath name	BN10-PortAreaClear
 Workplane Block Tool Machine tool Limit Port area clearance Workplane limits Workplane limits Yorder Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point End point Freeds and speeds History Notes and Description User defined settings 	Port area clearance Pattern A Tool clearance Cut direction Climb Cut direction Climb Cut direction Climb Cut direction Climb Preview Draw
	Calculate Queue OK Cancel

- Insert *Pattern*: 4
- Input *Tool Clearance*: 1.0

Workplane	Ramping
Tool Machine tool Machine tool Wit Port area clearance Workplane limits Ramping	Ramping Slope angle 10.0 Ramp diameter (TDU) 0.3
Workplane Block Tool Machine tool Limit Port area clearance Workplane limits Kamping Order	Order Order Machine Maximum from end v Spiral V Partial slices V
Tick Spiral.	

• Tick **Partial slices**.

6 Calculate and note the following advisory warning message:



The message is advising that the **Tool** is unable to fully machine the form to the current settings.

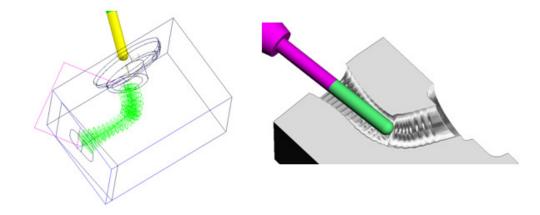
Later a visual check with **ViewMILL** will show that enough material has been removed to allow the finishing strategies to run.

- 7 Select **OK** to the message and wait for the **toolpath** to finish processing.
- 8 **Close** the dialog.
- 9 Activate Toolpath 1
- 10 Right mouse click on **toolpath 1** and from the local menu select **Simulate from start**.
- 11 Open the **Block** dialog and change the **Max Z value** from **40** to **0** before selecting **Accept**.

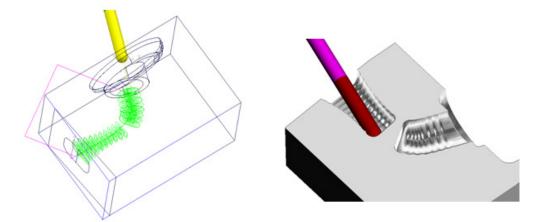


By defining the **Block** to be half the height of the **model** it will be possible to visualise the lower half of the port being machined.

12 Select an **ISO 2** view and run a **ViewMILL simulation** on all the remaining toolpaths in sequential order.



If the **Partial Slices** option had <u>not</u> been ticked then the **Toolpath** would have been created as shown below with a wall of material remaining in the middle of the port.



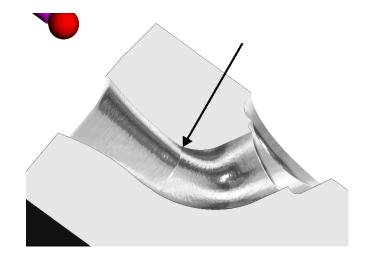
- 13 Activate the SPHR12.5 tool.
- 14 In **Toolpath Strategies** select **Ports** > **Port Spiral Finishing** and fill in the two featured pages of the dialog exactly as shown below.

- 3 4	Port Spiral Finishing ?
Toolpath nam	Port spiral finishing Pattern A 4
Port spiral finishing Workplane limits Workplane limits	Tool clearance 1.0 Cut direction Climb Tolerance 0.02 Thickness Image 0.0
End point Feeds and speeds History Notes and Description User defined settings	Stepover 2.0 Stepdown 0.3 Preview Draw

Workplane	Merge
	Merge
	Merge point 50.0
🕅 Limit	
🚊 🐗 Port spiral finishing	Lift start 10.0
Workplane limits	10.0
	Overlap 10.0
Automatic verification	Lift height 0.3
Point distribution	<u>Lift height</u>

The above **Merge** settings causes the **thickness** to gradually increase to **0.3** as it merges into the areas previously machined from the first end. This is to compensate for the cutter tending to dig in when the loading decreases.

- 15 Select **Calculate** and once the toolpath has been created select **Cancel**.
- **16** Perform a **ViewMILL** simulation on the latest toolpath, **Sphr12_5-PortSpiral**.





Note the **0.3mm** step where the machining from the second end of the port has gradually moved away from the form over the last **10mm** to the blend point.



If the **Lift Height** is **0** then there will not be a visible step appearing on the toolpath running from the second end.

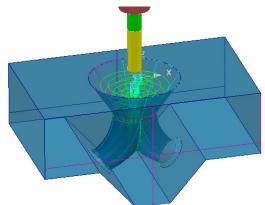
There is however a high risk of the **Tool** digging into this area if this **Toolpath** was to be run on the machine tool.

17 Select File > Save Project.

Twin Port Example

Only one **Port** at a time can be processed within the **Port machining** strategies. For this example, 2 **reference surfaces** have been created to blank access to the extra port while applying the **Port machining** strategies to the remaining **single Port** setups.

- 1 Select File > Delete All and Tools > Reset Forms.
- 2 Open the read only **Project**:
 - ...\PowerMILL_Data\five_axis\Ports\DualPort_Start



3 Save Project As:

```
...\COURSEWORK\PowerMILL-Projects\DualPort-ex1
```

- 4 Activate the existing toolpath **RghPort-3Axis** to reinstate all the settings.
- 5 Activate the BN16 tool.
- 6 **Calculate** a new **Block** to the full **Model** dimensions.
- 7 In **Toolpath Strategies** select **Ports** > **Port Area Clearance** and fill in the pages of the dialog exactly as shown below.

C PO	ort Area Clearance ? ×
Toolpath name	BN16-RghPort
Workplane Block Jool Machine tool Machine tool Machine aclearance Morkplane limits Morkplane limits Morkplane limits Morkplane limits Morkplane limits Morkplane limits Morkplane limits Morkplane limits Morkplane limits Machine axis control Applied move heights Leads and links Start point Feeds and speeds History Notes and Description User defined settings	Port area clearance Pattern 1 Cut direction Climb Cut direction Climb Tolerance 0.1 Thickness 0.5 Stepover 5.0 Stepown 5.0 Preview Draw

8 Switch on the **Level** named **reference**.



9 From the Port Area Clearance main page, select the Component Thickness icon

8			Со	mponent Th	ickness		? ×	
Surfaces	5 Verification	Surface De	efaults					
Entity	♥ BN16-Rgł	nPort	*		Clone		~	Y X
Machin	ning Mode] Use Axia	Il Thickness <u>Thickne</u>	55			
Ignore	• v			0.0				
Set	Mode	Thickness	Axial	Total Thick	ness Total Axial	#		
∞0	Machine	0	-	0	-	0		
< ⊗ 1	Ignore	0	14	0		1		
∞ 2	Machine	0	1	0	-	0		
€3	Machine	0	-	0	-	0		
1	Machine	0	15	0		0		
\$5	Machine	0	-	0	-	0		
6	Machine	0	-	0	-	0		
<₿7	Machine	0	17	0		0		
×	Machine	-	-	0	-	14		
			Apply	Accept	Cancel			

- 10 In the Component Thickness dialog, select and acquire the left hand reference surface (Shaded purple above right) to a row with the Machining Mode set to Ignore.
- **11 Apply** the dialog.

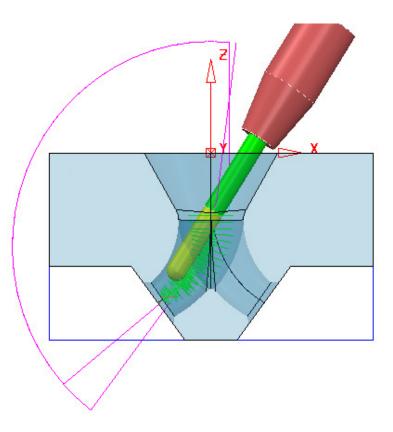
Workplane	Ramping				
Tool	Ramping				
	Slope angle 4.0				
🕅 Limit					
🖶 🔏 Port area clearance	Ramp diameter (TDU) 0.3				
Ramping					

3	Po	rt Area Clearance	?	×
Toolpath	n name	BN16-RghPort		
Workplane Block Tool Machine tool Machine tool Orker Port area clearance Workplane limits Machine Corder		Order Order Machine Maximum from star Sp Partial sli	iral 🗸	

12 In the **Order** page tick **Spiral**.

Pc	ort Area Clearance ?
Toolpath name	BN16-RghPort
Vorkplane	Rapid move heights
Tool Machine tool Machine tool Machine tool Machine area clearance Machine area clearance Machine aris Machine aris control Machine aris control Machine aris control Machine aris control	Geometry Safe area Cylinder Workplane TOP-CENTRE Position 0.0 0.0 -70.000326 Direction 0.0 1.0 0.0 Rapid radius 153.26564 Plunge radius 148.26564
	Calculate Dimensions Rapid clearance 5.0 Plunge clearance 5.0 Calculate

13 Calculate the **Port area clearance** dialog.



14 Activate the SPHR25 tool.

15 In **Toolpath Strategies** select **Ports** > **Port Spiral Finishing** and fill in the pages of the dialog exactly as shown below.

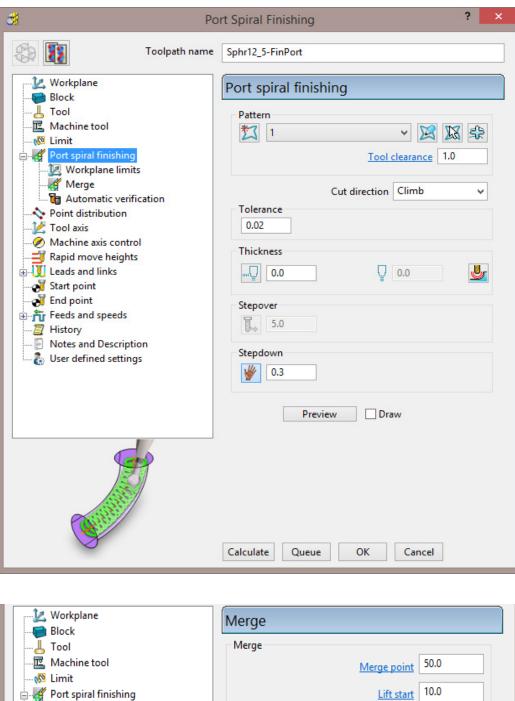


 Image
 Image

 Image

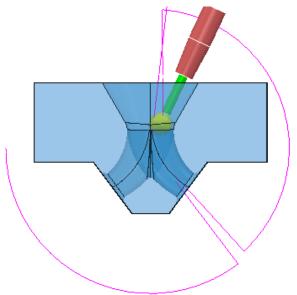
16 From the Port Area Clearance main page, select the Component Thickness icon



17 As shown in the following diagram, *Clone* the **Component Thickness** settings from the previously created toolpath **BN16-RghPort**.

			Con	nponent Thickne	ess	?		
urfaces	Verification	n Surface Def	aults					
Entity	Entity Sphr12_5-FinPort BN16-RghPort							
*	1		Use Axial	Thickness		<u>(</u>		
Machi	ning Mode			<u>Thickness</u>	1			
Ignore	• •			0.0		State State		
	v v Mode	Thickness	Axial	0.0 Total Thickness	Total Axial	#		
Ignore		Thickness 0	Axial		Total Axial	#		
lgnore Set ⊗0	Mode		Axial -	Total Thickness	Total Axial -			
lgnore Set	Mode Machine	0	Axial - -	Total Thickness	Total Axial - -	0		
Ignore Set ⊗0 ⊗ <mark>1</mark>	Mode Machine Ignore	0	Axial - - -	Total Thickness 0.5 0.5	Total Axial - - -	0 1		
Ignore Set ⊗0 ⊗ <mark>1</mark> ⊗2	Mode Machine Ignore Machine	0 0 0	Axial - - - -	Total Thickness 0.5 0.5 0.5	Total Axial	0 1 0		
Set	Mode Machine Ignore Machine Machine	0 0 0 0	Axial - - - - -	Total Thickness 0.5 0.5 0.5 0.5 0.5	Total Axial - - - -	0 1 0 0		
Ignore Set ⊗0 0 0 1 0 2 0 3 0 4 0 5 0 6	Mode Machine Ignore Machine Machine Machine	0 0 0 0 0	Axial	Total Thickness 0.5 0.5 0.5 0.5 0.5 0.5	Total Axial - - - - -	0 1 0 0 0		
Ignore Set ⊗0 ⊗1 ⊗2 ⊗3 ⊗4 ⊗5	Mode Machine Ignore Machine Machine Machine Machine	0 0 0 0 0 0	Axial	Total Thickness 0.5 0.5 0.5 0.5 0.5 0.5 0.5	Total Axial - - - - - - -	0 1 0 0 0 0		

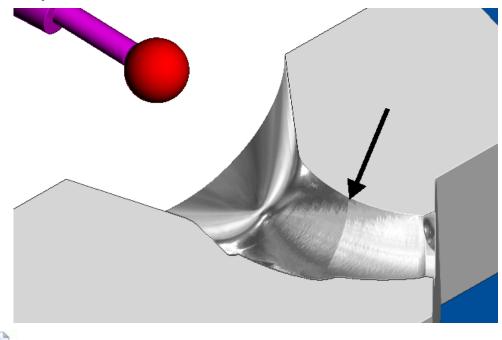
18 Apply and Accept the Component Thickness dialog, and then Calculate the Port spiral finishing strategy.



- **19 Activate the Workplane** *mc-OUTPUT*.
- 20 Activate the Boundary 1.
- 21 Calculate a Block Defined by Boundary and Type Model.

3	Block	? ×
Defined by		
Boundary	¥	🔊 🖪 💥
Coordinate Syste	m	
Active Workplar	ne v	~
Limits		
Min	Max	Length
× -125.0	۲ <u>ــــــــــــــــــــــــــــــــــــ</u>	250.0
Y -69.99967	70.000325	140.0
Z -150.0	§75.0 §	75.0
¥ z	2	6
Estimate limits		
Tolerance	Expansion	Туре
0.1	0.0	Model 🗸
Include refere	nce suffaces	Calculate
✓ Draw		Opacity
[Accept	Cancel

- 22 Change the Max Z value to -75.0.
- 23 Select an **ISO 3** view, open and run a **ViewMILL** simulation of all the **toolpaths**.



Note the **0.3mm step** where the machining from the second end of the Port has gradually moved away from the form over the last **10mm** to the blend point.

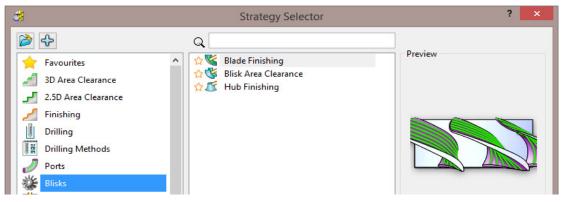
24 Select File > Save Project.

1

16. Blisks

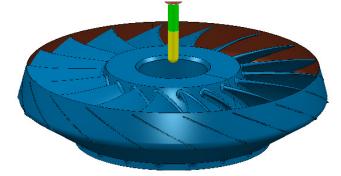
Introduction

In new strategies, the ${\bf Blisks}$ option provides 3 specialist strategies for machining Impellers.



Impeller Example

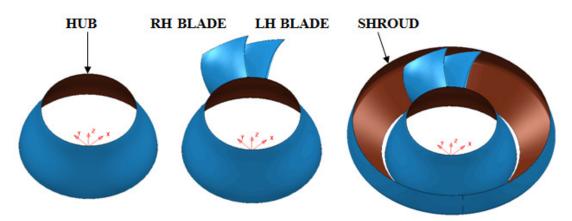
- 1 Select File > Delete All and Tools > Reset Forms.
- 2 Open the 'read only' **Project**:
 - ...\PowerMILL_Data\FiveAxis\Blisks\BliskSimple_Start



- 3 Select File > Save Project As: ...\COURSEWORK\PowerMILL_Projects\FiveAxis\Blisks\Blisk_Example
- 4 Activate **Workplane 1**.
- 5 Create a **Cylindrical Block** to the **Model** dimensions.

- 6 Calculate the Rapid Move Heights.
- 7 Set both Start and End Points to First/Last Point Safe.
- 8 In the Leads and Links dialog, set Links to *Short/Long* Skim and *Default* Incremental.

To be able to apply the **Blisks** machining options the component surfaces must first be acquired to a series of specifically named **levels**. In this example the **surfaces** in the imported model are already acquired to appropriate **levels**.



- 9 Activate the existing Ball Nosed tool named BN25.
- 10 From the main toolbar, select **Default Thickness** and in the **Thickness Preferences** dialog, select the **Surface Defaults** tab.

urfaces V	/erification	Surface Def	aults			
				Clone	-	
\lambda 🗗			Use Axial	Thickness		
machining	inouc					
	-	0.0				
Set Mo	ode	Thickness	Axial	Components		
Set Mo 🌣 D Ign	ode nore	Thickness)	Axial -	1		× 4 ^z ×
Set Mo 🛱 <mark>0 Ign</mark> 🛱 1 Ma	ode - nore (achine (Thickness 0 0	Axial -	1 0		Y AZ X
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- 11 Select the single *Shroud* Surface and acquire it to the first row in the above dialog.
- 12 Set the first row to *Machining Mode* Ignore and Apply the settings, before closing the dialog by clicking Accept.
- 13 In the Leads and Links options input Z heights Skim distance 15.
- 14 For both Lead in and Lead out, input 1st choice Extended move 10 and 2nd choice Surface normal arc Angle 90 and Radius 5.

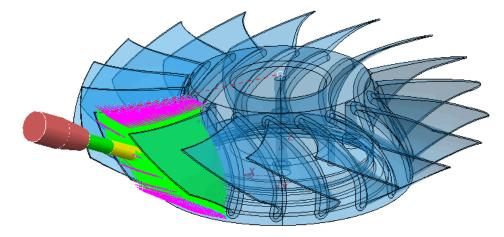
- **15** In the **Toolpath Strategies** dialog, select **Blisks** and from the three available options, select **Blisk Area Clearance**.
- 16 Enter data exactly as shown below with the **Fillets** and **Splitter Blade** options left blank.

BI	lisk Area Clearance	? ×
Toolpath name	BN25-RGH-a1	
Toolpath name Workplane Block Tool Machine tool Slisk area clearance Tool axis elevation Machining Automatic verification Notinit distribution Tool axis Machine axis control Rapid move heights Leads and links Start point End point Feeds and speeds History Notes and Description Suser defined settings	Blisk area clearance Blisk definition Hub Shroud Fillets Blades Left blade Right blade Splitter blade	Left Blade V Right Blade V One blade V
	Calculate Queue OK	Cancel



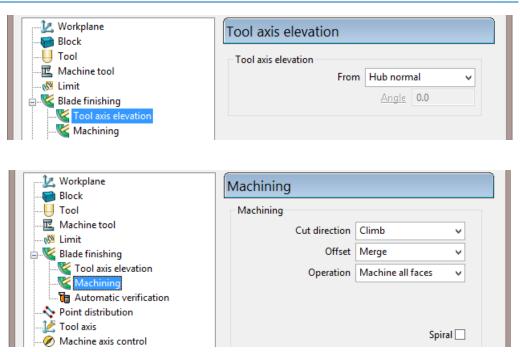
	Machining	
	Machining	
	Cut direction	Climb 🗸
Blisk area clearance	Offset	Offset up 🗸 🗸
	Method	Parallel V

17 Select **Queue** in the dialog to commence background toolpath processing.

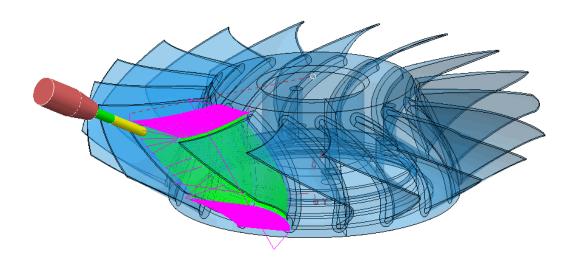


- 18 Activate the existing Ball Nosed tool named BN15.
- **19** In the **Toolpath Strategies** dialog, select **Blisks** and from the three available options, select **Blade Finishing**.
- 20 Enter data into the pages of the dialog exactly as shown below with the **Fillets** and **Splitter Blade** options left blank.

- 33	Blade Finishing ? ×
Toolpath name	BN15-FIN-a1
Workplane	Blade finishing
Tool	Blisk definition
	Hub 🗸 🗸
Blade finishing	Shroud Shroud 🗸
	Fillets
Machining	Blades
Point distribution	Right blade Right Blade V
	Splitter blade
Machine axis control Rapid move heights	Machine One blade
🗈 👿 Leads and links	Total number 0 Calculate
	Tolerance
	0.02
& User defined settings	Thickness
-	0.0
	Changer
	Stepover 5.0
	0.0
	Stepdown
	* 0.5
	Calculate Queue OK Cancel



21 Select **Queue** in the dialog to commence background toolpath processing.



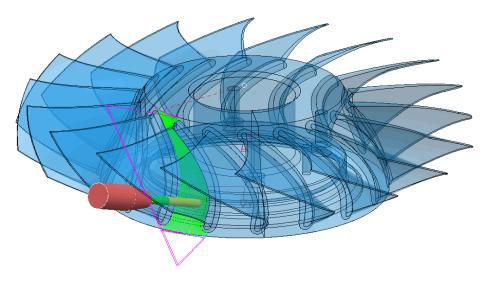
- 22 In the **Toolpath Strategies** dialog, select **Blisks** and from the three available options, select **Hub Finishing**.
- 23 Enter data exactly as shown below with the **Fillets** and **Splitter Blade** options left blank.

Toolpath name BN15-FINhut Workplane Block Tool Tool Machine tool Machine tool Machining Automatic verification Nachining Automatic verification Nachine axis control Rapid move heights Leads and links Start point	shing	
Block Tool Blisk defin Blades Bl	Inition Hub Hub V Shroud Shroud V Fillets V Left blade Left Blade V	
Machine tool Machine tool Machining Machining Machining Machining Machining Machining Machine axis control Machine axis	Hub Hub V Shroud Shroud V Fillets V Left blade Left Blade V	
	Splitter blade V Machine One blade V	
→ Start point → Y End point → T Feeds and speeds - □ History □ Notes and Description 0.0 Stepover ✓ 0.5		
Stepdown 1.0 Calculate		

Workplane Block	Tool axis elevation			
Tool	Tool axis elevation			
	Fror	n Average	hub normal 🔍	
🔞 Limit				
🗄 🚿 Hub finishing		Angle	0.0	
Machining				

Workplane	Machining
	Machining
	Cut direction Climb
Hub finishing	
Tool axis elevation	
🥂 Machining	

24 Select **Queue** in the form to commence background toolpath processing.



The next stage is to perform a full **ViewMILL simulation** of all 3 toolpaths.

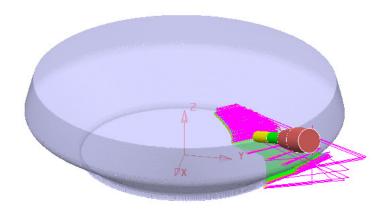
Before running **ViewMILL** it is necessary to define the **Block** as a *Triangle* model of the pre-turned, **Shroud** for an accurate representation of the material prior to milling.

- 25 Activate and *right mouse* click on the toolpath BN25-RGH-a1 and from the local menu select the option Simulate from Start.
- 26 Before starting the Simulation, open the Block dialog and select Defined By > Triangles followed by select the Load block from file icon.

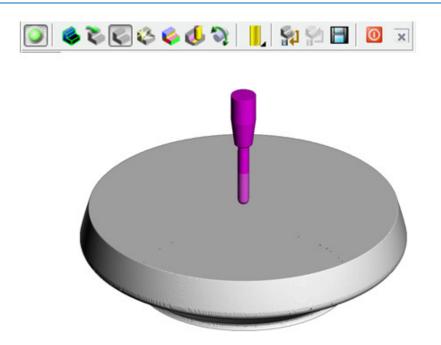
🛃 Block		8 ×
Defined by	Triangles	- 🗋 🖾
Coordinate System	m	
Active Workpl	ane 🚽 🔻	· · · · · · · · · · · · · · · · · · ·
Limits		

27 Browse and select the Triangle file:

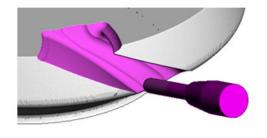
...\PowerMILL_Data\FiveAxis\Blisks\TurnedShroud.dmt

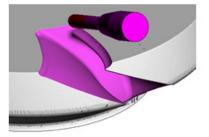


28 With the complex **Block** active, switch on a **ViewMILL** simulation.

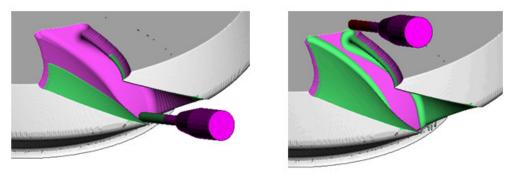


29 Select the **Play** button in the toolpath **Simulation** toolbar and observe the machining process for the toolpath **BN25-RGH-a1**.

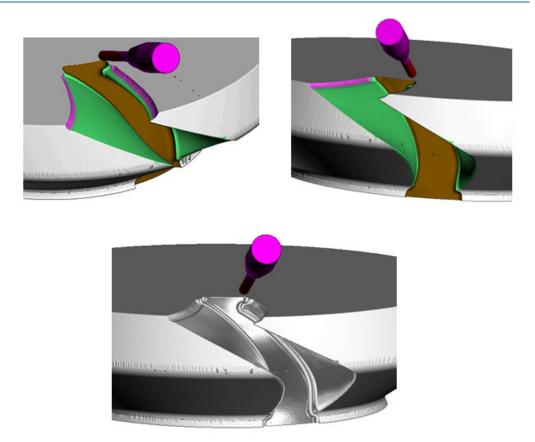




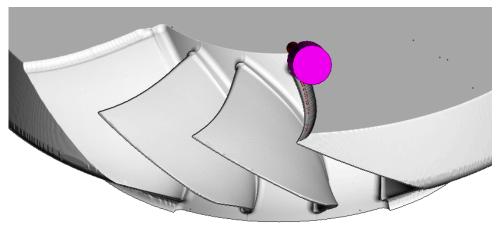
30 Continue the ViewMILL Simulation on toolpath BN15-fin-a1.



31 Continue the ViewMILL Simulation on toolpath BN15-finHUB-a1.

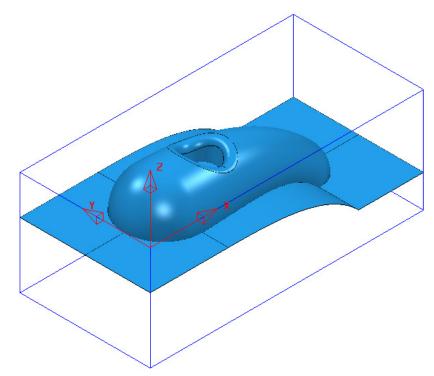


The final image (below) shows the result of a **ViewMILL simulation** including 17 copies of the **toolpaths** rotated by **20 Degree** increments around **Z**.



17. Five Axis-Tutorial

- 1 Select File > Delete All and Tools > Reset Forms
- 2 Open the (read-only) Project:....\PowerMILL_Data\FiveAxis\Cowling\Cowling-5Axis-Start.dgk

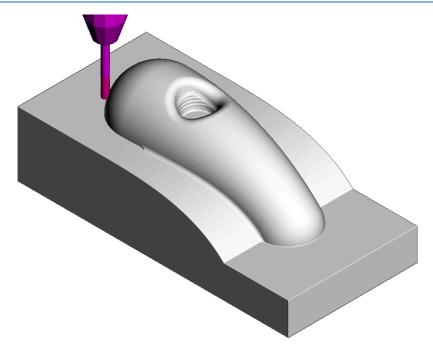


- 3 Save Project As:
 -\COURSEWORK\PowerMILL_Projects\Cowling-5Axis

The **Project** currently contains 8, 3-Axis Toolpaths.

This has left remaining areas that are either more suited to, or can only be machined using 5-Axis strategies.

- 4 Select an **ISO2** view.
- 5 Activate the Toolpath D16TR6-RGH1_step to restore the Block used in the strategy.
- 6 Perform a full ViewMILL simulation on the NC Program 1.



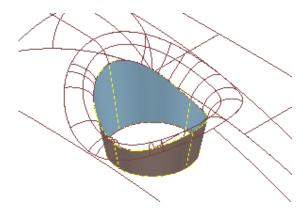
The remaining areas that require Five Axis machining include the central pocket (Swarf Machining), and the intersection between the main form and the 3D run-off (Embedded Pattern and Surface Finishing).



7 Select the *ViewMILL* No-Image display option and disconnect from the **simulation** process.

Central Pocket

8 Activate the tool EM12.

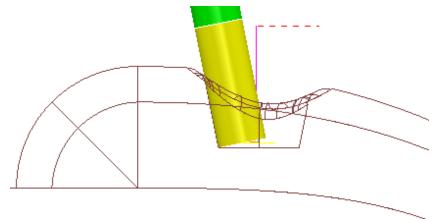


- 9 Select the **Pocket** wall.
- 10 Select the **Toolpath Strategies** dialog \bigotimes select the **Finishing** tab.
- **11** From the list of strategies select **Swarf Finishing** and then **OK**.

12 In the **Swarf Finishing** dialog enter data exactly as shown below:

3	Swarf Finishing ? ×
Toolpath name	EM12-SwarfPktWall-FIN1
Workplane Block Col Machine tool Swarf finishing Col Gouge avoidance Multiple cuts F High speed	Swarf finishing Drive curve Surface side Qutside Radial offset 0.0 Minimum fanning distance 0.0 Fan at end on planes Reverse axis Follow surface laterals
Automatic verification Point distribution Color axis Machine axis control Rapid move heights Color axis Color axis Color axis Color axis Color axis Color axis Color a	Surface joining tolerance 0.3 Gouge avoidance Gouge check Degouge tolerance 0.3
Feeds and speeds History Notes and Description User defined settings	Tolerance Cut direction 0.01 Climb Thickness Image: 0.0
	Preview Draw Calculate Queue OK Cancel

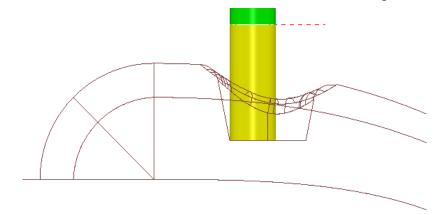
13 For both the Lead in and Lead out input Surface normal arc with *Angle* 180 and *Radius* 2, then Calculate the toolpath.



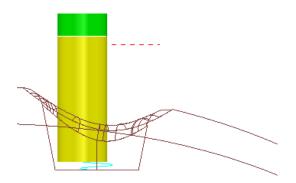
The **Swarf Finishing** strategy is created as *Five Axis* by default (The **Tool axis** option is set to **Automatic**). As shown in the above image this results in a wedge of material remaining on the flat base of the pocket. This can be removed with a second **Swarf Finishing** toolpath but this time with the **Tool Axis** set to **Vertical**.

đ	Swarf Finishing	?	×
Toolpath name	EM12-SwarfPktWall-FIN2		
Workplane	Tool axis		
Tool	Tool axis		
	Vertical 🗸		
🕅 Limit			
🗄 🚮 Swarf finishing			
Position			
Multiple cuts			
<mark>]</mark> F High speed			
Automatic verification			
Point distribution	Fixed angle		
Tool axis	None ¥ 90.0		
Machine axis control			

14 Make a copy of the Swarf Finishing strategy named EM12-SwarfPktBase-FIN2 but this time set the Tool Axis to Vertical before selecting Calculate.



15 Change the Lead in move onto this toolpath to a *circular* Ramp with *Angle* 4, *Circle Dia (TDU)* 0.65 and *Ramp Height* 2.

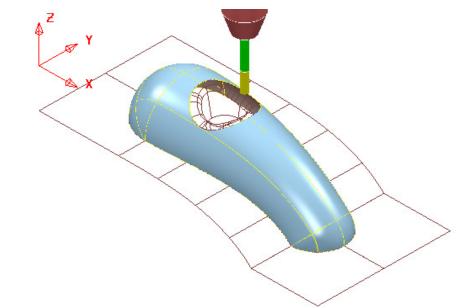


The Pocket is now fully machined.

16 Save (but do not close) the **Project**.

Main Form – Base Intersection

17 Activate the EM5 tool.



- **18 Select** the main form **surface** (as shown in the above image).
- 19 Select the **Toolpath Strategies** dialog \bigotimes select the **Finishing** tab.
- 20 From the list of strategies select **Surface Finishing** and then **OK**.
- 21 In the **Surface Finishing** page enter data exactly as shown in the image below.

3	Surface Finishing ? ×
Toolpath nam	e EM5-MainForm-FIN1
 Workplane Block Tool Machine tool Stock engagement Stock engagement Surface finishing Pattern Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point Feeds and speeds History Notes and Description User defined settings 	Surface finishing Surface Surface side Outside Surface units Degouge tolerance 0.3 Tolerance 0.01 Thickness 0.0 Stepover (Distance) 0.3 Output Stepover (Distance) Output Decime Decime
	Preview Draw

22 Select the **Tool Axis** page and again enter data exactly as shown in the image below.

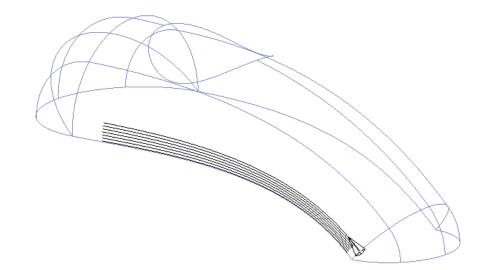
🛪 s	Surface Finishing	?	×
Toolpath name	EM5-MainForm-FIN1		
Workplane Block Glock G	Tool axis Tool axis Lead/Lean v Lead/Lean angles Lead 0.0 -90.0 Mode Contact normal	v	

23 Select the **Pattern** page and again enter data exactly as shown in the image below.

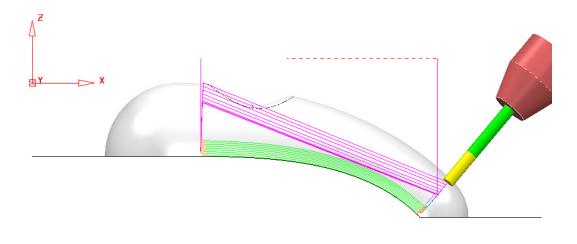
3 3 S	Surface Finishing	?	×
Toolpath name	EM5-MainForm-FIN1		
Workplane Block Tool Machine tool Machine tool Machine tool Machine aggement Surface finishing Machine axis control Automatic verification Machine axis control Rapid move heights Automate control Start point Leads and links Start point End point Feeds and speeds History Notes and Description Viser defined settings	Pattern Pattern Pattern direction U Ordering One way Start corner Max U max V Sequence None Limits (Distance) V Start 60.0 0.3 End 167.5 2.7	Spiral v	

The values shown in the above page were finally arrived at after a trial and error process. The actual values are unit distance along and across the surface, curve network (U V).

24 Select **Preview** to visualise the defined pattern on the **Surface**.



25 Select **Calculate** to process the toolpath.





To help visualisation the above images show the preview with a larger area and stepover than specified in the instructions.

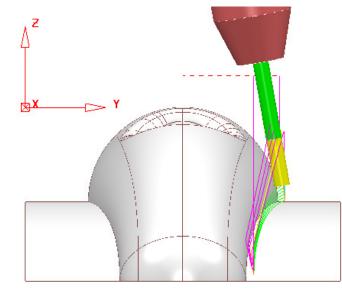
ć	*		L	eads a	nd Link	S	?	×
	Extensio	ns		Links		Point	distribution	
	Z heights	First lea	First lead in Lea			Lead out	Last lead o	out
	1st choice				2nd ch	oice		
	Vertical arc			~	Vertic	cal arc		~
		Distanc	<u>ce</u> 0.0			Ī	Distance 0.0	
		Ang	<u>le</u> 90.0				Angle 90.0	
		Radio	<u>us</u> 2.0				Radius 1.0	

26 Apply the following Lead in and Lead Out settings.

27 Make a copy of the **Surface Finishing** toolpath and rename it as **EM5-MainForm-FIN2**.

3	Surface Finishing ?	×
Toolpath name	EM5-MainForm-FIN2	
 Workplane Block Tool Machine tool Machine tool Stock engagement Stock engagement Surface finishing Pattern Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point End point Feeds and speeds History Notes and Description User defined settings 	Pattern Pattern Pattern direction U Spiral Ordering One way Start corner Min U min V Sequence None Limits (Distance) U V Start 60.0 92.3 End 167.5 94.7	

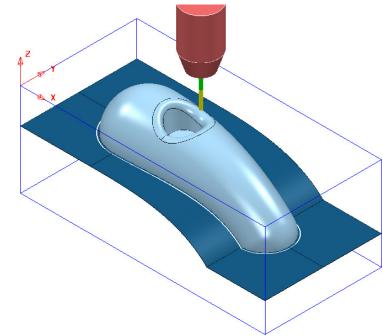
28 Modify the original settings in the **Pattern Page** and select **Calculate** to perform the same strategy on the other side of the main form.



The last 2 Surface Finishing strategies deliberately stop just short of the run-off surfaces. A more accurate, final pass will be created normal to the run-off surfaces using a separate **Embedded Pattern Finishing**.

29 Save (but do not close) the Project.

Final Pass around Main Form - Base Intersection

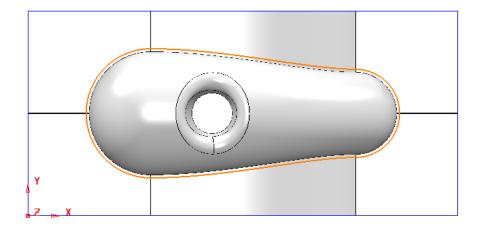


30 Activate the EM3 tool.

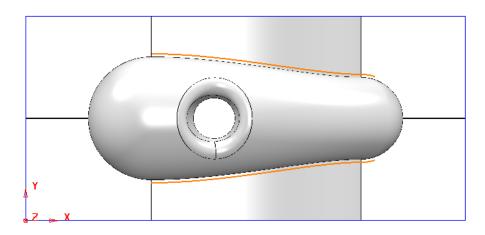
31 Select the *main form* and *Pocket surfaces* (as shown in the above image).

🥶 Selected Sur	face Boundary ? ×
Name	EM3-SeleSurf
Top ☐ Roll Over ✔ Tolerances 0.0 <u>Axial Thickness</u> 0.0 Use Axial Thickness ☐ Tool	Limit Boundary Inside Limiting Boundary Outside Automatic Collision Checking Holder Clearance 0.0
🐮 🗸 ЕМЗ 🗸	Shank Clearance 0.0
	Block
	Limit 😏 🗸
Private	0
Edit History	
Apply edit history on calculation	\odot
Apply Queue	Accept Cancel

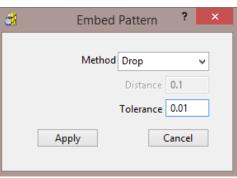
- 32 Create a Selected Surface Boundary (with Roll Over ticked).
- 33 Create an empty **Pattern** and insert the above **Boundary** segment into it.
- **34 De-Activate** the **Boundary**.



35 Use the **Curve Editor** to trim the **Pattern** into 2 segments that define the required extent for an **Embedded Pattern Finishing** strategy.



- **36 Reverse** the **Pattern** segments as required to produce a **Climb Milling** direction (Material to the right of the tool feed direction).
- 37 Right mouse click on the new Pattern and from the local menu select Edit Embed.



38 In the above dialog select *Method* as **Drop** with a **Tolerance** of **0.01** before selecting **Apply**.

A copy of the original **Pattern 1** is projected down Z onto the model as an **Embedded Pattern 1_1** (contains the surface normal).

- 39 Select the **Toolpath Strategies** dialog \bigotimes select the **Finishing** tab.
- 40 From the list of strategies select **Embedded Pattern Finishing** and then **OK**.

41 In the **Embedded Pattern Finishing** page enter data exactly as shown in the image below.

🛪 Embec	dded Pattern Finishing ? 🗙
Toolpath name	EM3-FIN1
 Workplane Block Tool Machine tool Limit Stock engagement Stock engagement Method pattern finishing Gouge avoidance Multiple cuts Automatic verification Point distribution Tool axis Machine axis control Rapid move heights Leads and links Start point Freeds and speeds History Notes and Description User defined settings 	Embedded pattern finishing Drive curve 1_1 Lower limit Axial offset 0.0 Gouge avoidance Gouge check Degouge tolerance 0.3 Tolerance 0.01 Thickness 0.0 Comparison Com

42 Open the **Component Thickness** dialog and acquire the **Main Form surface** to one of the rows.

			Con	nponent Thickne	ess		?
ourfaces	Verification	Surface Det	faults				
Entity	← EM3-FIN1		¥	Clor			~ !!
*	1		Use Axial	Thickness			(
	ning Mode			Thickness 0.0			
Ignore	e 🗸			0.0			549
Set	Mode	Thickness	Axial	Total Thickness	Total Axial	#	
00	Machine	0	67 <u>2</u> 43	0	820	0	
\$1	Machine	0		0		0	
\$2	Machine	0	-	0	-	0	
<∞3	Ignore	0	828	0	727	1	
₩4	Machine	0		0		0	
\$5	Machine	0	-	0	-	0	
\$6	Machine	0	0.70	0	100	0	
\$7	Machine	0	-	0	-	0	
×	Machine	0.20		0	1.11	9	
			Apply	Accept	Cancel		

43 Set the selected row to *Machining Mode* Ignore and Apply.

The Main Form **surface** is set to be ignored as it would otherwise result in the toolpath to fragment. This will result in the tool very marginally gouging the main form **surface**. If checked both visually and using the gouge checking options the actual results will be negligible.

44 Back in the main **Embedded Pattern Finishing** dialog, open the **Tool Axis** page and select **Lead/Lean** both with a **0** angle.

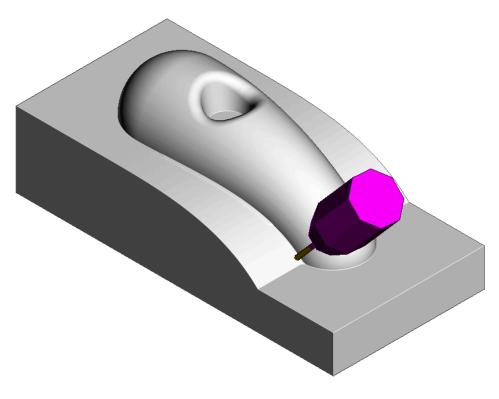
🕉 Ember	Embedded Pattern Finishing					
Toolpath name	EM3-FIN1					
···· ¹ / ₂ Workplane ···· <mark>●</mark> Block ···· <mark>□</mark> Tool ···· ⊡ Machine tool ···· № Limit	Tool axis Tool axis Lead/Lean					
¥ Stock engagement 	Lead Lean 0.0 0.0					
Automatic verification Point distribution Tool axis Machine axis control	Mode Contact normal	~				

45 Set all Link moves (Short/Long/Default) to Incremental.

This is to prevent the toolpath from linking straight through the main cowling surface (Component Thickness set to Ignore).

46 Calculate the Embedded Pattern toolpath.

47 Run a full ViewMILL simulation (Final EM3-FIN1 toolpath show below).



48 Save the Project.