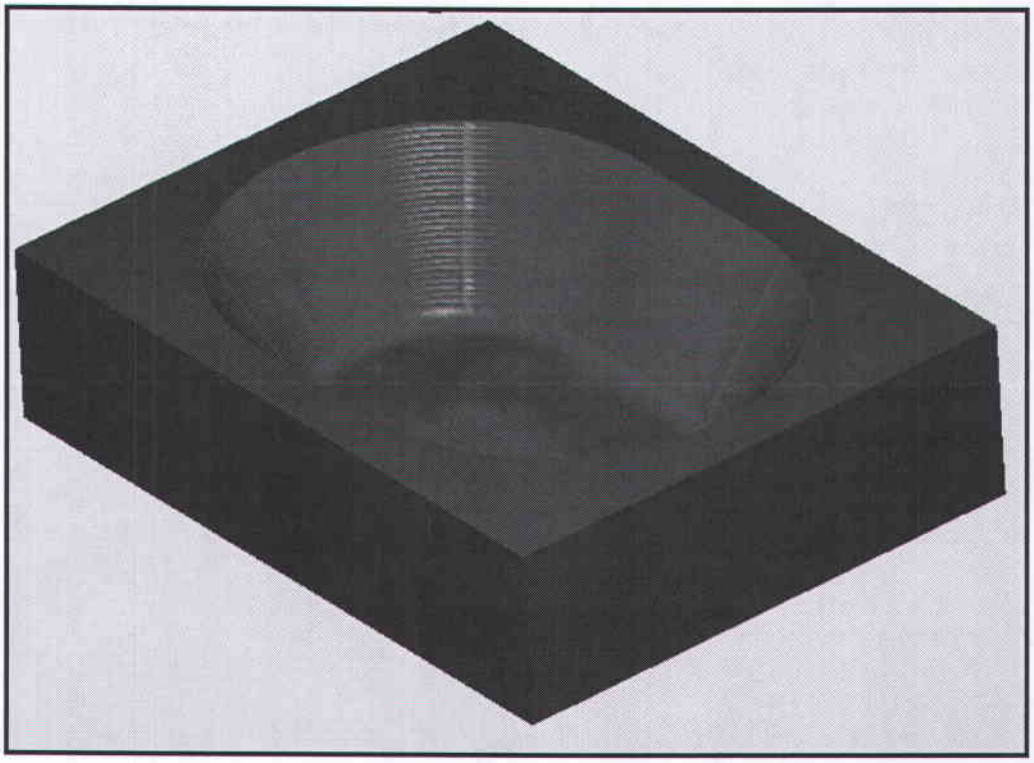
TUTORIAL SERIES FOR

Mastercam X²

TUTORIAL 12
EXTRUDE SURFACE, ROUGH PLUNGE AND FINISH CONTOUR AND SHALLOW TOOLPATHS.



Objectives:

The Student will design a 3-dimensional drawing by:

- Creating an obround shape using rectangle command.
- Creating the extrude surface.
- Creating fillet radii.
- Creating the bounding box.
- Translating the part to set the part datum.

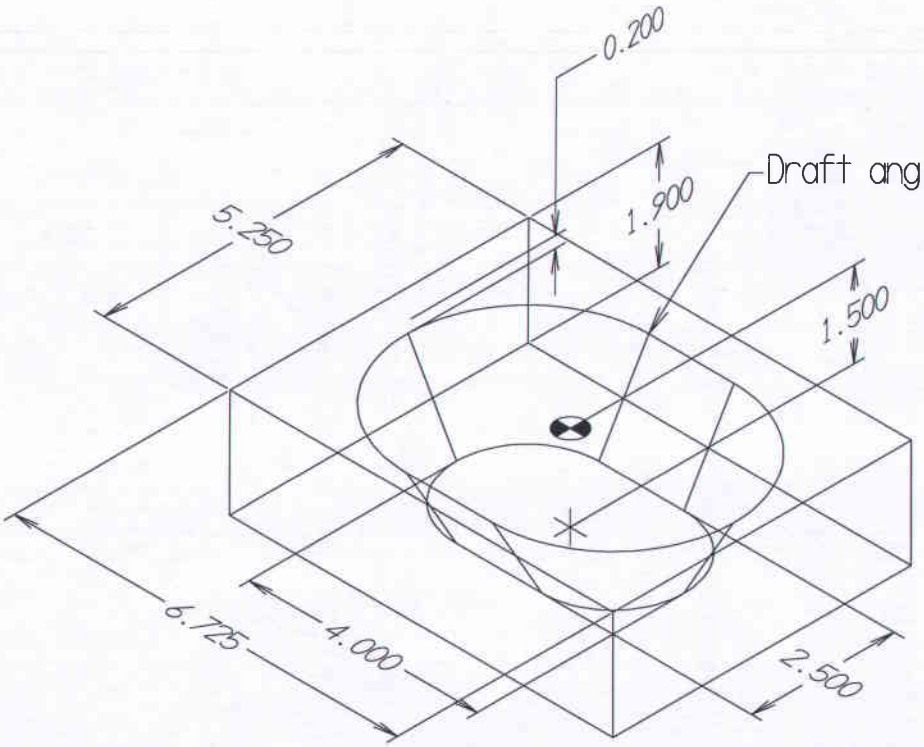
The Student will create a 3-dimensional milling toolpath consisting of:

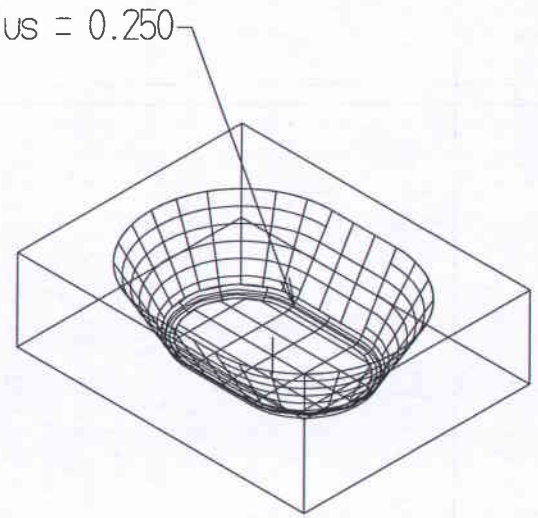
- Roughing the part using plunge toolpath.
- Finishing the part using contour and shallow toolpaths.

The Student will check the toolpath using Mastercam's Verify module by:

- Defining a 3-dimensional block, the size of the workpiece.
- Running the Verify function to machine the part on the screen.

ALL DIMENSIONS IN INCHES





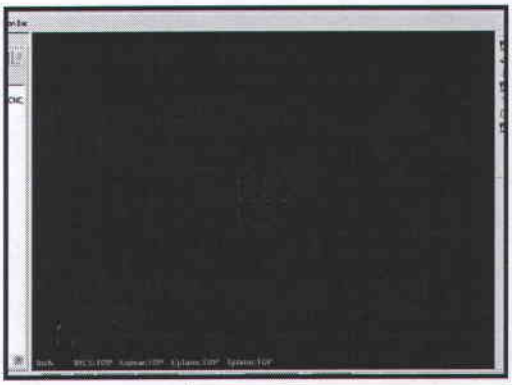
TITLE	TUTORIAL 12
MATERIAL	ALUMINUM T6061
DATE: Oct 20, 2004	eMastercam.com

GEOMETRY CREATION

To start a new file from Mastercam:

File
➢ **New**

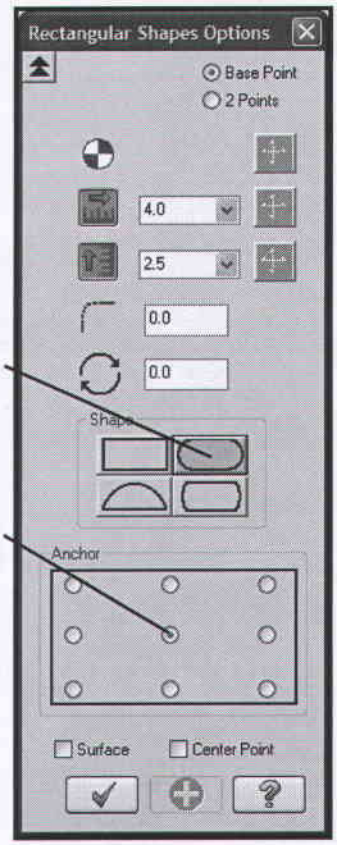
- Before starting the geometry creation we should customize the toolbars to see the toolbars required to create the geometry and machine a 3D part. See **Getting started** page A-5 in the **User Notes**.
- **Toolpaths/Solids manager** to the left of the screen can be hidden to gain more space in the graphic area for design. Press **Alt + O** to remove it.
- Before starting the geometry make sure that the **Grid** is enabled. It will show you at each moment where the part origin is. See **Getting started** page **A-5** for details.



STEP 1:
CREATE THE OBROUND SHAPE.

1.1 Create the obround shape.

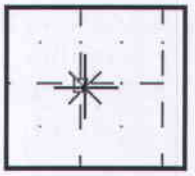
Create
➢ **Create Rectangular Shapes**
➢ Type the **Width** and the **Height** as shown in the following screenshot.
➢ Select the **Obround shape** and the middle radio button as the anchor.



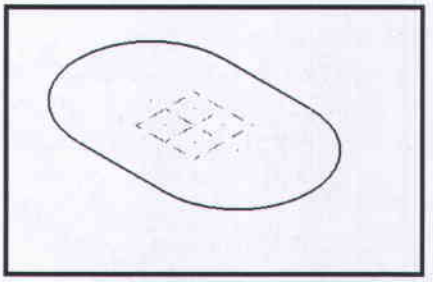
Select Obround shape

Select this radio button

- [Select position for the base point]: Select the center location of the grid (the origin).
- Select the **OK** button to exit the rectangle dialog box.

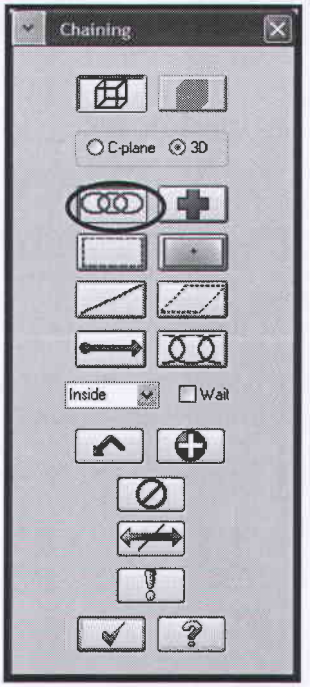


- Change the graphic view to **Isometric**. 

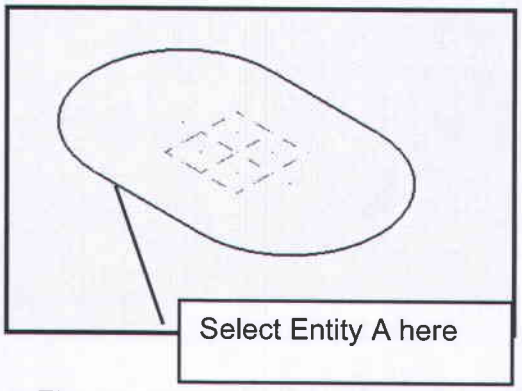


- During the geometry creation of this tutorial, if you make a mistake, you can undo the last step using the **Undo** icon. You can undo as many steps as needed.
- If you delete or undo a step by mistake, just use the **Redo** icon.

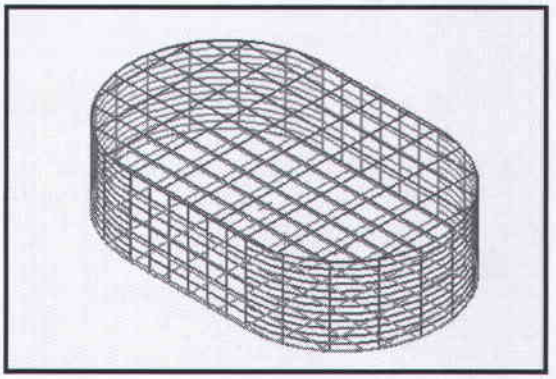
STEP 2:
CREATE THE EXTRUDE SURFACE(S).

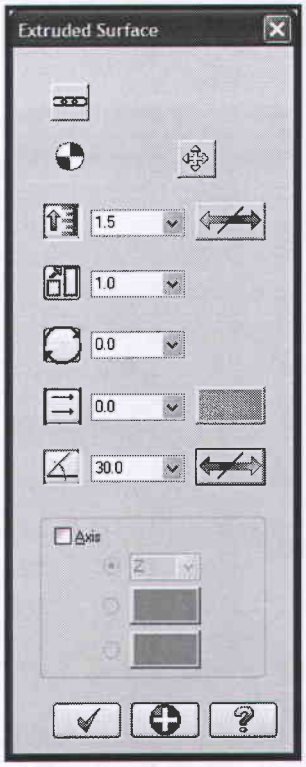


Create
- **Surface**
- **Create Extruded Surface**
- Make sure that **Chain** is selected.
- [Select Chain of Lines and Arcs or one closed spline]: Select Entity A as shown.

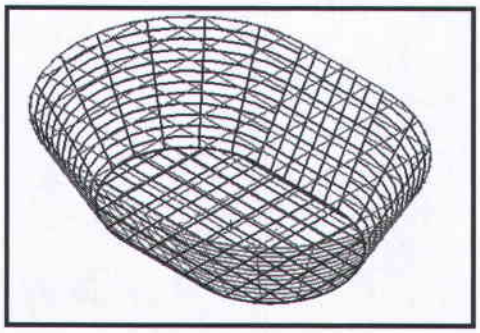


- The geometry should look as shown below.





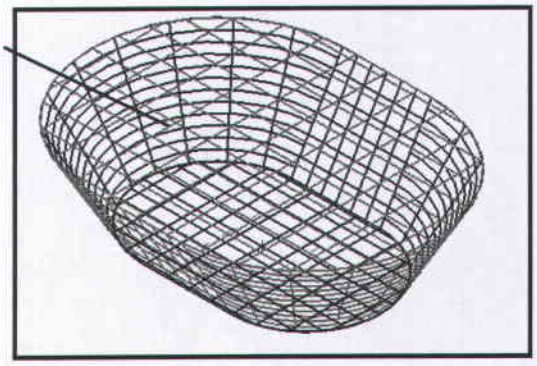
- Enter the **Height** value and press **Enter**.
- Enter the **Angle** value and press **Enter**.
- Select the **Flip Taper Angle** button if necessary for the geometry to look as shown below.



- Select the **OK** button to exit.

STEP 3: DELETE THE TOP EXTRUDE SURFACE.

Delete the top surface

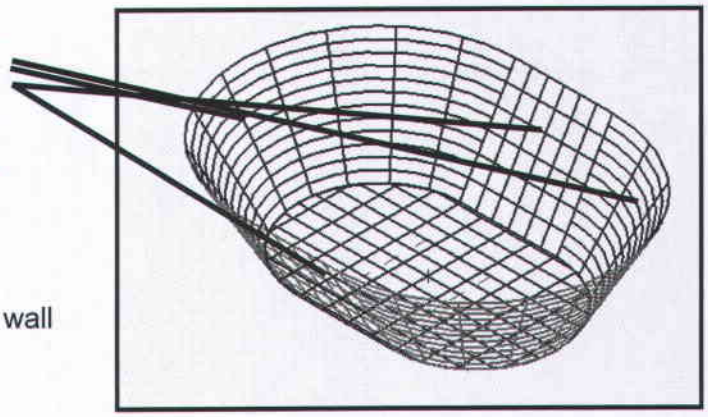


- Select the top surface as shown to the right.
- Select the **Delete** entity icon.

Note that to select a surface, click on one of the flowlines that display the surface.

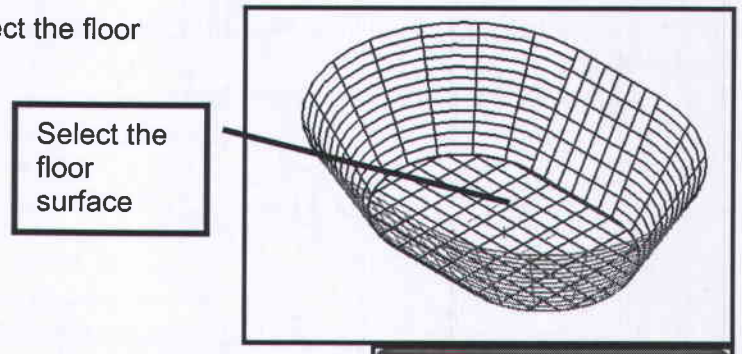
STEP 4: CREATE THE FILLET SURFACE.

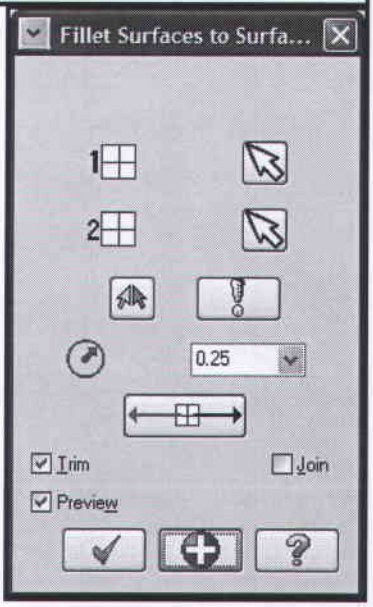
Select the wall surfaces



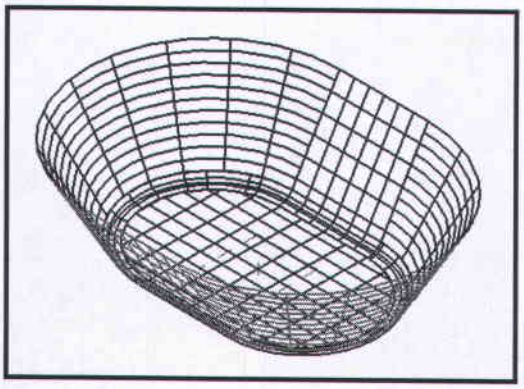
Create
- **Surface**
- **Fillet Surface**
- **Fillet Surfaces to Surfaces**
- [Select first set of surfaces]: Select the wall surfaces as shown.
- Press **Enter** to continue.

➢ [Select second set of surfaces]: Select the floor surface.





➢ Press **Enter** to continue.
➢ Change the parameters as shown in the screenshot to the left.
➢ The part should look as shown below.



➢ Select the **OK** button to exit.

STEP 5:
CREATE THE RECTANGULAR SHAPE.

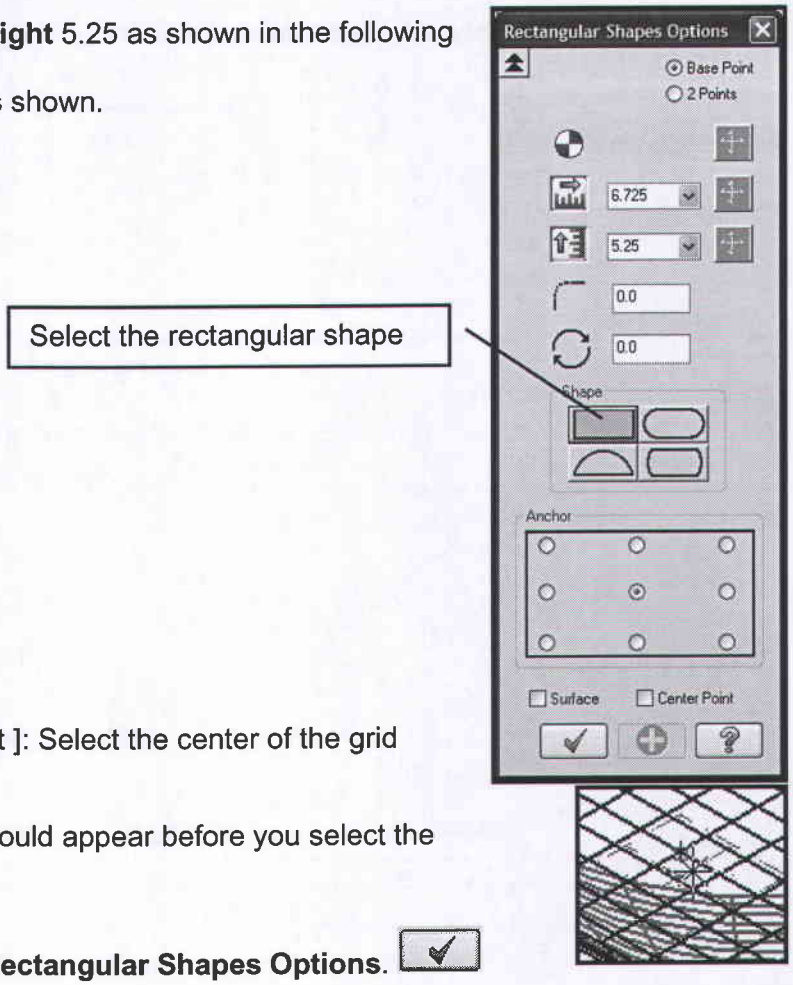
5.1 Change the Z depth of the construction plane, and the plane to 2D.

➢ In the **Z** depth field on the **Status bar**, enter the value -0.2.
➢ Select the toggle button **2D/3D** to change it to **2D**.

5.2 Create the rectangular shape.

Create
➢ **Create Rectangular Shapes**

➢ Type the **Width** 6.725 and the **Height** 5.25 as shown in the following screenshot.
➢ Select the **Rectangular shape** as shown.

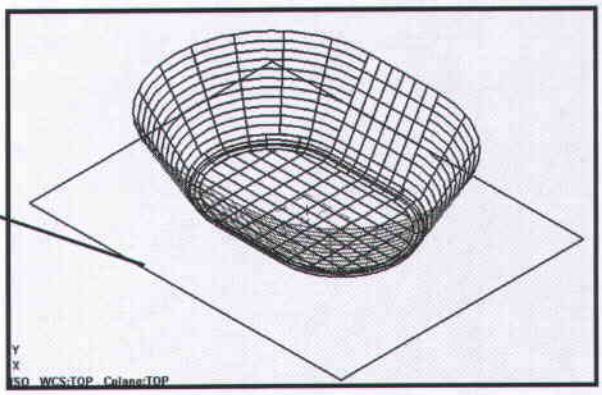


➢ [Select position for the base point]: Select the center of the grid (Origin).
The cursor display for **Origin** should appear before you select the point.

➢ Select the **OK** button to exit the **Rectangular Shapes Options**.

STEP 6:
CREATE THE 3D BOX USING TRANSLATE COMMAND.

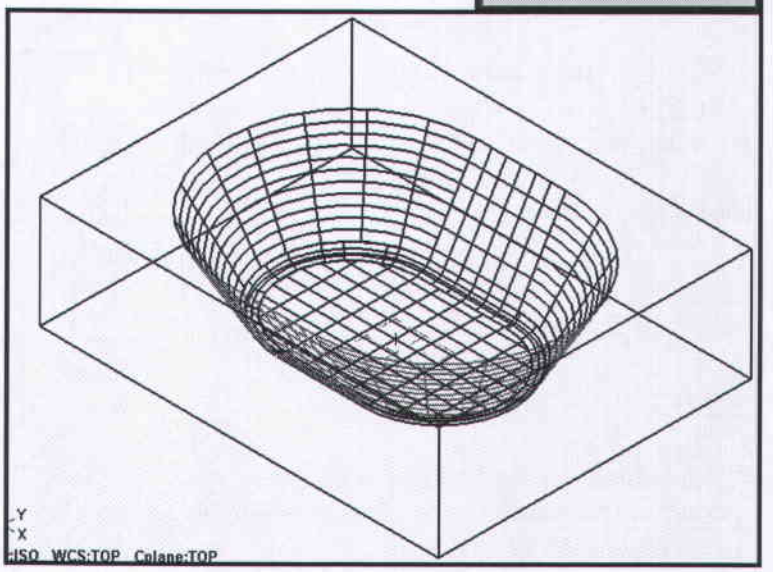
Xform
➢ **Xform Translate**
➢ [Select entities to translate]: Hold down the **Shift** key and select Entity A from the rectangle as shown.



➢ Press **Enter** key.

- Make the changes in the **Translate** dialog box to match the screenshot to the right.
- Make sure that the **Z** value is 1.7 and Join is enabled.
- Select the **OK** button to exit.
- Use the **Fit** icon to fit the drawing to the screen.

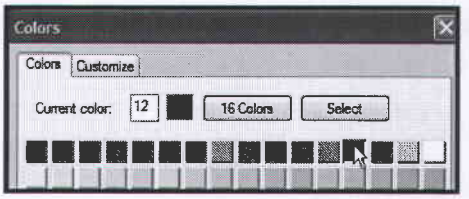
Screen
- **Clear Colors**



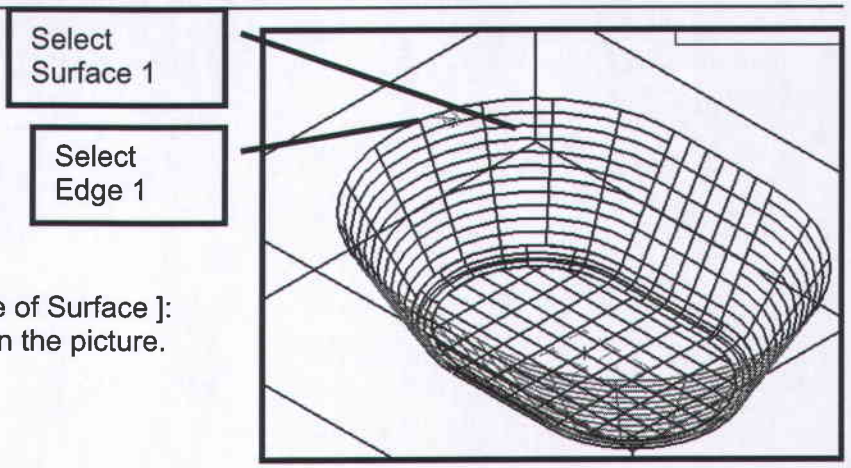
STEP 7: CREATE CURVES ON THE EDGES OF SURFACES.

7.1 Change the color.

- Select **Color** in the **Status bar**.
- Select the color red (**No 12**).
- Select the **OK** button to exit the **Color** dialog box.

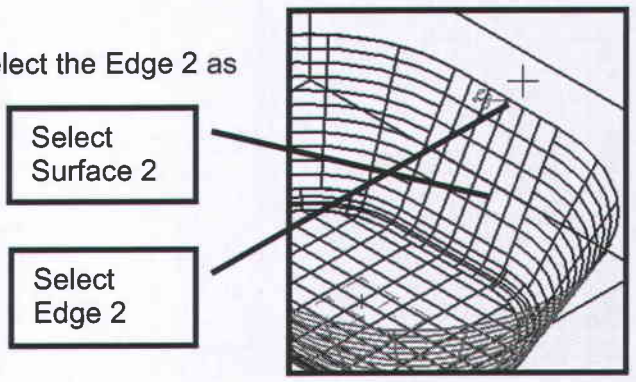


7.2 Create curves.

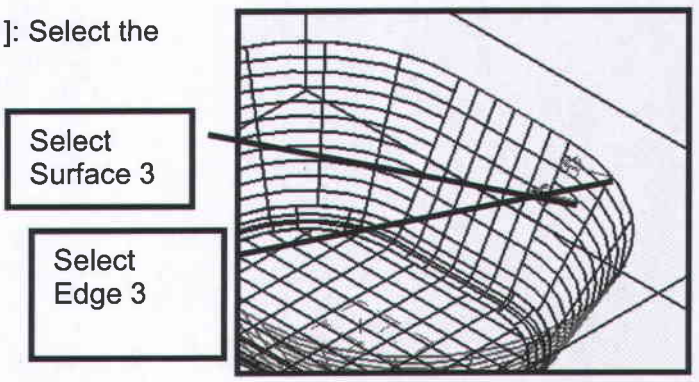


Create
- **Curve**
- **Create Curve on One Edge**
- [Select a surface]: Select Surface1.
- [Move arrow to Desired Edge of Surface]: Select the Edge 1 as shown in the picture.
- Press Enter.

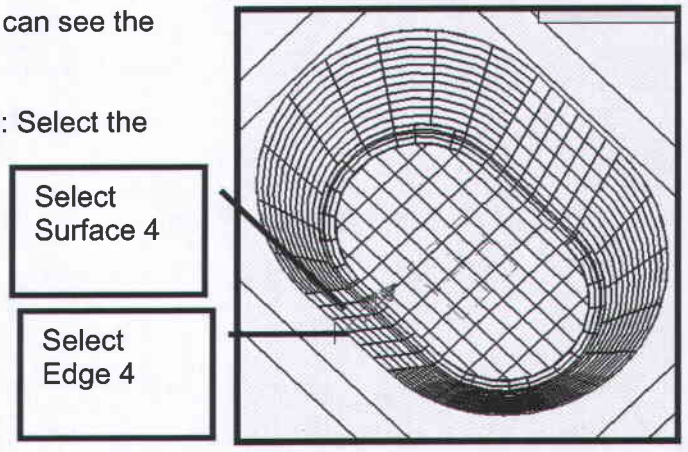
- [Select a surface]: Select Surface 2.
- [Move arrow to Desired Edge of Surface]: Select the Edge 2 as shown in the picture.
- Press Enter.



- [Set options, select a new surface]: Select Surface 3.
- [Move arrow to Desired Edge of Surface]: Select the Edge 3 as shown in the picture.
- Press Enter.



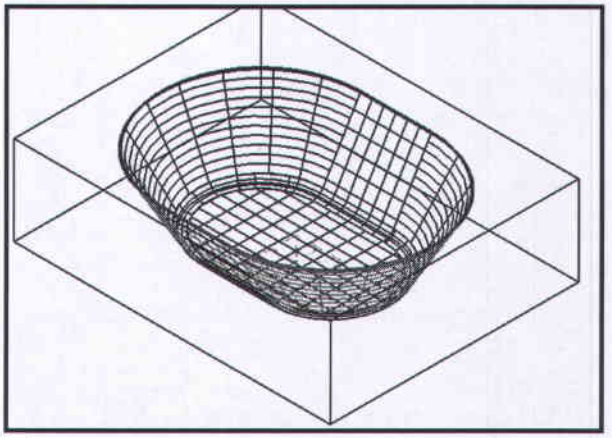
- Hold down the **Alt** key and select the down arrow cursor several times until you can see the part as shown below.
- [Select a surface]: Select Surface 4.
- [Move arrow to Desired Edge of Surface]: Select the Edge 4 as shown in the picture.



- Select the **OK** button to exit the command.

➢ Repaint the screen to see the red contour at the top of the surfaces. 

➢ Select the **Isometric View** icon. 
➢ The part should look as shown to the right.



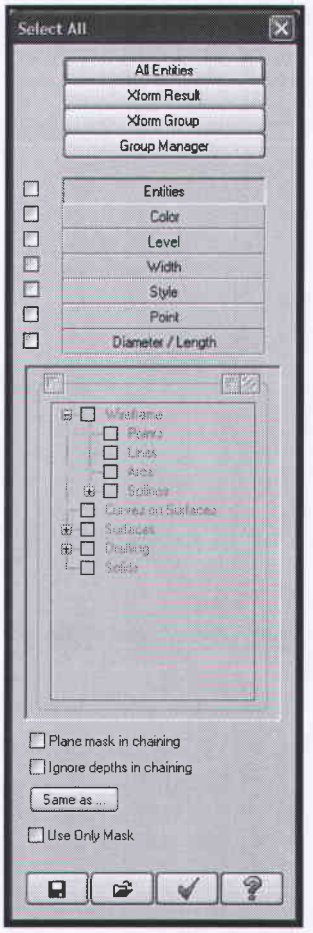
STEP 8:
TRANSLATE - SET UP THE DATUM (WORK ZERO).

We want to have Z0 at the top of the part rather than at the top of the stock.

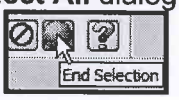
Xform

➢ **Xform Translate**

➢ Select the **All** button. 



➢ Select the **OK** button to exit the **Select All** dialog box. 

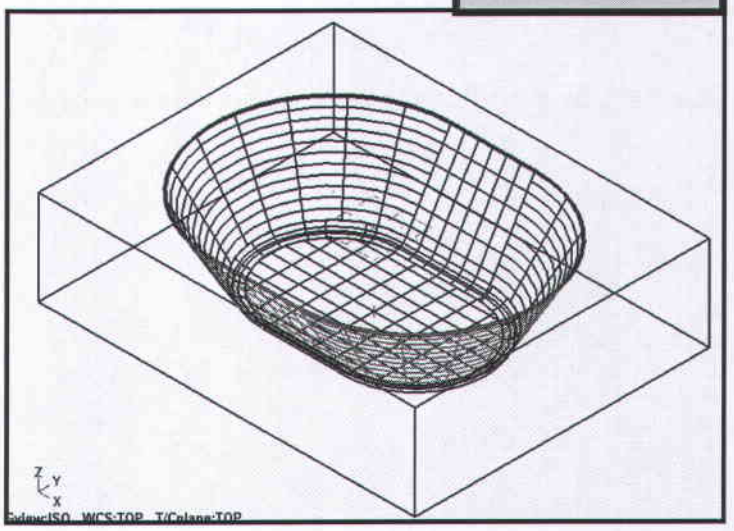
➢ Click on the **End Selection** button. 

- Make the changes in the **Translate** dialog box to match the screenshot to the right.
- Make sure that the **Z** value is **-1.5** and **Move** is enabled.
-
- Enable **Preview** and **Fit** options.

- Select the **OK** button to exit. 

Screen

- **Clear Colors**



STEP 9:
SAVE THE FILE.

File

- **Save as**
- **File name**: "Your Name_12"
- Select the **OK** button. 

TOOLPATH CREATION
STEP 10:
SET UP THE STOCK TO BE MACHINED.

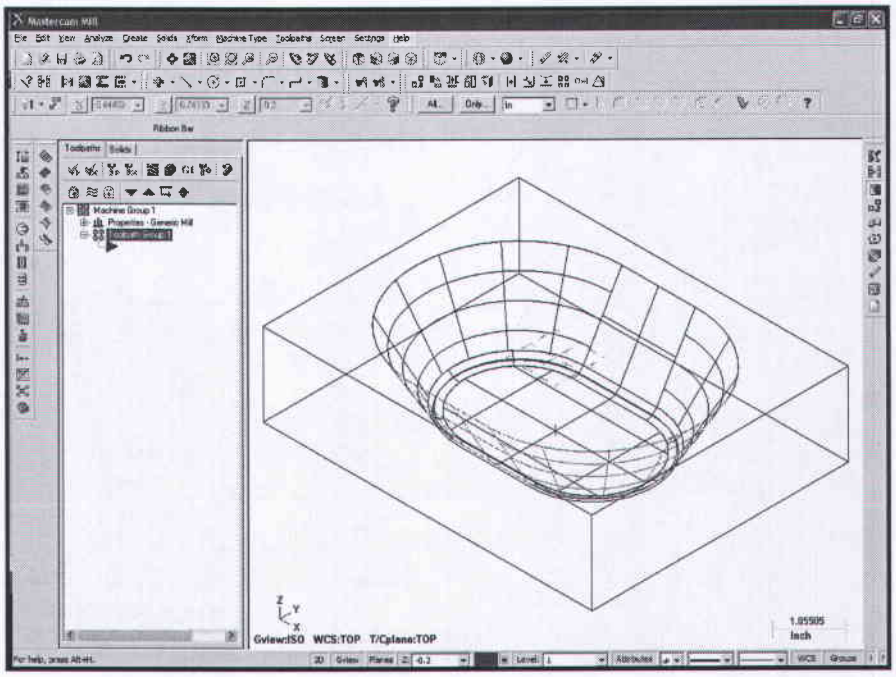
➢ To display the **Toolpaths Manager** press **Alt + O**.

Make sure that no machine is already selected.

Machine Type

➢ **Mill**

➢ Select **Default**.

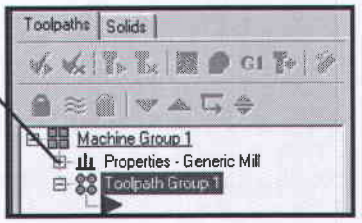


➢ Use the **Fit** icon to fit the drawing to the screen.

➢ Select the toggle button **2D/3D** to change it to **3D**.

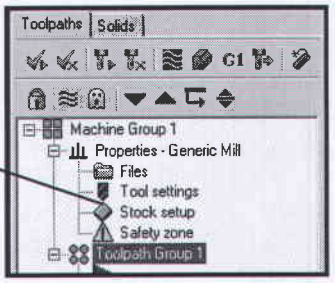
➢ Select the plus in front of **Properties** to expand the **Toolpaths Group Properties**.

Select the plus

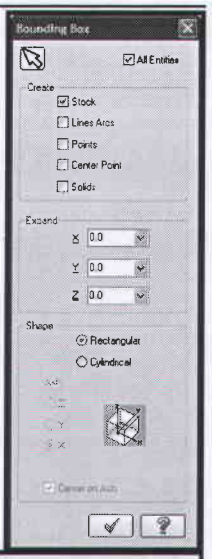


➢ Select **Stock setup**.

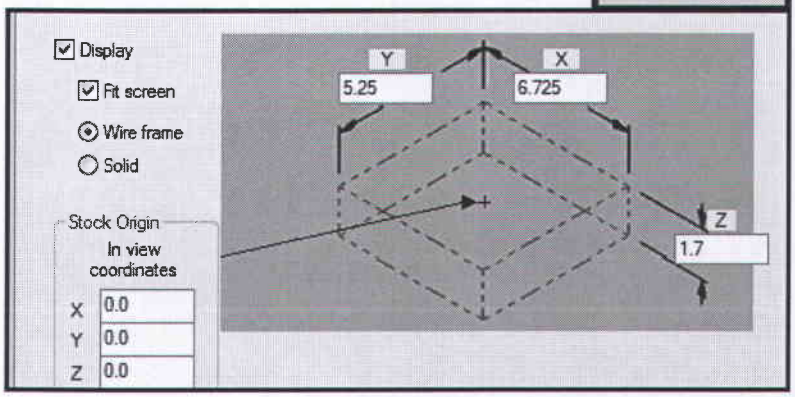
Select the Stock



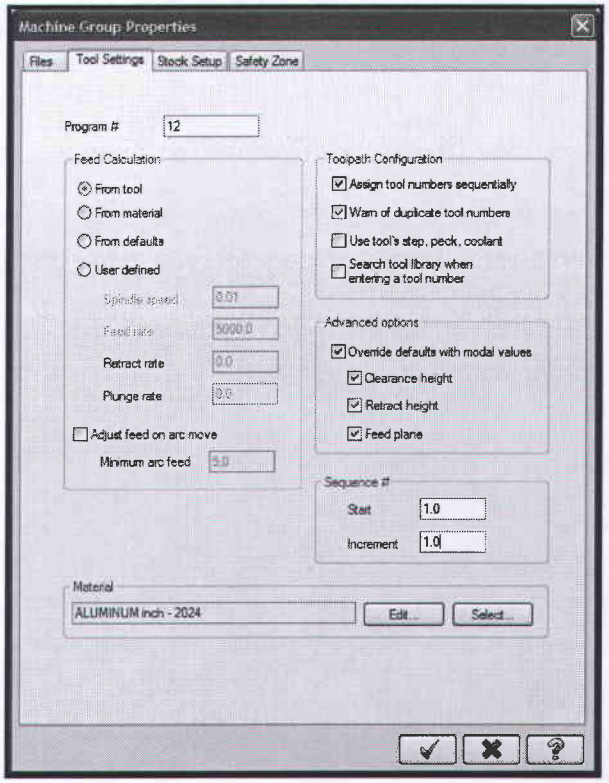
- Change the parameters to match the following screenshot.
- Select the **Bounding box** button to automatically find the part extents.



- Select the **OK** button to exit the **Bounding box** dialog box.



- Select the **Tool Settings** tab to set the tool parameters.
- Change the parameters to match the screenshot to the right.



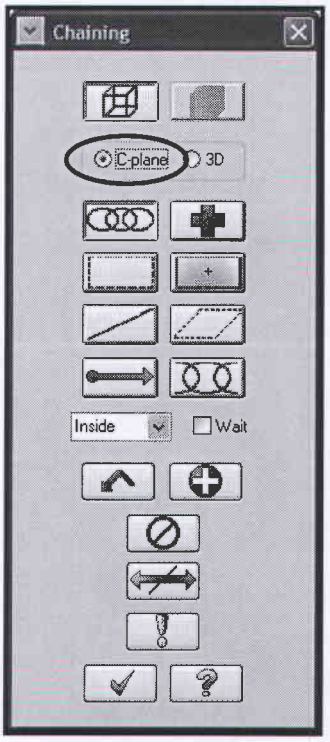
- Select the **OK** button to exit **Toolpath Group Properties**.

STEP 11:
ROUGH OUT THE SURFACE USING SURFACE ROUGH PLUNGE.

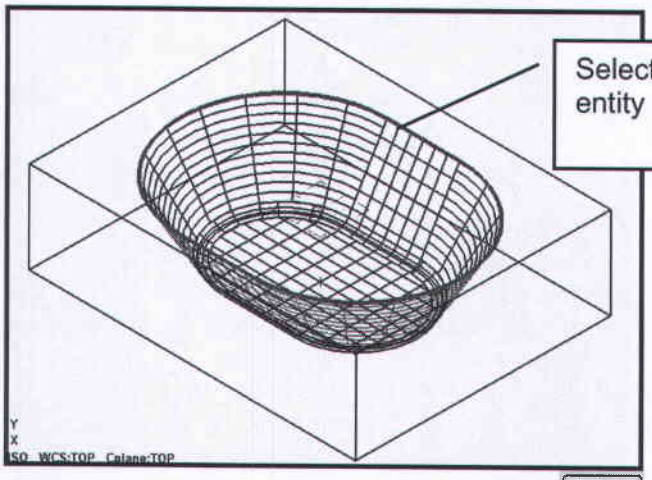
Plunge Rough toolpaths machine surfaces quickly with a drilling-type motion. You require a special tool capable of cutting with the center of the tool. This toolpath can be applied on both simple cavities and simple boss parts. The rough part surfaces can be improved by using a 2D pocket NCI file to provide a pattern for the plunge path.

11.1 Create the 2d pocket to provide the pattern for the plunge toolpath.

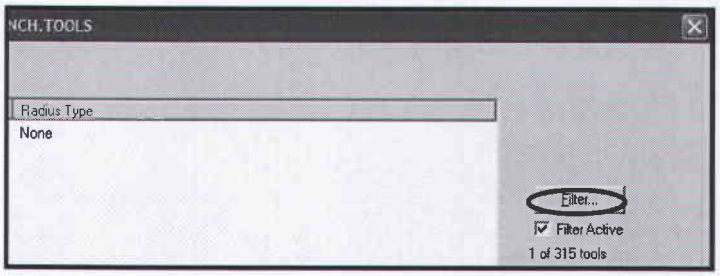
Toolpaths
➢ **Pocket Toolpath**



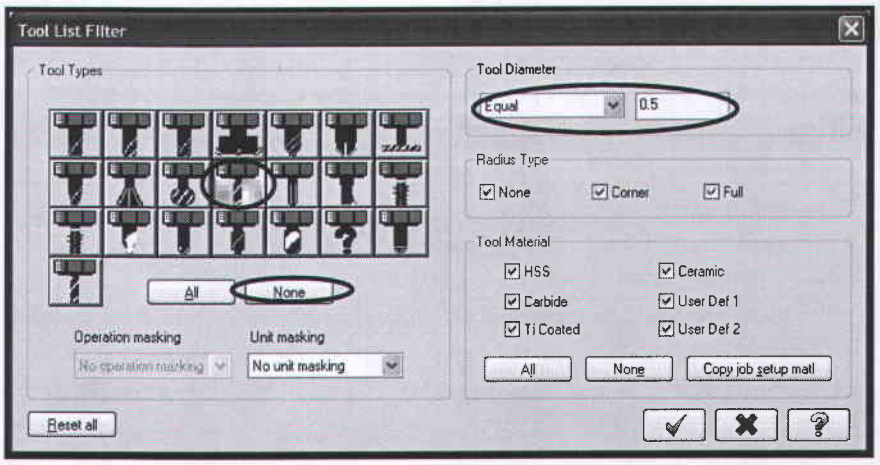
➢ Select the **OK** button to accept the NC name.
➢ Select the radio button in front of the **C-plane**.
➢ Enable **Chain** options.
➢ Select one entity of the pocket chain, as shown.



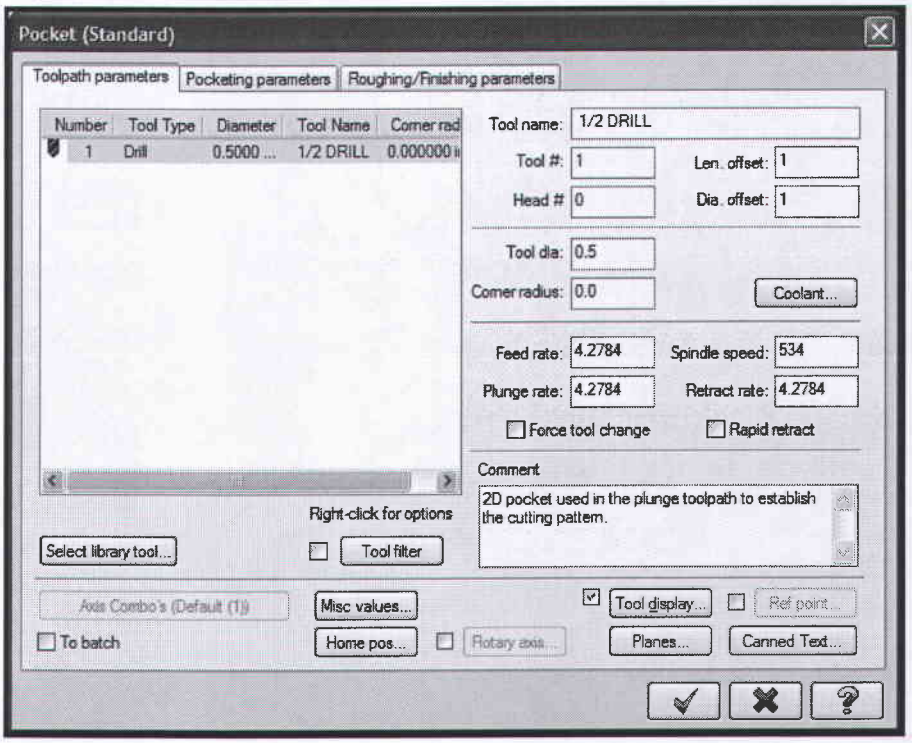
➢ Select the **OK** button to exit **Chaining**.
➢ Click on the **Select library tool** button to select 1/2 Drill .
➢ Select the **Filter** button in the **Tool Selection** dialog box.



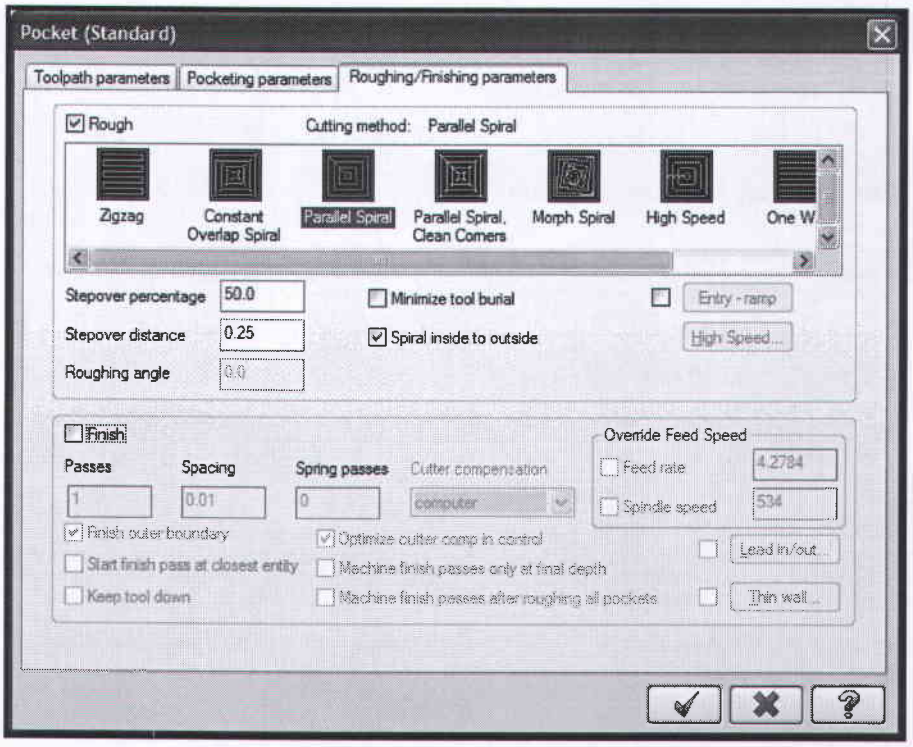
- Select the **None** button in the **Tool Types** area.
- Click on the **Drill** icon to select it.
- Select the **drop-down arrow** in the **Tool Diameter** field, and select **Equal**.
- Enter the diameter 0.5.
- Select the **OK** button to exit. 



- Make sure the tool is selected and select the **OK** button to exit the **Tool Selection** dialog box. 



➢ Select the **Roughing/Finishing parameters** and make all the necessary changes as shown below to establish the pattern.

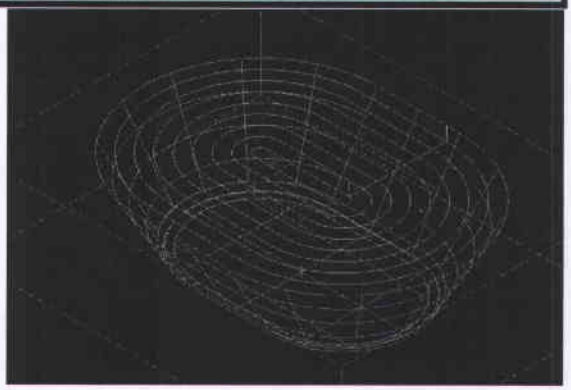


➢ Select the **Parallel Spiral** as the **Cutting method**.

➢ Disable the **Finish** area.

➢ Select the **OK** button to exit **Pocket parameters**.

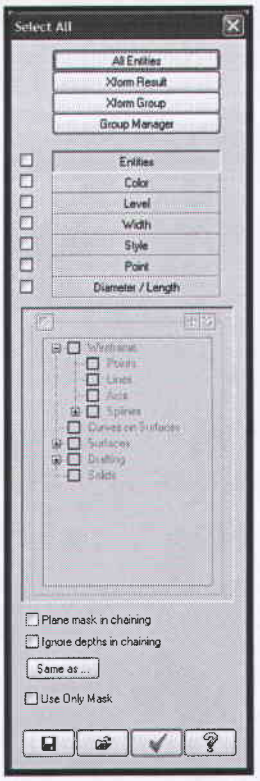
Stepover percentage sets the distance between roughing passes in the XY axis as a percentage of the tool diameter and it will automatically update the stepover distance.
Spiral inside to outside enabled allows you to spiral from the center to the pocket wall.
Entry-ramp sets a ramp entry into the part.
Finish area enabled allows the tool to make another cut around the pocket walls to "contour" the walls. Used when zig-zag or one way was selected as cutting method, to remove the scallops left by these cutting methods. Can be also used to finish only the pocket walls.



11.2 Surface rough plunge.

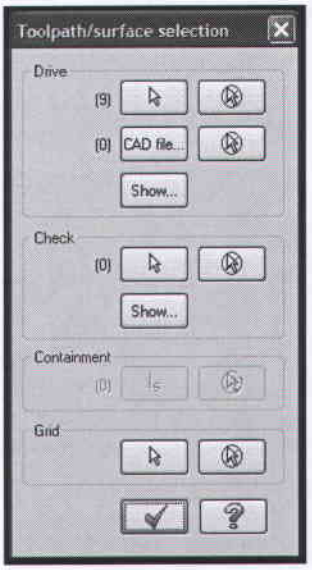
Toolpaths
- **Surface Rough**
- **Rough Plunge Toolpath**
- [Select Drive Surface]: Select the **All** button. 

- Select the **OK** button to exit. 

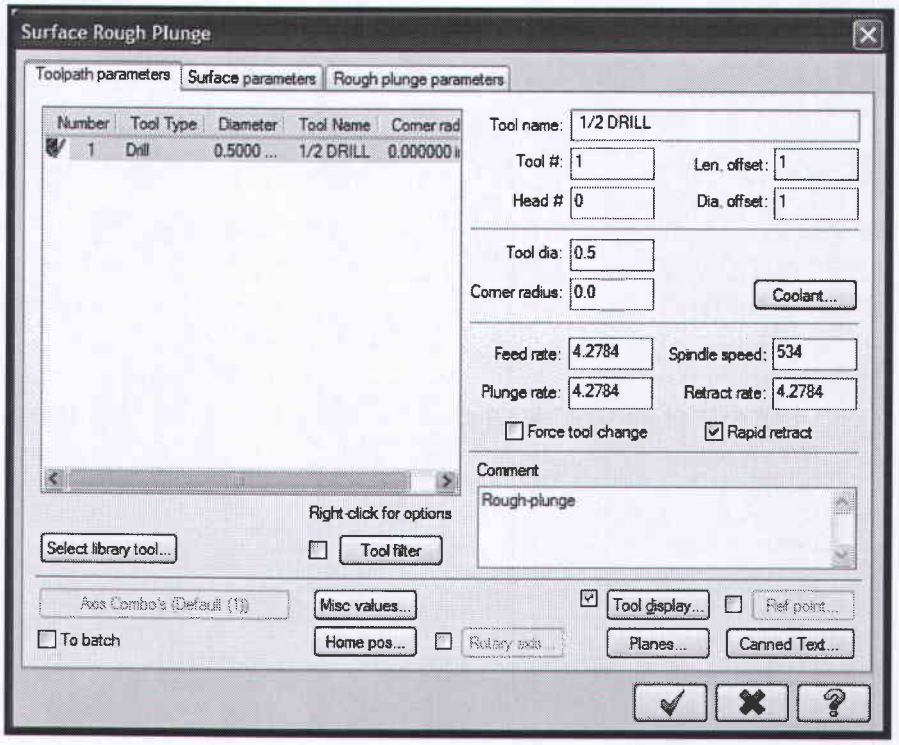


- Select the **End Selection** button. 

- Select the **OK** button to exit **Toolpath/surface selection.** 

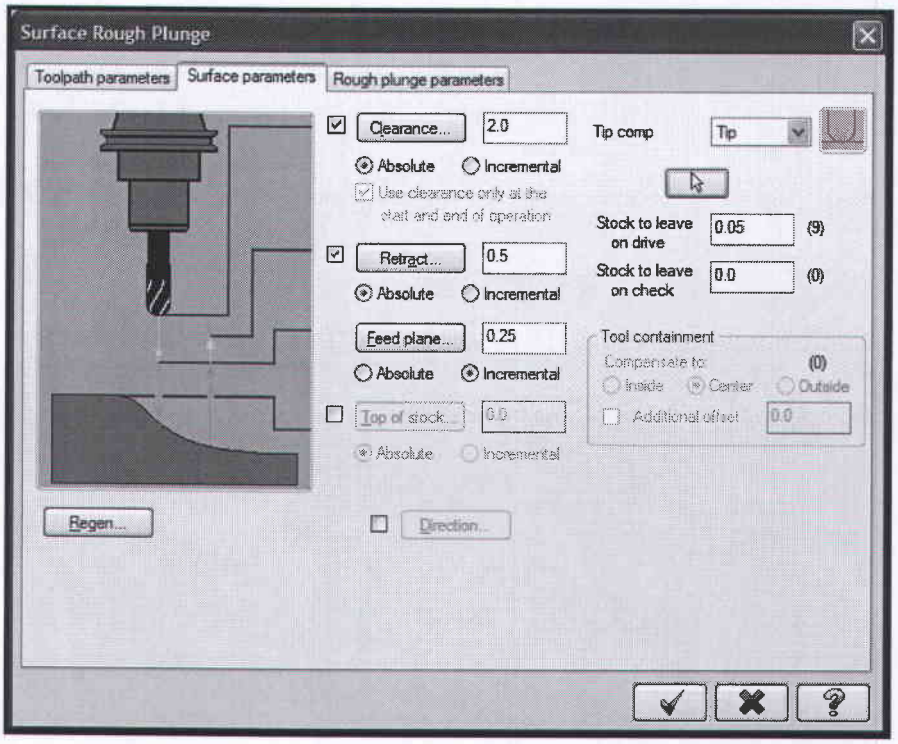


➢ Select the **0.5 Drill** and match the parameters with the following screenshot.



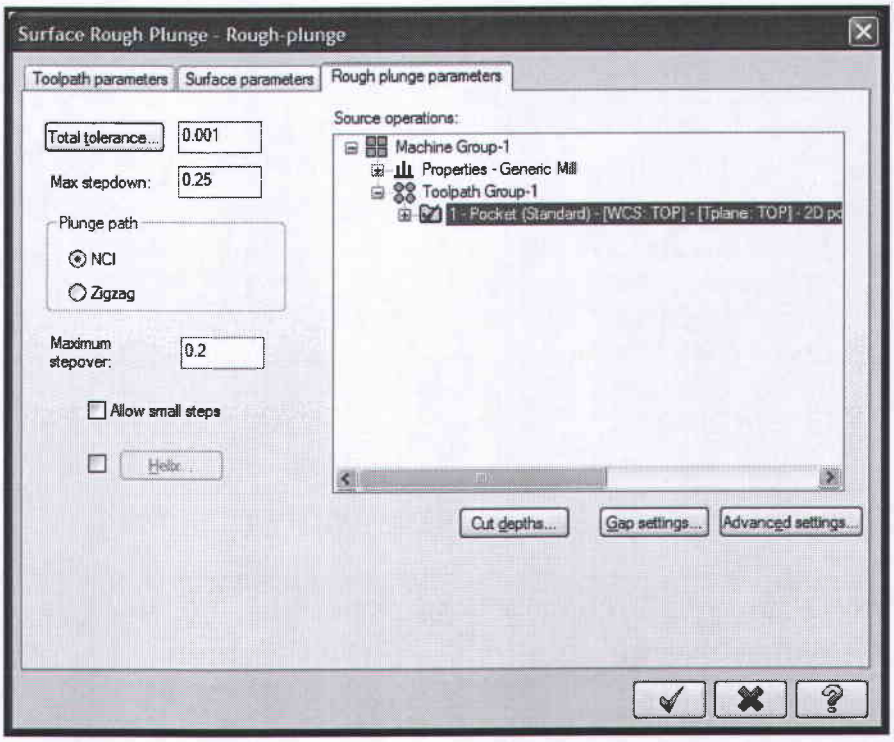
- The **Feed rate**, **Plunge rate**, **Retract rate** and **Spindle speed** are based on the tool definition. Change them as desired.

➢ Select the **Surface parameters** tab and make the changes as shown.

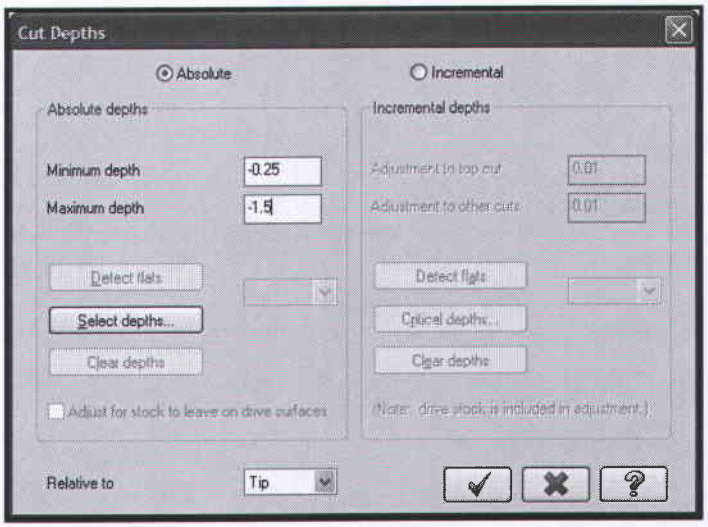


- Select the **Rough plunge parameters** page and make the changes to match the following screenshot.
- Make sure that you select **Plunge path NCI** and that you have the **Pocket** selected in the **Source operations**.

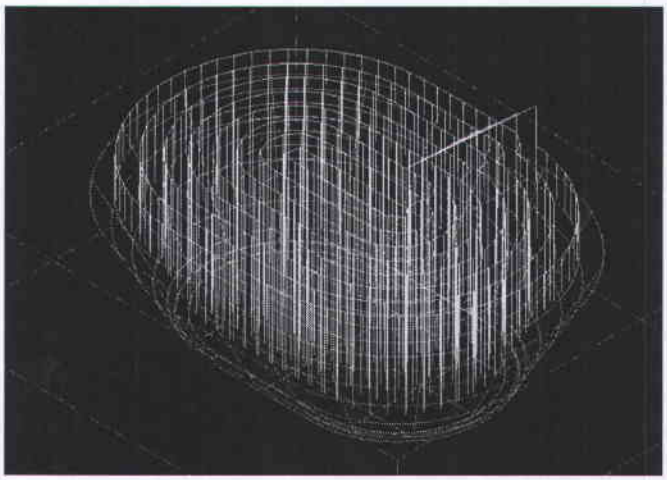
Total tolerance is the sum of the arc filter tolerance and cut tolerance. The cut tolerance determines the accuracy of the surface toolpath using chordal deviation. **Maximum stepdown** value sets maximum distance (along the Z-axis) between adjacent cuts in the surface toolpath. **Maximum stepover** value sets maximum distance (in the XY plane) between adjacent passes in the surface toolpath.



- Select the **Cut depths** button and change the settings to absolute measurements as shown below.

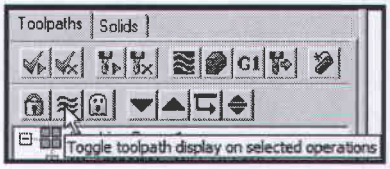


➢ Select the **OK** button twice to exit.



STEP 12: FINISH THE SURFACE USING SURFACE FINISH CONTOUR AND SHALLOW.

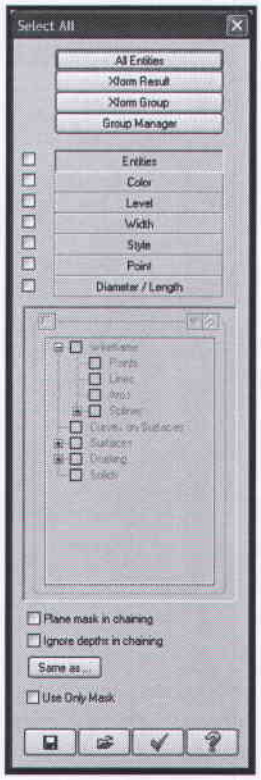
➢ Select the **Toolpaths Manager** tab to enable it.
➢ Select the **Select all visible operations** button.



➢ Select **Toggle toolpath display on selected operations** to remove the toolpaths display from the screen.

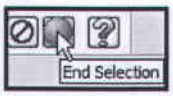
12.1 Surface Finish Contour toolpath

Toolpaths
➢ **Surface Finish**
➢ **Finish Contour Toolpath**

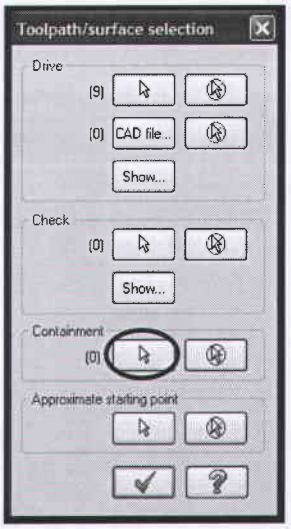


➢ [Select Drive Surface]: Select the **All** button.

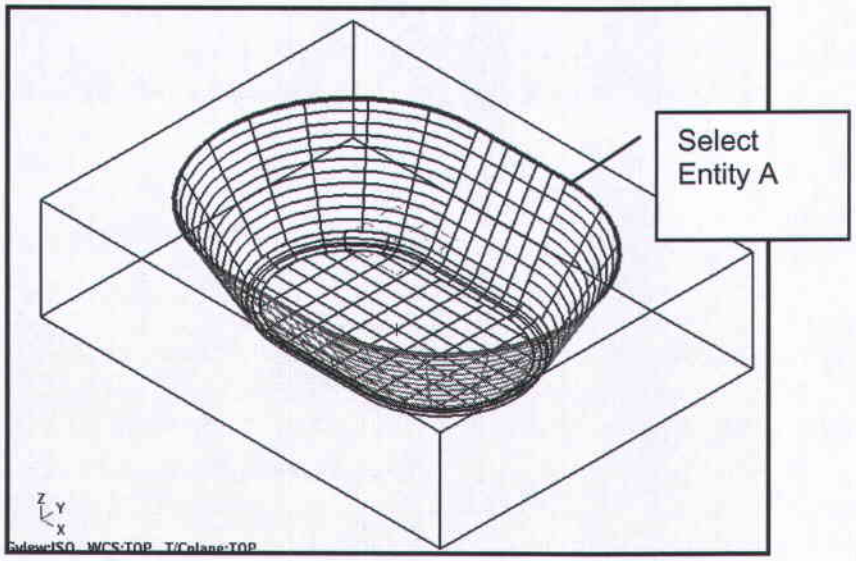
➢ Select the **OK** button to exit.

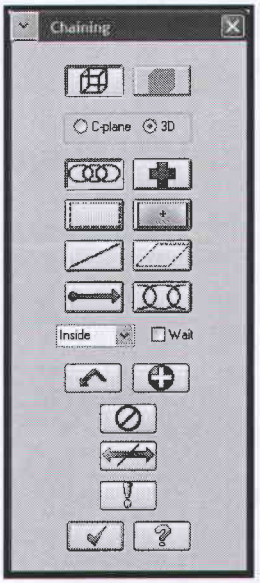


- Select the **End Selection** button.
- Select the **Containment** button.



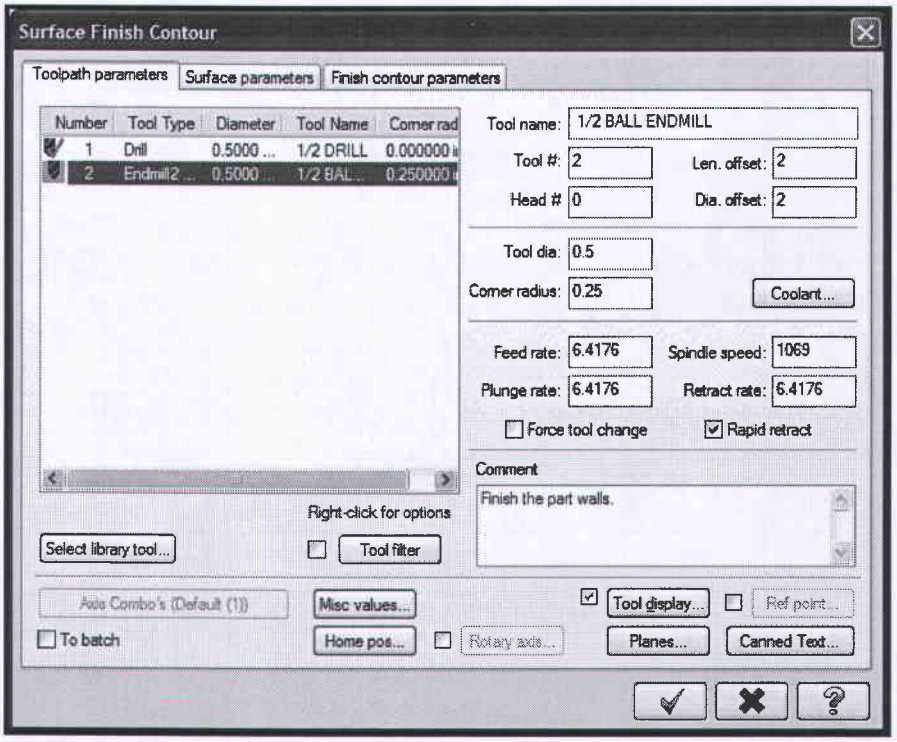
- [Chain 2D tool containment boundary #1]: Select Entity A.

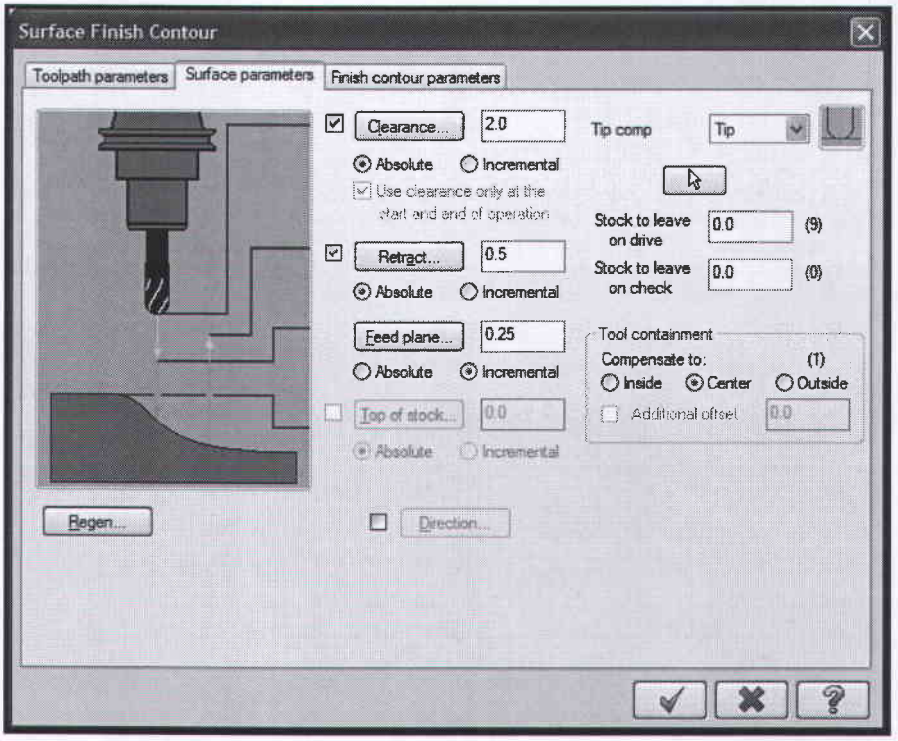




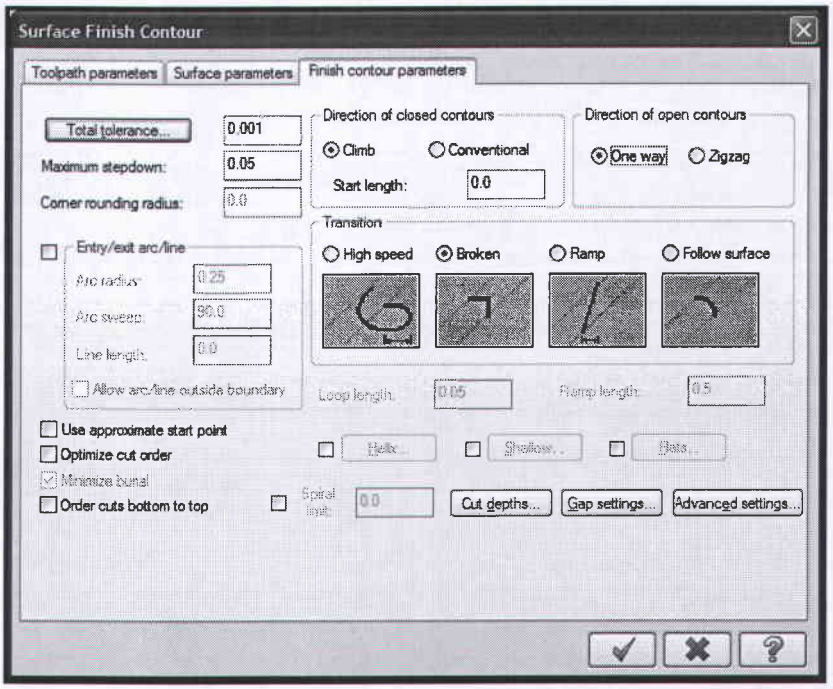
- Select the **OK** button twice to exit the **Toolpath/surface selection** dialog box.
- Click on the **Select library tool** button and use **Filter** to select 1/2 Ball Endmill.

➢ Make any necessary changes as shown in the following screenshots.

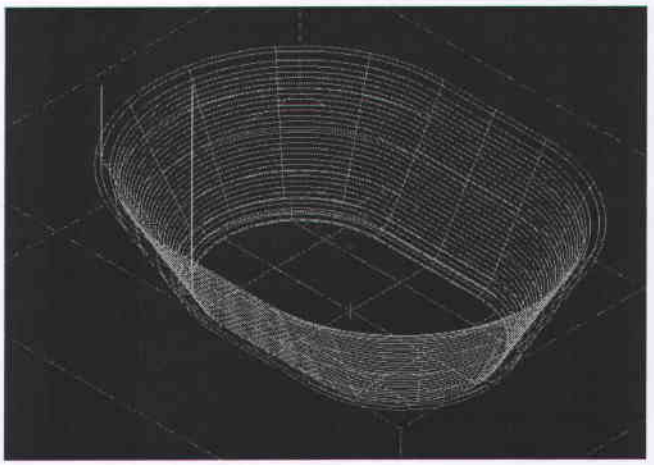




➢ Select **Finish contour parameters** and make the necessary changes.



➢ Select the **OK** button to exit **Finish contour parameters**.



Note the Finish Contour toolpath doesn't touch the flat surface. Contour rough and finish toolpaths perform multiple cuts at constant Z levels. Both toolpaths are recommended for parts with steep walls. To machine the flat area we are going to use a shallow surface toolpath.

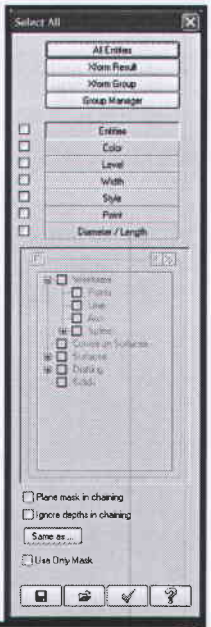
12.2 Surface Finish Shallow toolpath.

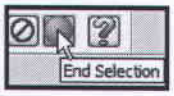
Shallow finish toolpaths clean remaining stock from shallow areas of the part. The shallow areas are determined by the slope of the surfaces. A shallow finish toolpath is often performed after a contour finish toolpath.

Toolpaths
➢ **Surface Finish**
➢ **Finish Shallow Toolpath**

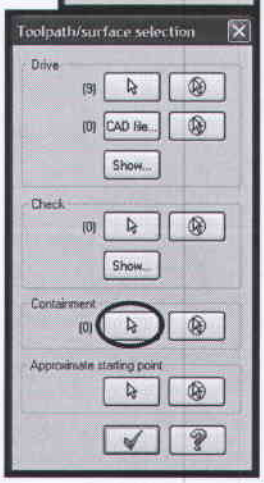
➢ [Select Drive Surface]: Select the **All** button. 

➢ Select the **OK** button to exit. 

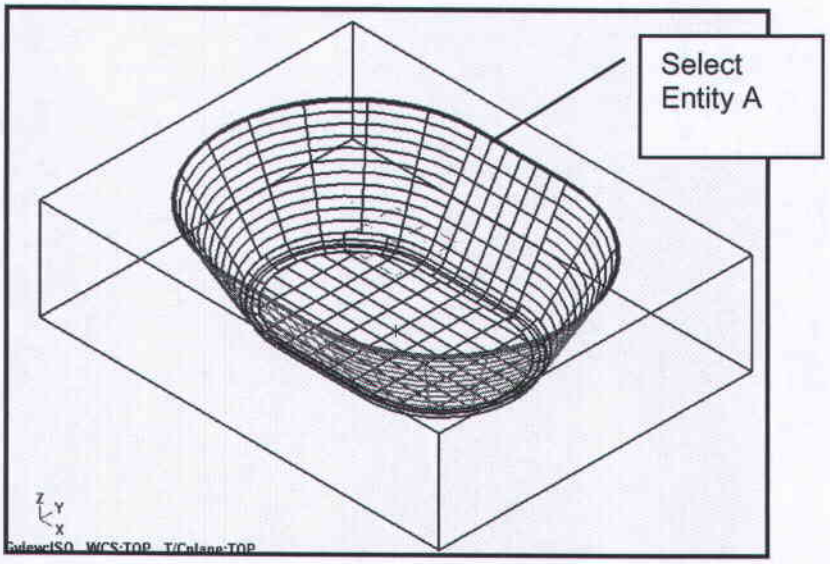


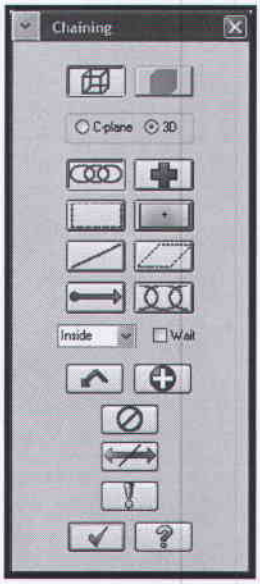
➢ Select the **End Selection** button. 

➢ Select the **Containment** button.

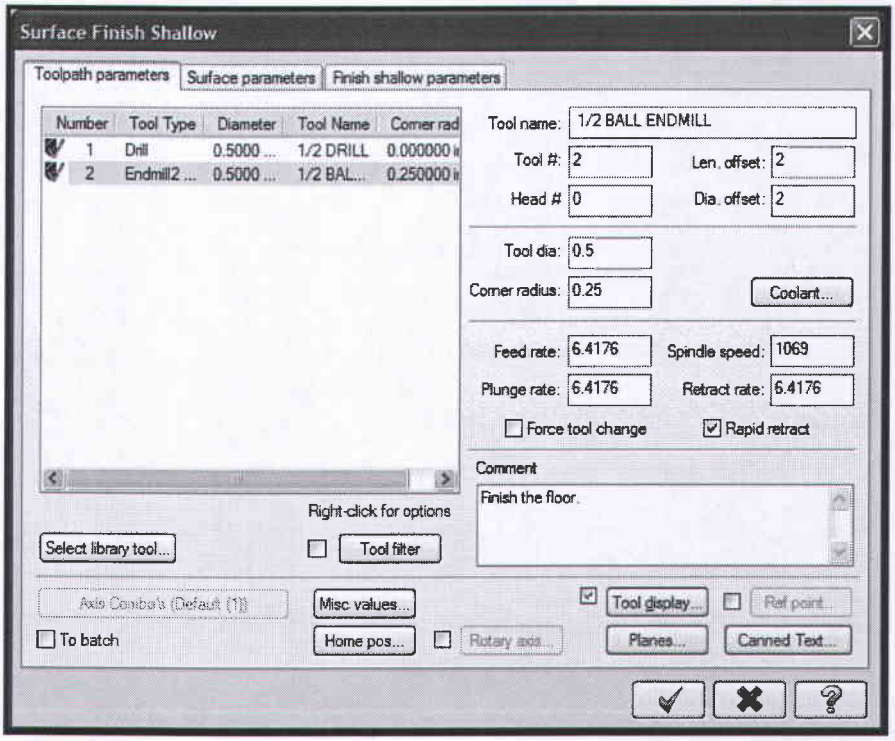


➢ [Chain 2D tool containment boundary #1]: Select Entity A.

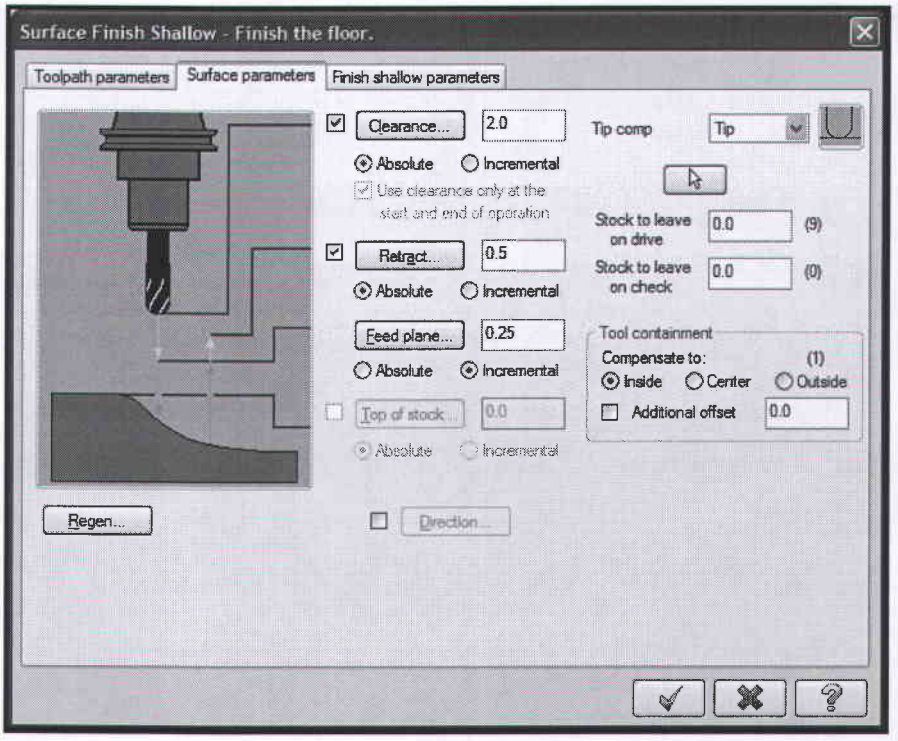




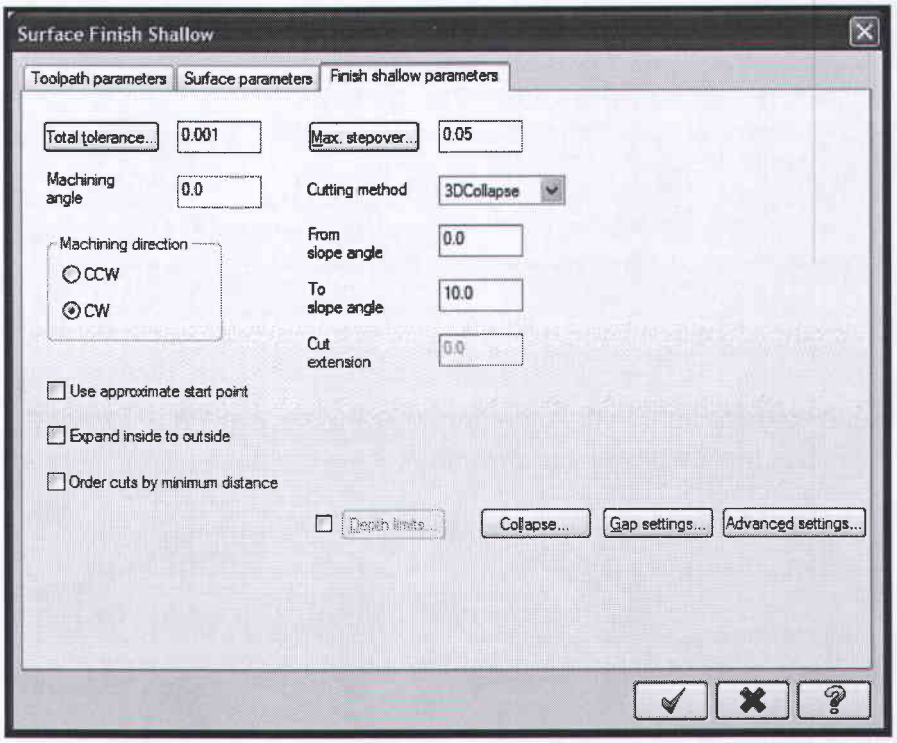
➢ Select the **OK** button twice exit **Toolpath/surface selection.**
➢ Select the 0.5 Ball Endmill and make the changes as shown in the following screenshots.



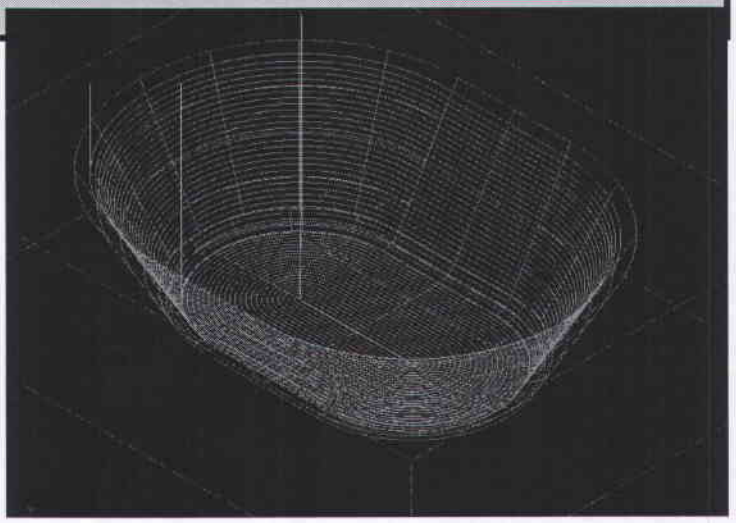
➢ Select **Surface parameters** and change the **Tool containment** to **Inside.**



➢ Select the **Finish shallow** parameters and make the changes to match the following screenshot.



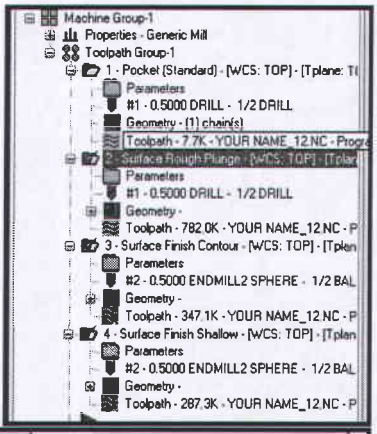
Machining direction allows you to choose between CW or CCW. It is available only with 3D Collapse as the cutting method.
From slope angle allows you to set the minimum angle to calculate the area to be machined.
To slope angle allows you to set the maximum angle to calculate the area to be machined.

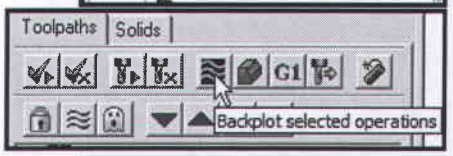


➢ Select the **OK** button to exit.

STEP 13:
BACKPLOT THE TOOLPATH.

- Enable **Toolpath Manager** by selecting the tab.
- Click on the **Surface Rough Plunge** toolpath.
- Holding down the **Shift** key select the **Surface Finish Shallow** toolpath.

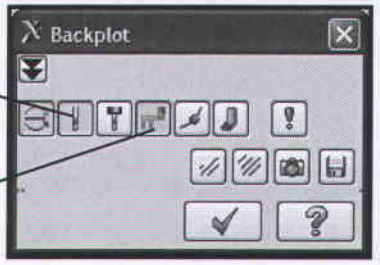




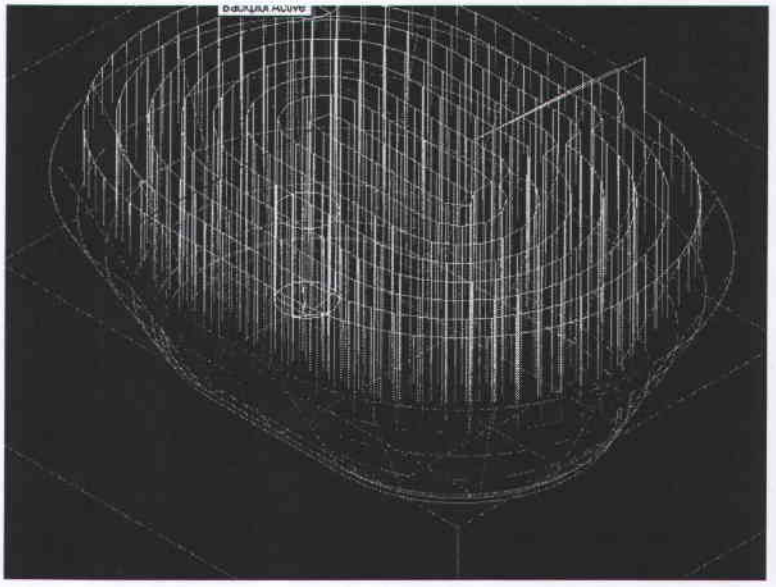
- Select the **Backplot** selected operations button.

- Make sure that you have the following buttons turned on (they will appear pushed down).

- **Display tool**
- **Display rapid moves**



- Select the **Play** button



- Select the **OK** button to exit **Backplot**. 

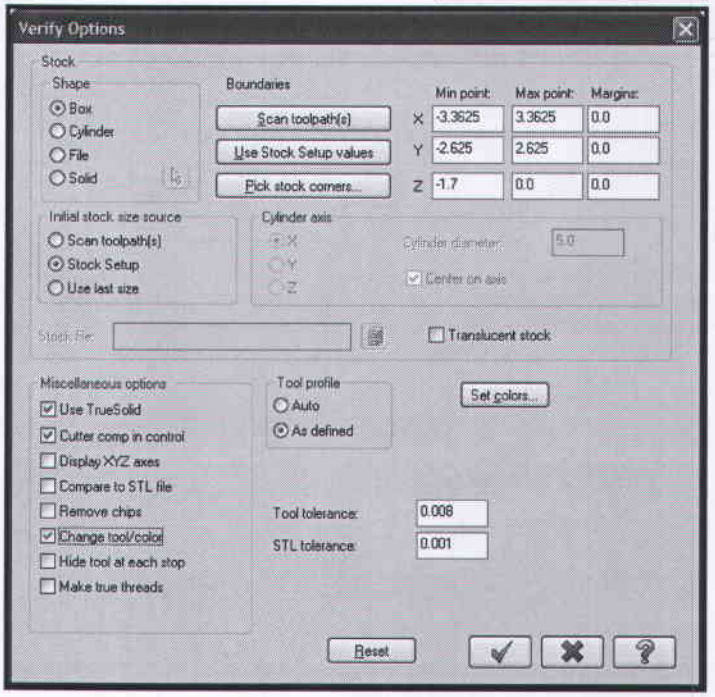
VERIFY-TOOLPATH VERIFICATION

STEP 14: VERIFY.

➢ Expand the **Toolpaths Manager** if necessary by dragging the right side.

➢ Select the **Verify all selected operations** button

➢ Select the **Configure** button. 



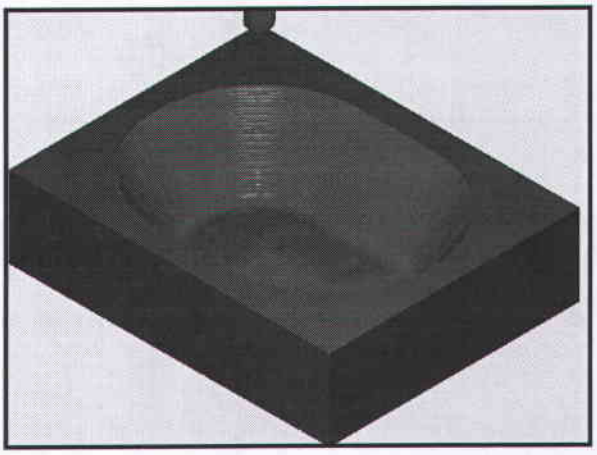
Initial stock size source should be set to **Job Setup** to use the stock information from Stock Setup.
Use True Solid allows you, after verifying the part, to rotate and magnify it to more closely check features, surface finish, or scallops.**Change tool/color** to change the color of the cut stock to indicated tool changes in the toolpath.

➢ Select the **OK** button to exit **Verify Options**. 

➢ Set the **Verify speed** by moving the slider bar in the speed control bar.

➢ Select the **Machine** button to start simulation.

➢ The finished part should appear as shown in the following picture.



➢ Select the **OK** button to exit **Verify**.

STEP 15:
POST PROCESS THE FILE.

➢ Select the **Post selected operations** button from **Toolpath Manager**.

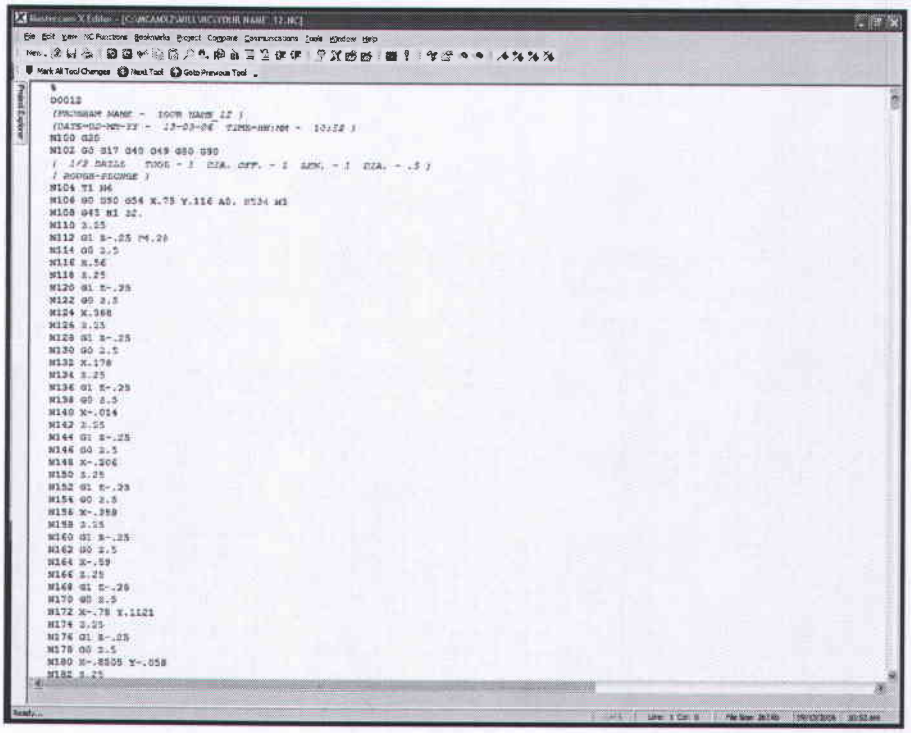
➢ In the **Post processing** window, make all the necessary changes as shown to the right.

➢ Select the **OK** button to continue.

➢ Select the **No** button as we do not want to machine the 2D pocket.

➢ Enter the same name as the geometry name in the NC File name field.

➢ Select the **Save** button.

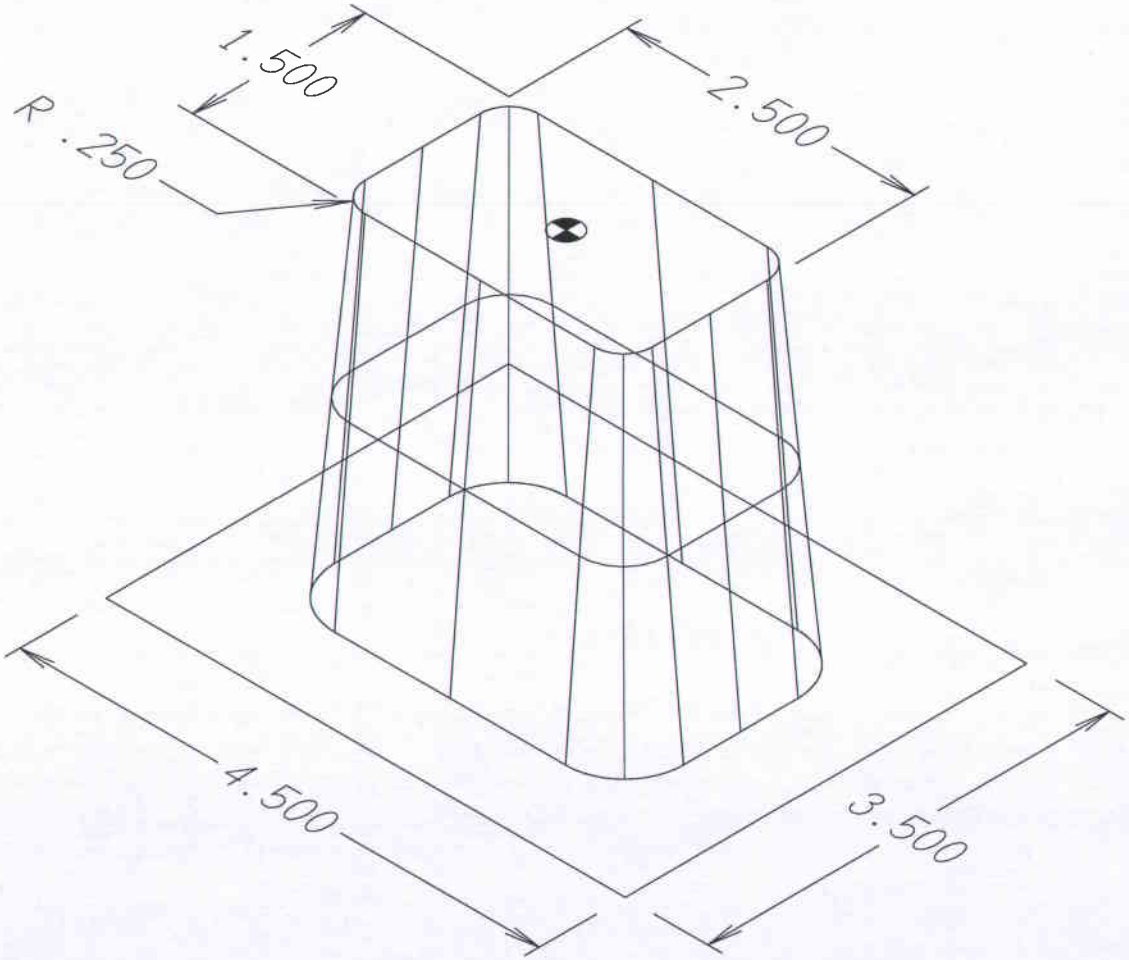


➢ Select the red **X** box at the upper right corner to exit the **Editor**.

STEP 16:
SAVE THE UPDATED MCX FILE.

➢ Select the **Save** icon.

ALL DIMENSIONS IN INCHES

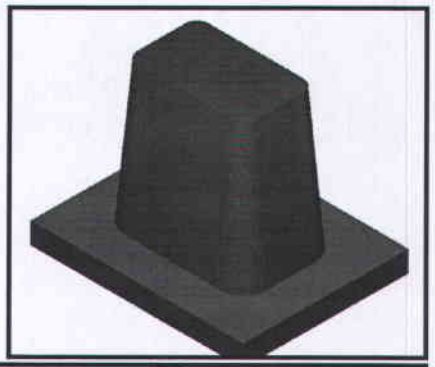


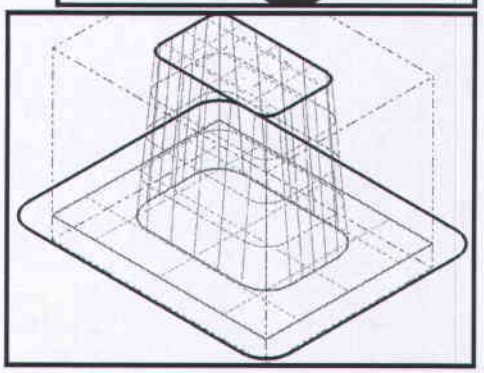
HEIGHT OF SURFACE = 3"
DRAFT ANGLE = 5 DEGREES

TITLE	TUTORIAL 12 - EXERCISE
MATERIAL	STEEL 4140 - 400 BHN
DATE: JUNE 12, 2000	eMastercam.com

REVIEW EXERCISES.

Student practise. Create the Toolpath for Exercise-Tutorial 12 as per the instructions below;

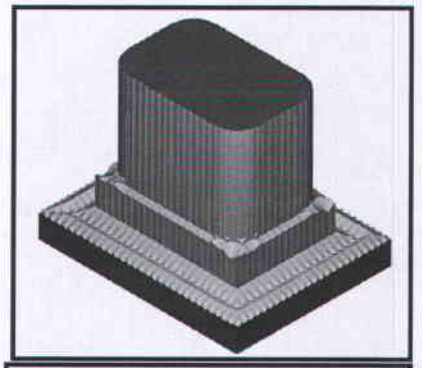




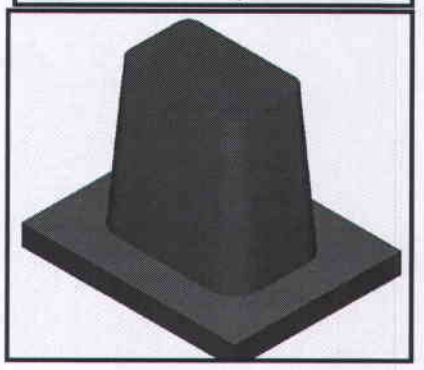
Tips:

1. Establish the **Stock size** Y = 3.5, X = 4.5, Z = 3.5
   Stock origin X = 0, Y = 0, Z = 0.05
2. **Create a rectangle** with surface option at Z-3, the same size as the stock.
3. **Offset** the rectangle (outside) with a **distance** =0.5
4. **2d pocket** toolpath selecting the contours as shown.
   Select the ½ Drill
   XY Stock to leave = .25

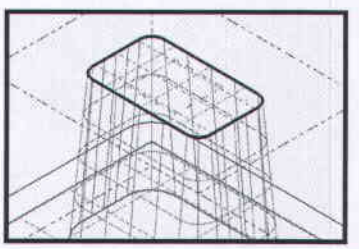
   Select the cutting method Parallel Spiral
   Disable Spiral inside to outside
   Disable Finish outer boundary



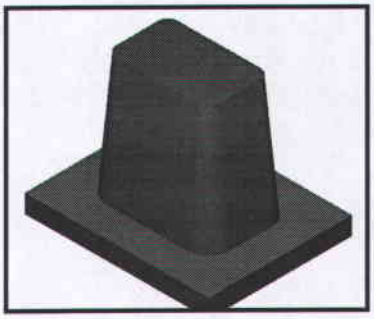
5. **Surface Rough Plunge**
   Use the same tool ½ Drill (edit the drill; Flute = 3.5; Shoulder = 4.0; Overall = 4.5)
   Stock to leave on drive = 0.05
   Total tolerance = 0.01
   Max stepdown =0.25
   Plunge path set to NCI
   Maximum stepover = 0.15
6. **Surface Finish Contour**
   Use 2" Flat Mill
   Stock to leave on drive = 0.0
   Total tolerance = 0.001
   Max stepdown =0.05
   Enable Entry/exit arc/line and set the radius to 0.25 and the arc sweep to 90.
   One way cutting direction
   Transition set to Broken



7. **Surface Finish Shallow**
   Use 2" Flat Mill
   Select the top contour as Containment boundary
   Stock to leave on drive = 0.0
   Total tolerance = 0.001
   Max stepover =0.25
   From slope angle = 0
   To slope angle = 10



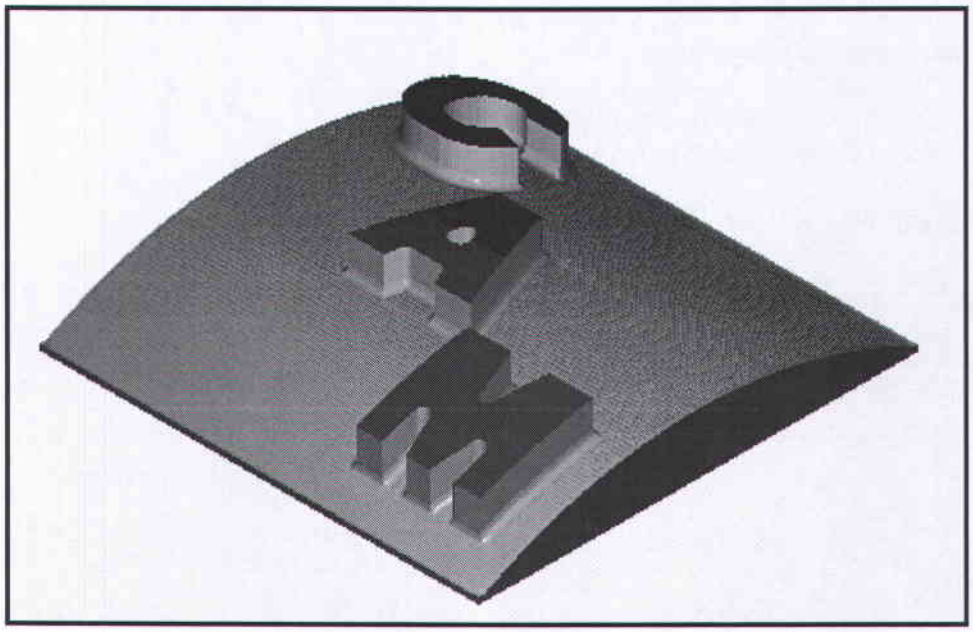
From slope angle = 0
To slope angle = 10
8. Backplot and Verify the toolpaths.
9. Post process the file.



TUTORIAL SERIES FOR

Mastercam X2

TUTORIAL 13
RAISED LETTERS PROJECT ON A SURFACE.



Objectives:

The student will create a part with raised letters on a 3D surface by:

- Creating rectangles.
- Creating letters.
- Creating arcs knowing the endpoints and the radius.
- Creating a ruled surface.
- Creating an offset surface.

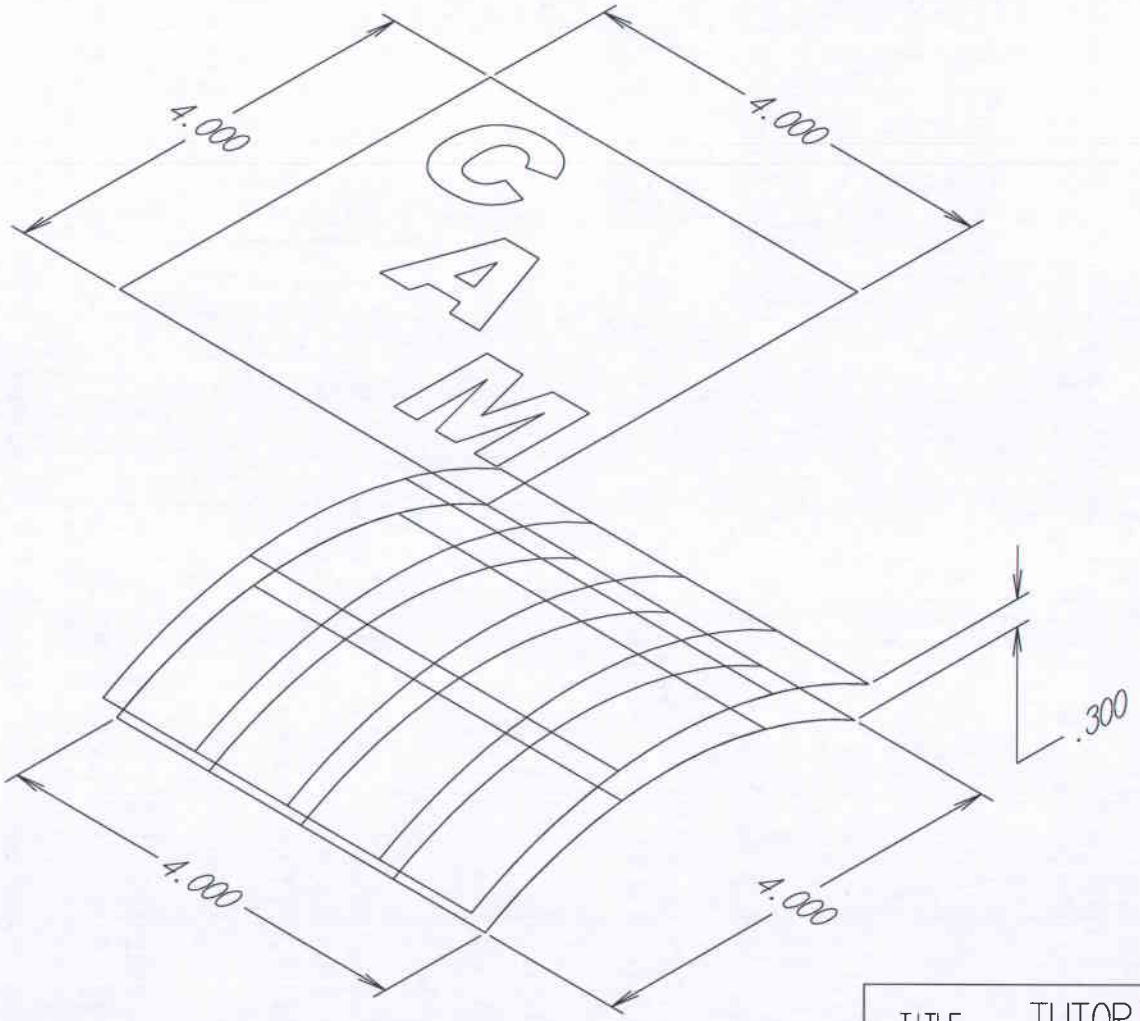
The student will create a milling toolpath consisting of:

- A 3-dimensional rough parallel toolpath.
- Editing the toolpath.
- A 2-dimensional pocket with island toolpath.
- A 3-dimensional finish project toolpath.

The student will check the toolpath using Mastercam's Verify module by:

- Running the Verify function to machine the part on the screen.

ALL DIMENSIONS IN INCHES

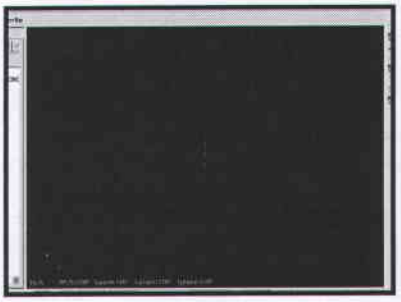


TITLE	TUTORIAL 13
MATERIAL	ALUMINUM T6061
DATE: JUNE 12, 2000	eMastercam.com

GEOMETRY CREATION

Setting the toolbar states:

- Before starting the geometry creation we should customize the toolbars to see the toolbars required to create the geometry and machine a 3D part. See **Getting started** page A-5 in the **User Notes**.
- **Toolpaths/Solids operations manager** to the left of the screen can be hidden to gain more space in the graphic area for design. Press **Alt + O** to remove it.
- Before starting the geometry make sure that the **Grid** is enabled. It will show you at each moment where the part origin is. See **Getting started** page A-5 for details.



STEP 1:
CREATE A RECTANGLE 4" X 4".

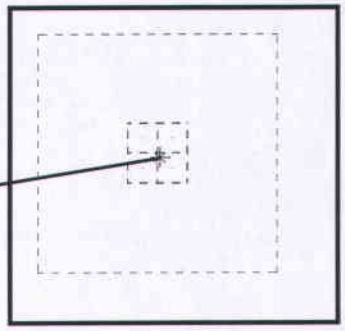
- Change to **2D** plane in the **Status Bar**.
- Enter the **Z** value: 4.0 in the **Status Bar**.

Create

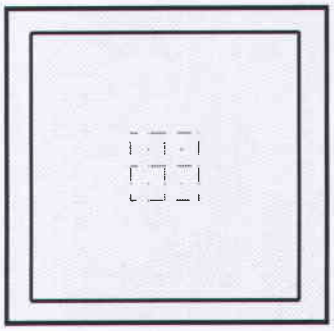
- **Create Rectangle**
- Enter the **Width** 4.0 (Tab).
- Enter the **Height** 4.0 (Enter).

- Enable **Anchor to center**.
- [Select position of first corner]: Select the **Origin** (center of the grid) as shown.

Select the Origin



- Select the **OK** button.
- Use the **Fit** icon to fit the drawing to the screen.

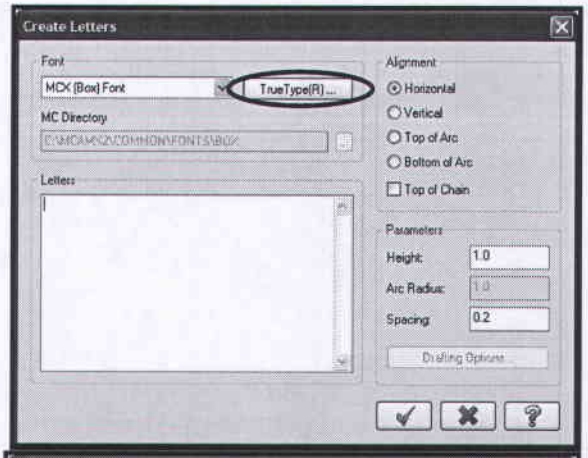


- During the geometry creation of this tutorial, if you make a mistake, to undo the last step you can use the **Undo** icon. You can undo as many steps as needed.
- If you delete or undo a step by mistake, just use the **Redo** icon.

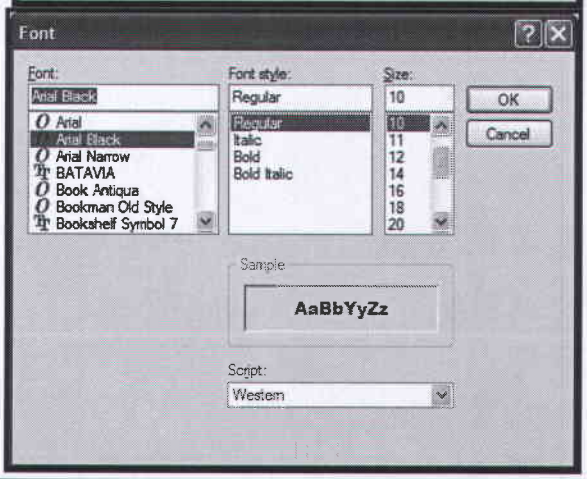
STEP 2:
CREATE THE LETTERS.

Create

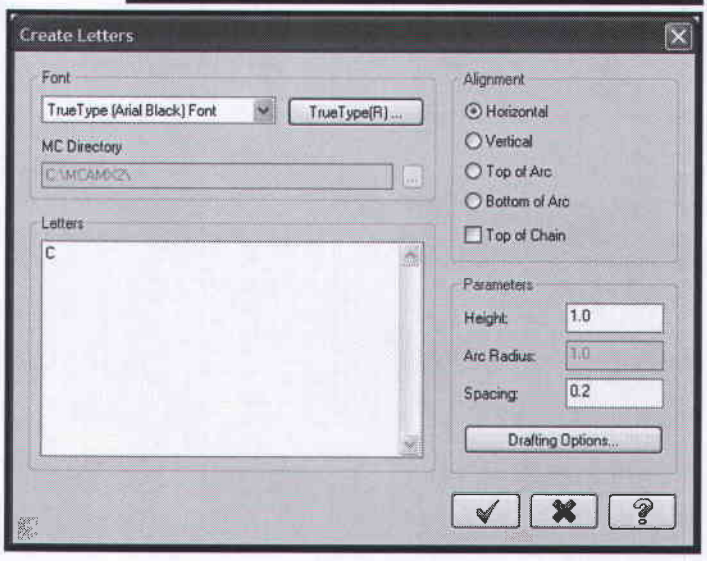
- **Create Letters**
- Make sure that the parameters are set as shown to the right.
- Select the **True Type** button.



- Select **Arial Black** font.
- Select the **OK** button to exit the **Font** dialog box.

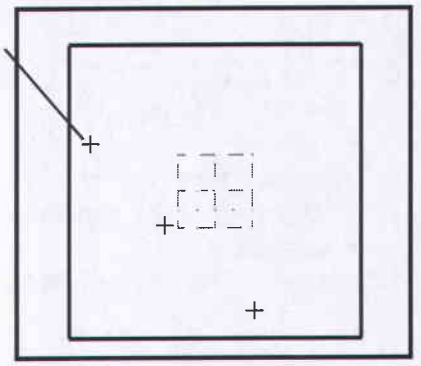


- Type the letter **C** (use capital letters).
- Select the **OK** button to exit.



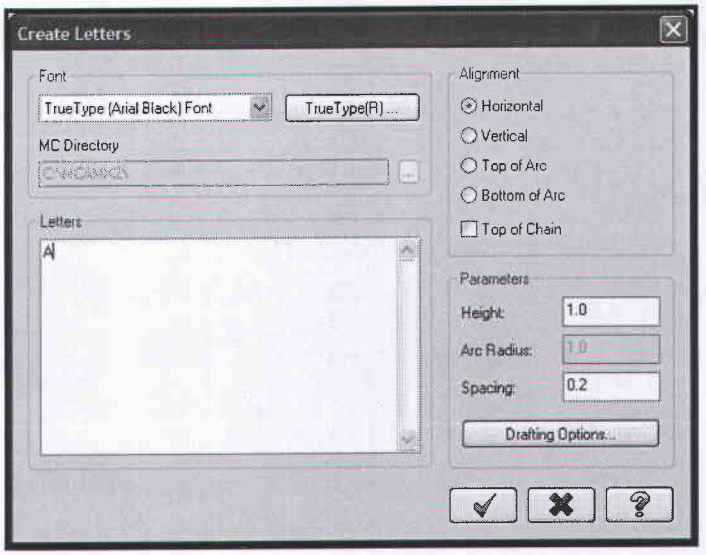
- [Enter starting location of letters]: See the following picture.

- Position the cursor near the top left-hand corner of the square. Once the cursor is positioned click the left mouse button. The letters will appear to the top and right of the cursor. You can **Undo** the command and reselect the point if necessary.
- Press **Esc** to exit.

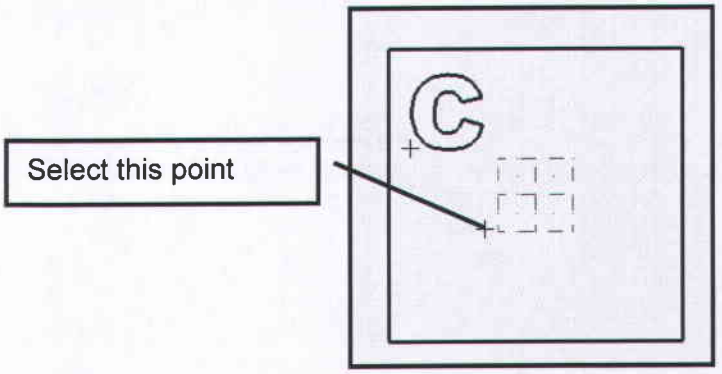


Create

- **Create Letters**
- Type the letter **A** and keep the same settings (use capital letters).
- Select the **OK** button to exit.

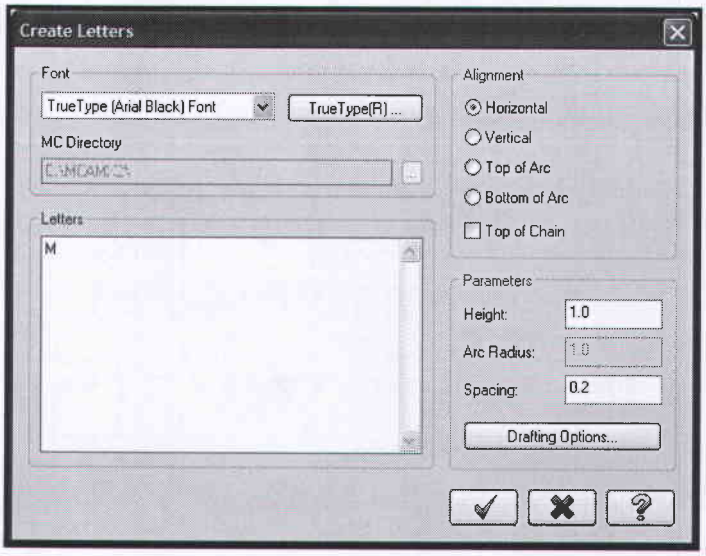


- [Enter starting location for letters]: See the picture below.
- Press **Esc** to exit.

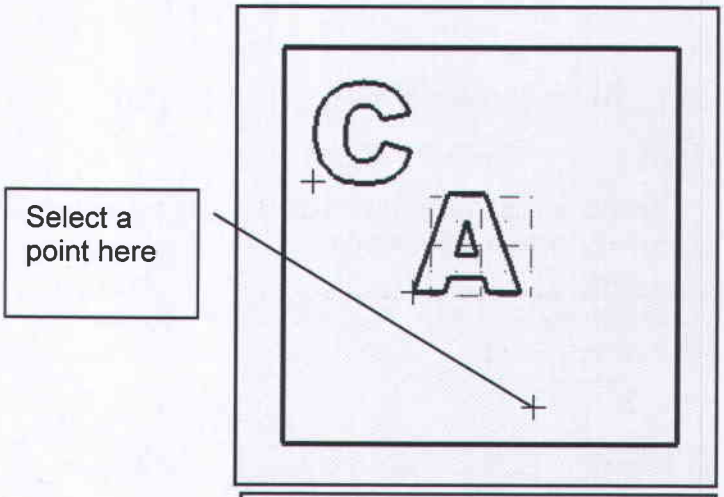


Create

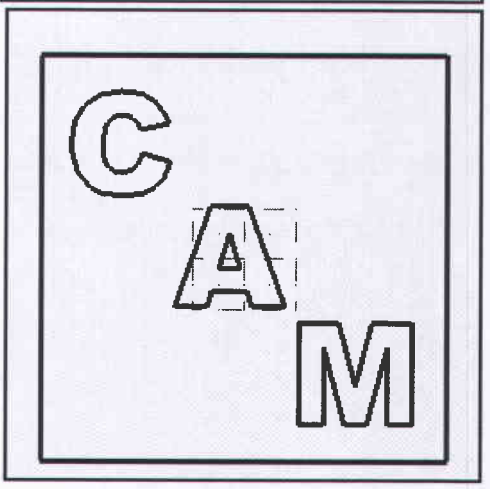
- **Letters**
- Type the letter M and keep the same settings (use capital letters).
- Select the **OK** button to exit.



- [Enter starting location for letters]: See the picture below.
- Press **Esc** to exit.



- The letters should now appear as shown in the diagram to the right, and be at least 0.150 away from each other and the edge of the lid.
- The geometry should look as shown to the right.

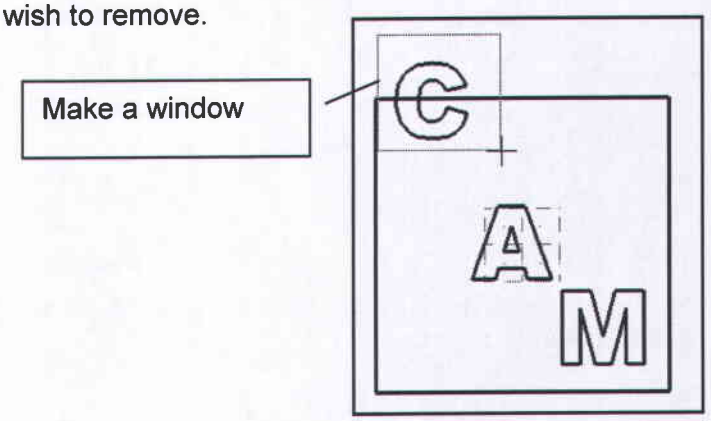


STEP 3:
MODIFY THE LETTERS.

If the letters do not appear in the correct spot, continue with this step. Otherwise move to **Step 4**.

Option 1: Delete the inappropriate letter(s).

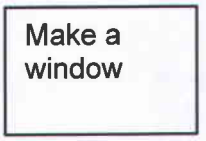
- Make a window around the letter(s) you wish to remove.
- Select the **Delete** icon.
- Repeat **Step 2** to re-create the letter.

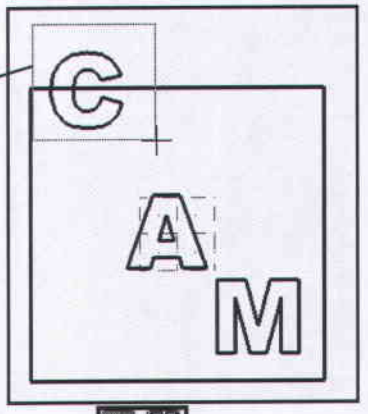


Option 2: Move the existing Letter

Xform

- **Xform Drag**
- [Select entities to drag]: Put a window around the letter you wish to move.



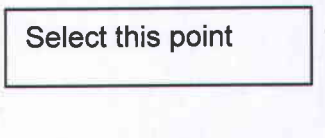


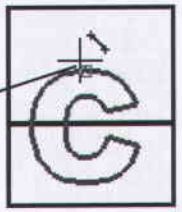
- Select the **End Selection** button.

- Click on the **Move** button to make sure that is selected in the Ribbon Bar.

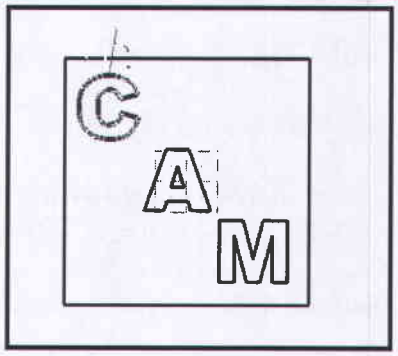
- Also **Translate** option should be selected.

- [Select the starting point]: Select the endpoint as shown.





- Drag the letter to the correct location and click.
- Select the **OK** button to exit.

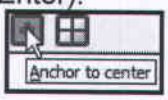


STEP 4:
CREATE THE WIREFRAME FOR THE RULED SURFACE.

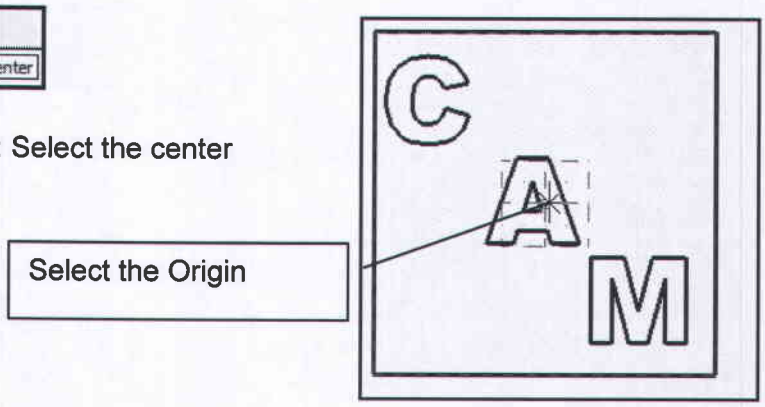
- Highlight the **Z** value in the **Status Bar** and change it to 0.

4.1 Create a rectangle 4" x 4".

- **Create Rectangle**
- Enter the **Width** 4.0 (Tab).
- Enter the **Height** 4.0 (Enter).
- Enable **Anchor to center**.

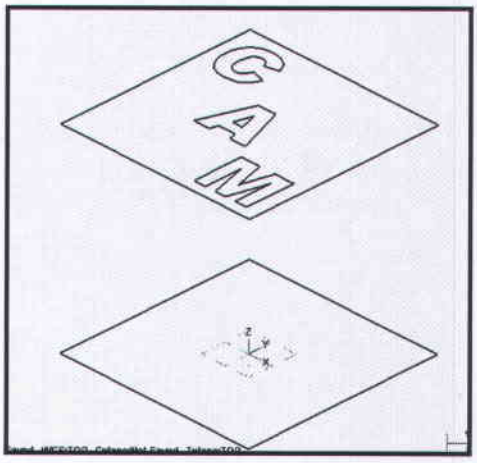


- [Select position for the base point]: Select the center location of the grid (the origin).

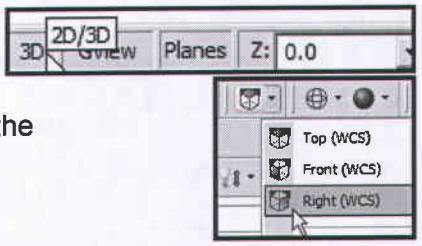


- Select the **OK** button.
- Change the **Graphic View** to **Isometric.**

- Use the **Fit** icon to fit the drawing to the screen.
- Hold down the Alt key and press the Up key once to rotate the image.
- The geometry should look as shown in the picture to the right.



4.2 Change to 3D and the construction plane to Side.

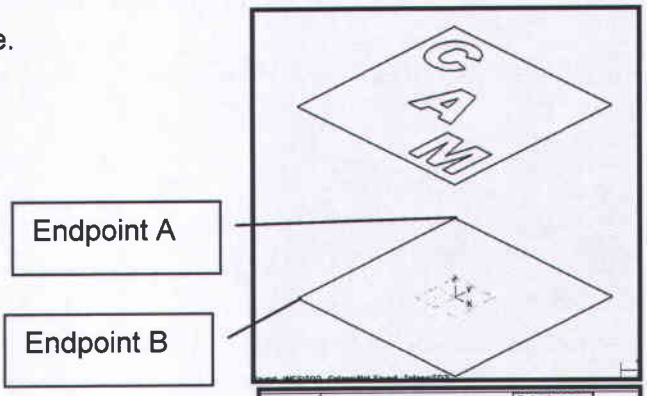


- Select the **2D/3D** toggle button and change it to **3D**.
- Select the **drop-down arrow** next to **Set Planes** and change the construction plane to **Right**.

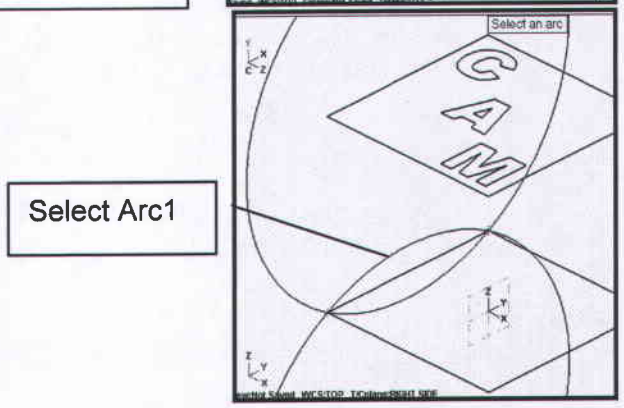
4.3 Create arc knowing the endpoints.

Create
- **Arc**
- **Create Arc Endpoints**
- Enter the **Radius** 4.0.
- Select the radius icon to lock the radius value.

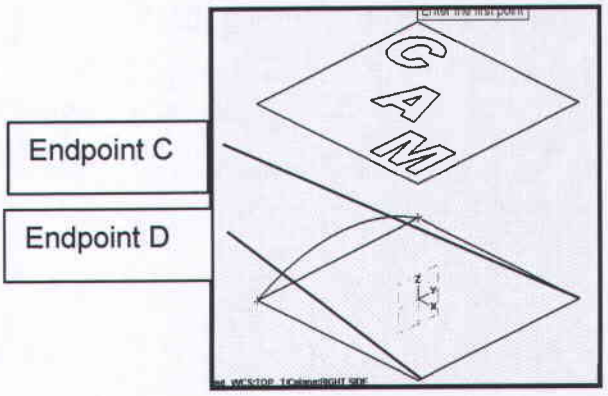
- [Enter the first point]: Select Endpoint A.
- [Enter the second point]: Select Endpoint B.



- [Select an arc]: Select Arc 1.

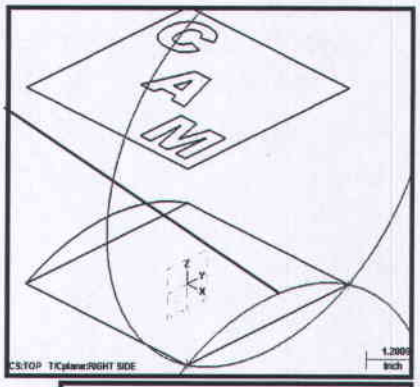


- Select the **Apply** button to continue.
- [Enter the first point]: Select Endpoint C.
- [Enter the second point]: Select Endpoint D.



➢ [Select an arc]: Select Arc 2.

Select Arc 2



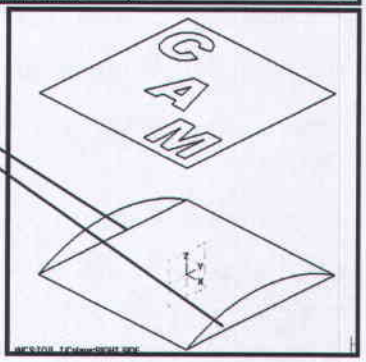
➢ Select the **OK** button to exit the command.

4.4 Delete the unnecessary lines.

➢ Select the two lines as shown.

➢ Select the **Delete** icon.

Select these lines



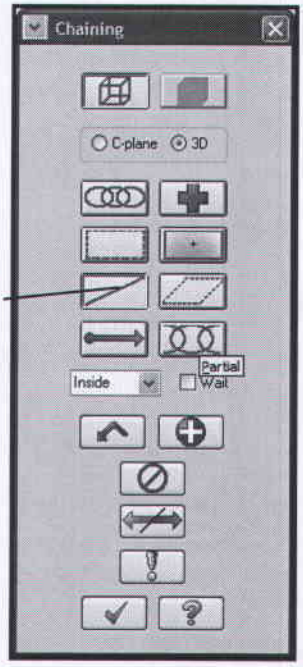
STEP 5:
CREATE THE RULED SURFACE.

Ruled Surface: A surface generated by connecting straight lines between two or more open or closed contours. As a result the surface has sharp edges at the intermediate contours.
Applications: Any time a surface must be fit between two or more open or closed contours.

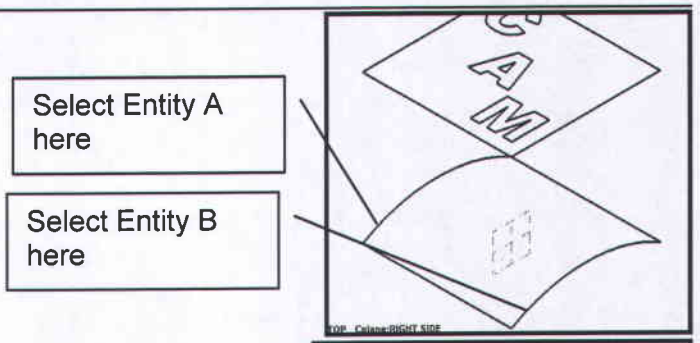
To properly define a surface:
1. all of the start points must be lined up, if necessary by breaking an entity of the contour in two pieces;
2. select the contours sequentially; and
3. chain the contours in the same direction or the surface will become twisted and therefore be incorrect.

Create
➢ **Surface**
➢ **Create Ruled/Lofted Surfaces**
➢ Select the **Single** button in the **Chaining** dialog box.

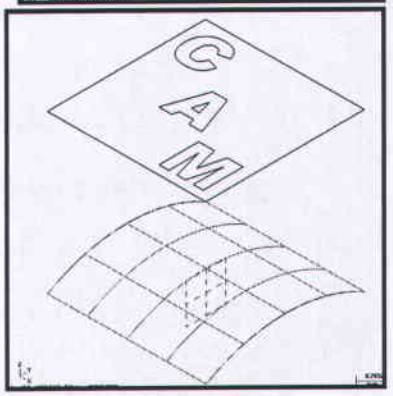
Select Single



➢ [Select chain 1]: Select Entity A.
➢ [Select chain 1]: Select Entity B.



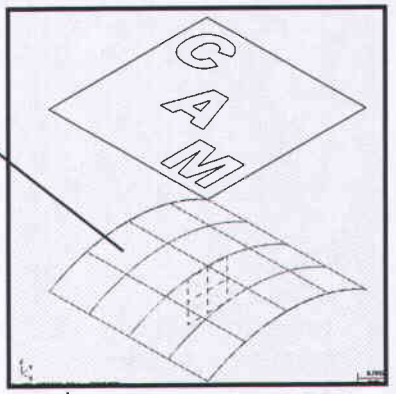
➢ Select the **OK** button to exit the **Chaining** dialog box.
➢ Select the **OK** button to exit the command.



STEP 6:
CREATE THE OFFSET SURFACE.

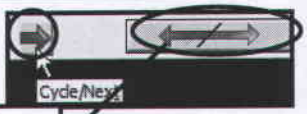
Offset Surface: A Derived Surface, created by offsetting an existing surface with a given distance. Each point from the offset surface is at a fixed, normal distance from the original surface.
Applications: Used to create a surface offset at a given distance from the original.

Create
➢ **Surface**
➢ **Create Offset Surfaces**
➢ [Select surface to offset]: Select the surface as shown.



➢ Select the **End Selection** button.

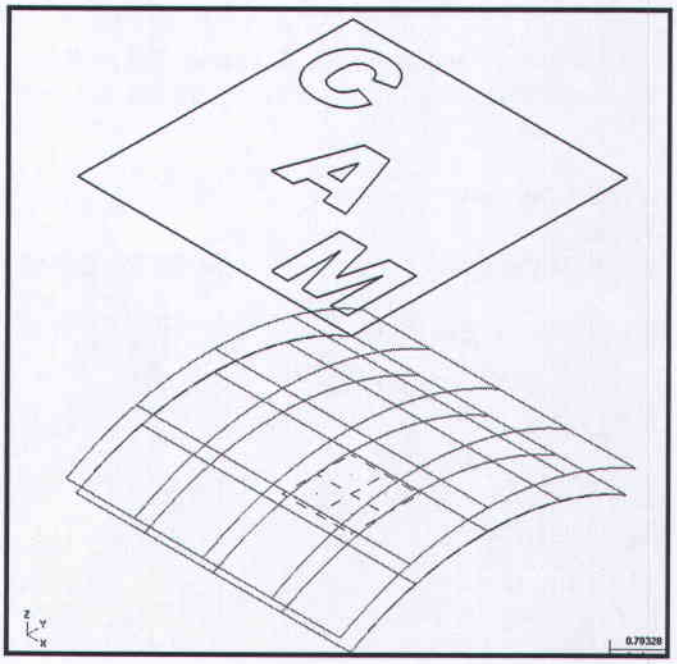
We want the offset surface to be above the original one. If you need to change the offset above the original surface select the **Cycle next** button and then the **Reverse** button.



➢ Enter the **Offset distance** 0.3.
➢ Select the **OK** button to exit this command.

➢ **Set planes** back to **Top**.

The drawing should look like this:



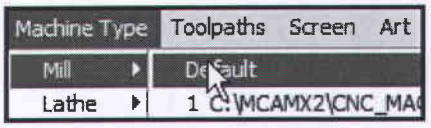
STEP 7:
SAVE THE DRAWING.

File
➢ **Save as**
➢ **File name**: "Your Name_13"
➢ Select the **OK** button.

TOOLPATH CREATION

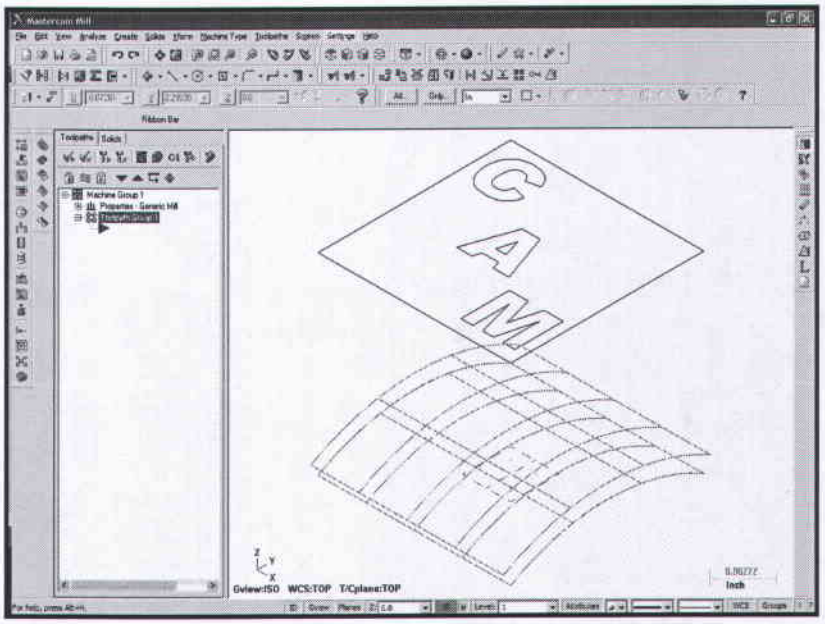
STEP 8:
SET UP THE STOCK TO BE MACHINED.

➢ To display the **Toolpaths Manager** press **Alt + O**.
Make sure that no machine is already selected; otherwise skip the machine selection.

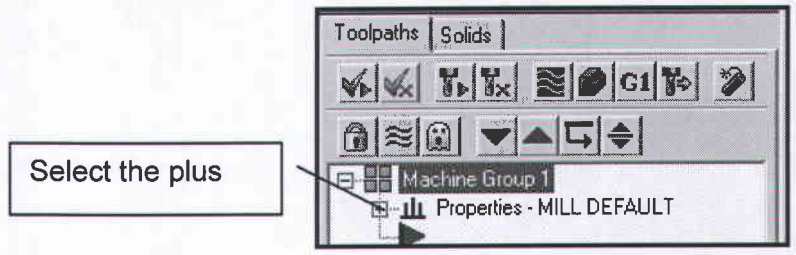


➢ **Machine type**
➢ **Mill**
➢ Select **Default**.

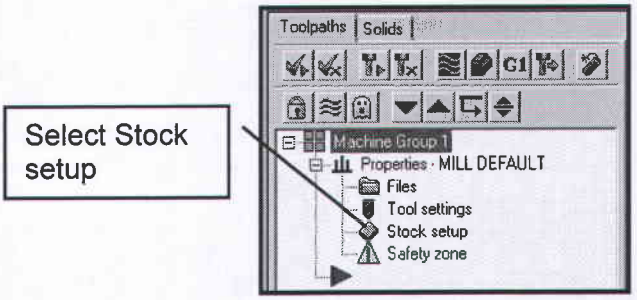
➢ Use the **Fit** icon to fit the drawing to the screen.



➢ Select the plus in front of **Properties** to expand the **Toolpaths Group Properties**.

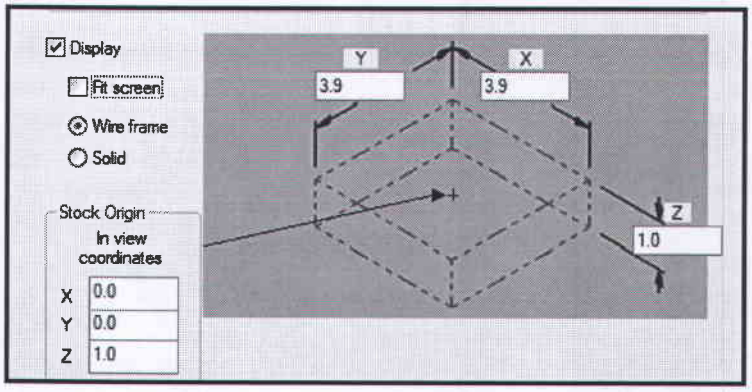


➢ Select **Stock setup**.



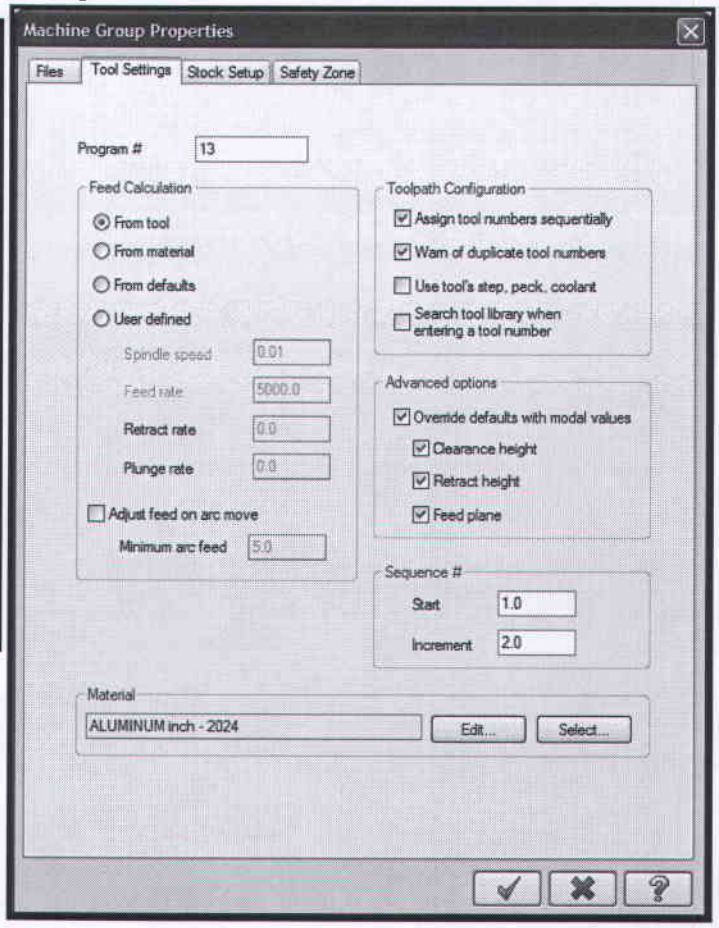
➢ Change the parameters to match the following screenshot.

The **Stock Origin** values adjust the positioning of the stock, ensuring that you have an equal amount of extra stock around the finish part.
Display options allow you to set the stock as **Wireframe** and to fit the stock to the screen (**Fit Screen**).



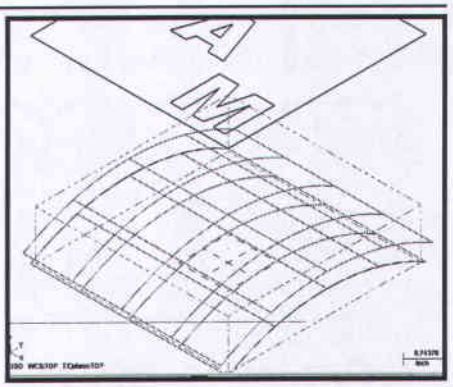
➢ Select the **Tool Settings** tab to set the tool parameters and the part material.
➢ Change the parameters to match the following screenshot.

Assign tool numbers sequentially allows you to overwrite the tool number from the library with the next available tool number. (First operation →tool number 1; Second operation →tool number 2, etc.)
Warn of duplicate tool numbers allows you to get a warning if you enter two tools with the same number.
Override defaults with modal values enables the system to keep the values that you enter.
Feed Calculation set **From tool** uses feed rate, plunge rate, retract rate and spindle speed from the tool definition.



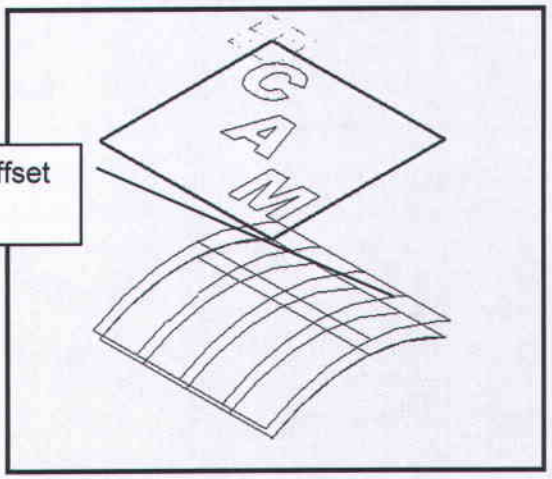
➢ Select the **OK** button to exit **Toolpath Group Properties**.

➢ The stock should look as shown to the right.



STEP 9:
SURFACE ROUGH PARALLEL.

Toolpaths
➢ **Surface Rough**
➢ **Rough Parallel Toolpath**
➢ Select **Undefined**.

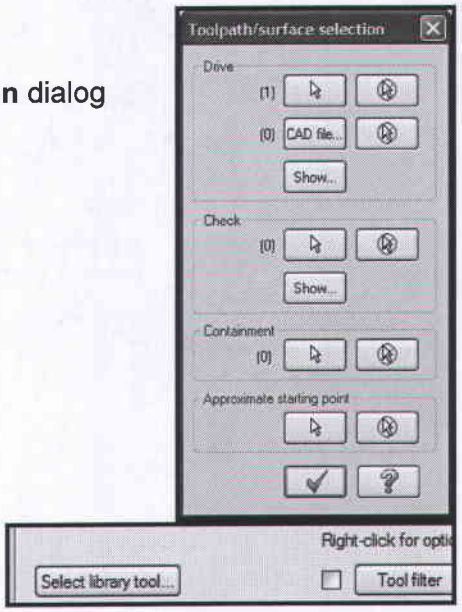


➢ Select the **OK** button to exit.
➢ Select the **OK** button to accept the NC name.

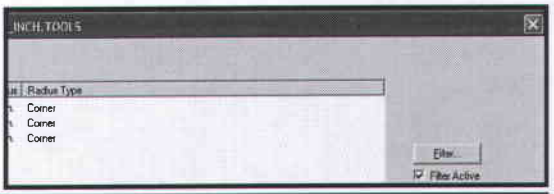
➢ [Select drive surfaces]: Select the offset surface.

➢ Select the **End Selection** button.

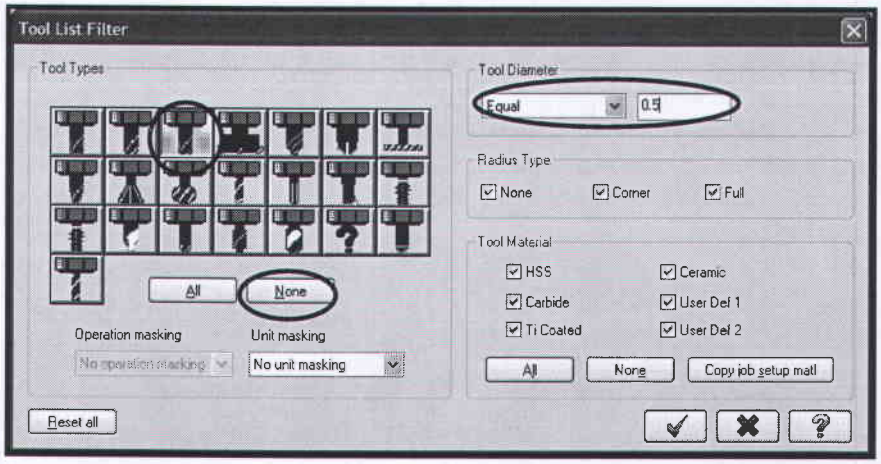
➢ Select the **OK** button to exit the **Toolpath/surface selection** dialog box.



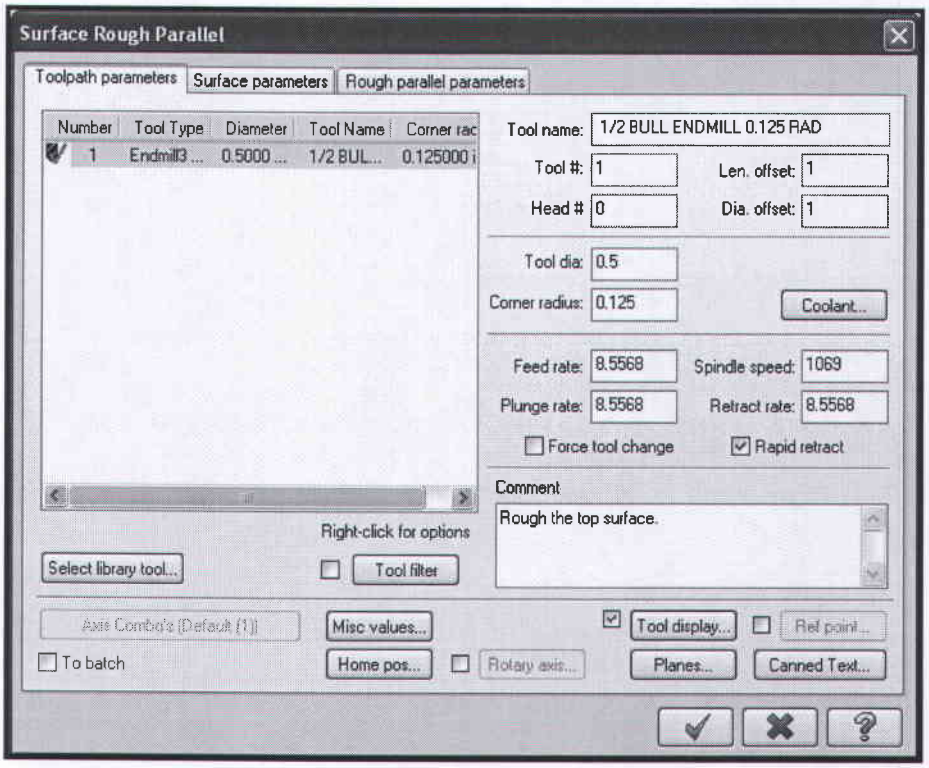
➢ Click on **Select library tool** to select the 0.5" Bull Nose with a corner radius of 0.125".
➢ Select the **Filter** button in the **Tool Selection** dialog box.



Select the **None** button in the **Tool Types** area.



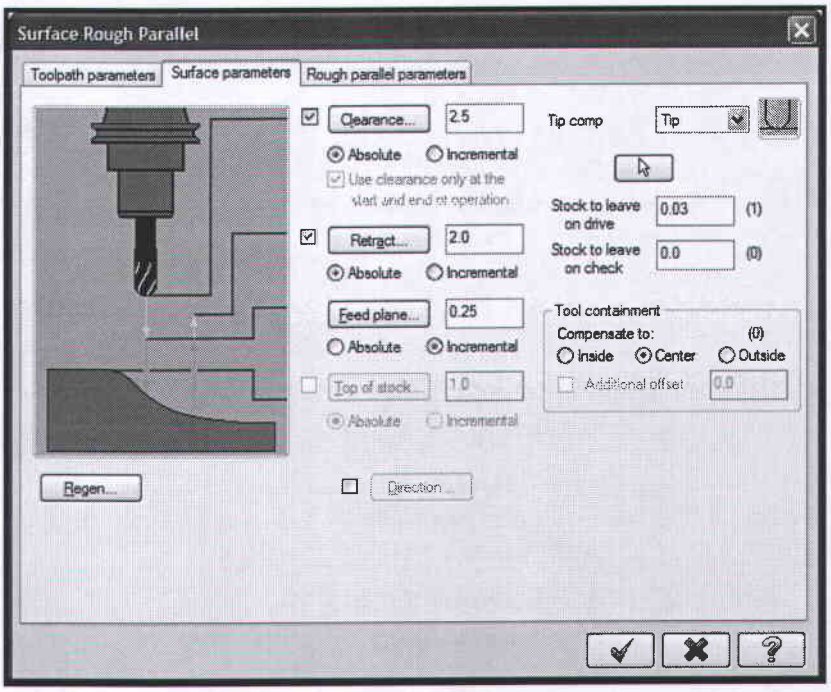
- Click on the **Endmill Bull** icon as the tool type.
- Select the drop-down arrow in the **Tool Diameter** field, and select **Equal**.
- Enter the diameter 0.5.
- Select the **OK** button to exit.
- Select **0.5" Bull Nose** with a **0.125"** corner radius.
- Select the **OK** button to exit **Tool Selection**.
- Make the necessary changes in the **Toolpath parameters** to match the following screenshot.



- The **Feed rate**, **Plunge rate**, **Retract rate** and **Spindle speed** are based on the tool definition. Change them as desired.

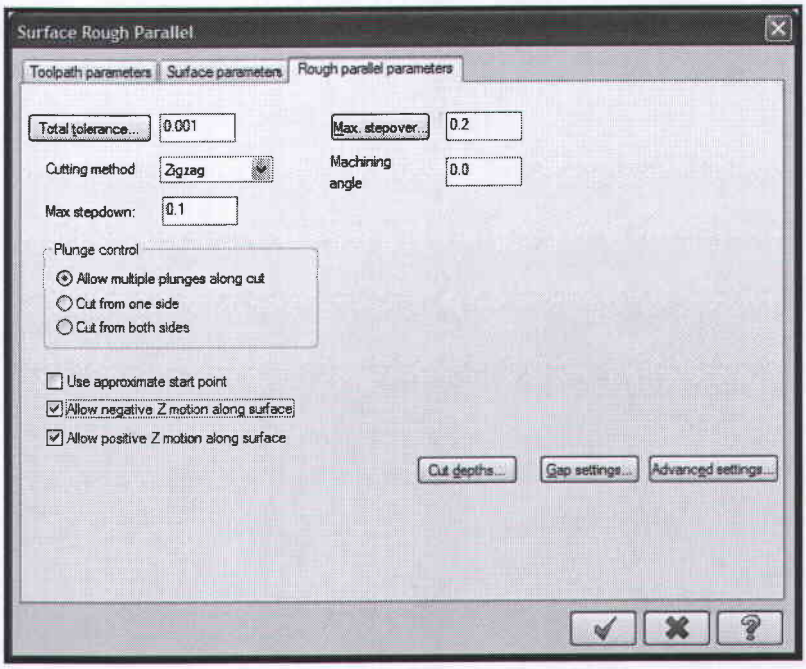
➢ Change the parameters in the **Surface parameters** page as shown in the following screenshot.

Clearance value sets the height at which the tool rapids to or from the part.
Retract value sets the height the tool rapids/feed-rates up to, before the next tool pass.
Feed plane value sets the height the tool rapids to before changing to the plunge rate.
Stock to leave (on **Drive surface**) sets the amount to leave for finish operation as a constant value all the way around the drive surfaces.

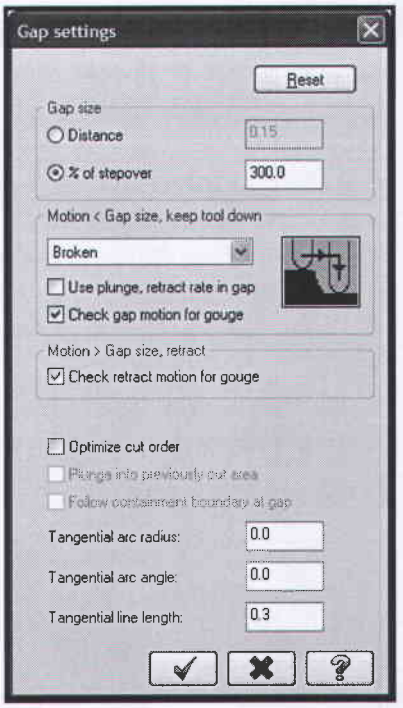


➢ Select the **Rough parallel parameter** tab and set the parameters to match the following screenshot.

Maximum stepdown value sets maximum distance (along the Z-axis) between adjacent cuts in the surface toolpath.
Maximum stepover value sets maximum distance (in the XY plane) between adjacent passes in the surface toolpath.
Plunge control determines the type of Z-axis movement for surface rough toolpaths. It can be used to prevent the tool from air-cutting through a previously cleared area of the part.
Allow negative/positive Z motion along surface lets the tool cut along the surface while plunging/retracting.

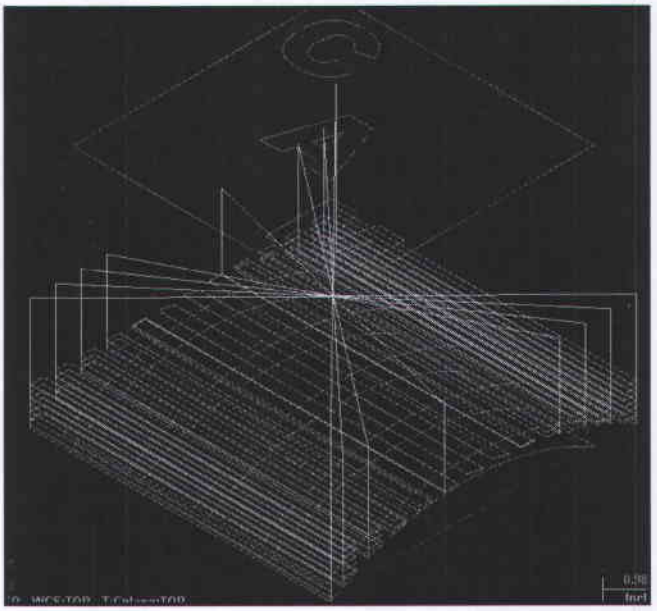


➢ Select the **Gap settings** button and change the parameters as shown in the screenshot to the right.



Gap settings sets the way in which the tool moves between gaps or spaces in a surface toolpath.
Tangential line length allows you to extend the toolpath with a tangent line at the entry and exit between passes.

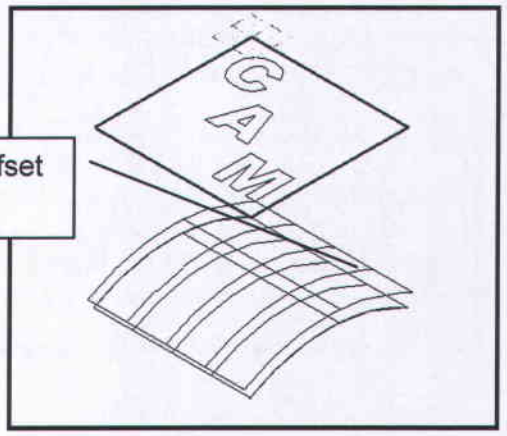
➢ Select the **OK** button to exit **Gap settings** dialog box.
➢ Select the **OK** button to exit the **Rough parallel parameters** page.



➢ Select the **Toolpaths manger** tab to enable it.
➢ Select the **Toggle toolpath display on selected operations** to remove the toolpath display.

Select Toolpaths manager

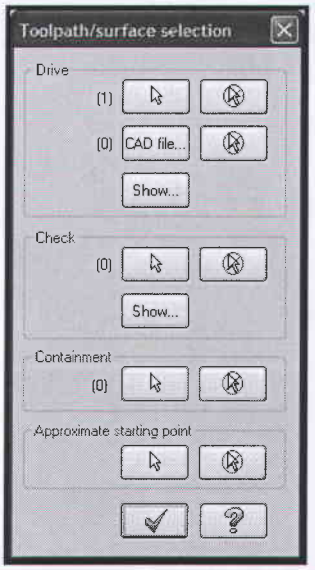
STEP 10:
SURFACE FINISH PARALLEL.



Toolpaths
- **Surface Finish**
- **Finish Parallel toolpath**
- [Select drive surfaces]: Select the offset surface.

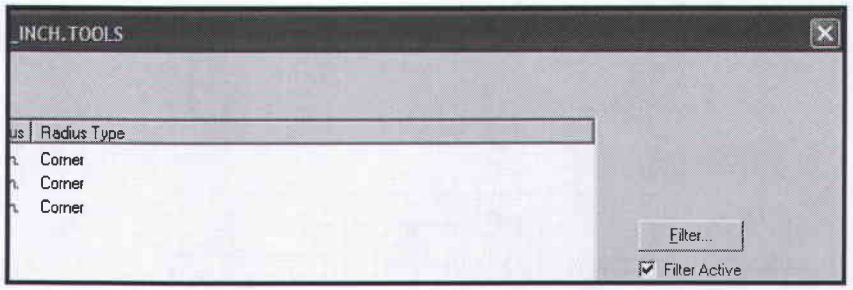
- Select the **End Selection** button. 

- Select the **OK** button to exit the **Toolpath/surface selection** dialog box. 

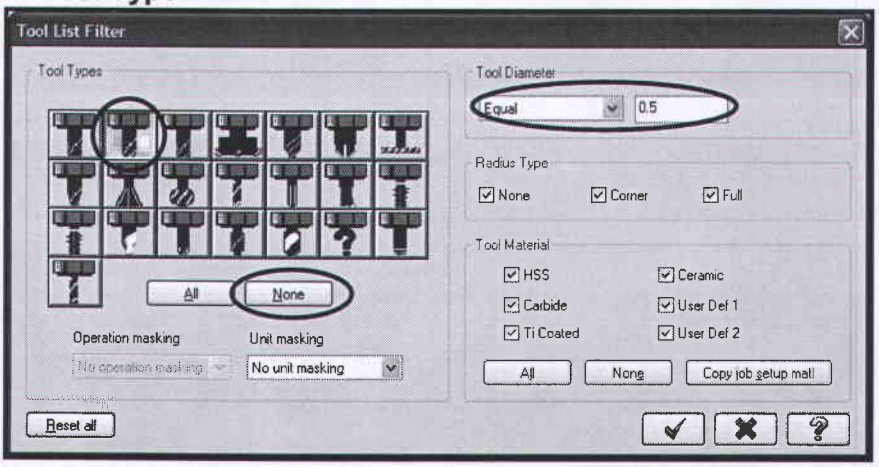


- Click on **Select library tool** to select the **0.5" Ball Endmill.**

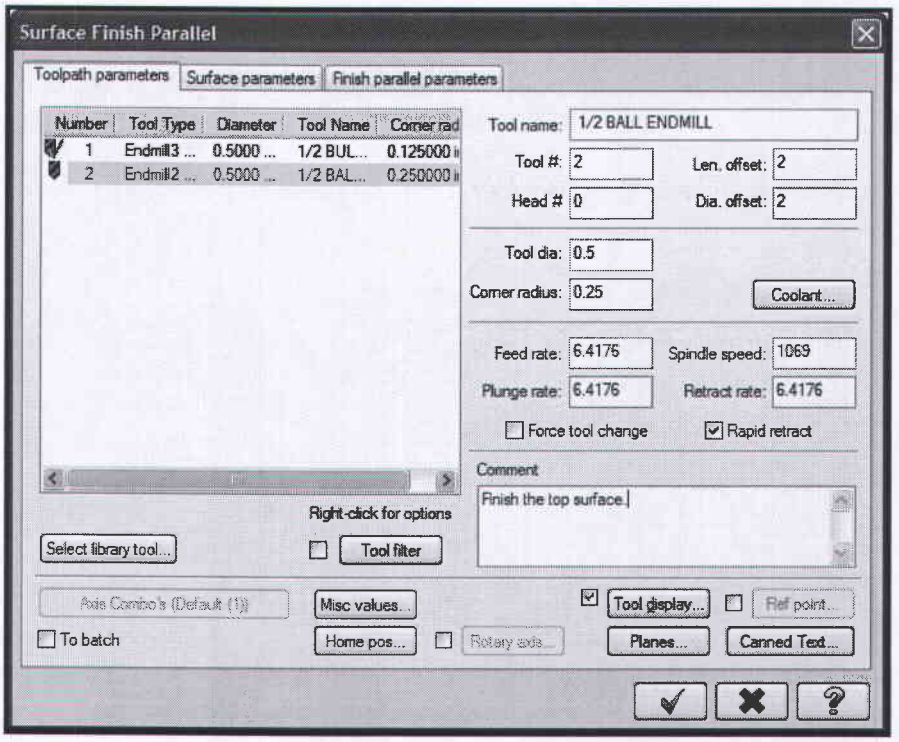
- Select the **Filter** button in the **Tool Selection** dialog box.



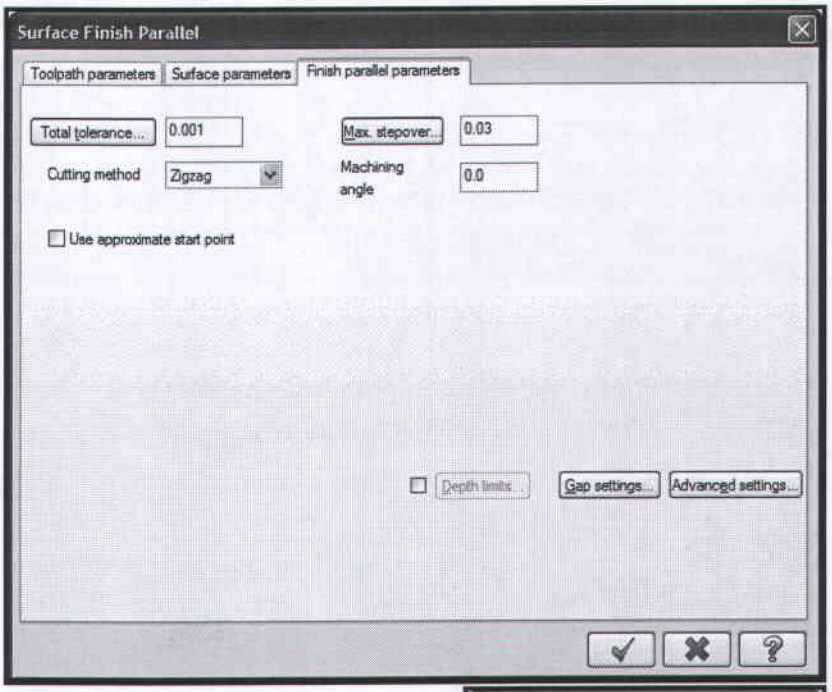
➢ Select the **None** button in the **Tool Types** area.



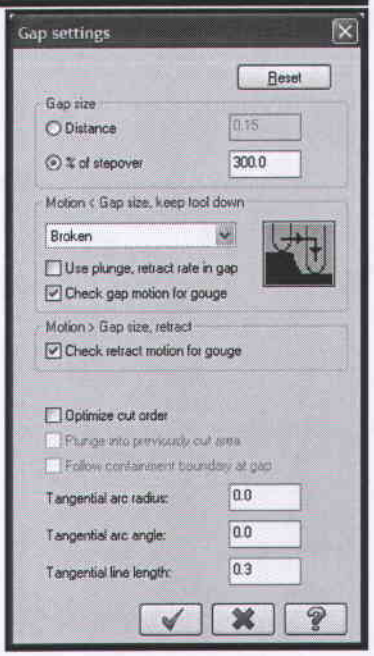
➢ Click on the **Endmill Sphere** icon as tool type.
➢ Select the drop-down arrow in the **Tool Diameter** field, and select **Equal**.
➢ Enter the diameter 0.5
➢ Select the **OK** button to exit.
➢ Make sure that the tool is selected and select the **OK** button to exit the **Tool Selection** window.
➢ Make the necessary changes in the **Toolpath parameters** to match the following screenshot.



➢ Select the **Finish parallel parameter** tab and set the parameters to match the screenshot to the right.

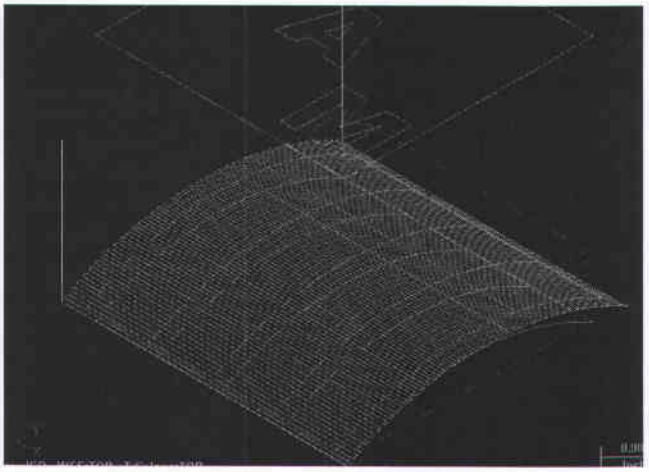


➢ Select the **Gap settings** button and change the parameters as shown in the screenshot to the right.

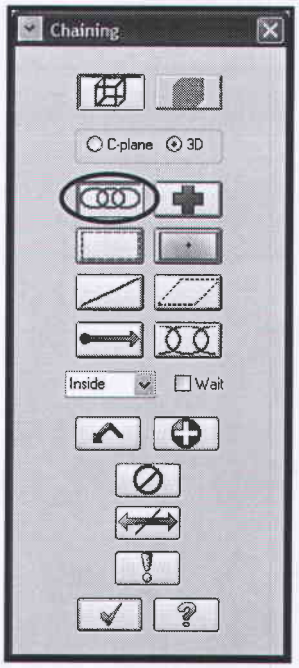


➢ Select the **OK** button to exit the **Gap settings** dialog box. 

➢ Select the **OK** button to exit the **Finish parallel parameters** page. 

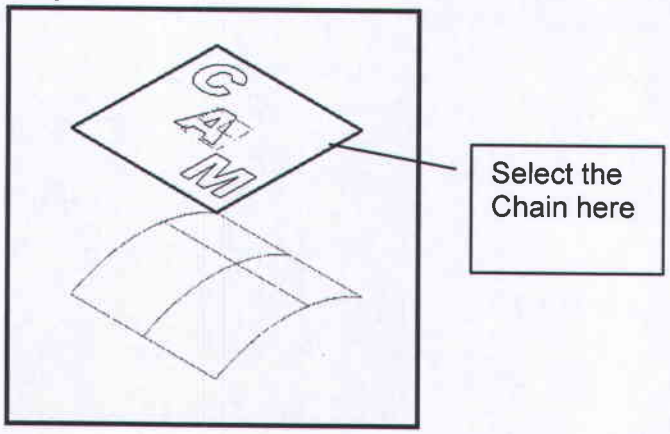


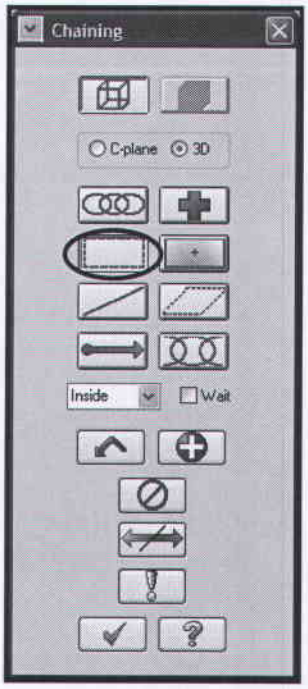
STEP 11:
2D POCKET WITH ISLANDS.



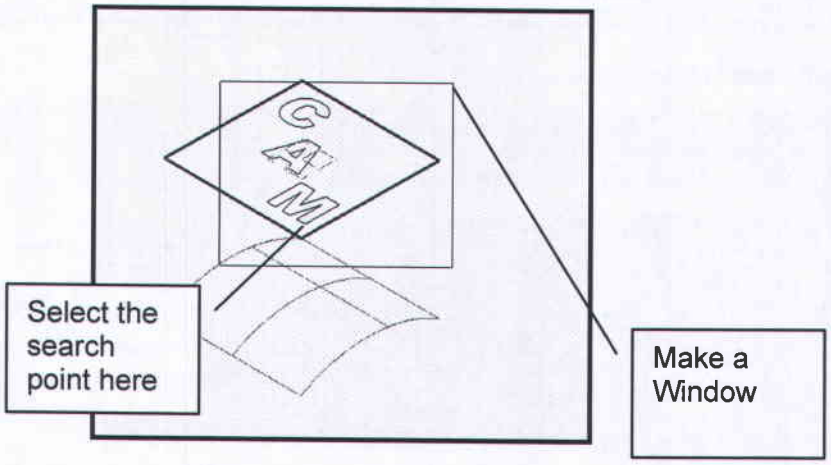
Toolpaths

- **Pocket Toolpath**
- Select the **Chain** button as shown in the screenshot to the right.
- With the cursor, click on the outside contour as shown below in the diagram.



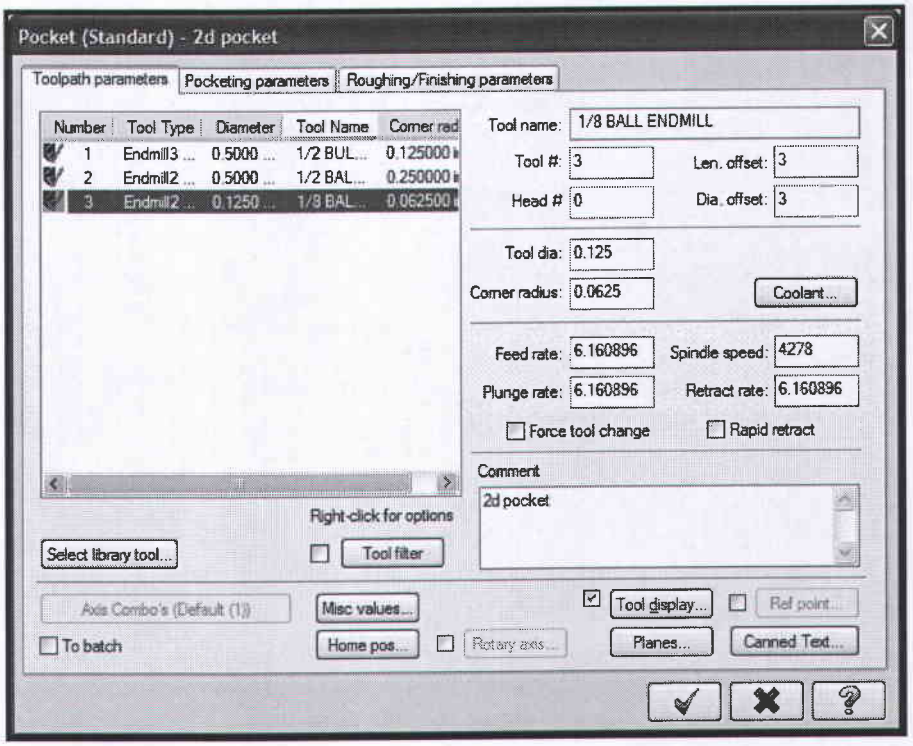


- Select the **Window** button in the **Chaining** dialog box as shown.
- Make a window around the letters as shown below.

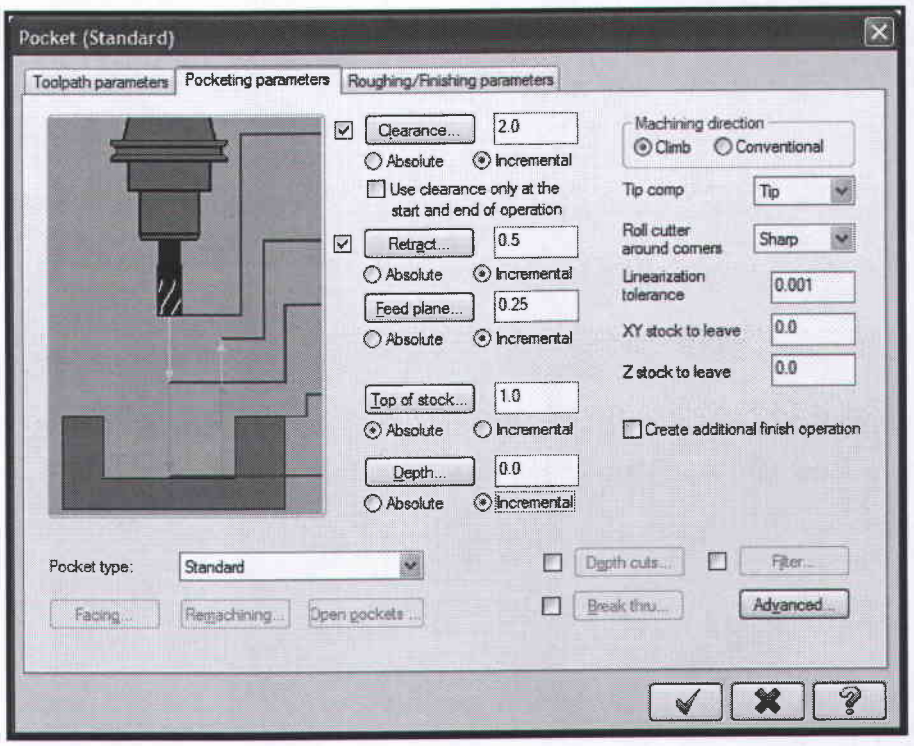


- [Enter search point]: Select a point inside the window as shown above
- Select the **OK** button to exit **Chaining**.

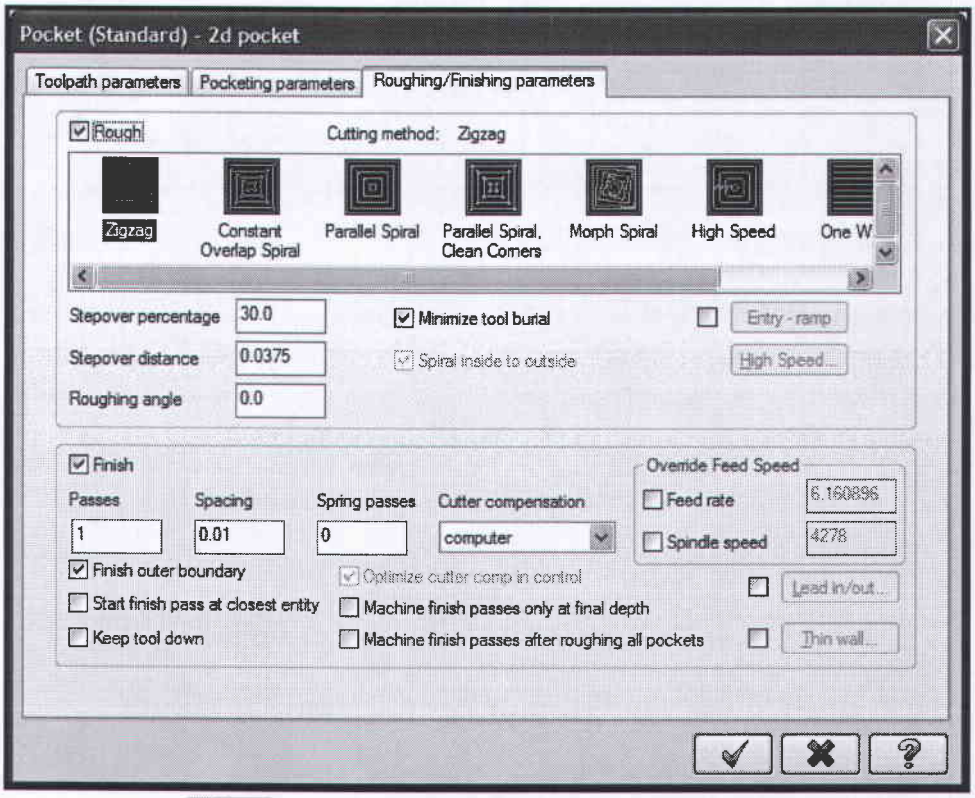
- Click on the **Select library tool** button and using the **Filter** dialog box and the information from the previous step, select a **1/8 Endmill ball**
- Enter the remaining information as shown in the following 3 parameter pages.



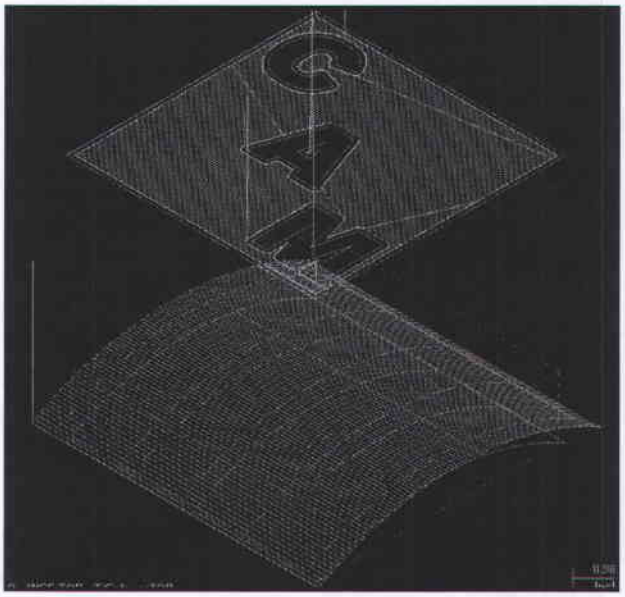
- Select **Pocketing parameters** and change them as shown.



➢ Select the **Roughing/Finishing parameters** tab and change the parameters to match the following screenshot.



➢ Select the **OK** to exit parameters.

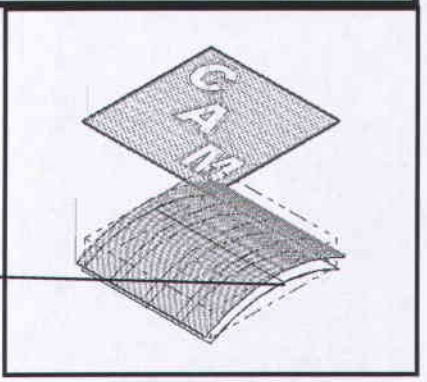


STEP 12:
SURFACE ROUGH PROJECT.

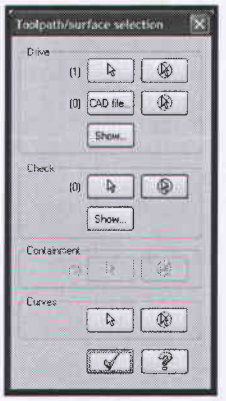
Project toolpaths allow you to project curves, points, or another NCI file onto selected surfaces. They provide free-form tool motion and give the most tool control. These toolpaths can closely match the cut motion to the shape of the part and can be used for engraving.

Toolpaths

- **Surface Rough**
- **Rough Project Toolpath**
- Select **Undefined**.
- Select the **OK** button to exit.
- [Select drive surfaces]: Select the bottom surface

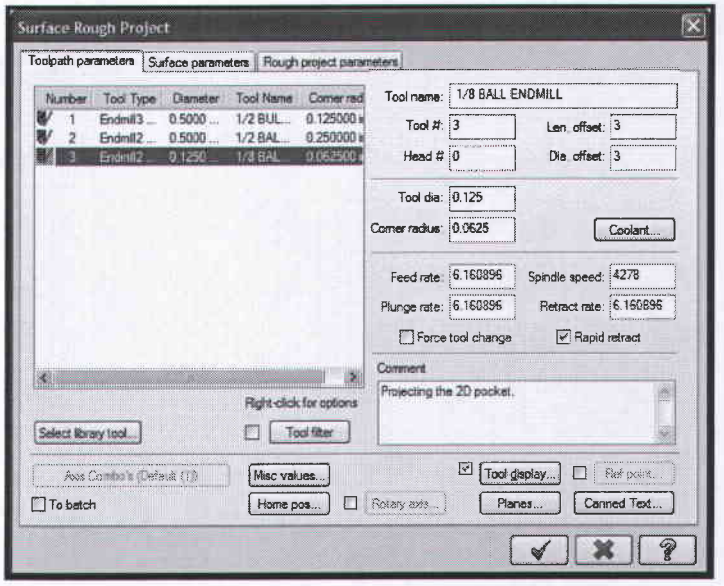


- Select the **End Selection** button.

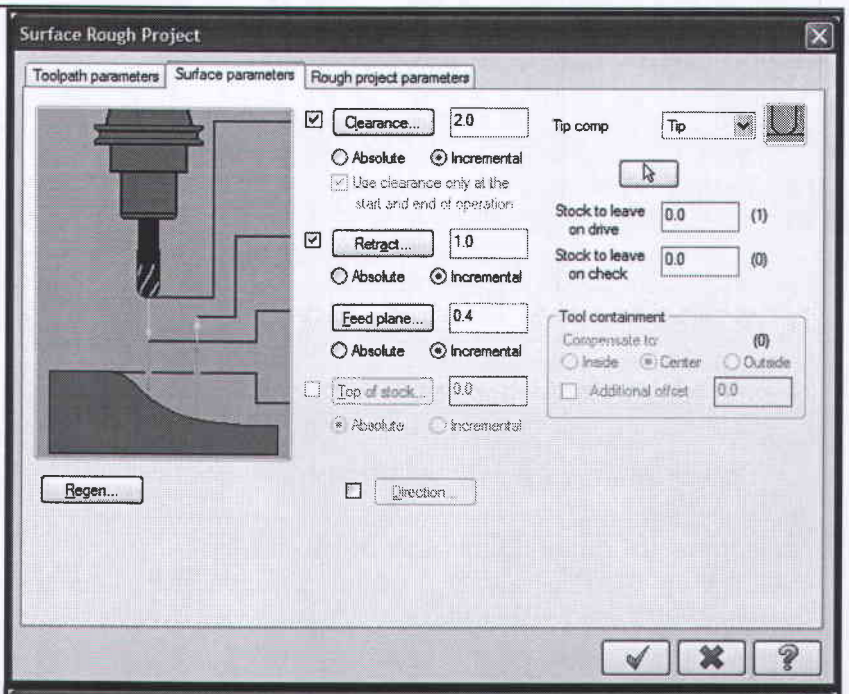


- Select the **OK** button to exit **Toolpath/Surface selection**.

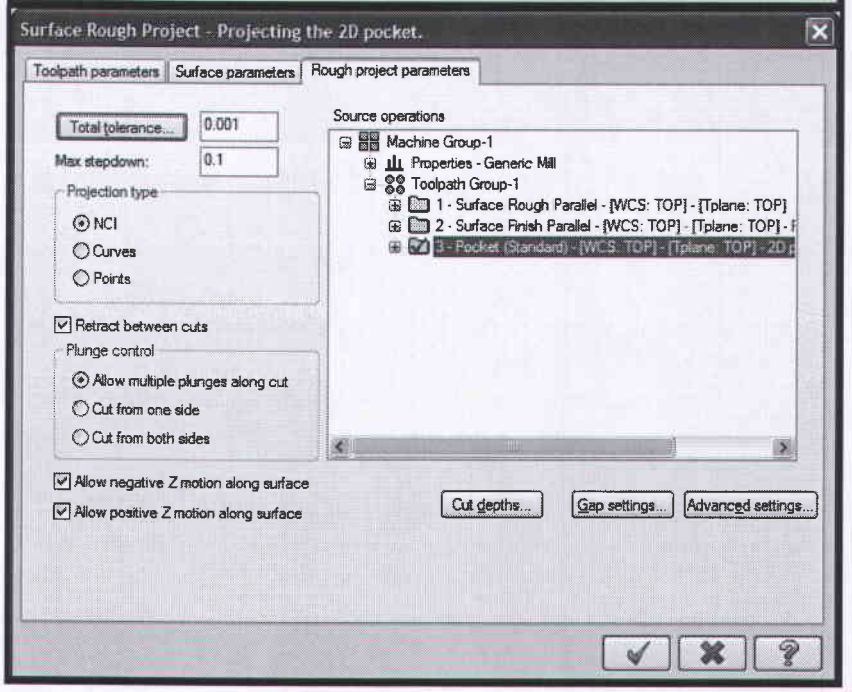
- Select the existing **1/4 Endmill ball**, and make the necessary changes in the **Toolpaths parameters** page.



- Select the **Surface parameters** tab and make the changes as shown.

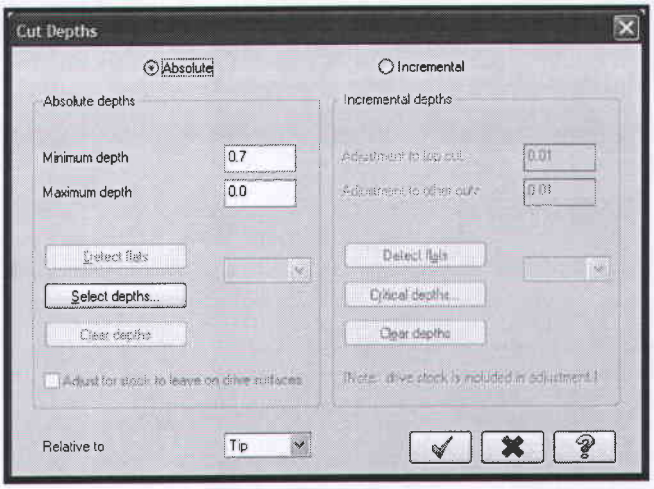


- Select the **Rough project parameters** and make the changes as shown.
- Make sure that you select the **Pocket operation** as the **Source operation**.



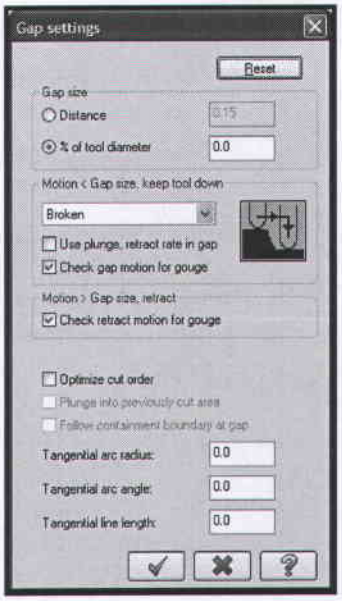
Maximum stepdown value sets maximum distance (along the Z-axis) between adjacent cuts in the surface toolpath.
Projection type NCI allow you to project another NCI file onto selected surfaces.
Plunge control determines the type of Z-axis movement for surface rough toolpaths. It can be used to prevent the tool from air-cutting through a previously cleared area of the part.
Allow negative/positive Z motion along surface lets the tool cut along the surface while plunging/retracting.

➢ Select **Cut depths** button and change the parameters as shown.



➢ Select the **OK** button to exit **Cut Depths**

➢ Select **Gap Settings** and change the gap size to 0 to avoid small gap moves in pocket islands and force the tool to retract.

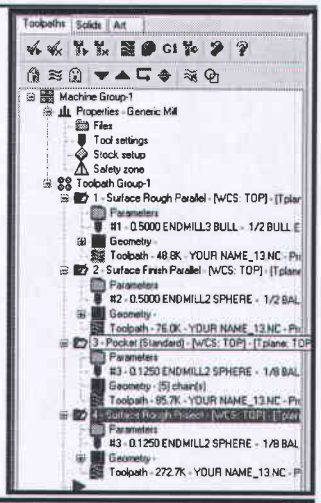


➢ Select the **OK** button to exit **Gap settings**.

➢ Select the **OK** button to exit **Parameters**.

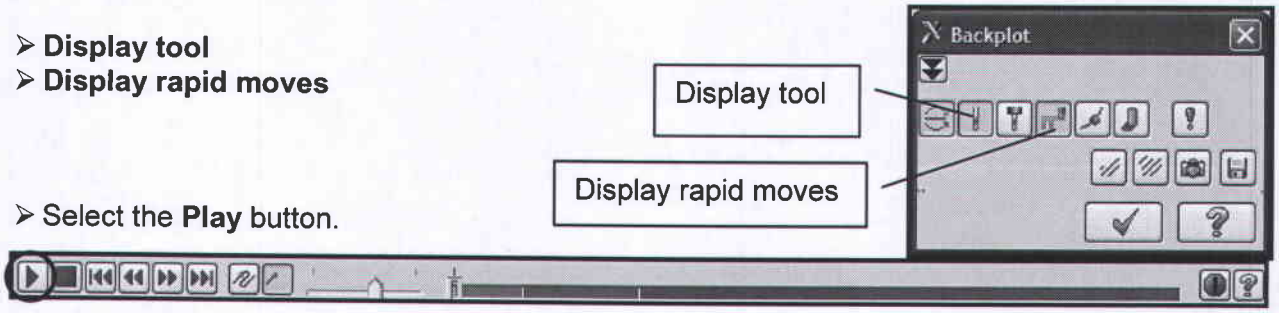
STEP 13:
BACKPLOT THE TOOLPATH.

- Enable **Toolpath Manager**.
- Select the first operation.
- Hold down the **Ctrl** key and select only the operations shown in the screenshot to the right. (Do not select the Pocket toolpath.)



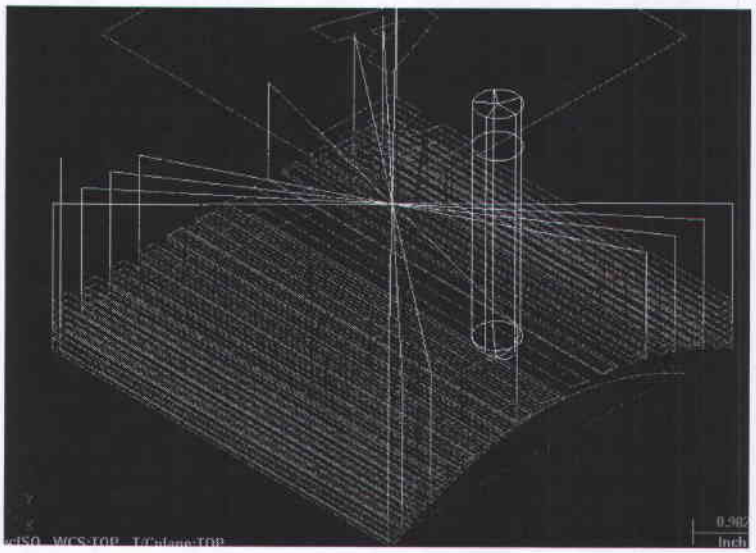
- Select the **Backplot selected operations** button.
- Make sure that you have the following buttons turned on (they will appear pushed down).

- **Display tool**
- **Display rapid moves**

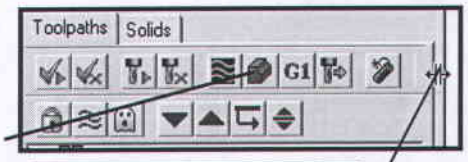


- Select the **Play** button.

- Select the **OK** button to exit **Backplot.**



VERIFY-TOOLPATH VERIFICATION
STEP 14:
VERIFY.



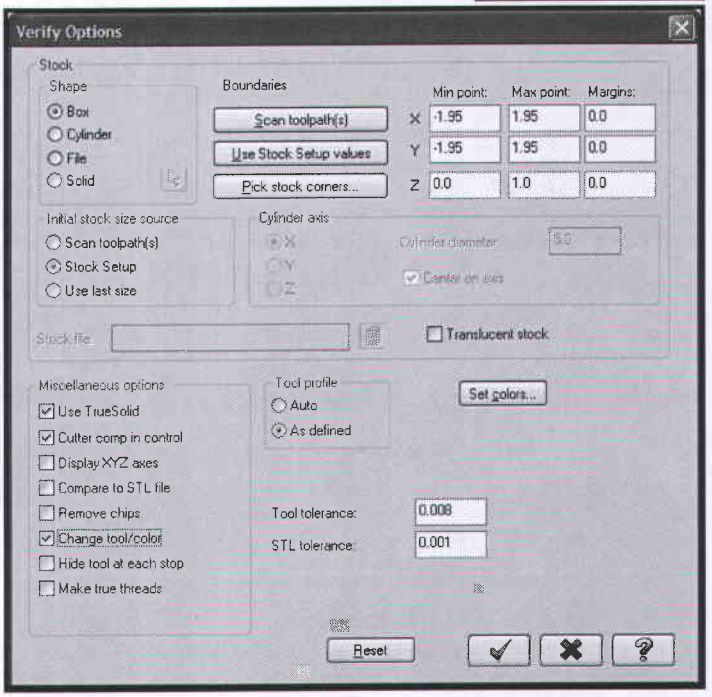
Select Verify

Drag the right side to expend it

- Expand the **Toolpaths Manager** if necessary by dragging the right side.
- Select the **Verify all selected operations** button.

- Select the **Configure** button.

Initial stock size source should be set to **Job Setup** to use the stock information from Stock Setup.
Use True Solid allows you, after verifying the part, to rotate and magnify it to more closely check features, surface finish, or scallops.
Change tool/color to change the color of the cut stock to indicated tool changes in the toolpath.

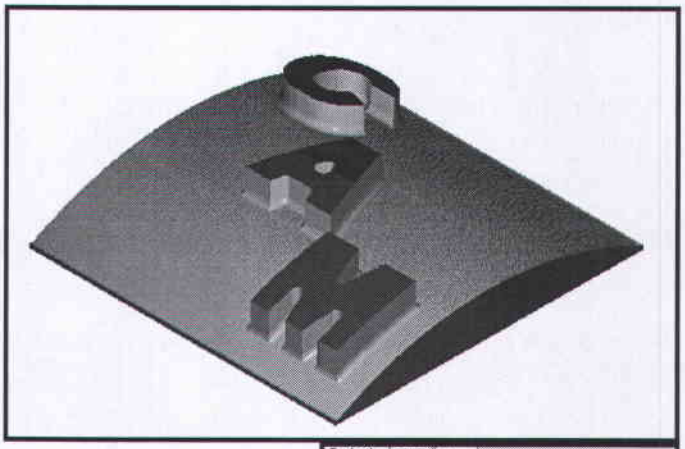


➢ Select the **OK** button to exit **Verify Options**.

➢ Set the **Verify speed** by moving the slider bar in the speed control bar.

➢ Select the **Machine** button to start simulation.

➢ The finished part should appear as shown in the following picture.

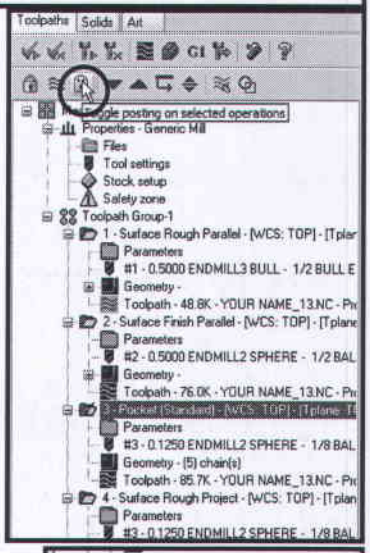


➢ Select the **OK** button to exit **Verify**.

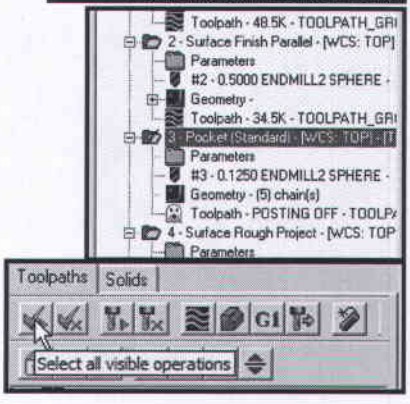
STEP 15:

POST PROCESS THE FILE.

➢ To make sure that you are not posting the pocket operation, select **Pocket toolpath** in the **Toolpaths Manager**.

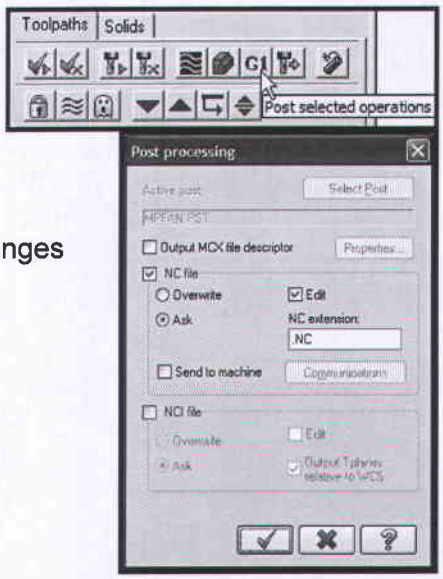


➢ The **Toolpaths Manager** will look as shown to the right.



➢ Click on the **Select all visible operations** icon.

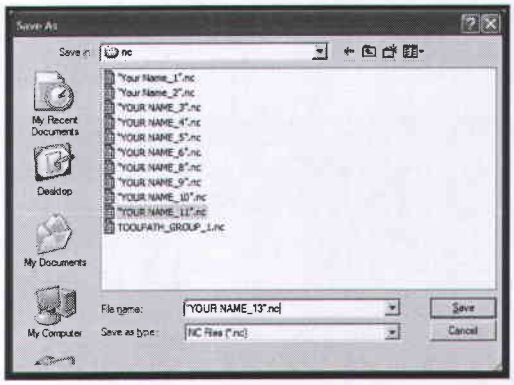
➢ Select the **Post selected operations** button from **Toolpath Manager**.



➢ In the **Post processing** window, make all the necessary changes as shown to the right.

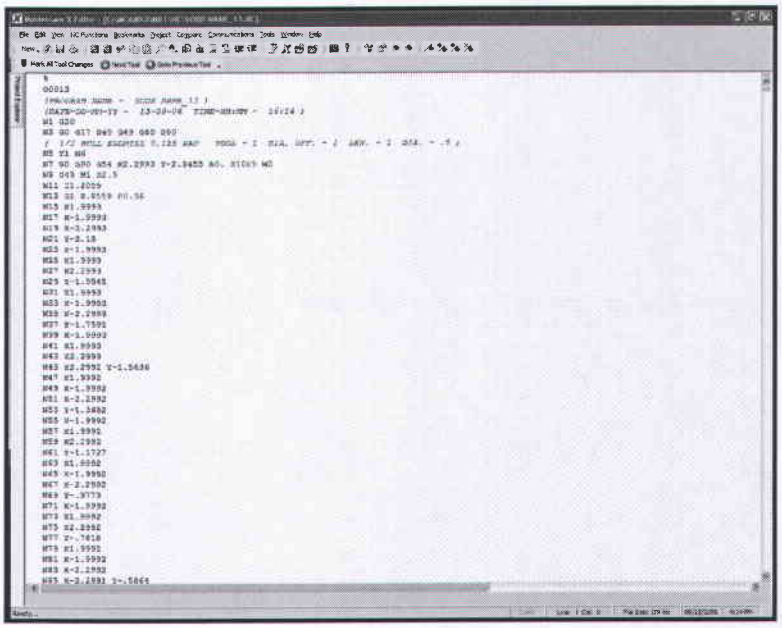
➢ Select the **OK** button to continue.

➢ Enter the same name as the geometry name in the NC File name field.



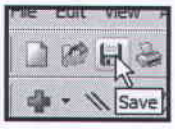
➢ Select the **Save** button.

➢ Select the red **X** box at the upper right corner to exit the **Editor**.

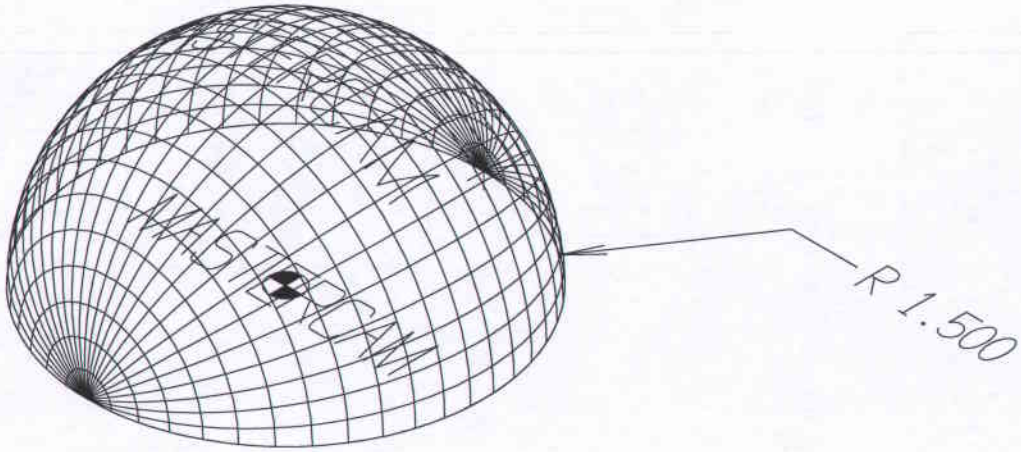


STEP 16: SAVE THE UPDATED MCX FILE.

➢ Select the **Save** icon.



ALL DIMENSIONS IN INCHES

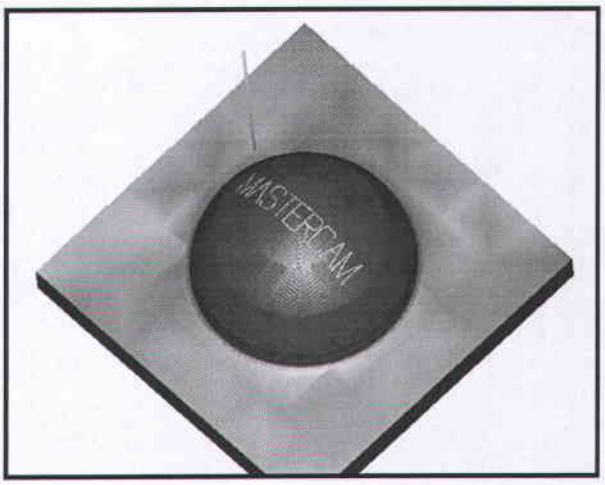


Create half of a sphere with a radius of 1.500".
Create MASTERCAM using drafting letters.
Scale the letters with 1.5 scale factor.
Drag the letters in the middle of the sphere.
Engrave the letters using Surface Finish Project toolpath.

TITLE TUTORIAL 13 - EXERCISE	
MATERIAL ALUMINUM T6061	
DATE: JUNE 12, 2000	eMastercam.com

REVIEW EXERCISE

Student practise. Create the Toolpath for **Exercise-Tutorial 13** as per the instructions below;

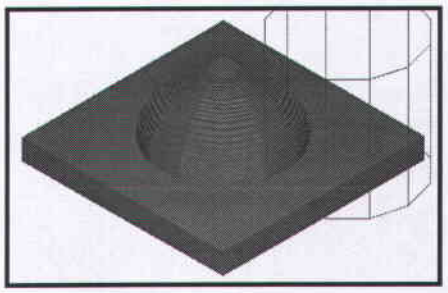


☞ **Tips: You need only the flat letters!**

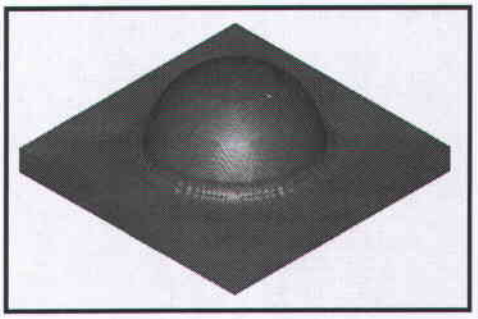
1. Establish the **Stock size** Y = 5, X = 5, Z = 2
Stock origin X = 0, Y = 0, Z = 1.505

2. Create a rectangle with surface option at Z0, the same size as the stock (5 X 5)

3. Surface Rough Contour

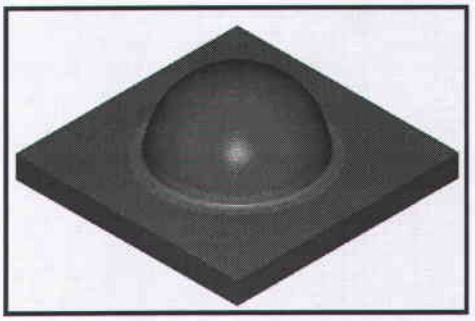


Select all surfaces
Use 3" Face Mill (change the library to Big.Tools and edit the tool: Taper angle=0)
Clearance = 2.5
Retract = 2
Stock to leave on drive surfaces = 0.02
Total tolerance = .005
Max. stepdown = 0.1
Enable Entry/exit Arc Radius = 0.25, Arc Sweep = 90
Enable Shallow
Add cut to shallow areas
Min stepdown = .005
Limiting stepover = .05
Disable Allow partial cuts
One way cutting



4. Surface Finish Scallop

Use 1/2" Ball End Mill
Total tolerance = .001
Max. stepover = 0.05
Expand inside to outside

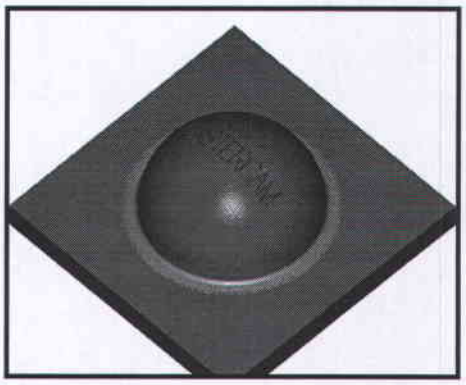


5. Surface Finish Leftover

Use 1/8" Ball End Mill
Total tolerance = .001
Max. stepover = 0.02
Cutting method 3D Collapse
Roughing tool diam = .5
Roughing corner radius =.25

6. Surface Finish Project

Use 1/32" Ball End Mill
Stock to leave on drive surfaces = -0.01
Projection type Curves
Enable Retract between cuts
Select the Letters using window selection see **Tutorial#13 page 13-22**



7. Backplot and Verify the toolpaths.

8. Post process the file.