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# Tombstone Machining Tutorials

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# TOMBSTONE MACHINING TUTORIALS

## About the Tutorials

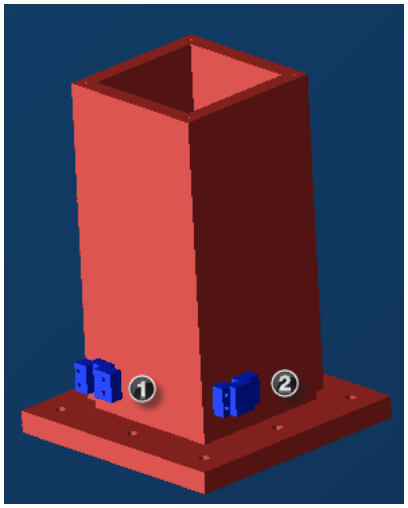
There are two tombstone machining tutorials. The first is an introduction to basic setups. The second tutorial is more streamlined and focuses on custom setups.

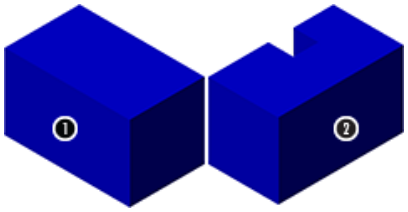
# INTRODUCTION TO TOMBSTONE

This tutorial will discuss how to go about setting up a basic Tombstone Part. We will go through creating operations with which to machine the part, then we demonstrate how to setup the Tombstone and how to define the parts arrangement using Stock and Fixture Layout. We will then check the results using Machine Simulation and a very basic horizontal mill model.

## About the Part

Most of the setup has already been complete for this part. The part uses a custom MDD called "Tombstone Tutorial Machine". The custom MDD will allow us to use Machine Simulation more effectively. What remains for us to do in this tutorial is generate the operations and define the tombstone setup. The feeds and speeds are set to use cast aluminum alloy and are calculated by clicking on the appropriate button.



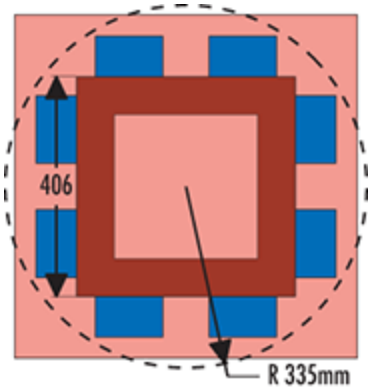

1. Face 1 Stock
2. Face 2 Stock

1. Open the part file `Sample Parts/Tombstone Management System/TMS - Required/TMS Tutorial.vnc`.

   The Sample parts are installed with GibbsCAM. A version of this part with all operations completed is provided in the TMS - Completed folder. While it is possible to begin with either file, creating the operations and becoming familiar with the part will make it easier to understand how TMS works.

Please note that you may see a message about the part using a particular MDD. This is to be expected as the part was created with a custom MDD for the Machine Simulation rendering. If you do see the message simply click the "OK" button. The system will create a copy of the MDD in the GibbsCAM folder so that you can use the part.

# Part Setup

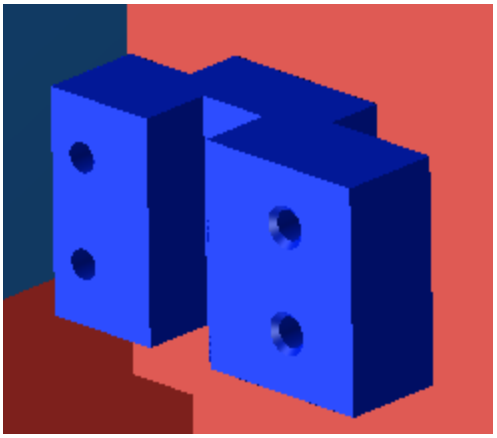



The center of the length and width of the tombstone lie at X0Z0. The bottom of the tombstone is at Y0. The four faces of the tombstone are parallel to the XY and YZ planes. Note that we have 2 stock conditions. The first is a multi-lump stock body. This body is there for toolpath generation. There are also 2 individual stock bodies. These are actually “Display Only” stock. These items will be used to help define the tombstone layout.

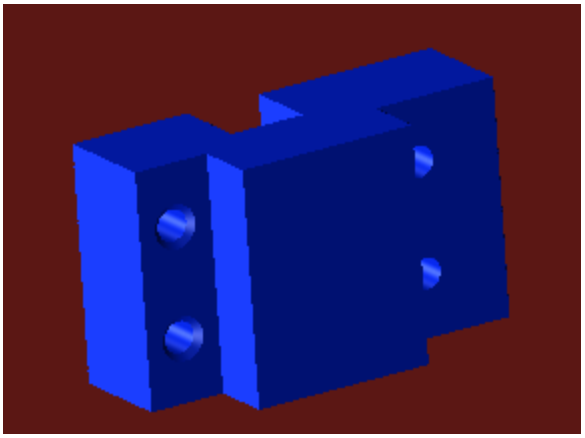
1. Set the Master Clearance Plane Z level to 335mm.

   The Clearance Plane setting (in the Document Control dialog) is essential. It must be high enough to clear the sides of the tombstone as well as the parts. In this case, 335mm is adequate to clear the 406x406mm tombstone. Note that we do not have to clear the 635mm base of the tombstone.

   We will be creating operations to machine the front and back of the part model. The parts are arranged such that the front is on sides 1 and 3 of the tombstone while the back of the part is on sides 2 and 4.



Face 1 Part



Face 2 Part

# Tool Setup

The tool list contains four tools.

| # | Type | Total Length | Diameter | Bottom Rad./Tip Angle | # Flutes | Flute Length | Material |
|---|---|---|---|---|---|---|---|
| 1 | Shell Mill | 86mm | 75mm | 0° | 10 | 50mm | Carbide |

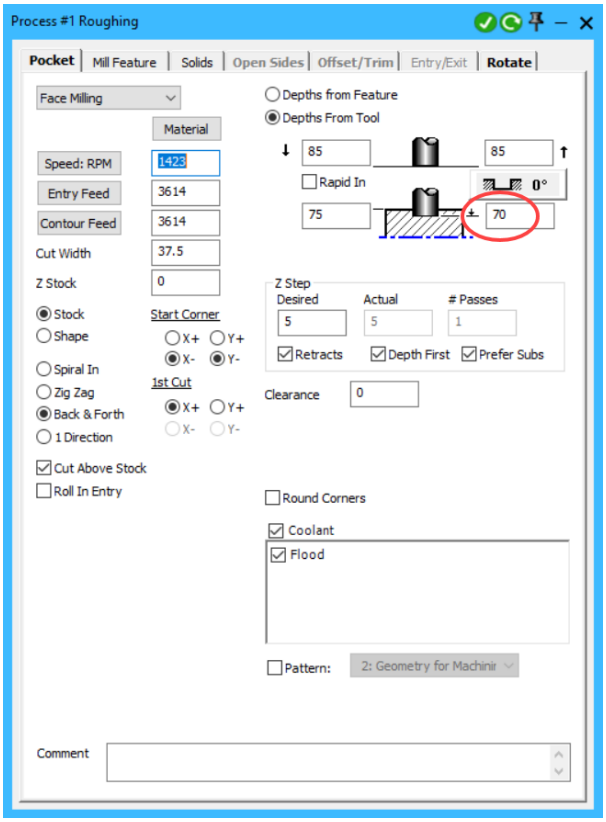
| # | Type | Total Length | Diameter | Bottom Rad./Tip Angle | # Flutes | Flute Length | Material |
|---|---|---|---|---|---|---|---|
| | | | | | | | Insert |
| 2 | Rough EM | 90mm | 25mm | 0° | 3 | 45mm | TiN Coated |
| 3 | Drill | 90mm | 10mm | 118° | 2 | 43mm | TiN Coated |
| 4 | Countersink | 35mm | 16mm | 90° | 3 | 70mm | TiN Coated |

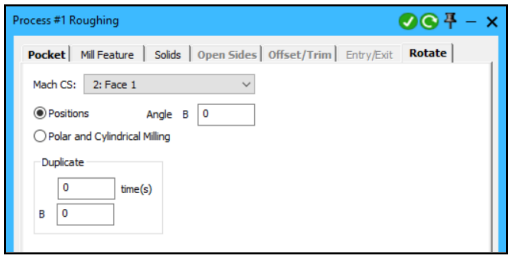
# Machining The Part

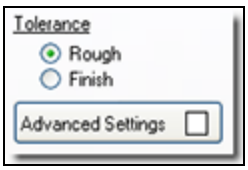
## Op 1 - Face Milling Face 1

The first thing we will do is a face milling operation on the part.

1. Create this Roughing process in CS 2 with the 75mm Shell Mill (Tool #1).



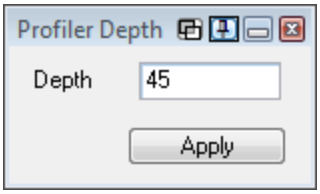

Ensure that Advanced Settings (found on the Solids tab) are disabled. We want to use the option Use Global Settings for Solids.

2. Create the toolpath.

# Op 2 - Profiler Contour Face 1

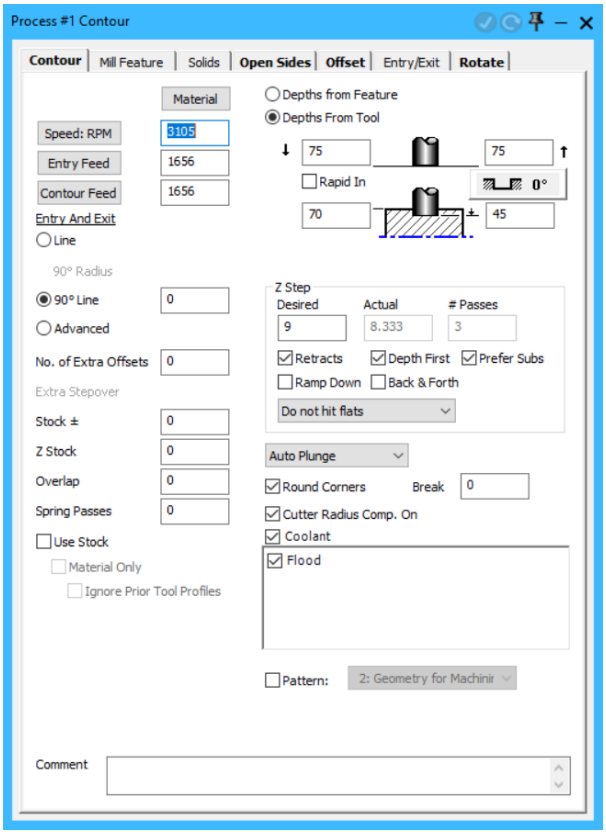
To machine the slot in the center of the part we will use the Profiler to make several passes down the side of the slot, using a tool that is the correct size.

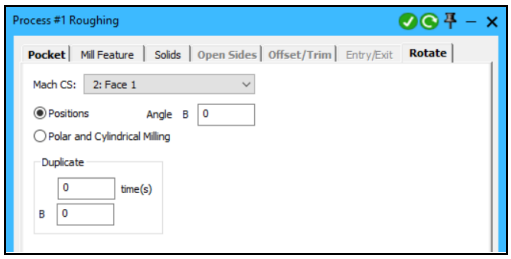
1. Activate the Profiler, Slice Plane  in CS2: Face 1 and set the depth to 45mm.



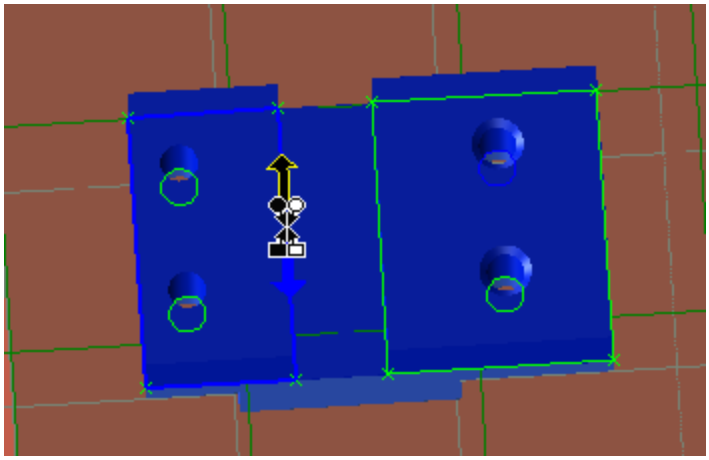

The bottom of the pocket is at 45. The depth is easily learned by interrogating the face.

2. Create this Contour process in CS 2 with the 25mm Rough Mill (Tool #2).



3. Set the Machining Markers on the feature shown.



To get the correct output we need to limit the features the profiler will cut.

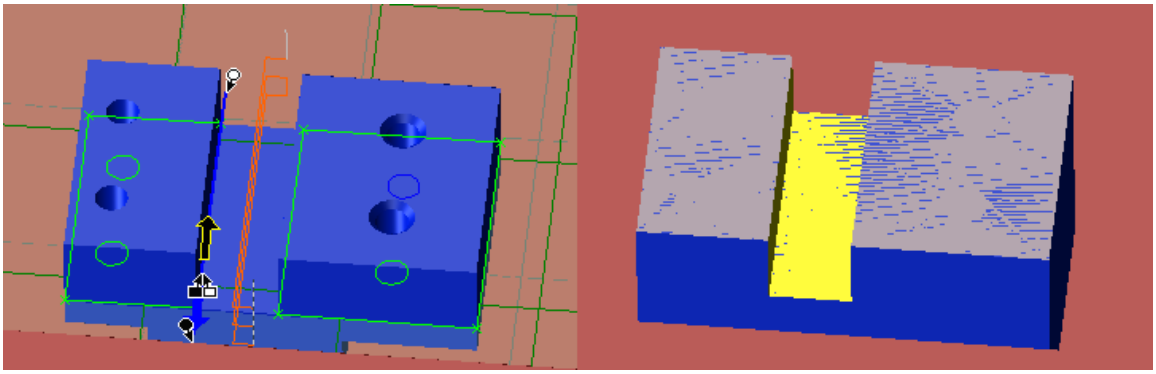
4. `Right-click` either the start or end marker and select "Single Feature Cut".

   This limits the toolpath to the feature the markers are on. We will also set the markers at a specific distance from the profile.

5. `Right-click` the start point marker and select Move Start/End Point to ... Enter an offset of `13mm`.

6. `Right-click` the end point marker and select Move Start/End Point to ... Enter an offset of `13mm`.

   This precise placement of the markers will ensure the tool's approach and entry are off of the part.

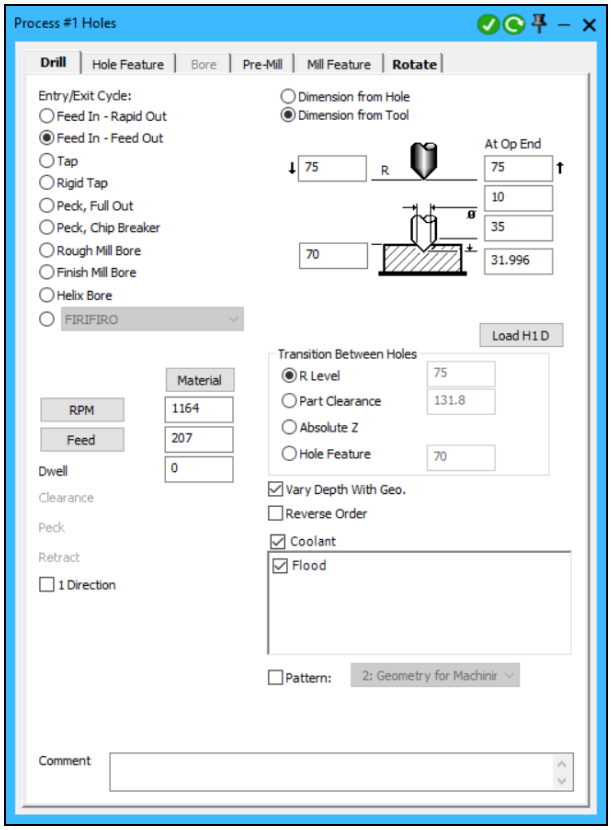


7. Create the toolpath and render the operation.

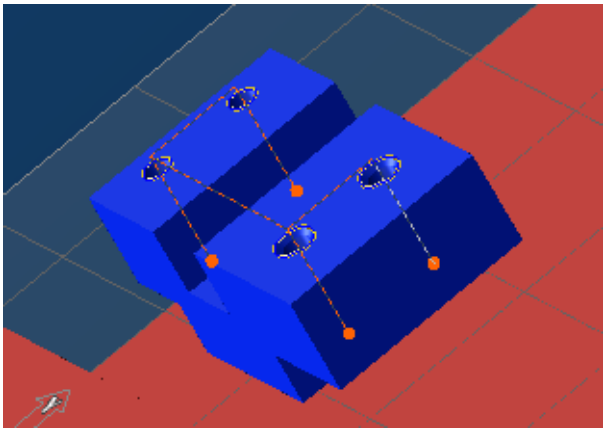
## Op 3 - Drilling Face 1

The next step is to drill all of the holes for this part. We will make blind holes so we don't cut into the tombstone. A Pocketing Op on Side 2 will make these through holes.

1. Create this Holes process in CS 2 with the 10mm Drill (Tool #3).



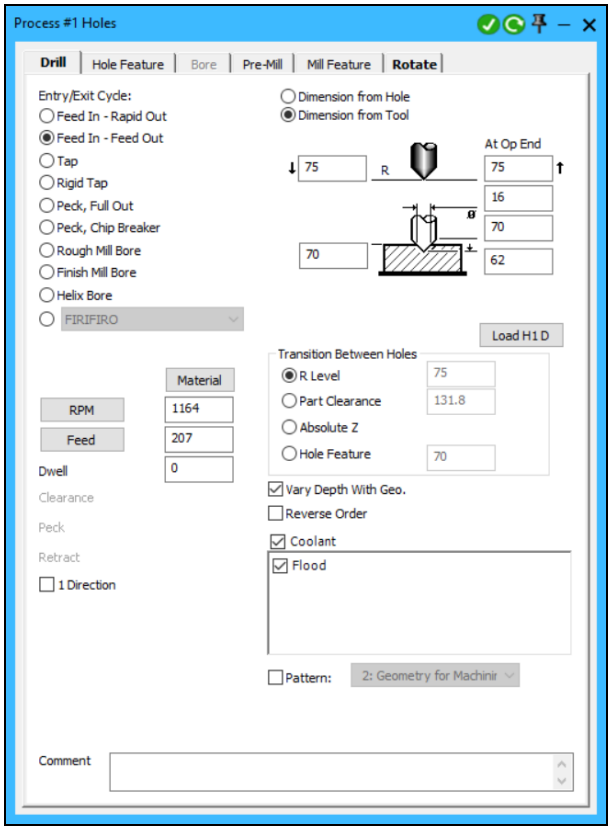

2. Switch the Profiler off and select the four circles on the top of the part. Create the toolpath.



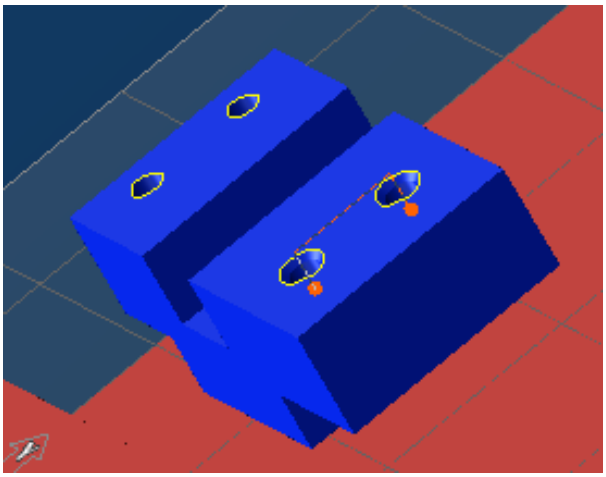
## Op 4 - Chamfering Face 1

The next step to complete this side of the part is by chamfering the two holes on the right.

1. Create a Holes process in CS 2 using the 16mm Countersink tool #4.




2. Select the two larger circles on the right of the part and create the toolpath.



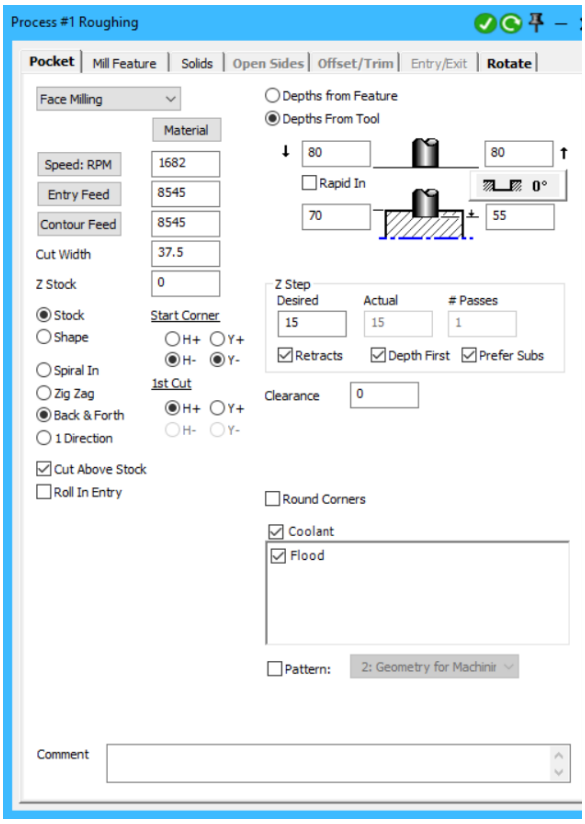
3. Render the operations.

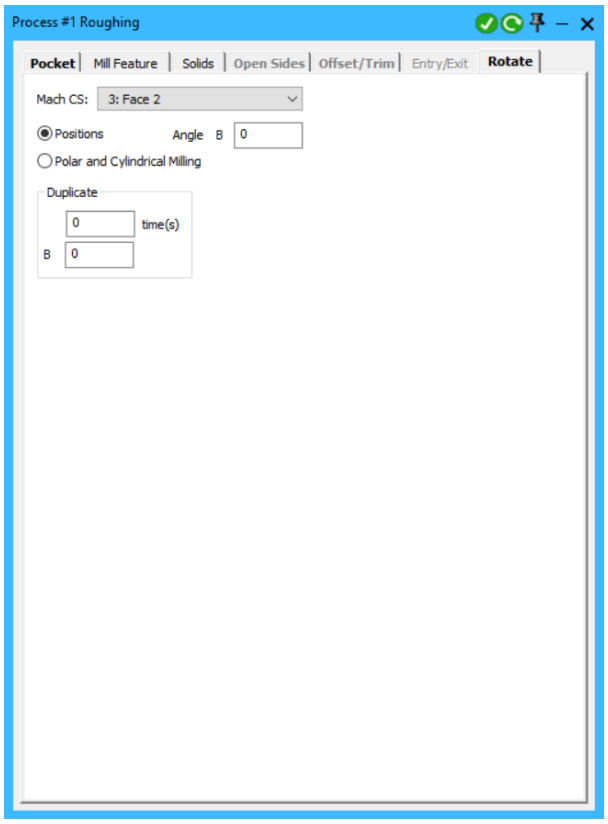

# Op 5 - Face Milling on Face 2

We now move to the operations on the back of the part. These operations are created on the part model that lies on the second side of the tombstone, which is parallel to CS3: Face 2.

This part and operations could have been created in CS2: Face 1, but for better visualization we've created them in their actual positions.

1. Switch to CS 3 and create this Roughing process with the Shell Mill tool (Tool #1).



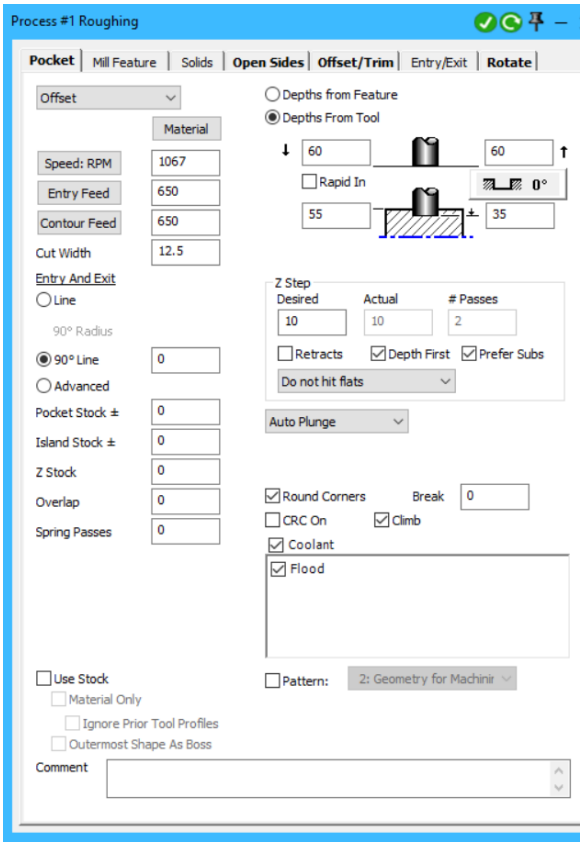



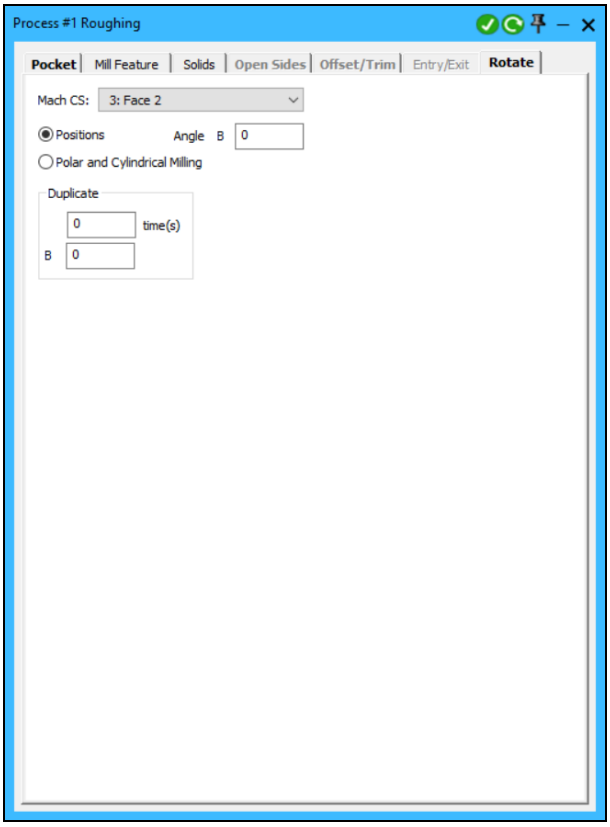

2. Create the toolpath.

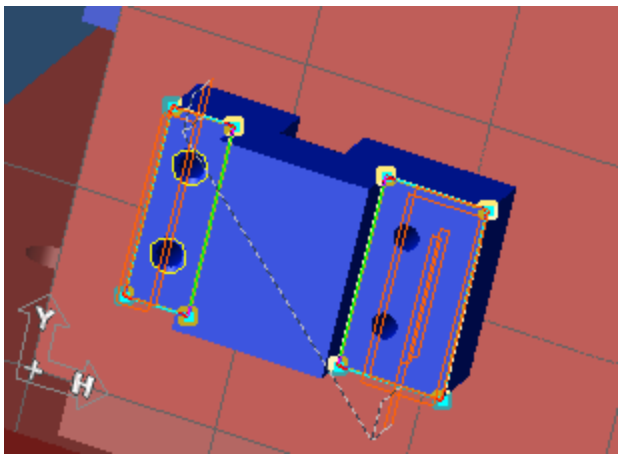
# Op 6 and 7 - Pocketing Face 2

Next we will rough two open pockets and expose the holes created in Op 3.

1. Select the combination Air-Wall rectangles for the cut shapes.
2. Create this Roughing process with the Rough 25mm Endmill (Tool #2).



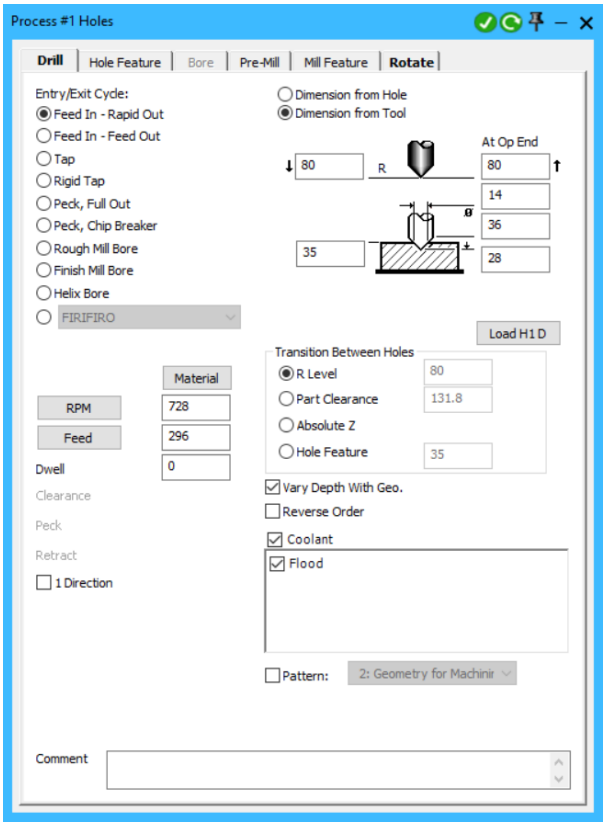



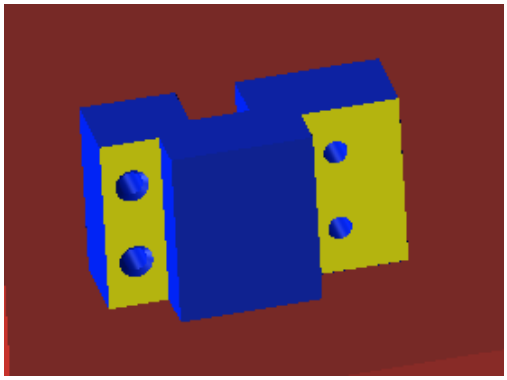



# Op 8 - Drilling on Face 2

The last operation is to chamfer the holes at the bottom of the smaller open pocket.

1. Select the two circles on the smaller pocket.
2. Create this Drilling process with the Countersink (Tool #4) and render the operations..



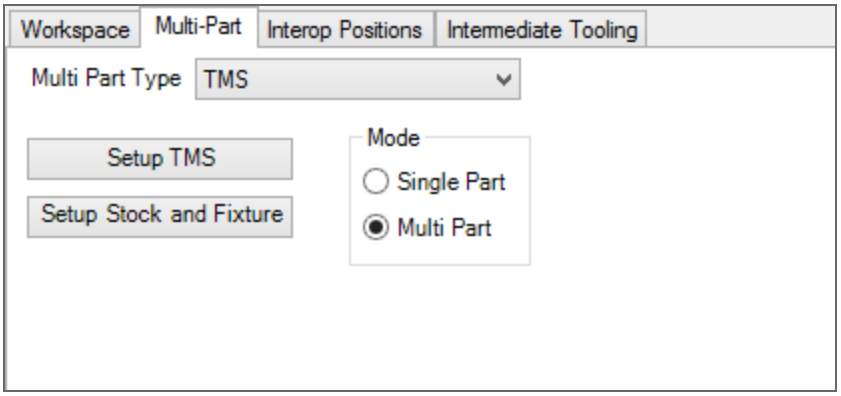



# Tombstone Setup

## Creating TMS Data

Now that the machining is complete we can create the TMS setup data. To do this we need to set up the TMS data.

1. Go to the DCD and choose the Multi-part Type TMS.

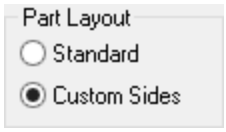


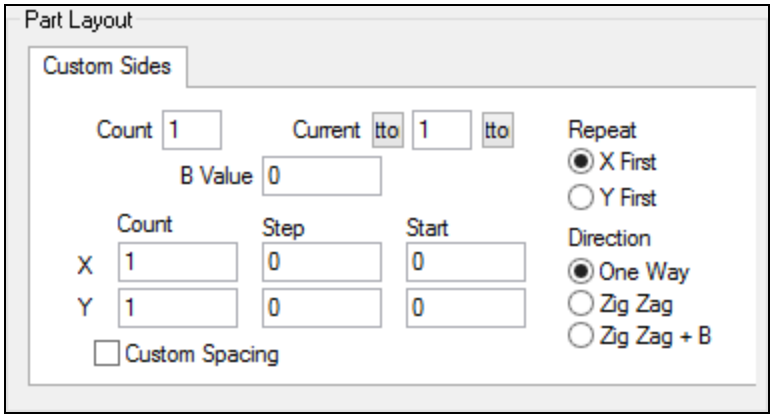

2. Click Setup TMS. This opens the Tombstone Management System dialog. This dialog allows us to define how our parts are to be cut on the tombstone.

Choosing which Part Layout option to use is typically determined by how your parts are laid out on the tombstone.

If the tombstone has the same number of parts with the same distances between each part, then you would use the Standard layout. Despite having to apply special filters to get operations on the correct sides of the tombstone, this option is probably faster and easier.


If the tombstone has different numbers of parts on a side or different stepover between parts (typically due to using different fixtures) for more automatic control of the positioning you would use the Custom Sides layout.

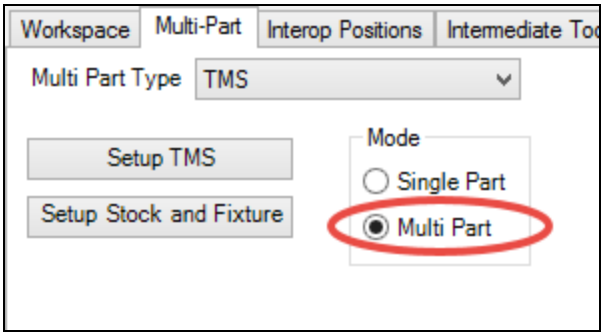


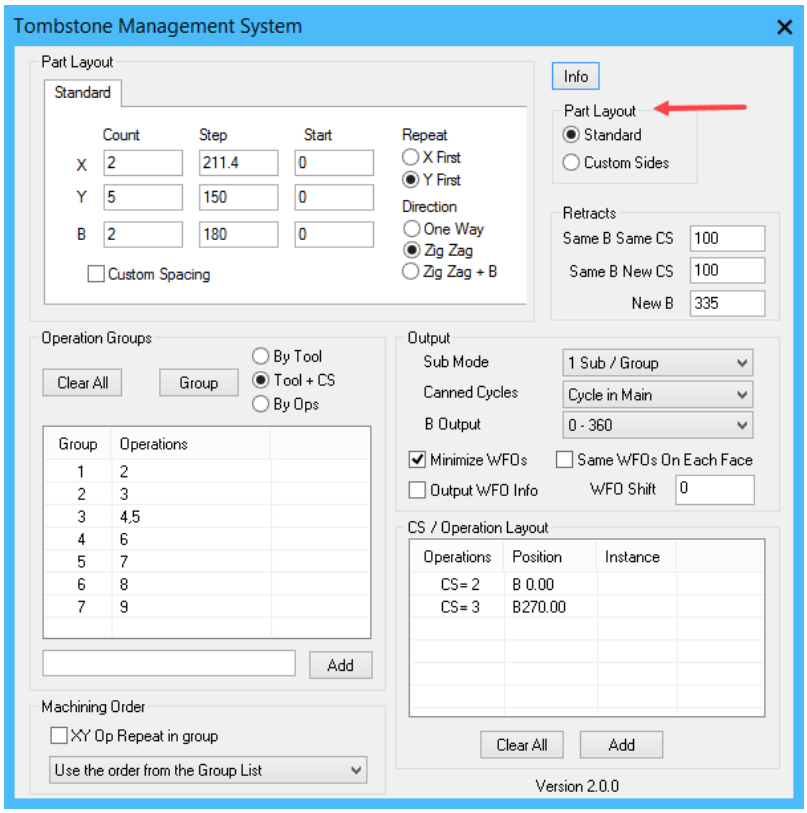
# Part Layout

The Mode selection on the DCD Multi-part Tab determines what kind of G-Code will be output. . Single Part will generate G-Code that takes the tombstone setup into account including WFOs and B positions Only one iteration of the program will be output. Multi Part will output the full G-Code including the repeated data for the additional parts.

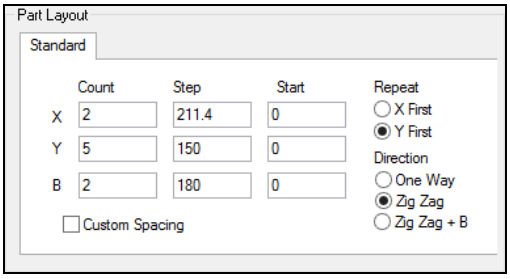
1. Ensure that Multi Part is selected.

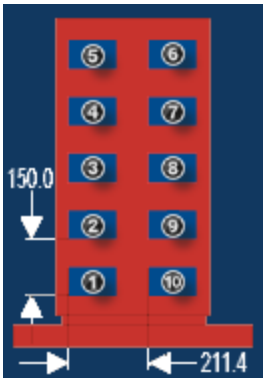



Now click the TMS Setup Button. This is where you will define the programming of the tombstone.



2. This tutorial can be defined using the Standard Part layout option. Click the Standard button and enter the data as shown.



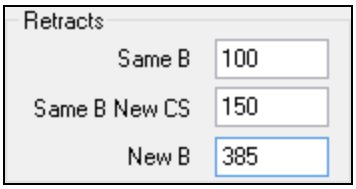

The tombstone is set up such that there are two parts in X with a stepover of 211.4mm from edge to edge and five parts in Y with a stepover of 150mm. This setup is repeated twice so a B count of 2 is entered. The rotation between sides is 180°.

Repeat is set so that the second part machined will be above the first (cut "Y First") and the repeat will be Zig Zag pattern - when the machine has cut all parts in Y it will move to the right and machine down.

## Retracts and Output

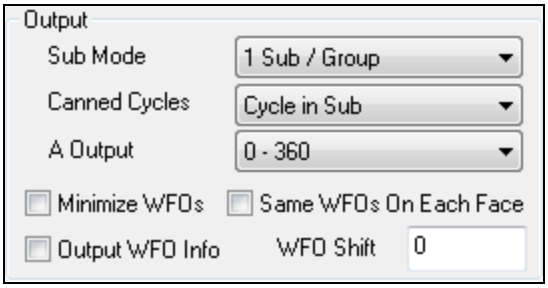
On the TMS setup dialog, the Retracts information must be set so that we don't crash the machine. The Same B setting is the retract level (from the part origin) for parts on the same face. The New B setting is the retract level for moving to a new face on the tombstone.

3. Set the Same B to 100, Same B New CS to 150 and the New B to 385.




The part stock is 75mm deep so a clearance plane of 100mm is more than adequate. The Same B New CS provides extra clearance options if you have multiple CS's. The 385mm value (Part Setup) is sufficient for changing B positions. If fixtures were defined for this part, the clearance may not be adequate, but as this is a simple tutorial without fixture bodies, we'll pretend we don't need to clamp the parts to the tombstone.

4. Set the Sub Mode to 1 Sub / Group, the Canned Cycles to Cycle in Main and the B Output to 0-360 in the Output section of the Tombstone Management System dialog.

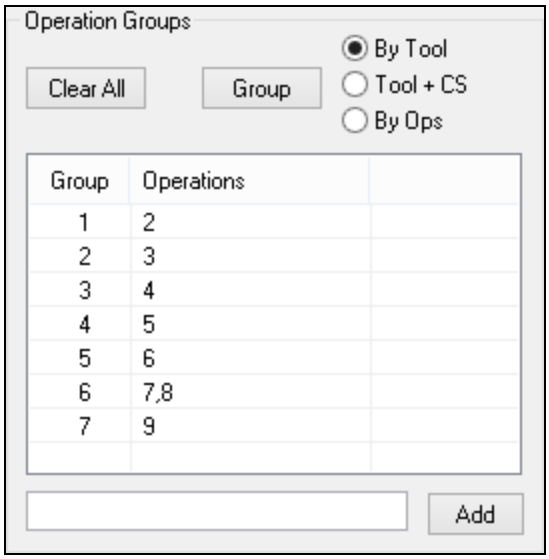



This data affects how our posted output will appear. The 1 Sub / Group option will create the fewest number of subroutines, and each subroutine will contain one or more operations that have been grouped, (we will group the operations in next section). Canned cycles will not be in a subroutine but will be output in the main part of the program. All B values will be between 0 and 360 degrees, e.g. 390° is output as 30.

## Operation Groups

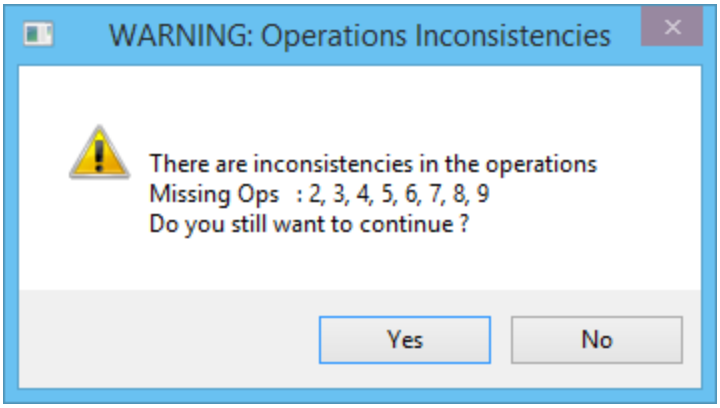
Operation groups allow us to optimize a program. Groups may be automatically generated or may be manually entered. There are three options for grouping operations, By Tool, Tool + CS and By Ops. By ops will create the greatest number of groups, one group per operation. The Tool + CS option will create a group of the same tool if it is used in the same CS. By tool will create groups by the tool used. It is important to note that this is all dependant upon the order of the operations. That is, if tool #1 is used in operations 1 & 20, it will not be grouped using any option. The operations will need to be optimized in the operations list.

1. Select By Tool in the Operation Groups section and `click` the Group button.




This grouping is not very optimal. The only group of tools we have is operations 7 and 8. This is barely different than the results we would get with By Ops. We know this can be better as operations 2 and 6 use tool 1. To optimize the program we should avoid the unnecessary tool change that will result from the way we currently have the operations set.

2. `Click` the Clear All button and the ✕ button.




This clears the groups and will attempt to close the dialog but a warning comes up alerting us that there are items in the Operations list that are not grouped.

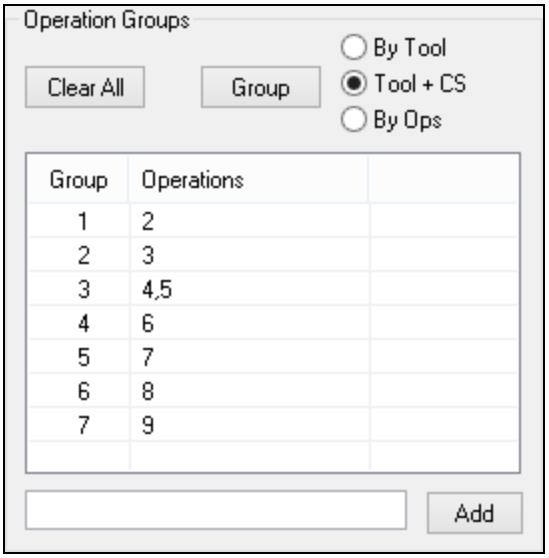
3. `Click` the `Yes` button to continue and close the Tombstone Management System dialog.

   We need to reorganize some operations to optimize our program. We will sort the operations by tool to minimize rotations and tool changes.

4. Move operation 5 to position 2 by dragging the tool tile.
5. Move operations 6 and 7 to position 3.

   This puts the operation before another operation with tool 2. This is done because the tombstone will already be on face 2. Placing these tiles on position 5 would create an undesired rotation. The rest of the operations are in positions that will not incur any unnecessary tool change or rotation.

6. Go to the DCD and click the Setup TMS button.
7. Select `Tool + CS` and `click` the `Group` button to create the groups.

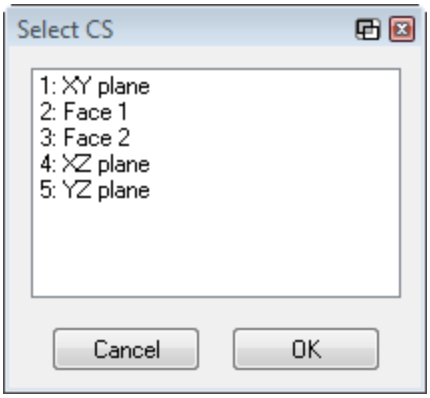



This is a more optimal program. We have not changed the number of groups but we have minimized some rotations and tool changes. The only grouped operations are the pockets on Face 2. The posted output will have seven subroutines, with one or two operations each.

# CS/Operation Layout

The last thing we need to do in the Tombstone Management System is to define the operation layout. Since we have two different parts on the tombstone this is particularly vital.

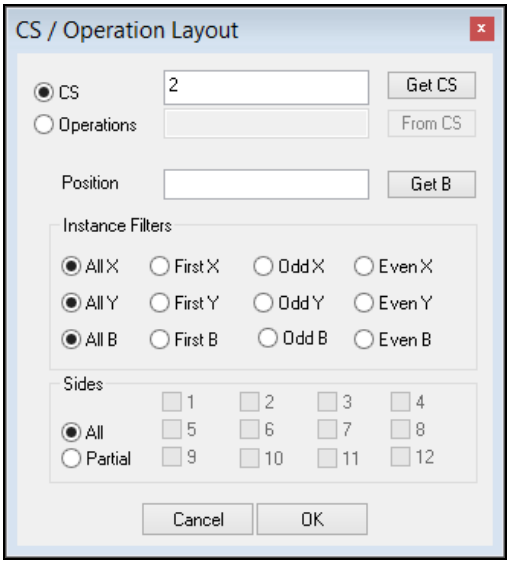
1. Click the Add button and select the CS option and click the Get CS button.

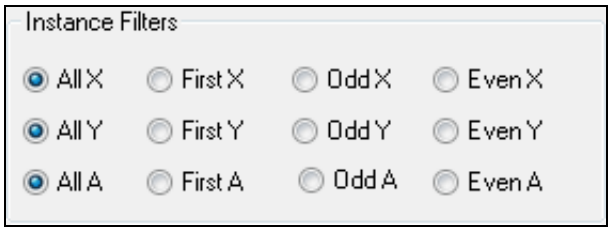


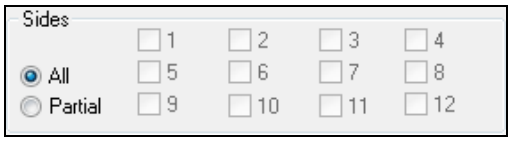

The Select CS list opens that lists all of the part's coordinate systems. This allows us to choose which CS a filter is to applied to.

2. Choose 2: Face 1.

The CS/Operations Layout dialog now contains an entry. In some cases we might need to define what the filters are for accessing this CS. There are two functions we can use to control the layout, Instance Filters, which control the layout by X Y and B data or the Sides option, which specifies what sides of a tombstone will use the CS in question.

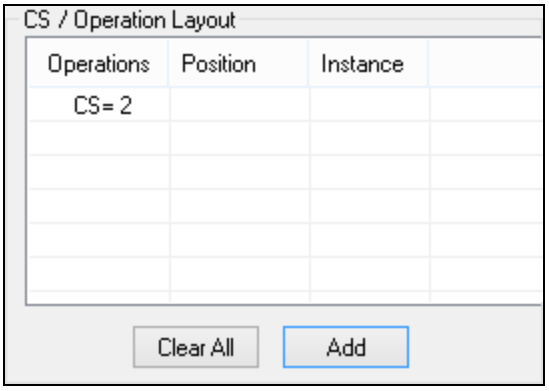


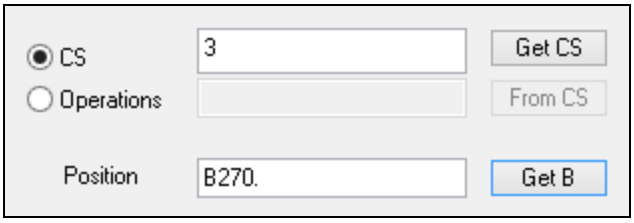

As this is a fairly simple setup, we do not need to use a filter. We already stated that the Part Layout has two sides that are 180° apart, starting at B0. The Instance Filters and Sides options should be left at "All".

3. Click the OK button.



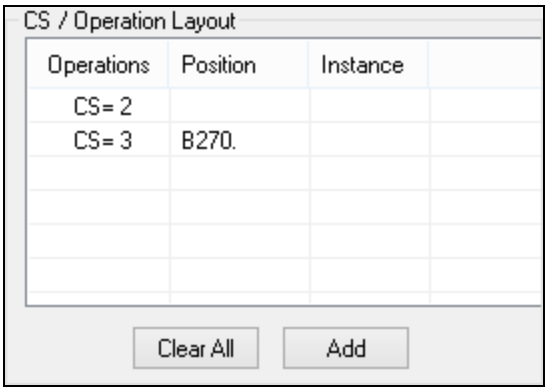

The dialog closes and we have an entry in the CS/Operation Layout list. We need to add one more for the back face.

4. Click the Add button then select CS and click the Get CS button.
5. Choose 3: Face 2.




We need to properly define the position of this CS for machining.

6. Click the Get B button and then OK.




We now have a complete listing. The setup for the operations in CS3 (faces 2 and 4) is identical to the Part Setup, but is rotated by 90°.

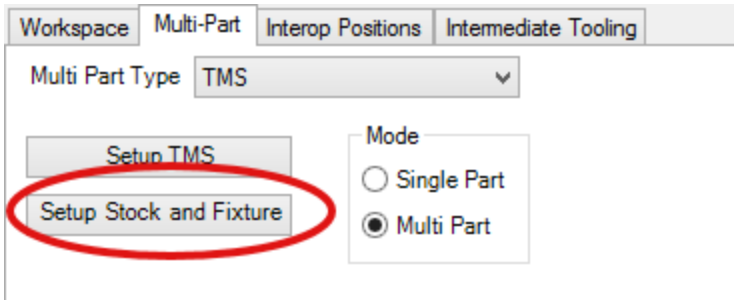
7. Click the ✕ button.

   This closes and saves the dialog.

# Stock and Fixture Layout

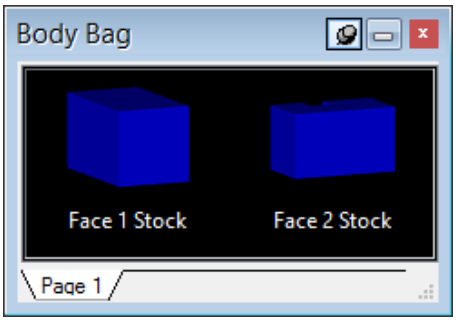
## The Stock/Fixture Layout dialog

To get the TMS part ready for machine simulation we need to define the parts, and in some cases, the fixtures for Machine Simulation. This is accomplished via the Setup Stock and Fixtures item.




The Stock/Fixture Layout dialog allows us to define what parts will be rendered in Machine Simulation and where they are placed. As solid models are designated, the workspace will draw a wireframe to display where the part stock and/or fixtures are situated. When Machine Simulation is activated the proper stock and fixture bodies are rendered.

We have two stock bodies that need to have a layout defined. The tombstone fixture body does not need to be set, but if we had models for the fixtures needed to hold the stock in place we would have to define their layout as well.

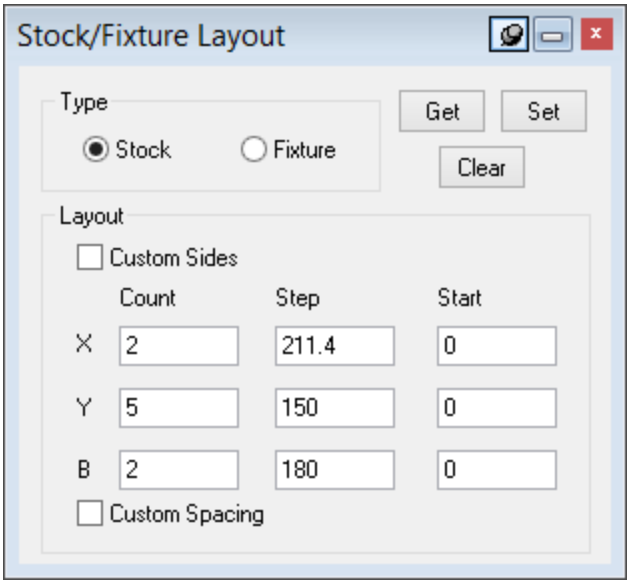



1. Un-bag the two part models from the Body Bag.

   This will make it easier for selecting the stock bodies. The bodies we will use for our stock setup are “Display Only” stock bodies named Face 1 Stock and Face 2 Stock. The multi-lump stock body was used for the toolpath generation, specifically the face milling “Stock” designation.

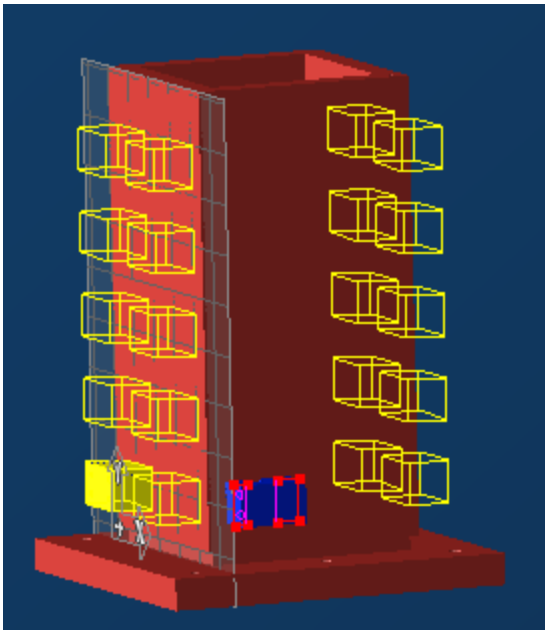
## Face 1 Stock Definition

1. Choose > DCD> Multi-part > Setup Stock and Fixtures.
2. Select the Face 1 Stock body.
3. Select the Stock option and enter values in the Layout section as shown.




The X and Y values should be familiar to you as they were used to define the Tombstone Management System. Values in the start column would be used if a part needed a custom X or Y position or were not on the first face of the tombstone. The custom spacing checkbox enables exact positions to be entered.

4. Click the Set button. Do not close the dialog.



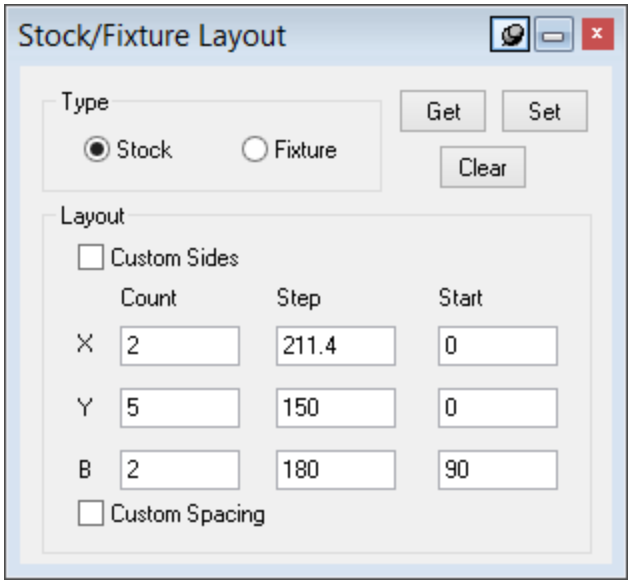
Yellow wireframe shapes appear on the tombstone. If the arrangement was incorrect you could click the Clear button to remove and change the setting. If nothing appears make sure the stock body is selected.

## Face 2 Stock Definition

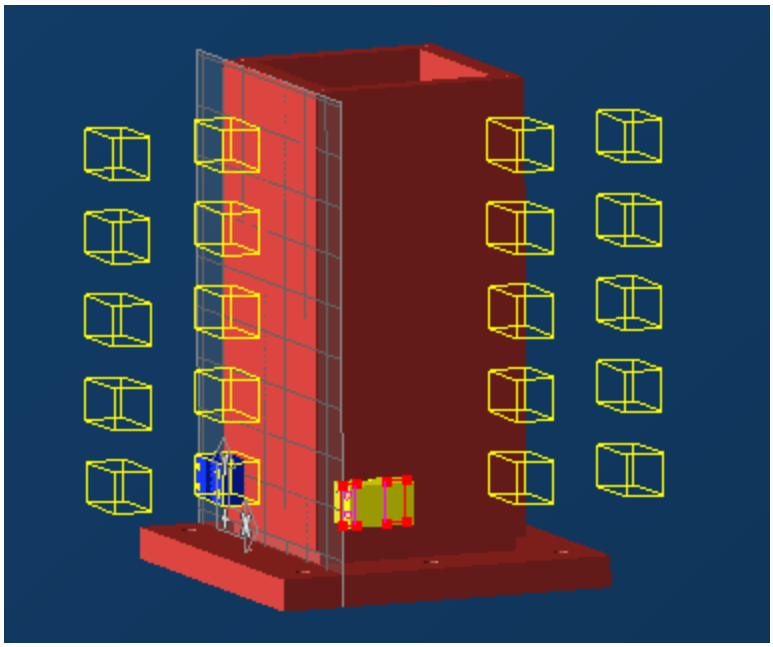
We will now set the layout for the Face 2 Stock body.

1. Select the Face 2 Stock body.

2. Change the B values as shown and `click` the Set button. Do not close the dialog.



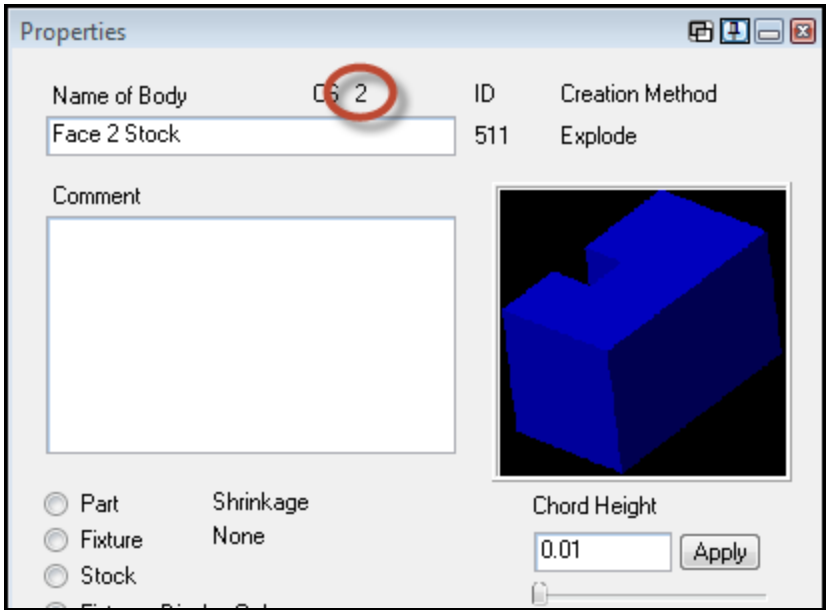

## CS Error Resolution



We have made two mistakes. One of the values we entered is incorrect but more than that is wrong. Since the wireframe shapes are being drawn in the wrong position we can assume that the problem has to do with coordinate systems.

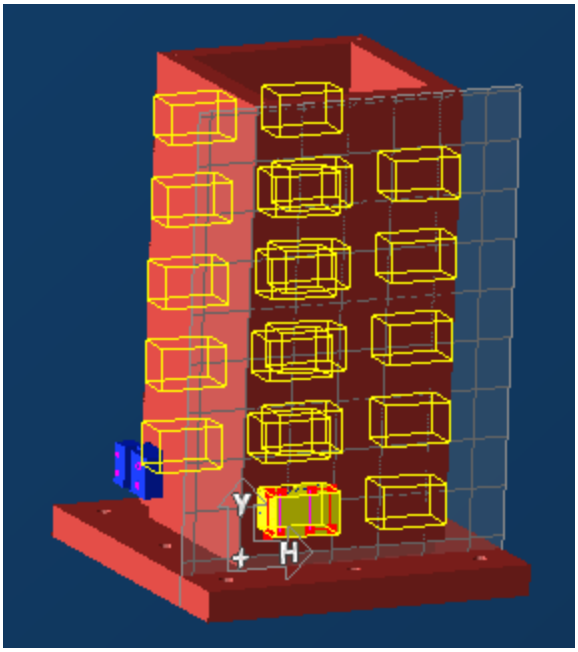
1. `Right-click` the Face 2 Stock Body and select Show Properties.

This body is assigned to CS2, the CS aligned to Face 1. Normally, bodies are not dependent on CS data, but for TMS the CS is important. The data entered in the Stock/Fixture Layout dialog is relative to the CS of the body. We need to change the CS this body is assigned to. Leave the properties dialog open.




2. Switch to CS3: Face 2 and choose Modify > CS > XYZ Change CS (XYZ). The CS changes to CS 3. Close the Properties dialog.
3. Change the B Start value to `0` and `click` the Set button. Do not close the dialog.

If you force a screen redraw (`Ctrl-R`) the stock display will update.




## About the Wireframe Display

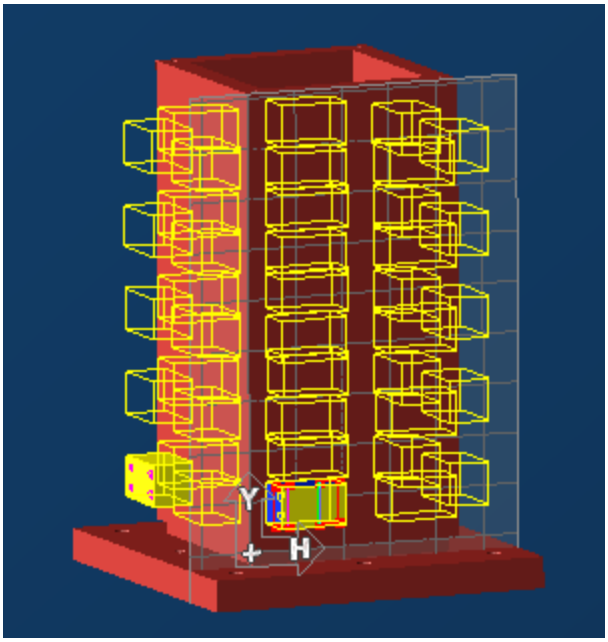
The proper arrangement is set. Note that the system still displays only a wireframe shape that bounds the stock shape. This is so the system does not slow down. When Machine Simulation is activated the full shape will be drawn.

1. Select the Face 1 Stock body.

Note how the display changes to the layout we defined for this body.

2. `Ctrl-Click` the Face 2 Stock to add it to the current selection.

The wireframe display now shows our entire layout. The wireframe display is only available when the Stock/Fixture Layout dialog is open. If you close the dialog and open it and select a body the system will draw the wireframe shapes again.

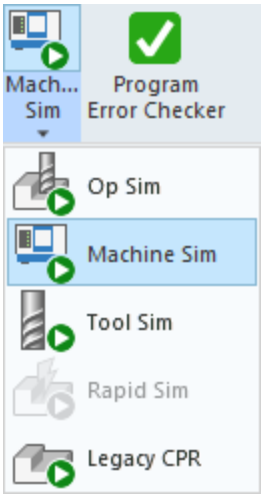



3. Close the Stock/Fixture Layout dialog.

# Machine Simulation

## Setup

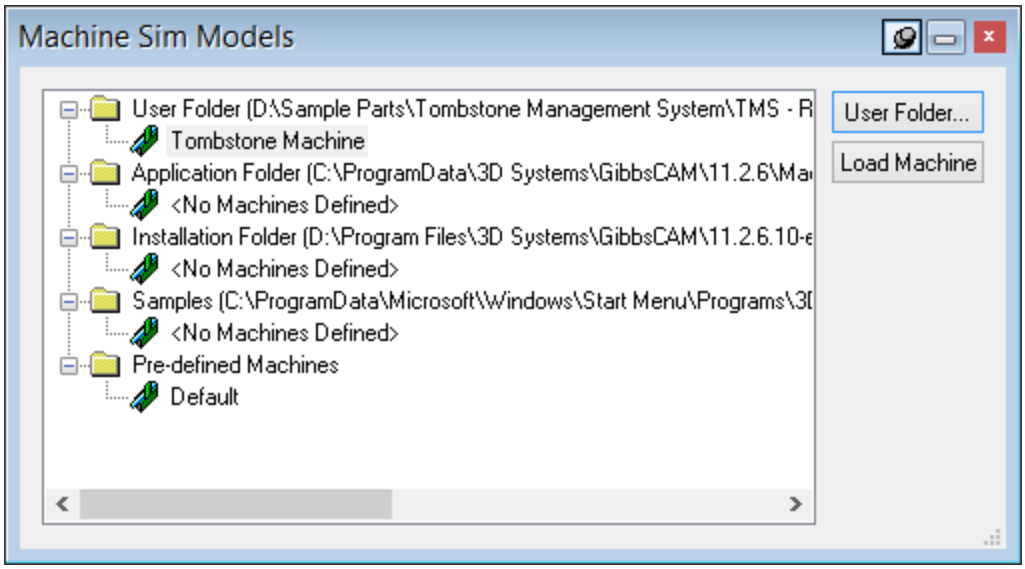
1. Select Machine Sim from the Simulation dropdown menu in the Command Palette..




When Machine Sim is activated the rendered image is in Part mode and includes the stock setup we just completed. We need to select a machine assembly model for Machine mode to work. A four-axis horizontal mill assembly file has been created for the TMS tutorials and can be found in the Part Files folder.

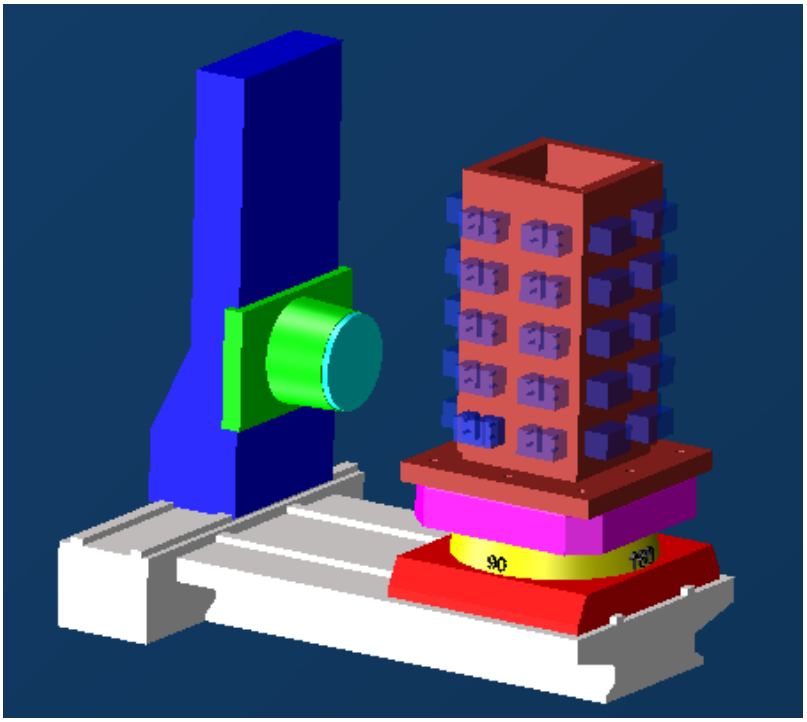
2. Choose the Load Machine  icon in the Machine Sim Render Control palette.

3. Click the User Folder box and navigate to your Sample parts folder (Sample Parts\Tombstone Management System\TMS - Required).




This will make any existing machine assembly models available for our use.

4. Select the Load Machine option.




The tombstone is set up as well as the horizontal mill tombstone machine model. Please note that the orientation will probably not be the same as seen here.

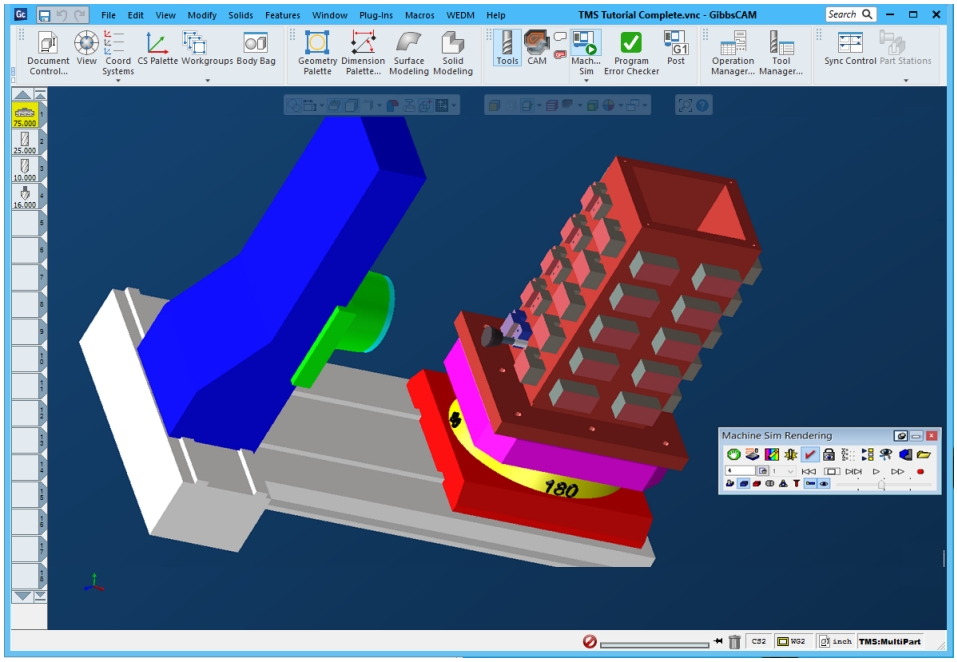
This is a fairly simple 4-axis horizontal mill. The table is mounted to the Z axis while the spindle is on the Y axis which is on the X axis. We have added angle values so that you may more readily see the rotations.

# Rendering

Machine Sim rendering is dynamic, meaning the part image may be manipulated while being rendered. Tombstone Machining with Machine Sim will show all inter-operation and inter-operation moves. The only thing not rendered is tool changes. The tool will simply retract and the next operation will have a new tool (and associated holder).

1. Render the operations.

We can zoom in on the part to check the machining, though you may find that Op/Tool Sim or Legacy CPR may be more appropriate for part verification while Machine Sim is more appropriate for program verification.



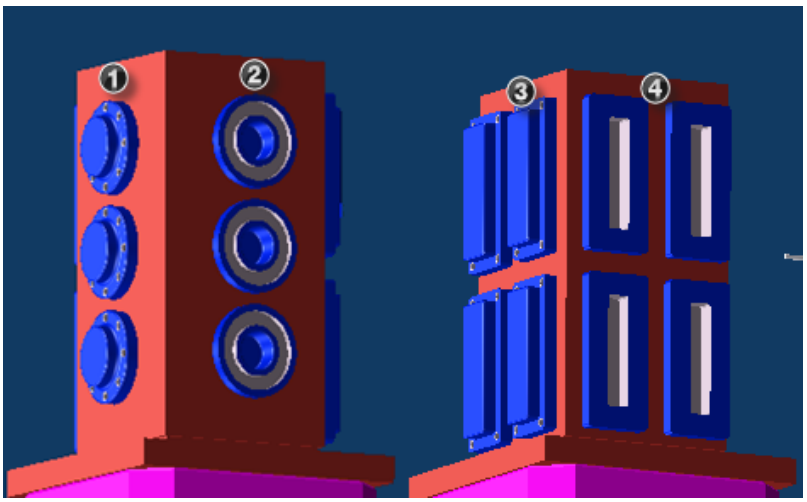

2. Save the part.

# CUSTOM SIDES

This tutorial is designed to familiarise you with a "Custom Sides" setup. The part file already contains models, tools and operations that create the base parts. We will create the TMS operation and define the custom stock layout for Machine Simulation.

1. Open the file Custom Sides.vnc.

The existing operations drill and chamfer the parts on sides 1 and 3. The parts on sides 2 and 4 have pockets that get roughed and finished. There are four tools: a drill, a countersink, a rough endmill and a finish endmill.




## Setup TMS

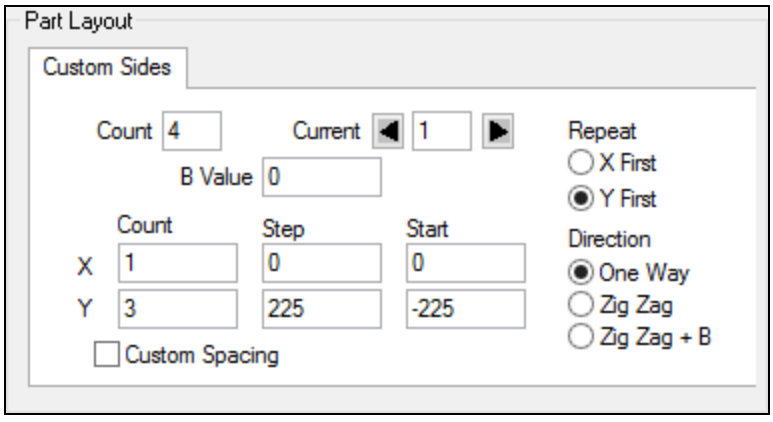
1. Choose DCD > Multi-Partand set the mode to Multi-Part.
2. Click Setup TMS and for the Part Layout choose Custom Sides.
3. Set the Same B retracts to 80mm and the New B retracts to 350mm

## Part Layout

We need to define each side of the tombstone individually.

1. Click In the Custom Sides tab and set the Count to 4.

The dialog shows the Current side is 1. Side one has three parts vertically on the center of the tombstone's face.

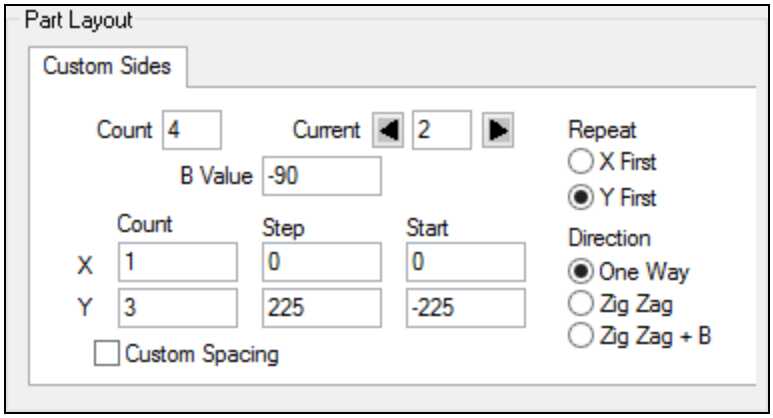


2. Set the Repeat to Y First and designate a One Way cut.
3. Set the Count, Step and Start values as shown.

   The parts are 225mm apart. Note that we've specified a Start of -225mm. The part we have used for creating the operations lies in between two other parts. Therefore we have to specify an offset so that we cut all three parts. In this case we will start at the bottom of three parts and move up.

4. Click the right arrow ▷ to change the Current setting to 2.

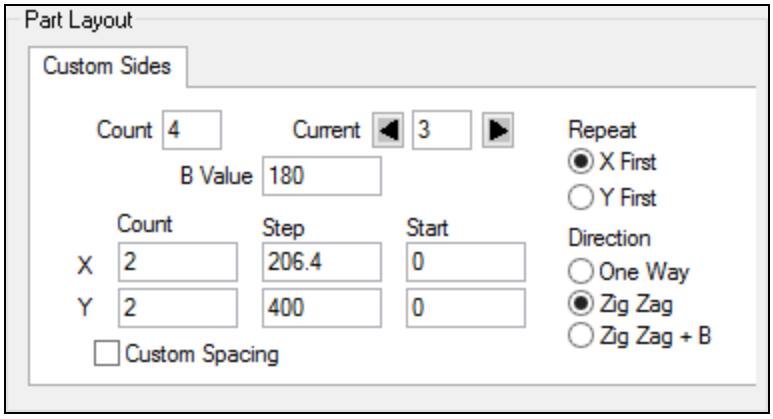
5. Set the Repeat, Count, B Value, Step and Start values as shown.




   The data is essentially the same as side 1 except that the B Value needs to be set to -90.

6. Click the right arrow ▷ to change the Current setting to 3.

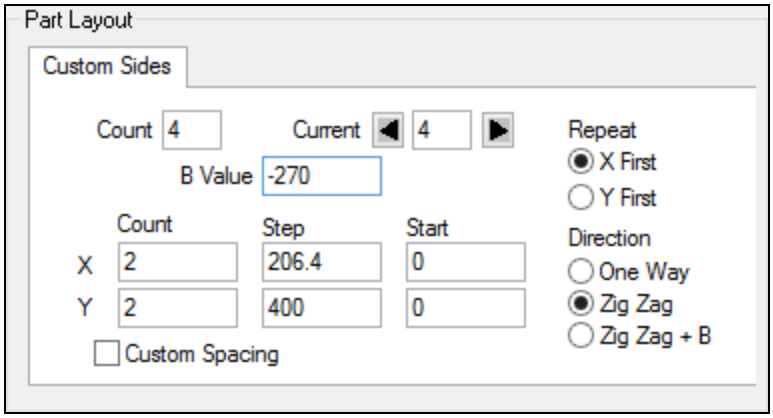
7. Set the Repeat, Count, B Value, Step and Start values as shown.




   There are four parts on this face with the operation being defined in the bottom left corner. The Repeat is set for X First with a stepover of 206.4mm in X and 400 in Y. The stock is cut in a Zig Zag pattern. This part is on the third face so the B Value is 180.

8. Set side 4 as shown.

The data is essentially the same as side 1 except that the B Value needs to be set to -270

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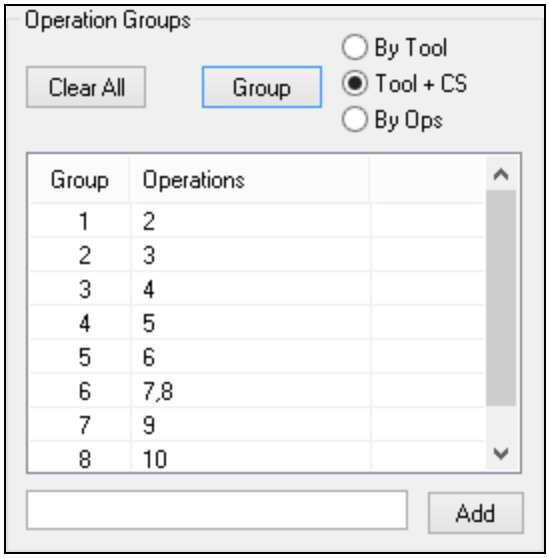
## Operation Groups

The operations are already arranged by tool in the Operations list, we simply need to group them for TMS.

1. Select Tool + CS and click the Group button.

We now have eight groups, one for each operation except group 6 (operations 7 & 8) which is the finishing contour operation.

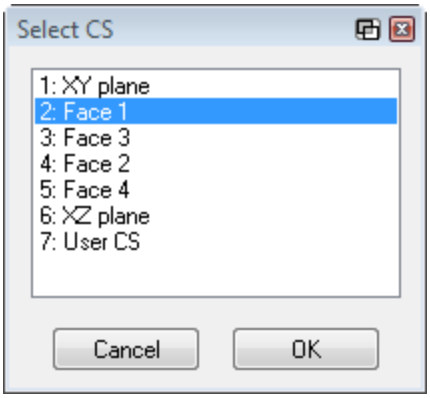



## Instance Filters and Sides Layout

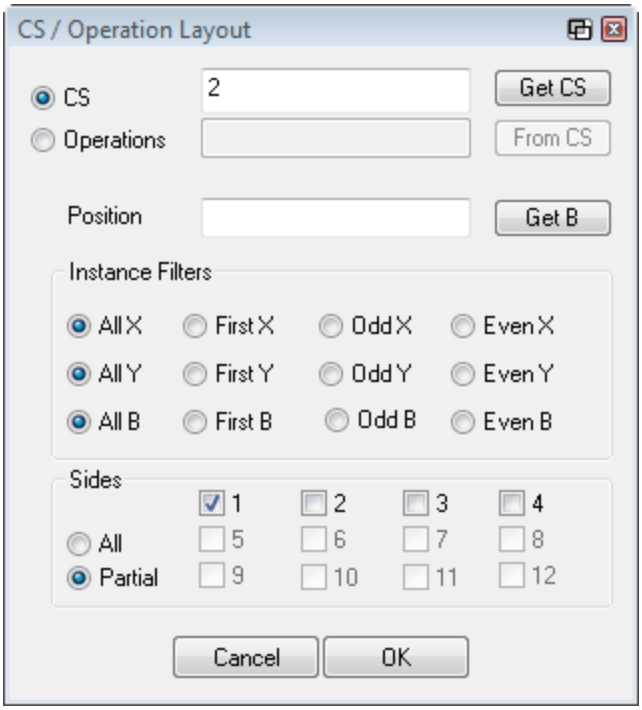
We need to define a filter for each side of the part.

1. Click the Add button and in the CS/Operation Layout dialog click the CS radio button.
2. Click the Get CS button.

3. Choose CS 2 as the filter, then click OK.




4. Select the Partial Sides, 1 filter.

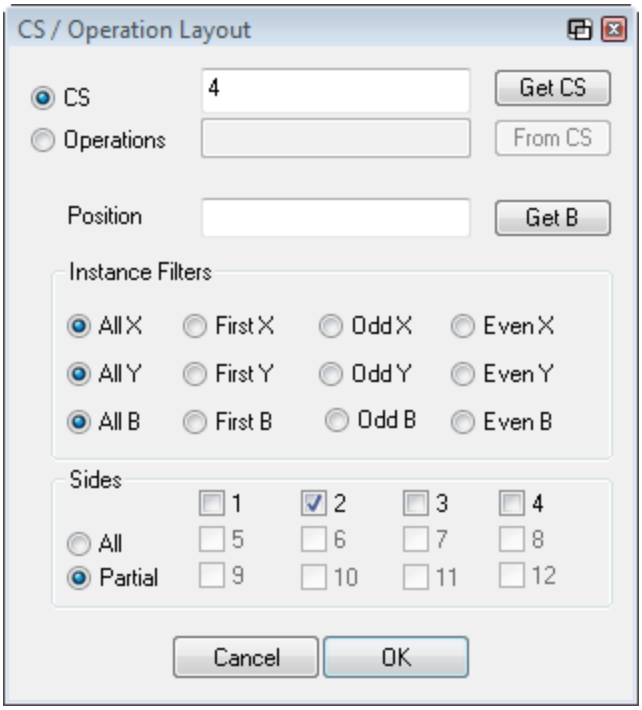



This tells the system that operations in CS 2 will be performed on face 1 of the tombstone.

5. Click the OK button.

We will now define the layout for the second face of the tombstone.

6. Add CS 4 and set the Partial Sides option as 2.



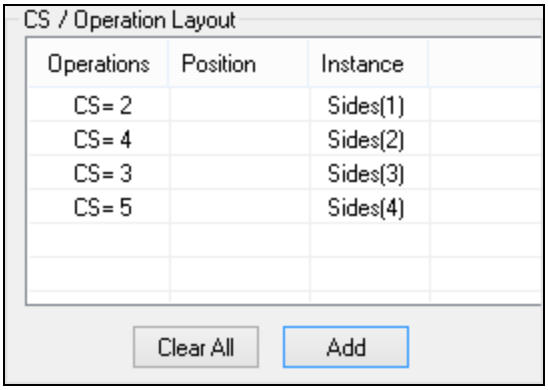

Since there is no other way to define a single side that is not the first side the Partial option is our only choice.

> Note that we do not need to set the B Position for this face as we already described it in the Custom Sides setup.

7. Click the OK button and close the dialog.

8. Repeat the process of defining a partial side setup based on the CS for sides 3 and 4.

   When complete the layout should look like the image to the right.



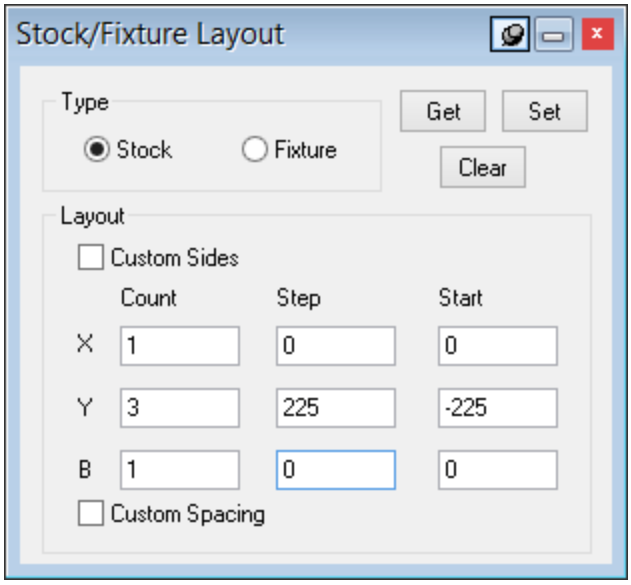

9. Click the OK button to save and close the dialog.

## Stock Layout

1. Choose DCD > Multi-Part > Setup Stock and Fixtures.
2. Select the Face 1 stock body.

3. Enter the values as shown and `click` the Set button.

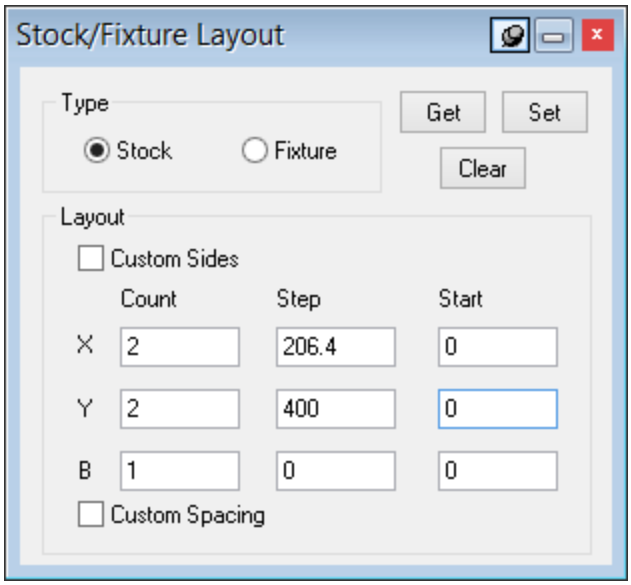
   This will create three vertically aligned stock frames.

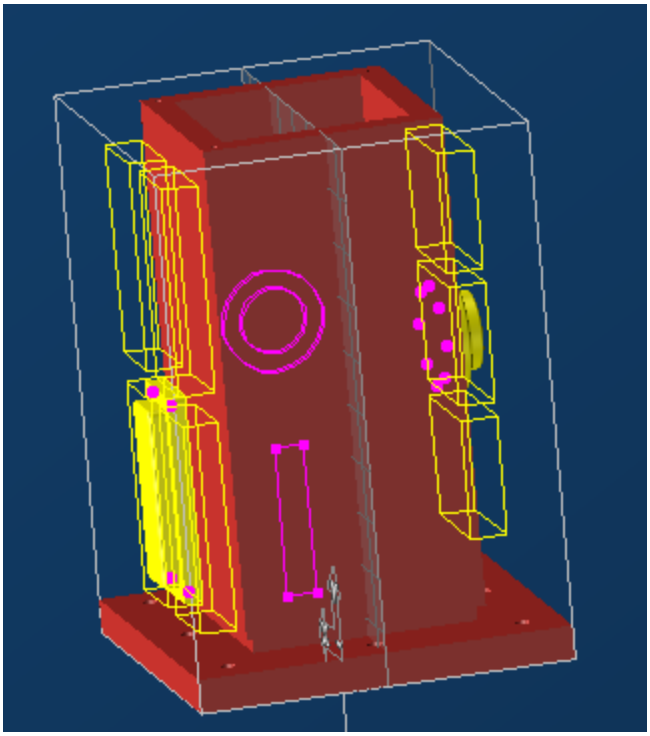



4. Deselect the Face 1 stock body.
5. Select the Face 3 stock body.

6. Enter the values shown and `click` the Set button.

   This will create a matrix of four rectangular stock frames.





7. `Ctrl-click` the Face 1 stock body to show the current definition.

   We are doing this in a slightly odd order to show the usefulness of the Get button.

8. Deselect the Face 3 stock body.

   The body on Face 1 should be selected and the wire frame stock should be displayed.

9. `Ctrl-click` the Face 2 stock body to add it to the selection.

10. `Click` the Get button. 


    The values for that body are now loaded in the Stock/Fixture Layout dialog.

11. `Click` the Set button.

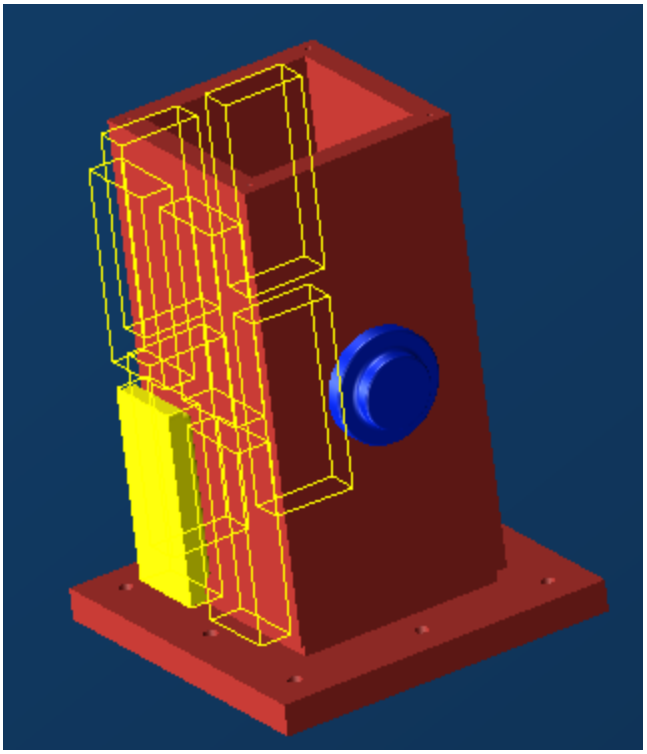
    The stock definition for this body is now set, using the duplicate data from Face 1. Since the B values are relative to the body's CS we do not need to change anything.

12. Select the Face 3 stock body.

13. `Click` the Get button.

14. Select the Face 4 stock body.

15. `Click` the Set button.



The stock layout for this part is complete.

16. Close the Stock/Fixture Layout dialog and save the part.

## Operation Ordering

Before we get into the rendering we need to optimize our machining order.

1. Move operations 4 and 5 (the face 3 machining) to positions 3 and 4.

   This will prevent any unnecessary tool change and B rotation.

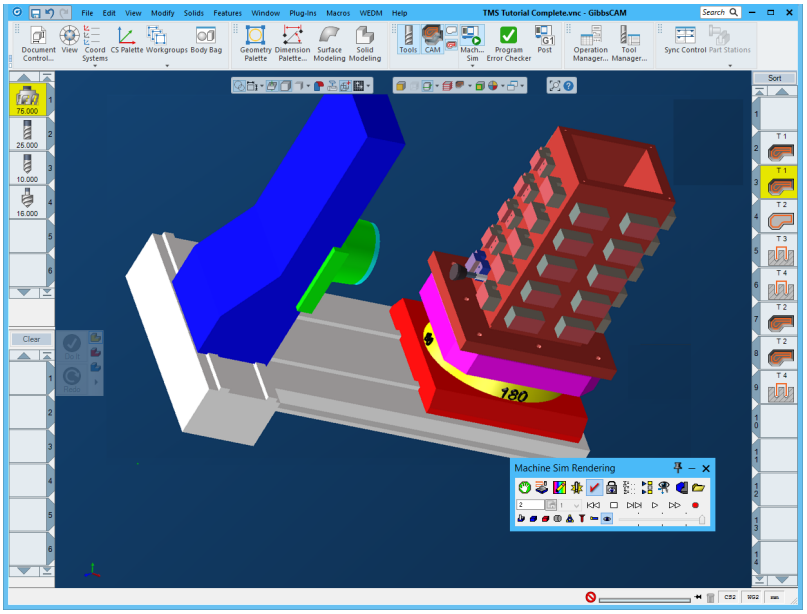
2. Move operation 9 to position 7.

## Machine Simulation

We will render the machine simulation using the same horizontal 4-axis mill as in the prior tutorial.

1. Choose Machine Sim from the rendering dropdown.
2. From the Machine Sim palette choose the Load Machine icon and choose the Tombstone Machine as in the previous tutorial.

As the system already had the location of the machine files, it was not necessary to search for them. In the event your version of the software lost the User Directory we set in the prior tutorial, see Setup for directions on setting the directory.




You may want to rotate the model so that you can actually see the tool's interaction with the part.

## Sequence of Events

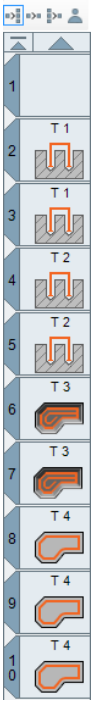
1. Render the part.

   Let's look at what is happening.

   - The program first drills holes and chamfers face 1.
   - The program rotates to face 4 and drills and chamfers face 4.
   - The program rotates to face 2, changes tools and cuts the slot on the face 2 part, then finishes it.
   - The program rotates and the pockets on face 4 are roughed out and then finished.

   Obviously there are too many tool changes - we can do better.

2. Close Machine Sim.




3. Move operation 9 to position 7.
4. Move operation 4 to position 3.
5. Move operation 10 to position 8.

   Your Operation list will now look as shown on the right.

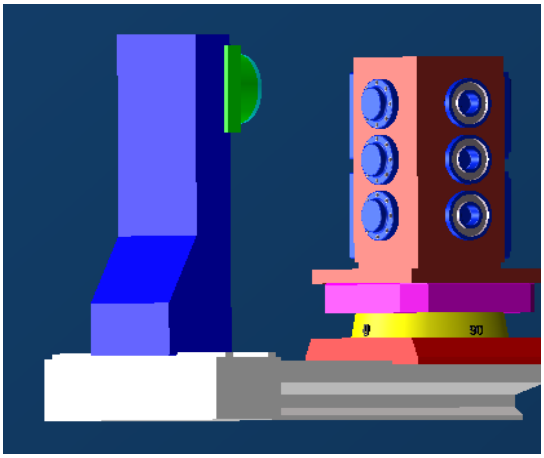
   If Machine Sim were still open it would reprocess the order of the operations and re-render the tombstone setup. Unfortunately, as you can see, the TMS operation is out of sync.

6. Open the TMS setup and `click` the Group button.

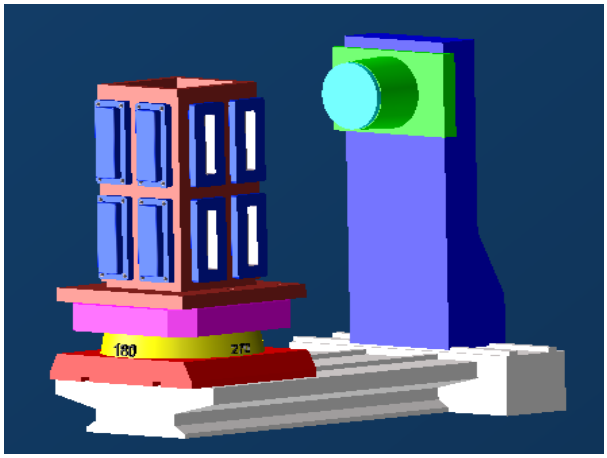
   The order will change, placing ops 9 and 10 in the last group.

7. `Click` the OK button to reset the operation.
8. Render the operations in Machine Sim.

   The order of operations is now more optimal, as we have minimized tool changes and rotations.



Sides 1 and 2 completed




Sides 3 and 4 completed

9. Save this part as it is complete.