RhinoCAM Strategies

with Jim Thompson Marine Carpentry (JTMC)

Jim Thompson Marine Carpentry (JTMC), located at 1 Washington Street, Newport, RI is the Newport Shipyard's carpentry shop who specializes in Yacht Carpentry, Finishing, Furnishings and more. Here is a short list of just some of the quality work performed at JTMC: Reef refits, decks, replace cabin house, replace/repair spars, main, mizzen, booms, custom interior design, furnishings and more! You can read more about JTMC below.

Jim Thompson Marine Carpentry (JTMC) specializes in complete yacht restoration, refitting and refurbishing. Here are just a couple of the recent projects completed at Jim Thompson Marine Carpentry (JTMC).

The RhinoCAM Project

We recently sat down with David St. Angelo, CNC Programmer & Operator for JTMC to discuss the company's use of RhinoCAM CNC software from MecSoft Corporation. Here is some of what David had to say about his RhinoCAM:
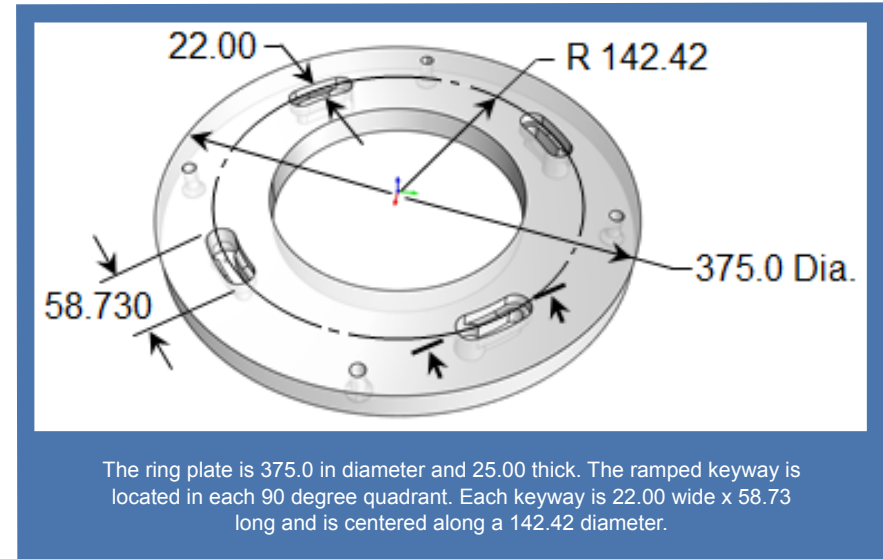
"I have only been using RhinoCAM for 3 months now. This is the first time I've used any CAM software, also the first time programming a CNC. After only a 2 week training period, we were impressed by the fact I could learn and understand Rhino and RhinoCAM enough to get a tool path and complete cuts on the CNC. I think it is extremely well set up and gives the user many different tools to navigate the plug in. I am excited to learn more as time goes on."

David St. Angelo, CNC Programmer & Operator
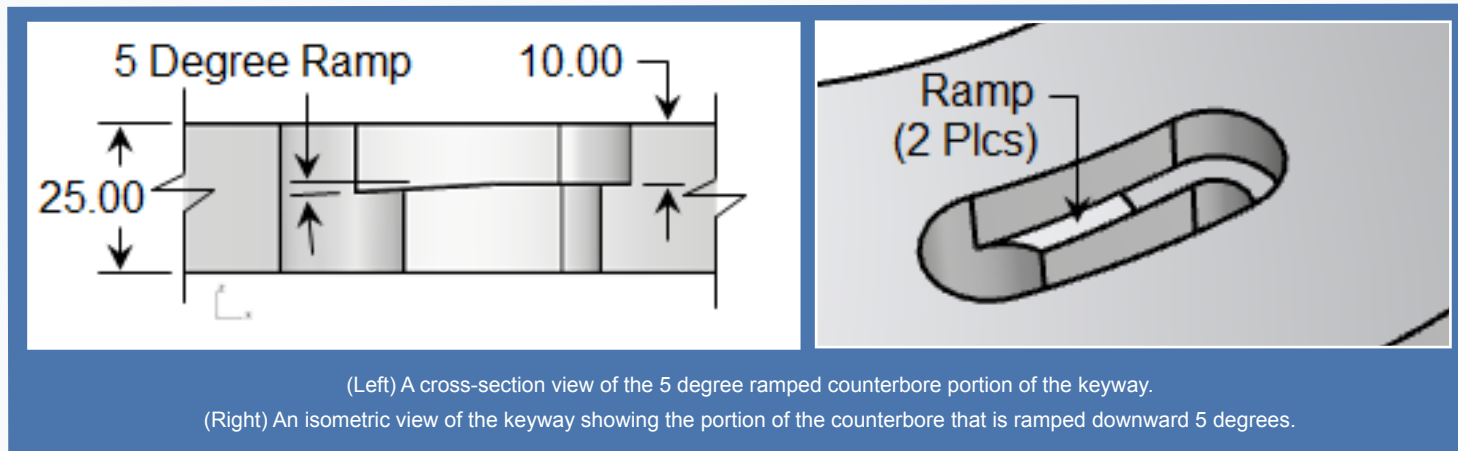*Jim Thompson Marine Carpentry, Newport, RI*

The Part Geometry

Note: All dimensions mentioned in this article are in millimeters (mm).

This part is referred to as Viasat. It is used as a mounting bracket for a large satellite receiver on the top of a 90 foot catamaran. The CAD geometry for this project is a 375.0 diameter x 25.00 thick ring of T10 steel (very hard). Please refer to the illustrations below for reference. The ring contains 4 keyway slots that are 22.00 wide, 58.730 long and are positioned along a 142.42 center-line radius. So the length of each keyway slot is on a radius. Each keyway also contains a stepped counterbore. The full 22.00 wide keyway drops down to 10.00 before narrowing to 11.96 wide. What makes this keyway feature very unique is that the base of the counterbore ramps downward 5 degrees on each side. You can refer to the elevation images below for more details.

The ring plate is 375.0 in diameter and 25.00 thick. The ramped keyway is located in each 90 degree quadrant. Each keyway is 22.00 wide x 58.73 long and is centered along a 142.42 diameter.

What makes this keyway feature very unique is that the base of the counterbore ramps downward 5 degrees on each side. The elevation view below shows a cross section of the ramp clearly. The length of the ramp is approximately 16.00 long. The ramp also occurs on both sides of the keyway.

(Left) A cross-section view of the 5 degree ramped counterbore portion of the keyway.

(Right) An isometric view of the keyway showing the portion of the counterbore that is ramped downward 5 degrees.

Want to see how RhinoCAM can help you? Click Here to download a demo!

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Additional CAD Geometry

In many machining strategies you will want to add reference geometry that will help guide your toolpaths. In this example we are adding the two curves shown in the illustration here labeled Inner Curve and Outer Curve. **We created these two curves by**

1. Creating curves that are offset inward from the base of the counterbore (this is the 10.00 depth dimension shown above). These curves define the 5 degree ramp angle.

2. We then joined and trimmed these new curves into just two curves, one inner curve and one outer curve.

3. We added another half circle curve of radius 3.905 positioned on the outer curve at the end closest to the thru hole. This half circle curve is labeled "Radius for Engraving" in the illustration. We have also added a geometry point located at the top of the 22.00 thru hole. This point is labeled Start Point for Roughing in the illustration. As described, this point will be used as the cut start point for a 3 Axis Roughing operation.
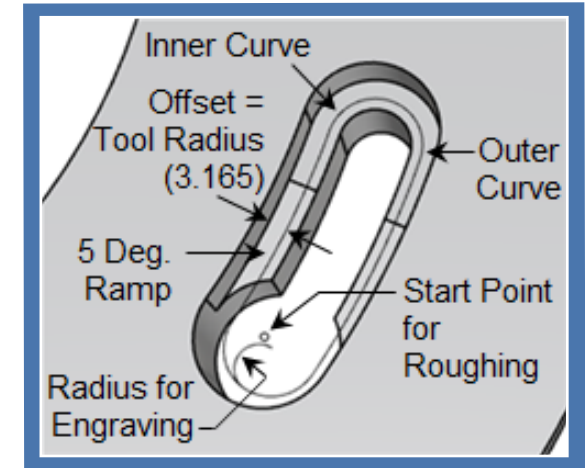

Let's review:

1.   **We created curves that are offset from the base of the keyway inward by a distance of 3.905 which is the radius of the flat end mill tool we plan to use.**

2.   **We then merged and trimmed these curves to form just two curves, one inner curve and one outer curve.**

3.   **We also added a new curve that is a half circle and located it at the end of the outer curve closest to the thru hole.**

4.   **These curves will drive the center tip of the tool during a 2½ Axis Engraving operation.**

Add Machining Regions

In this step we will create 4 pre-defined machining regions. MecSoft CAM allows you to create machining regions and save them for use with toolpath operations. In this example we will predefine 4 machining regions. We will use these regions to drive our cutting tool during a 2½ Axis Engraving toolpath operation. See Finishing Operations below for more about how these predefined regions are used. Also refer to the Optional Methods section below. You will also find suggestions on alternate methods to achieve the same goal. When we are finished creating the predefined regions, the Regions tab of the Machining Objects Browser will look like the image below. We see that there is one Machining Region Set: Radial Slot that contains 4 regions below it. These 4 regions are named Slot Top, Slot Bottom, Slot Ramp Outer and Slot Ramp Inner.

The Region tab (identical for all MecSoft CAM plugins)
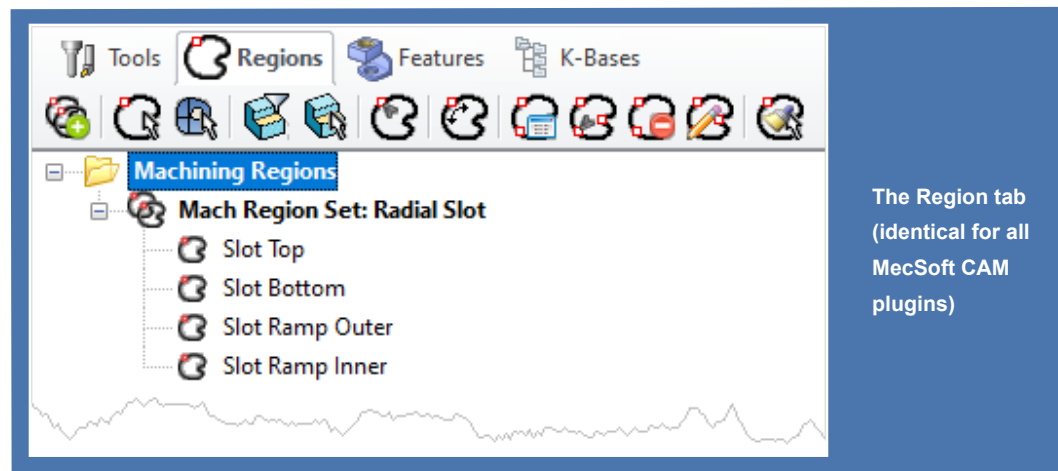
The toolbar on the Regions tab contains the icons and commands you need to create the region set and the four regions. These are the first two icons on the left side of the toolbar. The first being the Create Machining Region Set command. Selecting it adds a new set with nothing under it. Then when you pick the Select Curves icon, you are prompted to select curves. So we selected the top edges of the keyway slot and pressed enter. A region named "Curve Region #" is added under the region set. If you create the region first, the region set is added automatically. We then renamed this region as Slot Top.

| Slot Top | Slot Bottom | Slot Ramp Outer | Slot Ramp Inner |
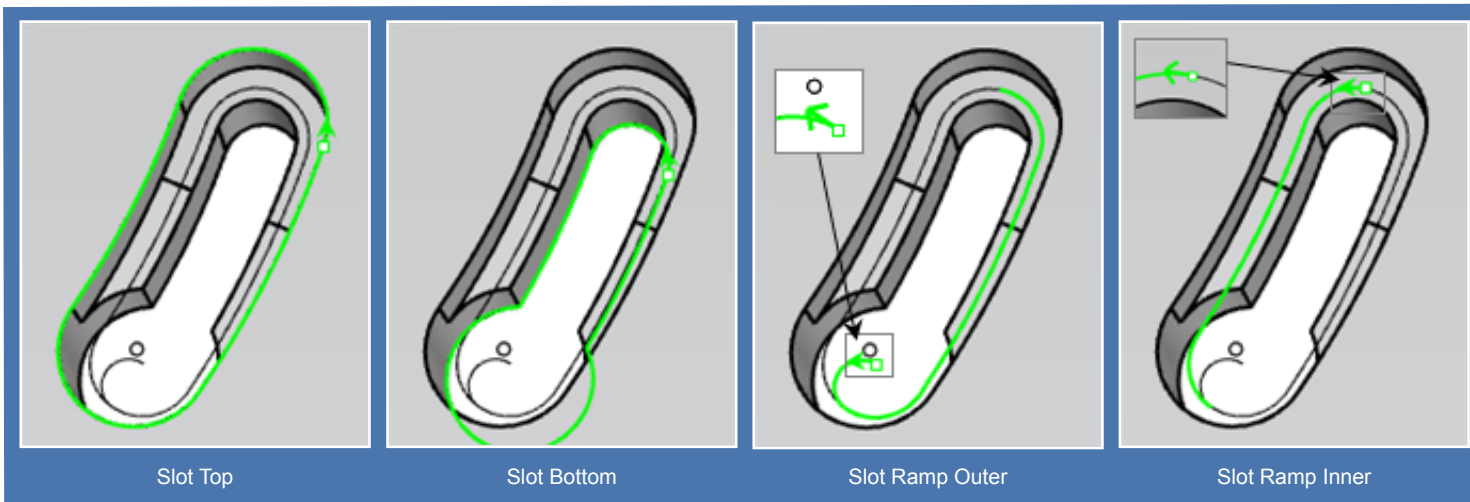
We repeated this procedure to create a region named Slot Bottom. We then created the two regions named Slot Ramp Outer and Slot Ramp Inner. You can also select all of the 4 curves at one time and add each to the set and then rename them. Now when you select each region from the Regions tab you see that they highlight green on the part. The illustrations above show you what each region looks like.
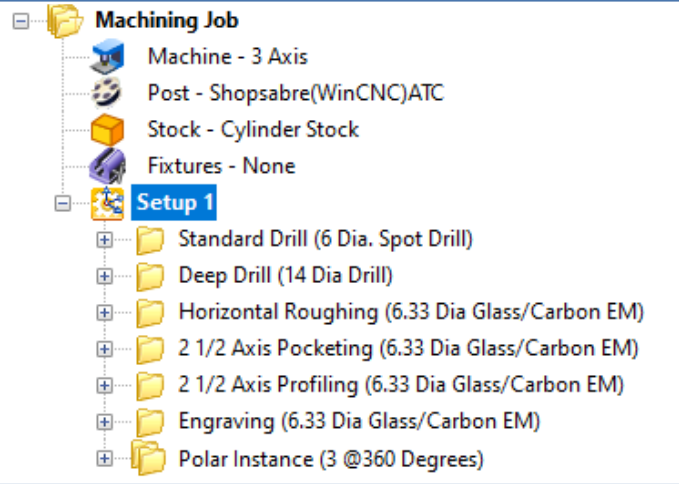
The Stock & Setup

The stock definition for this project is a Part Bound Cylinder Stock. It is referred to as Part Cylinder Stock on the Stock menu on the Program tab. This stock definition computes the size of your part and then allows you to add an offset value to both the Radial and the Axial dimensions. You can also set the axis of the cylinder and the Axial Offset Direction. In our case we selected the Z axis, set the Radial Offset (r) to 5, the Axial Offset (a) to zero. Since we set the Axial Offset (a) to zero, we need not bother with setting the Axial Offset Direction as it will be ignored. Also, to make sure only the 3D solid was calculated, we checked the box to Ignore Wireframe Geometry in Bounds Computation. The stock and stock dialog are shown on right.
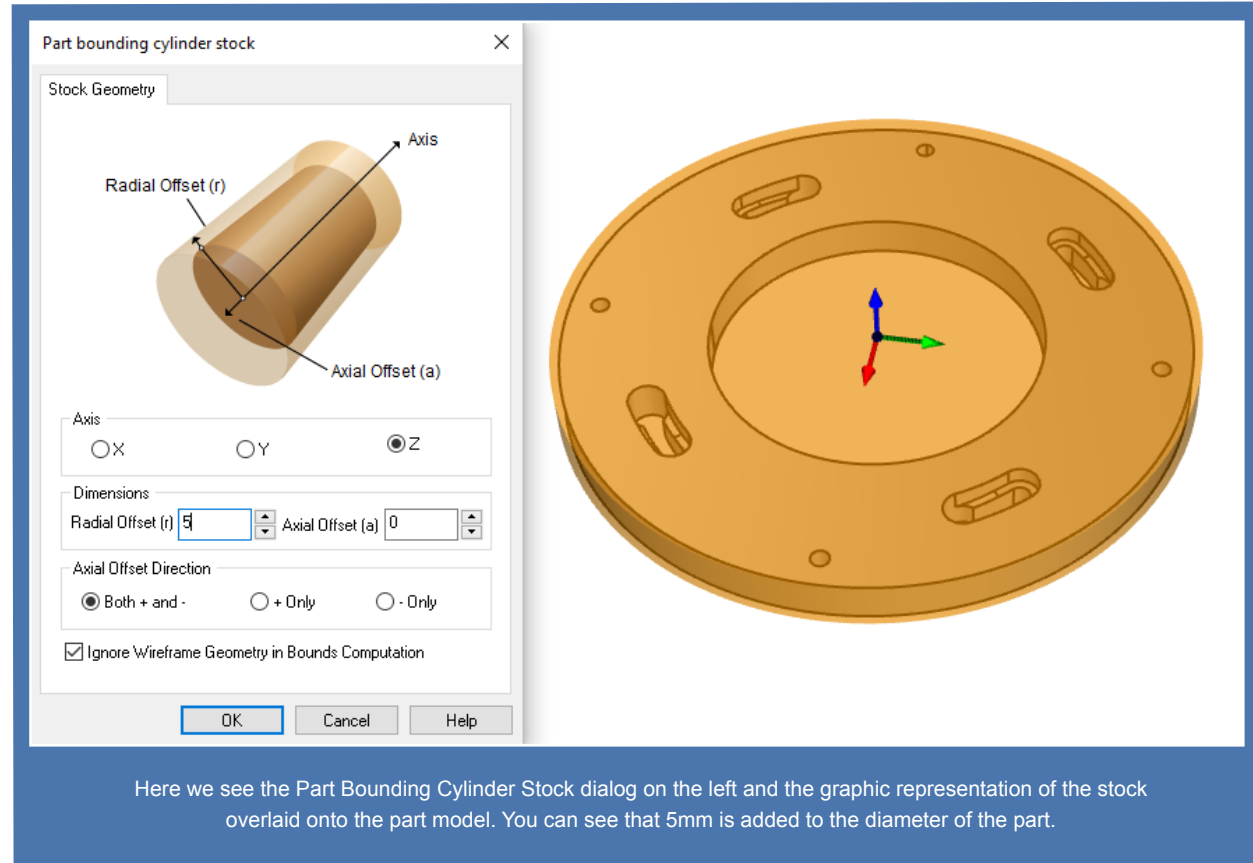
Here we see the Part Bounding Cylinder Stock dialog on the left and the graphic representation of the stock overlaid onto the part model. You can see that 5mm is added to the diameter of the part.
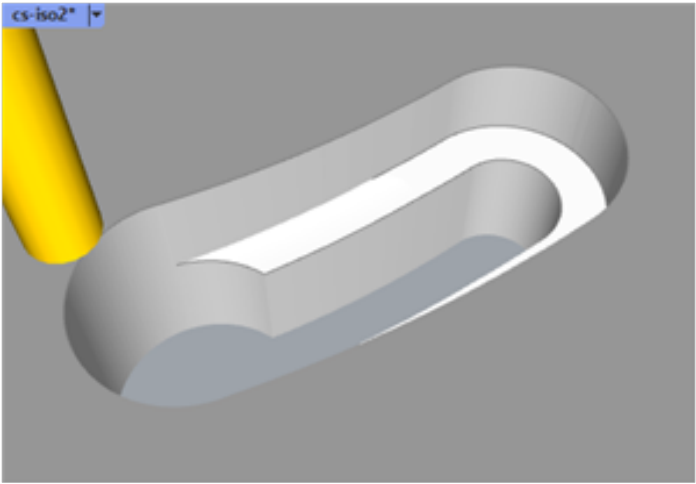
Sequence of Operations

The Machining Job and Setup 1 shown below includes two Drilling operations, one 3 Axis operation and three 2½ Axis operations. Note that the 2½ Axis Engraving operation cuts the 5 degree ramp and is the next to the last operation in the Machining Job. The last operation is the Polar Instance that will cut the remaining 3 keyway slots automatically. Also refer to the Optional Methods section below. You will find suggestions on alternate methods in this operational sequence.

The Machining Job tree shows all machining operations (MOps) in Setup 1. The first six MOps will cut the first Keyway slot. The last operation will cut the remaining 3 keyway slots.
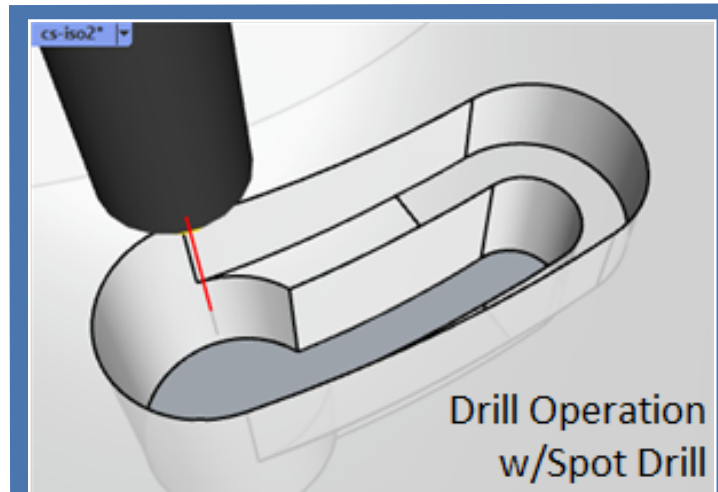

Here we see a cut material simulation of the first six operations under Setup 1 to cut the first keyway slot. Note that the last 2½ Axis Engraving operation is the finishing cut for the 5 degree ramp.
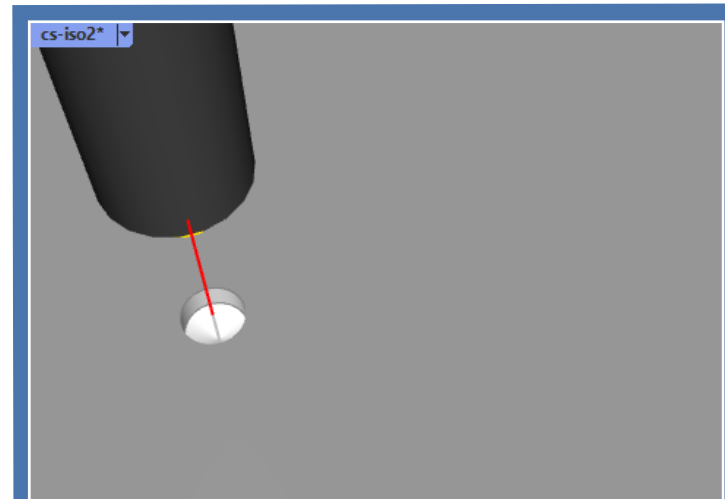
Drilling Operations

We have used Drilling as the first two operations. These will spot drill (referred to as a Center Drill) a 6mm x 1mm deep hole followed by a Deep Drill to drill a 14mm dia hole through the part at 5mm step increments. The Add Tooltip to Drill Depth option is checked to make sure the drill passes completely through the part. These two drilling operations are illustrated at (A-1 & A-2) and (B1 & B2) in the table below. The toolpath is shown on the left and the resulting cut material simulation is shown on the right. Both drilling operations are located at the Point geometry that we added at the top of the 22 diameter through hole on the keyway.
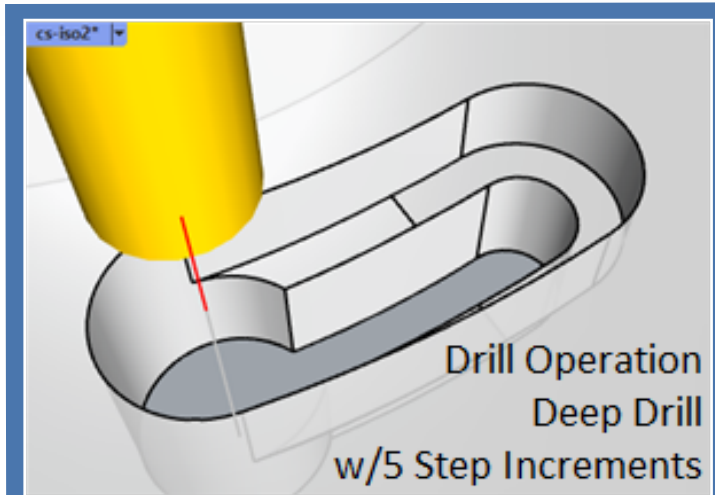

Drill Operation w/Spot Drill

(A-1)
Here we see the first drill operation toolpath. This will spot drill (referred to as a Center Drill) a 6mm x 1mm deep hole.

(A-2)
Here we see the cut material simulation showing the in-process stock remaining after the spot drill is completed.

J. Thompson
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(B-1)
Here we see the Deep Drill operation toolpath.
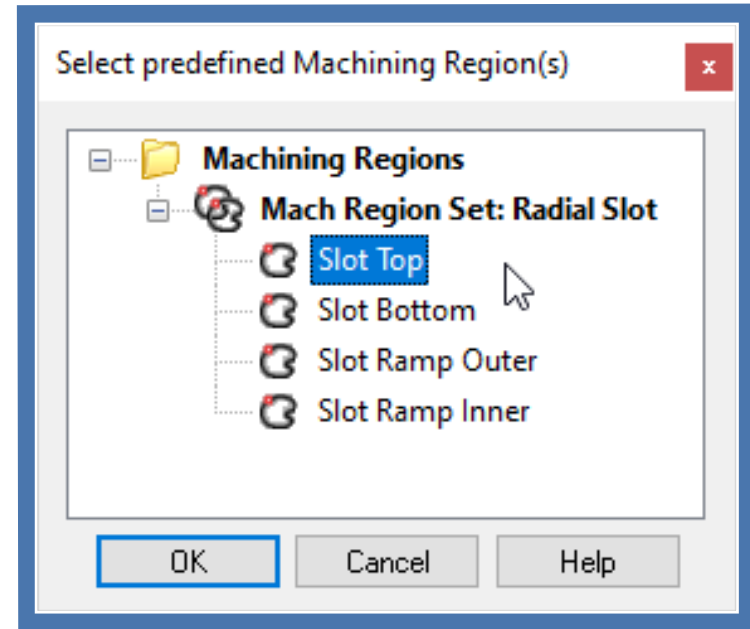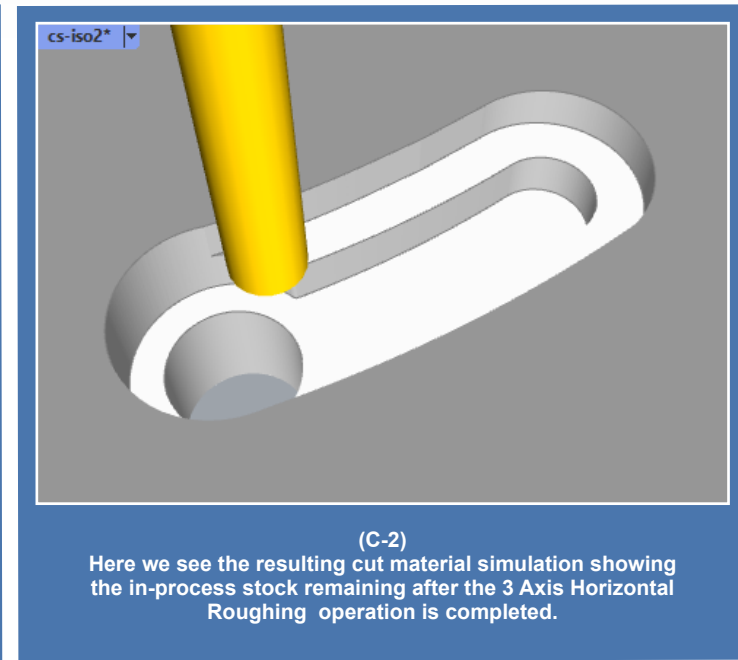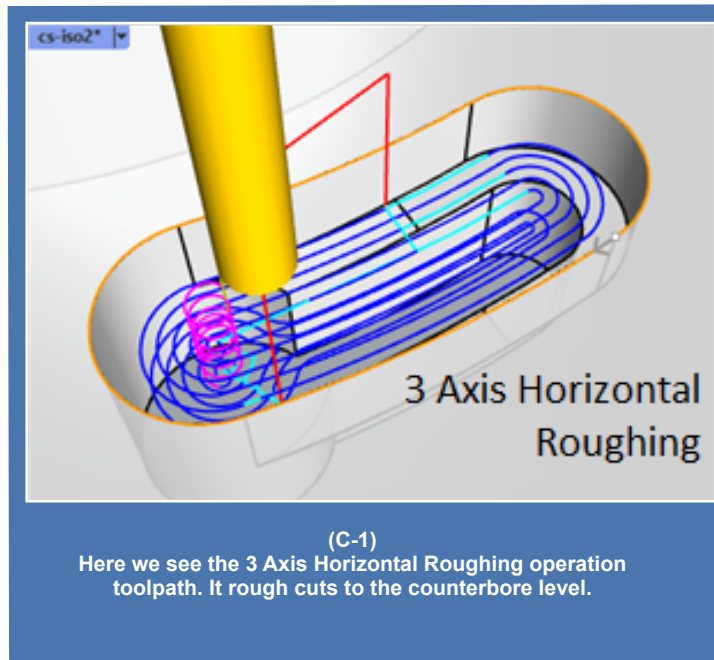It cuts a thru hole 14mm in diameter.
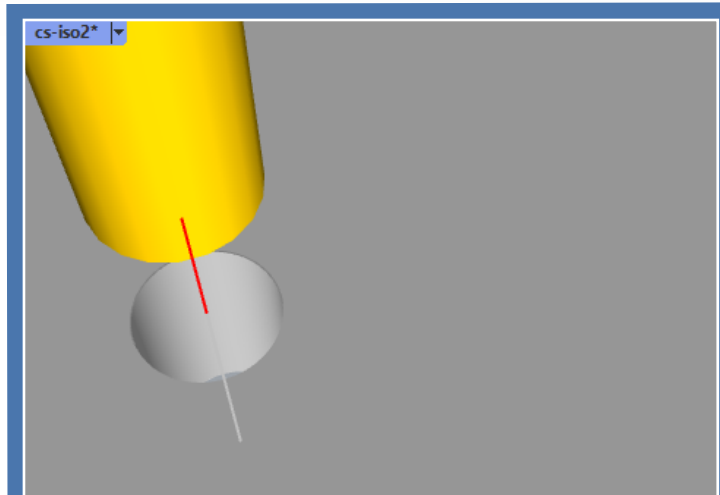
(B-2)
Here we see the cut material simulation showing the in-process
stock remaining after the Deep Drill is completed.

Roughing Operations

The next two operations in the Machining Job are considered roughing operations. They are a 3 Axis Horizontal Roughing and a 2½ Axis Pocketing operation. The 3 Axis Horizontal Roughing is used to rough cut the upper counterbore level of the keyway. For the Control Geometry tab we are picking the Select Predefined Regions button to display the Select Predefined Region(s) dialog shown here. Selecting Slot Top and picking OK, assigns that region to this operation.

For the Cut Parameters tab, Stock is set to 0.5, an Offset cut pattern, Mixed cut direction and a 25% (of the tool diameter) stepover. On the Cut Levels tab the Stepdown is set to 2 levels and the Bottom (B) under Cut Levels is set to -10.84 which is the bottom of the 5 degree ramp. The engage and retract are set to helix motions. This toolpath and resulting cut material is shown at (C-1 & C-2) below. It should be noted here that David wants to use the same cutter for all milling operations.

(C-1)
Here we see the 3 Axis Horizontal Roughing operation toolpath. It rough cuts to the counterbore level.

(C-2)
Here we see the resulting cut material simulation showing the in-process stock remaining after the 3 Axis Horizontal Roughing operation is completed.

The next operation in the Machining Job is 2½ Axis Pocketing. You can see the toolpath and the cut material simulation at (D-1 & D-2) below. For the Control geometry tab, we are using a predefined region in the same manner as we did above for the 3 Axis Horizontal Roughing. This time however, we have selected the Slot Bottom region. Also from the Control Geometry tab we have selected the Start Points sub-tab and then picked the Select Start Points button to add the point geometry we modeled to this operation (see CAD Geometry above). This will force the cutting to start at the top of our predefined thru hole location.

This is considered a roughing operation because on the Cut Parameters tab we have Stock set to 0.2. This will leave 0.2 of material around the side walls of the bottom level of the keyway. Other cut parameters include an Offset cut pattern, a Mixed cut direction, and a stepover of 25%.
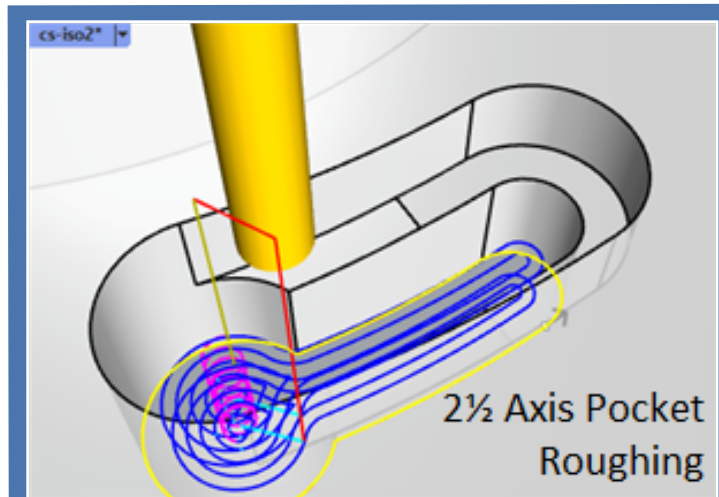
(D-1)
Here we see the 2½ Axis Pocketing operation toolpath.
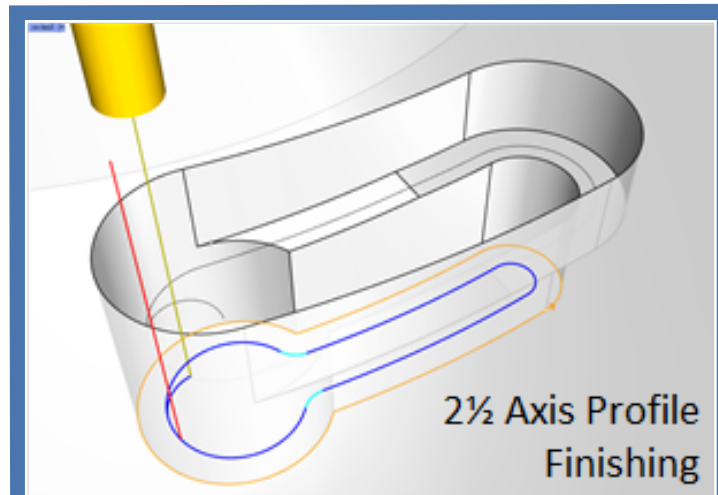It rough cuts the bottom level of the keyway slot.
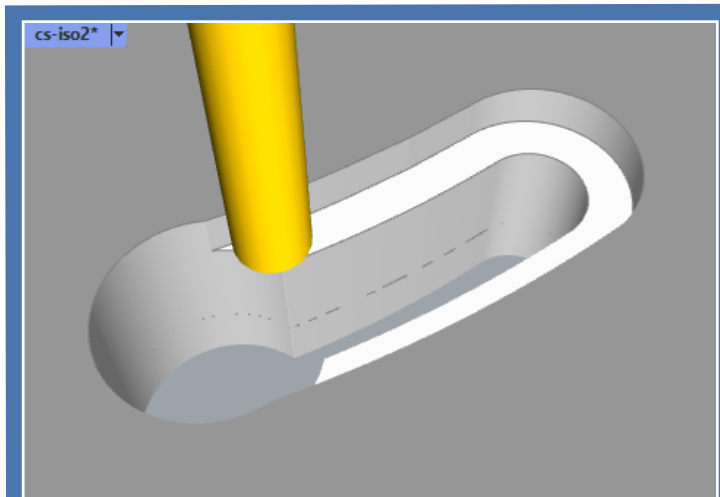
(D-2)
Here we see the cut material simulation showing the
in-process stock remaining after the 2½ Axis Pocketing
operation is completed.
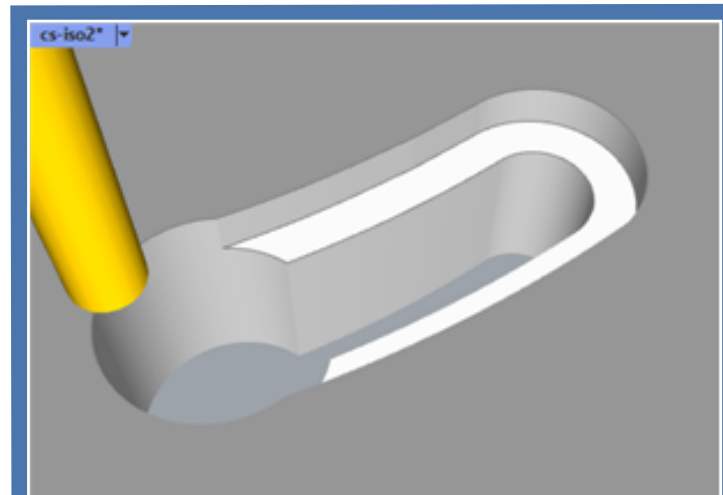
Finishing Operations

The remaining two operations in the Machining Job are considered finishing operations. They are a 2½ Axis Profiling and a 2½ Axis Engraving operation. The 2½ Axis Profiling MOp is used to finish the side walls of the bottom level of the keyway slot. The Control Geometry tab of this operation is assigned the same pre-defined region (Slot Bottom) as the previous 2½ Axis Pocketing operation.

For Cut Parameters the Tolerance is set to 0.01 and Stock is set to zero and Cut Direction is set to Mixed. For Cutting Side, the Determine using 3D Model is checked. The option Use Mid-Point of Longest Side is also checked which will move the start point to the our pre-drilled thru hole location. For the Cut Levels tab, the Location of Cut Geometry is set to At Bottom and the Total Cut Depth, Rough Depth, Finish Depth, Rough Depth/Cut and Finish Depth/Cut are all set to zero. This will produce one cutting pass at the bottom of the keyway slot. You can see the toolpath and the cut material simulation at (E-1 & E-2) below.


(E-1)
Here we see the 2½ Axis Profiling operation toolpath. It finish cuts the side walls on the bottom level of the keyway slot.

(E-2)
Here we see the cut material simulation showing the in-process stock remaining after the 2½ Axis Profiling operation is completed.

The final finishing operation is the 2½ Axis Engraving. This operation completes the keyway slot by machining the 5 degree ramp and finishing the side walls of the upper counterbore at the same time. From the Control Geometry tab we have selected the remaining two predefined regions. Also note the order of the regions in the Control Geometry tab. The Slot Ramp Outer region is listed first. This region will control the location of the tool at the cut start point. The Slot Ramp Inner region is listed second.
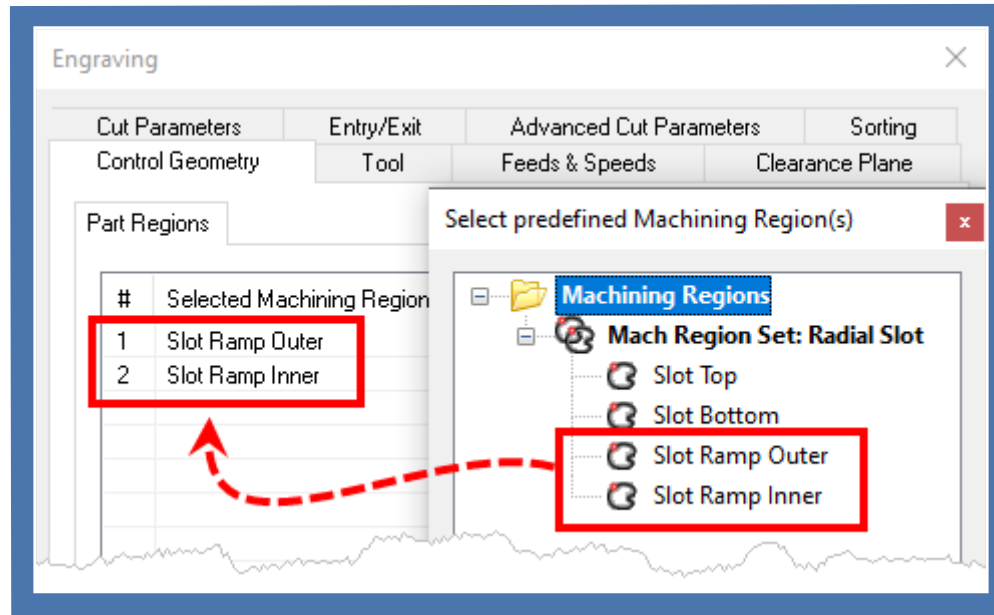
When the cutter reaches the end point of Ramp Slot Outer it will immediately continue cutting from the start point of Slot Ramp Inner and then proceed to its end point to complete the operation. You can see the toolpath and the cut material simulation at (F-1 & F-2) below.

In 2½ Axis Engraving the center tip of the cutting tool (6.33 Diameter Glass/Carbon 46264 Flat End Mill) will follow the assigned control geometry exactly. In this case the predefined regions that we have created are driving the cutter to produce the finish cut of the 5 degree ramp at the base of the counterbore (on each side)!

(F-1)
Here we see the 2½ Axis Engraving operation toolpath. It finish cuts the 5 degree ramp and side walls on the top level of the keyway slot.
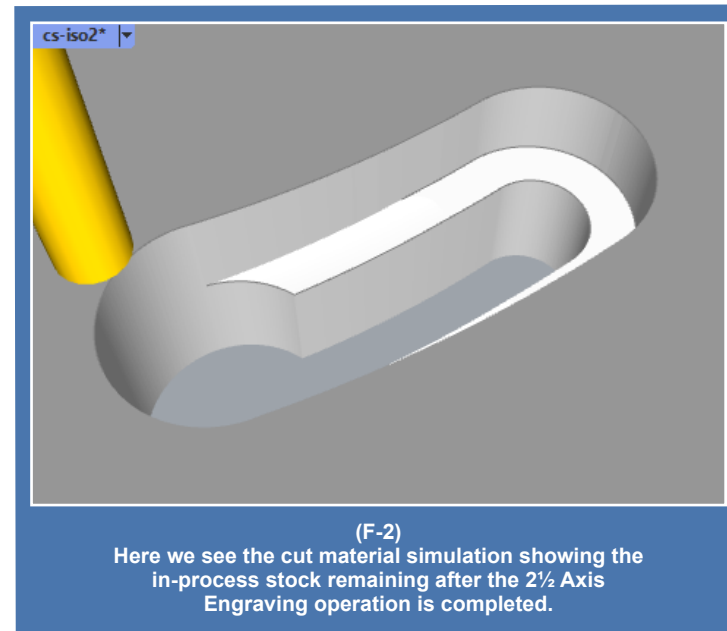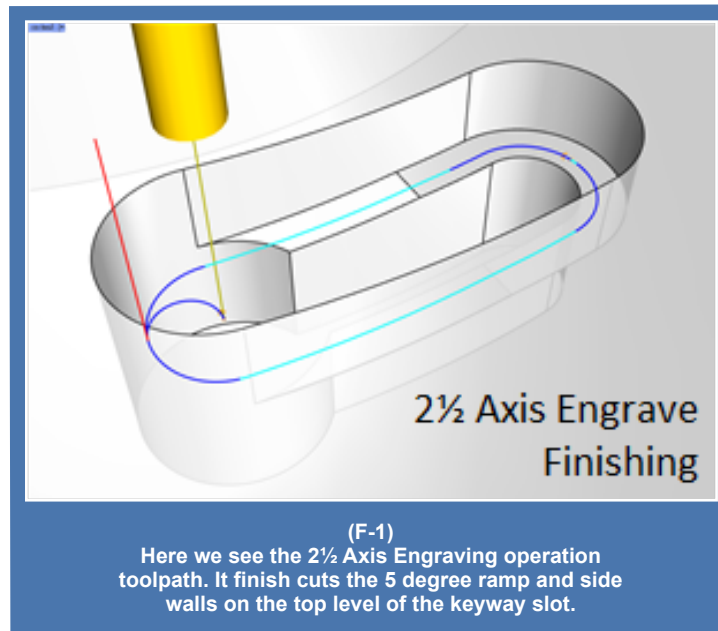

(F-2)
Here we see the cut material simulation showing the in-process stock remaining after the 2½ Axis Engraving operation is completed.

The Cut Parameters tab simply states that the Tolerance is 0.01, the Cut Direction is Natural (meaning it is following the direction of the predefined regions), Location of Cut Geometry is At Bottom, all Cut Depth Control values are set to zero (one pass). For entry and exit both are set to None. From the Advanced Cut Parameters tab, Arc Fitting tolerance is set to 0.02.

Polar Instancing

The last item in the Machining Job tree is called Polar Instance 3@360 Degrees. As the name suggests this folder contains a copy of the six operations described above and defines the polar instance for the remaining three keyway slots. David can generate the gcode needed for all 4 keyway slots by simply posting out the Polar Instance.

Polar Instance
3 @360 Degrees

Original Instance

3 Polar Instances of all 6 operations spanning 360 Degrees.
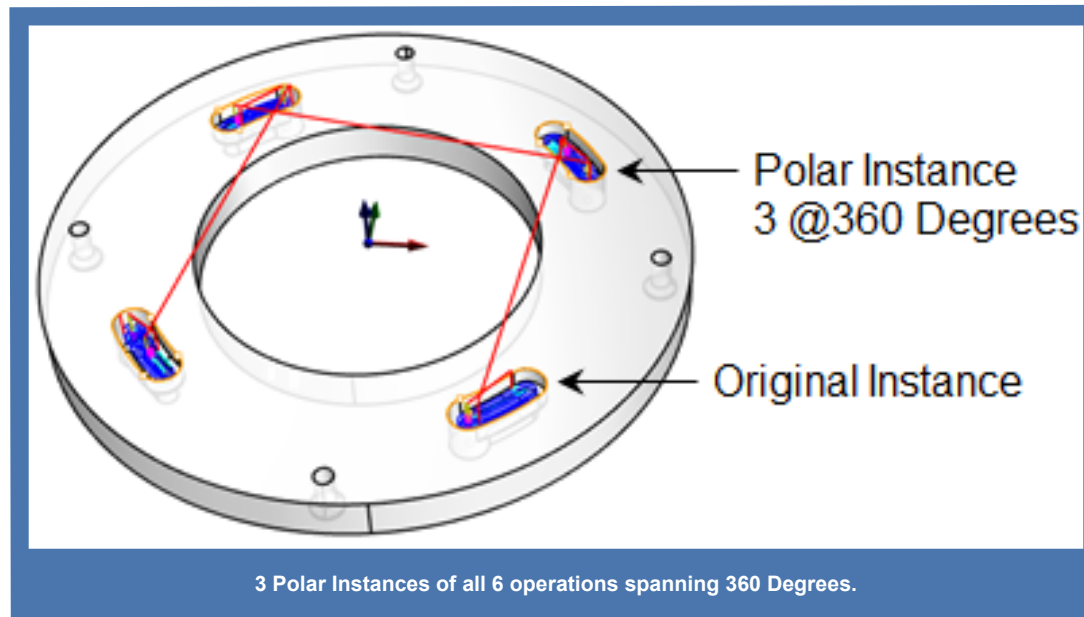
Optional Methods

As we all know there are different approaches and methods to complete any CAM project. You may have already thought of a few while reading this article. We have to and would like to share a few of them with you here.

1. **Use native CAD system Curves instead of Curve Regions:**
   In the Add Machining Regions section above we used MecSoft CAM regions derived from the native CAD system's curve geometry. There is a reason for this.
   (a) We wanted to show you how to use Regions.
   (b) At times it can be easier to define, edit and select Regions rather than rely on the native CAD system to do this.

   However, we could have skipped the Add Machining Regions section, and simply selected the native curves as Control Geometry. However, we would have needed to make sure the curve start points are correct. In RhinoCAM you can use the Mark Curve Start command (CrvStart) to do this. In VisualCAD/CAM you would use the Reverse Curve Direction command located on the Curve Modeling tab if the curve start point is incorrect.

2. **Use 3 Axis Parallel Finishing instead of 2 Axis Engraving:**
   We could have used the 3 Axis Parallel Finishing method but would have had to settle for less control of the cutter. Again, in 2½ Axis Engraving, the tip of the cutter follows the control geometry (i.e., the curve regions) exactly. There is no greater control than this.

3. **Reverse the direction of Slot Ramp Inner:**
   If you look closely at the illustration below, you will notice that the start point of the Slot Ramp Inner predefined region is located at the end point of Slot Ramp Outer causing the cutter to ramp downward, cutting with the flat bottom of the cutter during the 2½ Axis Engraving operation. This is not ideal. If we reverse the direction of this curve region, the cutter will ramp upward, allowing the tool to cut along it's flute length.

Illustration showing the cut direction of the 2½ Axis Engraving operation.
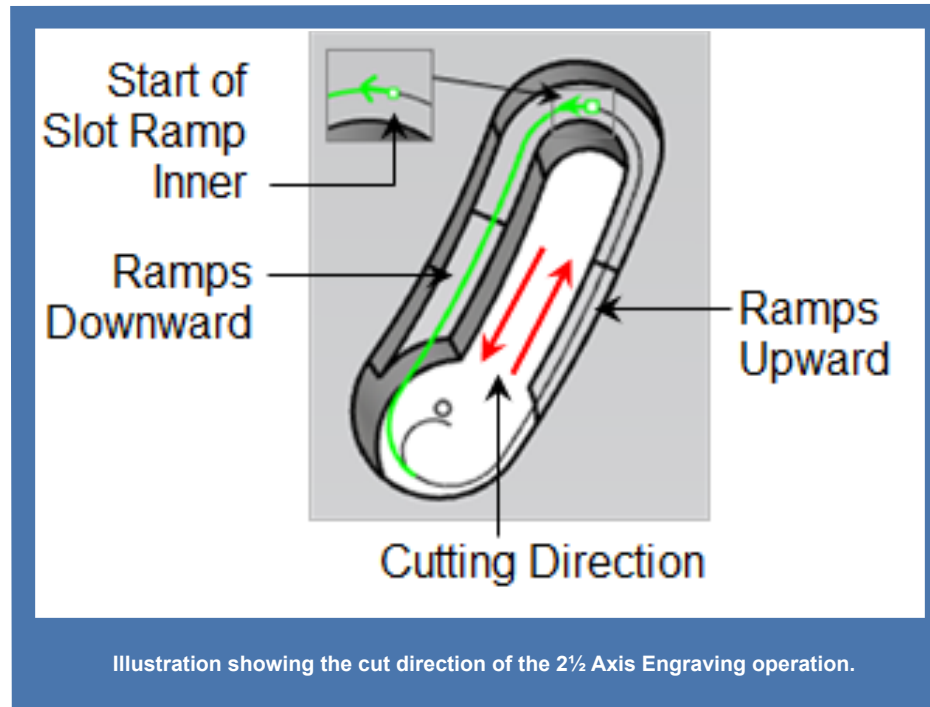
Cool Project David!
Thank you for allowing us to showcase your work
at Jim Thompson Marine Carpentry!

More about Jim Thompson Marine Carpentry

From new decks to custom cabinetry, Newport Shipyard's carpentry shop, managed by J. Thompson Marine Carpentry, produces the highest quality woodwork on every new build and refit. All carpenters and craftsmen are versed in the widest range of materials, methods and technologies, be it wood, Corian, or composite from new to classic yacht restoration. The right fit and finish is a constant at Newport Shipyard!

Follow Jim **Thompson Marine Carpentry** Online:

More about RhinoCAM

RhinoCAM - MILL from MecSoft Corporation is available in five different configurations (Express, Standard, Expert, Professional and Premium). The part shown here was programmed using the Standard configuration. Here are some additional details about each of the available configurations. For the complete features list, visit the RhinoCAM Product Page.

- **RhinoCAM MILL Express**: This is a general-purpose program tailored for hobbyists, makers and students. Ideal for getting started with CAM programming. Includes 2 & 3 axis machining methods. Includes ART & NEST modules as well!

- **RhinoCAM MILL Standard**: This configuration includes everything that is in the Express configuration and additional 2-1/2 Axis, 3 Axis & Drilling machining methods. Also now includes 2½ Axis Turning!

- **RhinoCAM MILL Expert**: Suitable for 4 Axis rotary machining. Includes the Standard configuration, plus 4 Axis machining strategies, advanced cut material simulation and tool holder collision detection.
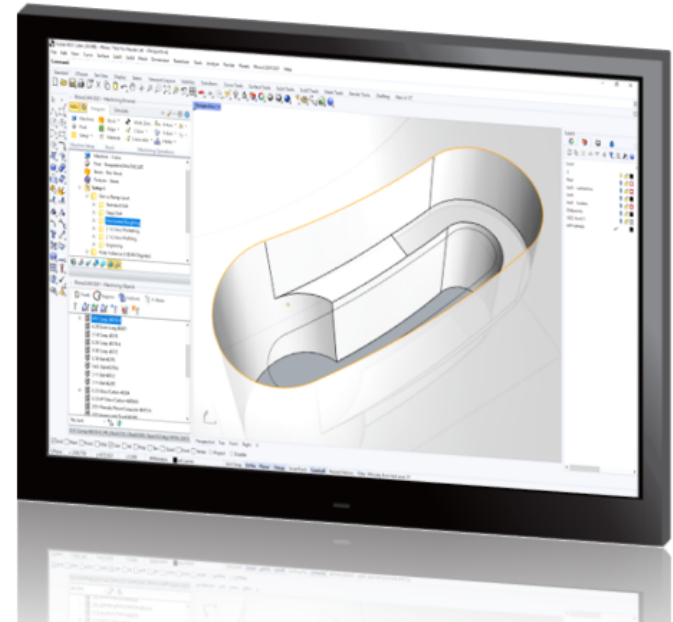
- **RhinoCAM MILL Professional**: Ideal for complex 3D machining. Includes the Standard and Expert configuration, plus advanced 3 Axis machining strategies, 5 Axis indexed machining, machine tool simulation, graphical toolpath editing and a host of other features.

- **RhinoCAM MILL Premium**: Tailored for complex 3D machining with both 3 Axis and full 5 Axis methods. Includes the Standard, Expert and Professional configurations, plus 5 Axis simultaneous machining strategies.

For the complete features list, we invite you to visit the
RhinoCAM Product Page: mecsoft.com/rhinocam

Try RhinoCAM Today!

Powerful production CAM for Rhino users!

More about MecSoft Corporation

MecSoft Corporation was founded in December of 1997 by a team of programmers from Unigraphics Solutions (now Siemens PLM) with the aim of providing affordable yet powerful CNC software solutions to the manufacturing industry. Our founding and operating principles are based upon the notion that our most important partner is our customer. This allows us to:

Develop quality products that meet or exceed customer needs and to
Deliver them at a price to performance value that is unbeatable in the industry
Provide excellent customer service and support. MecSoft Corporation is based in coastal Orange County, CA, south of Los Angeles.

RhinoCAM®

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