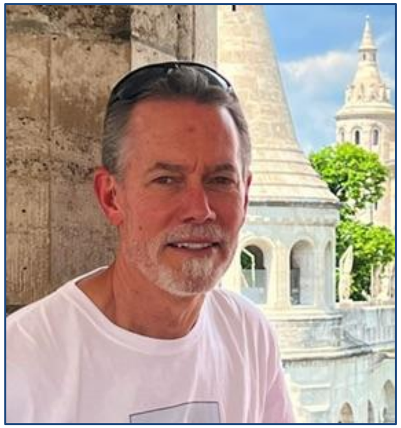
VisualCAD/CAM at KOZM Guitars

Jeff Komoski is a Mechanical Engineer who has used various CAD packages in his day jobs since the early 80s. These have included Unigraphics, CADKEY, ProE / Creo, Solidworks, and most recently, NX. Jeff currently works for ThermoFisher Scientific, working on electron microscopes and ion-generating columns. Jeff also has experience in numerous product arenas including Aerospace, Medical, Robotics, Color Printers, Scientific Instruments as well as Consumer Products.

The VisualCAD/CAM Difference

In his spare time, Jeff is the “Lead Dude” of KOZM Guitars where he fulfills his passion for crafting quality custom-made electric and bass guitars. In addition to his guitar designs, Jeff is always eager to craft custom designs and CAD/CAM services for other players and builders. We recently sat down with Jeff to discuss his craft and his use of VisualCAD/CAM from MecSoft Corporation. Here is some of what Jeff Komoski had to say about his VisualCAD/CAM.



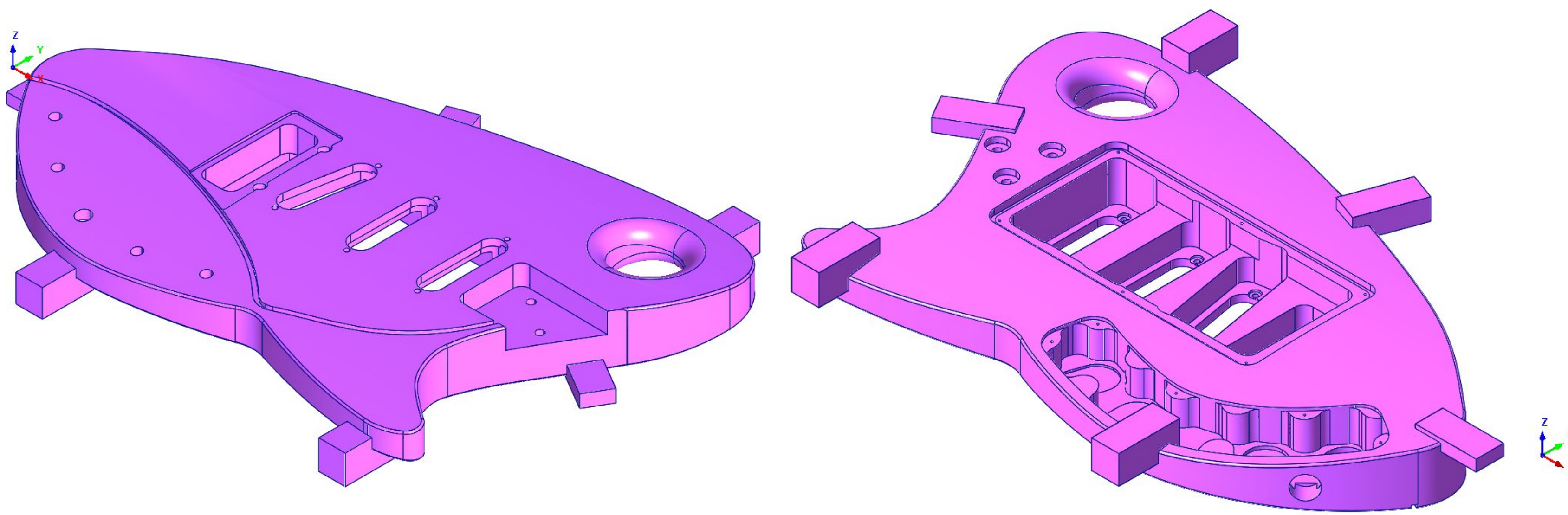
“I purchased my ShopSabre CNC machine and VisualCAD/CAM back in 2010. I originally purchased VisualCAD/CAM because of the cost – especially when compared to programs like MasterCam and SurfCam. It was easy to learn and it does what I need it to do.”

Jeff Kosmoski, Main Dude

KOZM Guitars

The 3D Design Model

The part illustrated in this case study is a guitar body consisting of 2D and 3D features including holes, pockets, and sculpted surfaces as shown in the illustrations below. More specifically, we will discuss how best to CAM program 3D contoured groove features in guitar bodies using a current project of Jeff's as the perfect example.



The 3D model of the guitar body is shown.

The 3D Groove Geometry

The part-to-machine is a 3D solid/surface model of a guitar body. The 3D Contoured Groove feature that needs to be machined traverses the entire length of the guitar body on a contoured path. The 3D Contoured Groove has a constant dimension of 0.145” wide and 0.133” deep. This means that the depth of the groove is measured from the contoured top surface of the guitar body and that it changes in elevation as it traverses.

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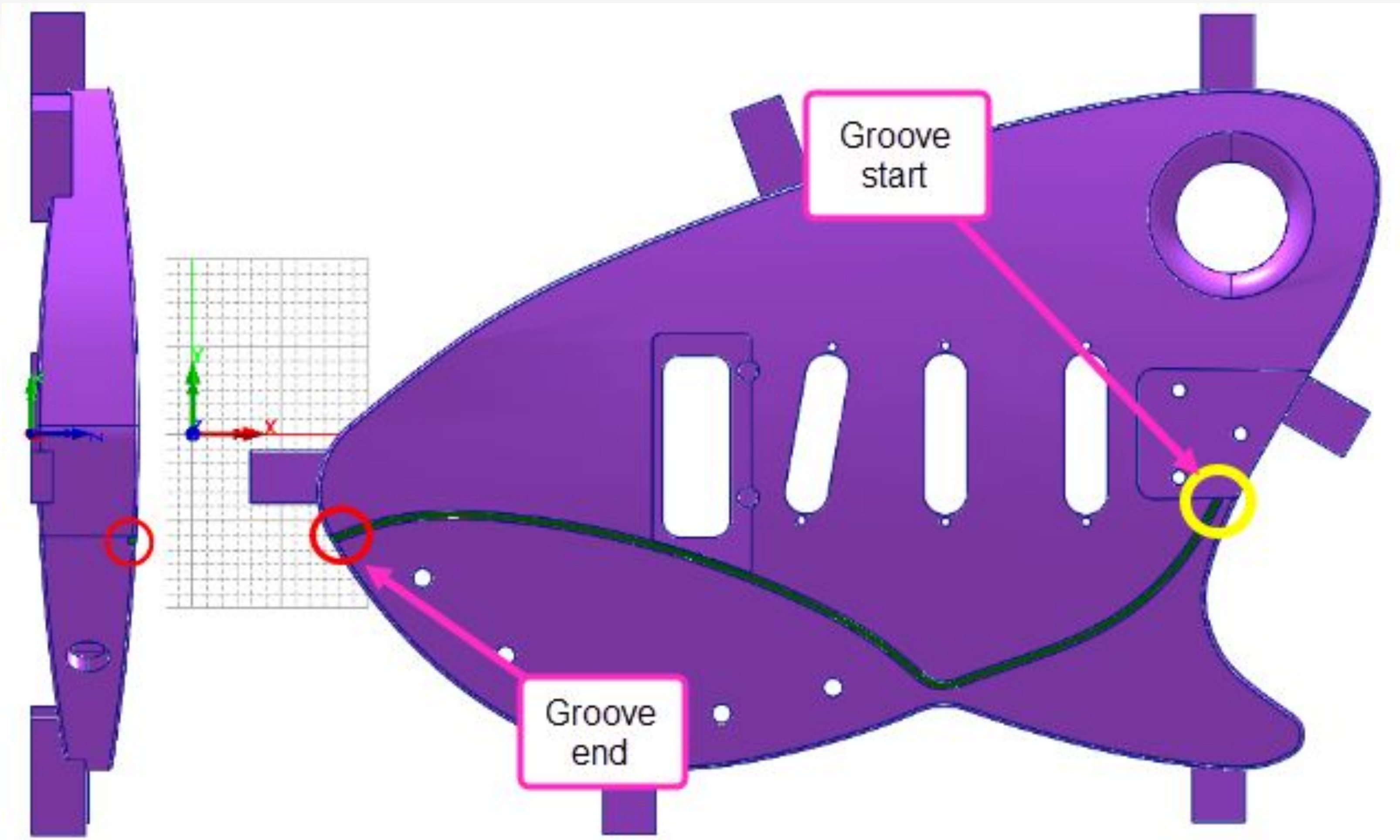


The guitar body has a 3D groove that runs the length of the part from left to right. The red circle on the left side image shows where the 3D groove exits the guitar body

Why use 2½ Axis Engraving?

The 3D Contoured Groove poses and unique challenge to the CAM designer. The groove is not flat and it is not straight. It is a constant width and depth, but both relative to the top-side contour of the guitar body. The 0.145” width of the groove also poses a challenge. Using a cutting tool smaller in diameter than 0.145” is not recommended due to the hardness of the wood causing tool deflection.

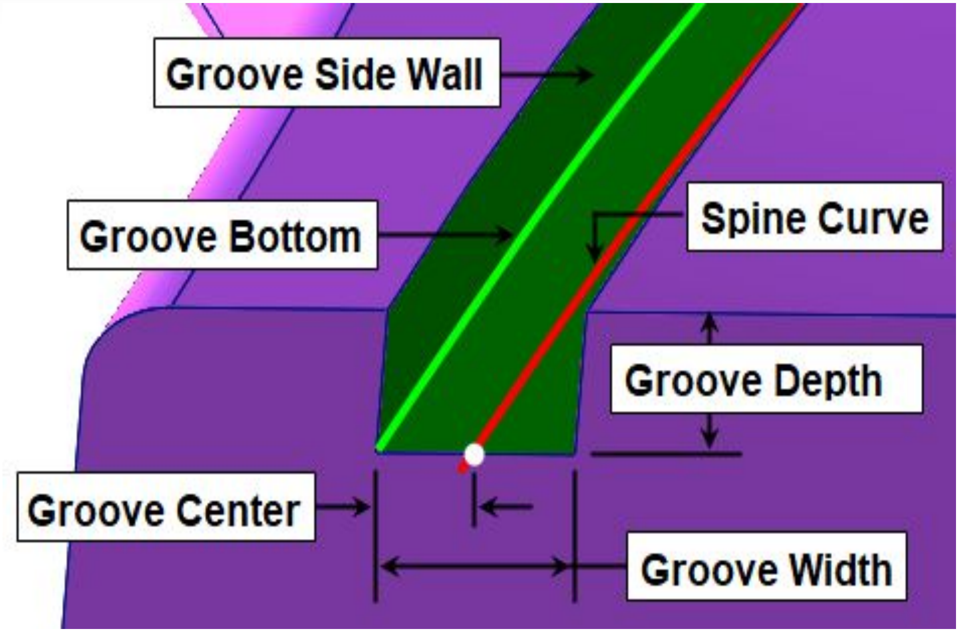
Several standard 3 Axis toolpath methods are immediately discarded. The Parallel Finishing method is not ideal for contours that are not straight on the XY plane. The Horizontal Finishing method is not ideal for contours that vary in the Z elevation. Even the more advanced 3 Axis methods would require a cutting tool that is smaller in diameter than the width of the groove to prevent the cutting path from traveling up and down on the side walls of the groove.

Luckily, however, there is one 2½ Axis cutting method that is ideal for cutting this 3D Contoured Groove. We are referring to the versatile 2½ Axis Engraving toolpath method. Don’t let the “2½ Axis” in the name of this toolpath deter you. In this method, the tip of the cutting tool will follow any 2D or 3D curve. All we have to do is create a curve for the cutter to follow. We will call this the Spine Curve.

Creating the Spine Curve

The Spine Curve will be located at the bottom center of the groove. The Spine Curve is created from the surface edges located at the bottom side of the groove. The following CAD steps are performed.

1. 3D Curves are created from the surfaces located on the side wall of the groove. More specifically, new curves are created from all edges located at one side and at the bottom of the groove.
2. These curves are then merged to form one curve that runs the entire length of the groove at its base on one side.
3. The 3D curve is then offset inward, toward the center of the groove, by 0.0725" which is exactly one-half of the 0.145" width of the groove.
4. The new curve is now positioned at the mid-way and at the bottom of the groove. We are calling this the Spine Curve shown in red in the illustration below.

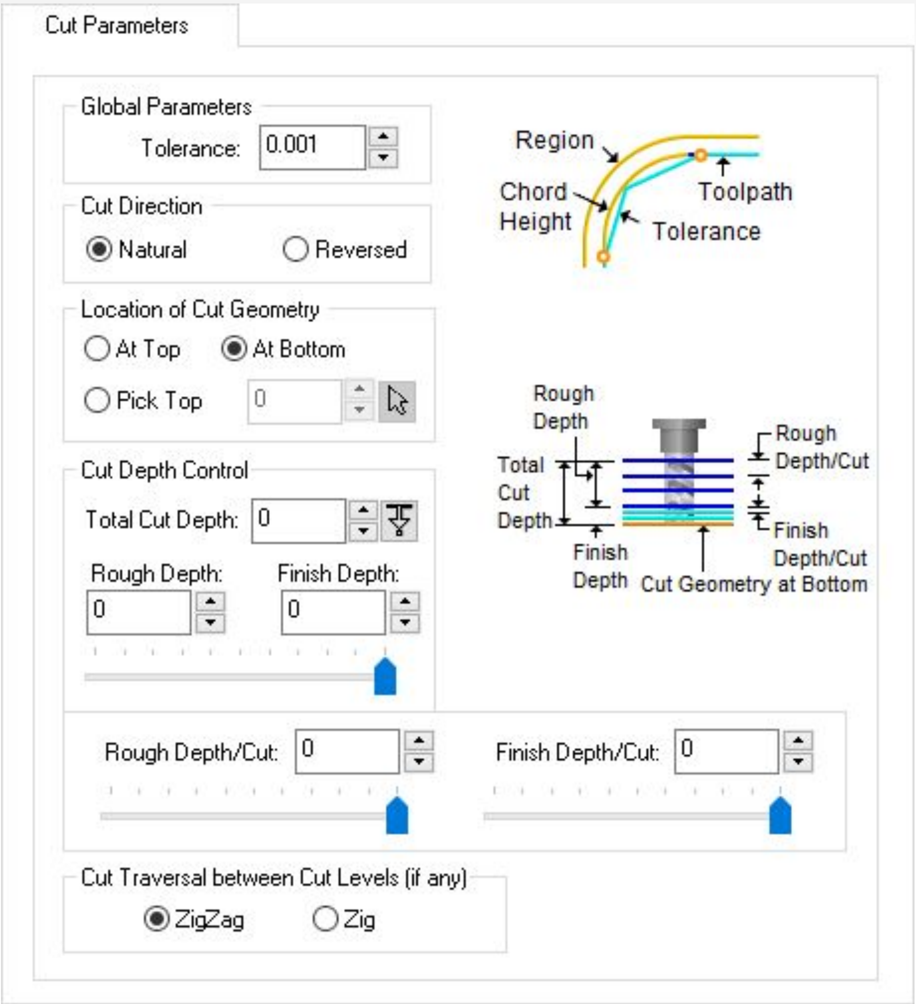


The 3D Contoured Groove is a part feature. The Spine Curve is shown in red.

Creating the 2½ Axis Engraving Operation

A 2½ Axis Engraving toolpath operation is performed on the Spinr Curve using a 0.145" diameter flat-end mill. The center flat tip of the end mill will follow the spine curve from start to end.

The 2½ Axis Engraving Operation Cutting Parameters include a global tolerance of 0.001". The location of Cut Geometry (i.e., the spine curve) is set to At Bottom. This is the bottom of the cut. The Cut Depth, Rough Depth, Finish Depth, Rough Depth/Cut, and Finish Depth/Cut are all set to zero. This means that the cutter will follow the spine curve in one pass and not cut any deeper than that. The Cut Parameters tab of the Engraving operation is shown below.

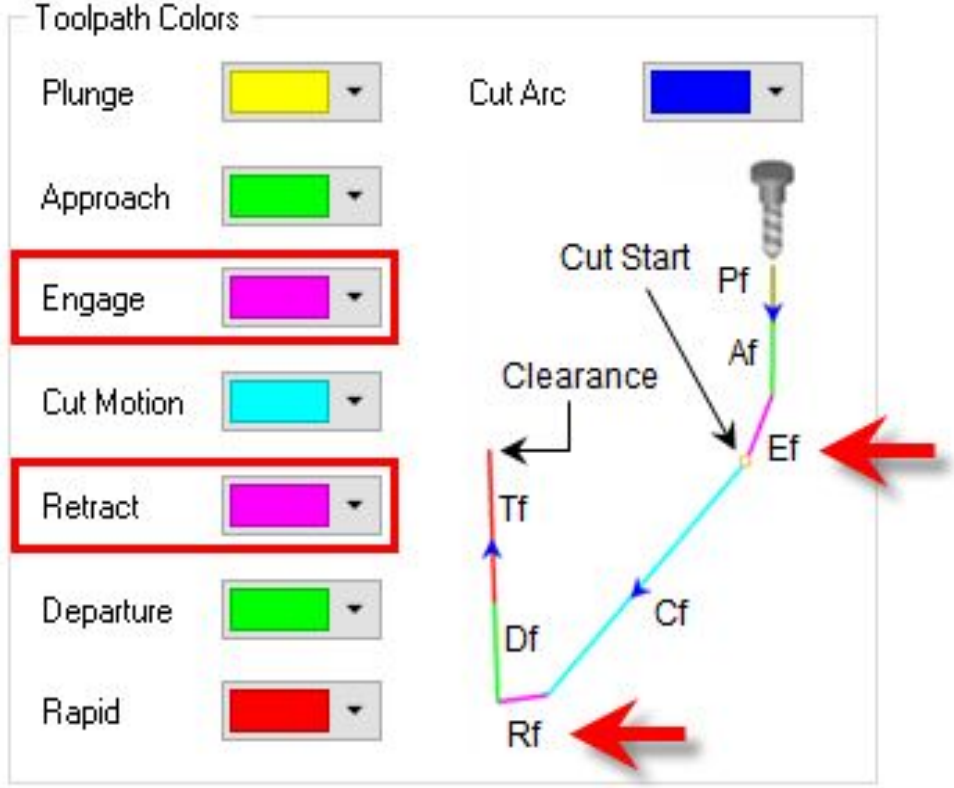


Here is the 2½ Axis Engraving Operation Cut Parameters tab.

Engraving Toolpath Entry and Exit Parameters

Controlling how the flat-end mill cutter enters and exits at the spine curve is of particular importance. The Entry and Exit of the flat-end mill must remain normal to the direction of the spine curve in order to remain dimensionally accurate to the 3D Groove.

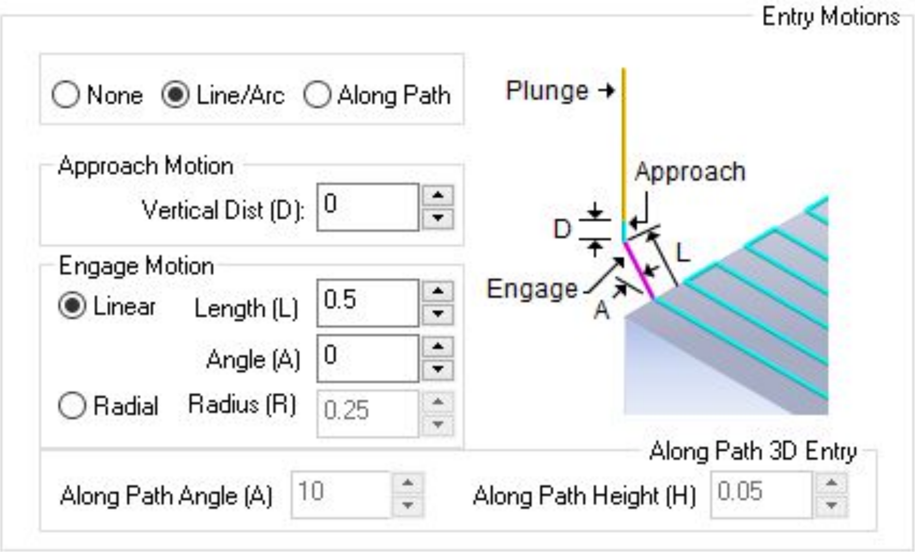
For display and illustration purposes, we see that any toolpath is divided into the following 7 segments; Plunge, Approach, Engage, Cut Motion, Retract, Departure, and Rapid. The motions that will control how the flat end mill enters and exits the 3D Contoured Groove are the Engage at the start of the groove, and the Retract at the end of the groove. The default Toolpath Colors are shown in the Toolpath tab of the CAM Preferences dialog.



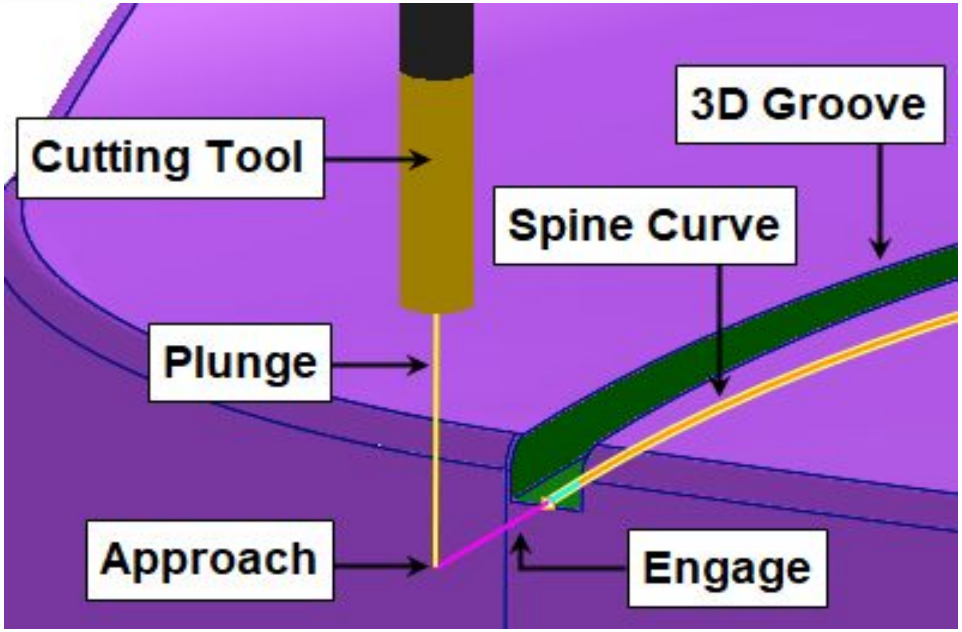
Toolpath Segments and Colors

Engraving Toolpath Entry Parameters

The dialog below is the Entry Motion portion on the Entry/Exit tab of the Engraving operation dialog. The Entry Motions are adjusted so that the toolpath will Plunge vertically (from outside the groove) to the Approach Motion Vertical Distance. It will then begin a 0.5” Linear Engage motion that ends at the start point of the Spine Curve. The Cut Motion then begins at the start of the Spine Curve.



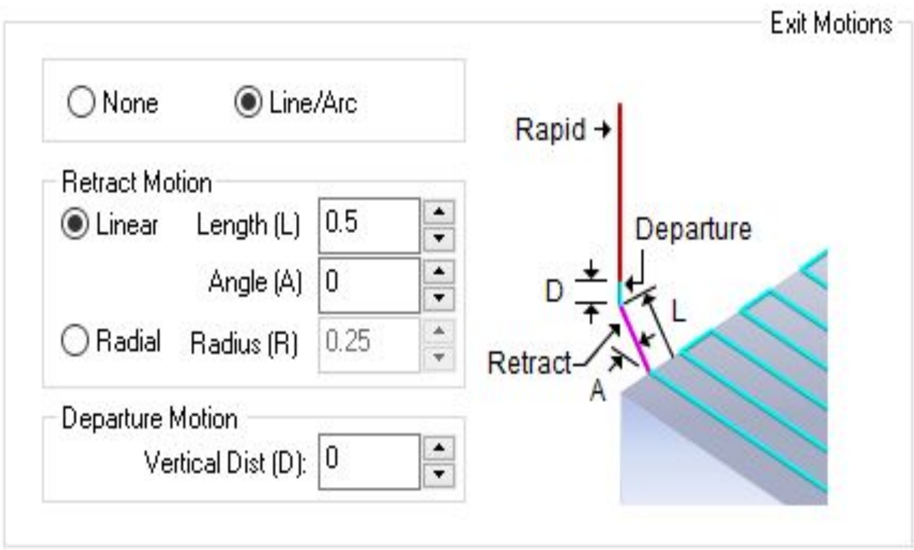
2½ Axis Engraving toolpath operation Entry Motion Parameters



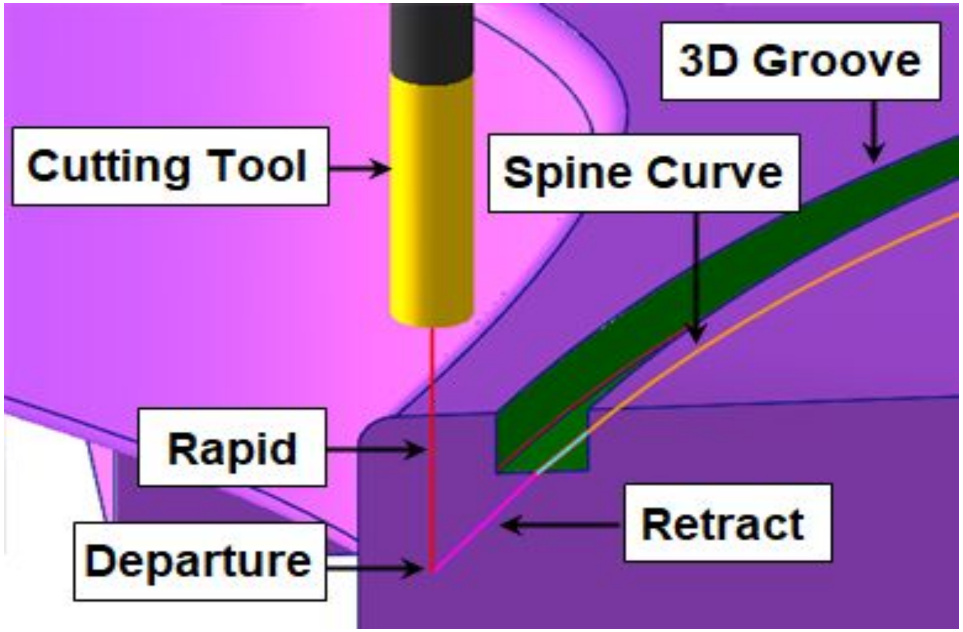
2½ Axis Engraving toolpath operation Entry Motion Illustrated

Engraving Toolpath Exit Parameters

The dialog below is the Exit Motion portion on the Entry/Exit tab of the Engraving operation dialog. The Exit Motions are adjusted so that the Cut Motion stops at the end point of the Spine Curve. The cutting tool then Retracts a Linear distance of 0.5”. At this point the toolpath rapids vertically to the clearance plane.



2½ Axis Engraving toolpath operation Exit Motion Parameters



2½ Axis Engraving toolpath operation Exit Motion Illustrated

Controlling the Entry and Exit Angles

The Entry and Exit Angles refer to the elevation of both the Engage and the Retract segments of the toolpath. In this case, we want the cutting tool to remain tangent to the Spine Curve, achieving a smooth entry into and exit from the groove.

In the Entry/Exit dialogs shown above you will see a parameter named Angle (A). This is the angle at which the Engage and the Retract segments connect to the Spine Curve. In both cases, Angle (A) is set to 0 (zero). This keeps the Engage and the Retract segments tangent to the Spine Curve.

Here we see the end result of machining the 3D Groove using the 2½ Axis Engraving method.

Technique Used to *Flip-Machine* the Guitar Body

Understanding how to machine 2-sided parts is a concept difficult to grasp for many new CAM users. The more complex the part, the more this process is relied upon for a successful machining job. There are different approaches. All of the reliable methods will involve two or more dowel pins.

Jeff has a reliable technique that he is happy to share with other users; we have documented it below. It involves two ¼" diameter dowel pins. However, Jeff mounts the dowel pins to the part itself as well as to a base fixture plate. His technique holds the stock firm without having to leave tabs holding the part and stock together. Follow the illustrations below to understand this technique.

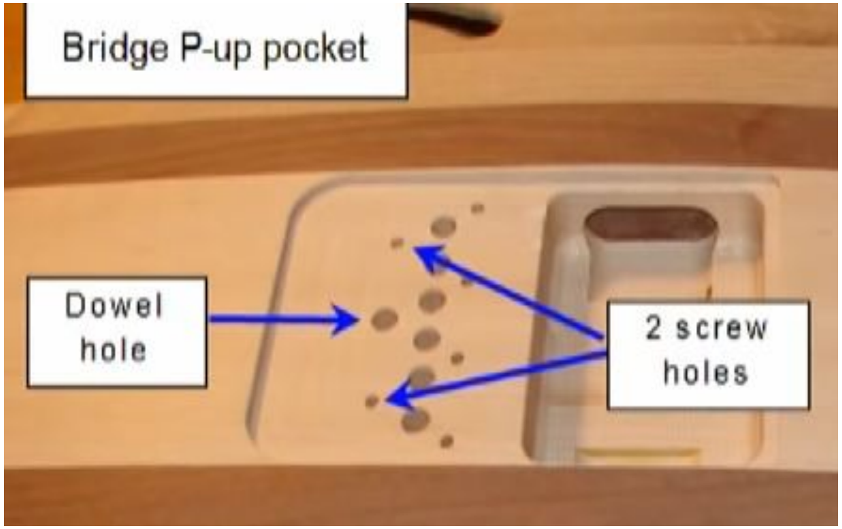
Watch the video of Jeff's technique here.

(A)
Stock blanks are cut from sheet stock.

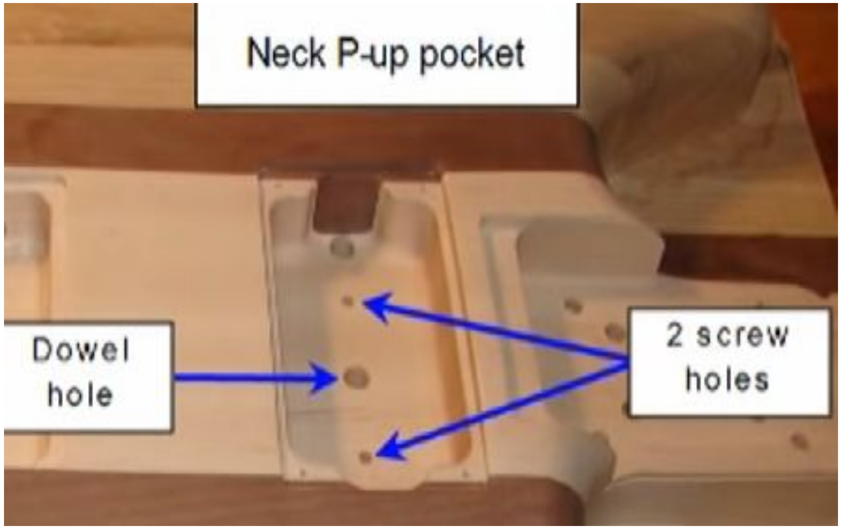
(B)
The stock blanks are glued together and mounted to the CNC router bed.

(C)
The top side of the guitar body is machined without leaving any stock tabs.

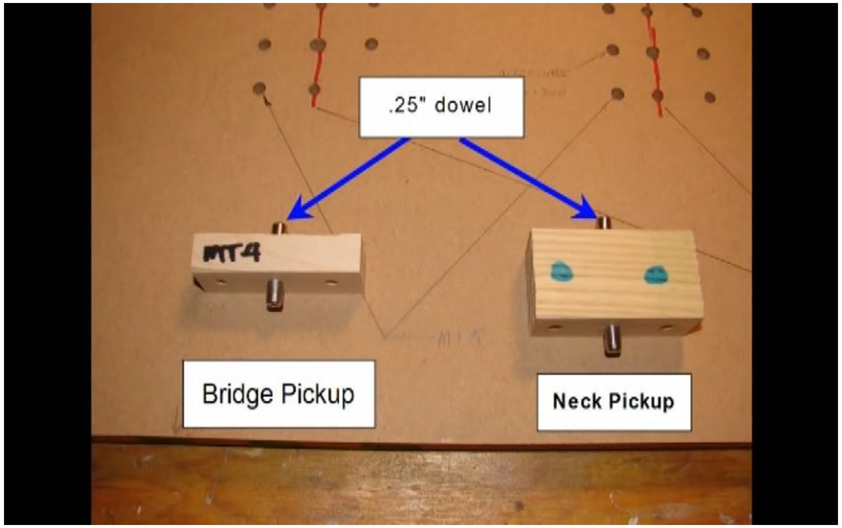
(D)
Here we see a view of the top machined side of the guitar body.



(E)
¼” dowel pin holes and screw mounting holes are machined on the bridge area.

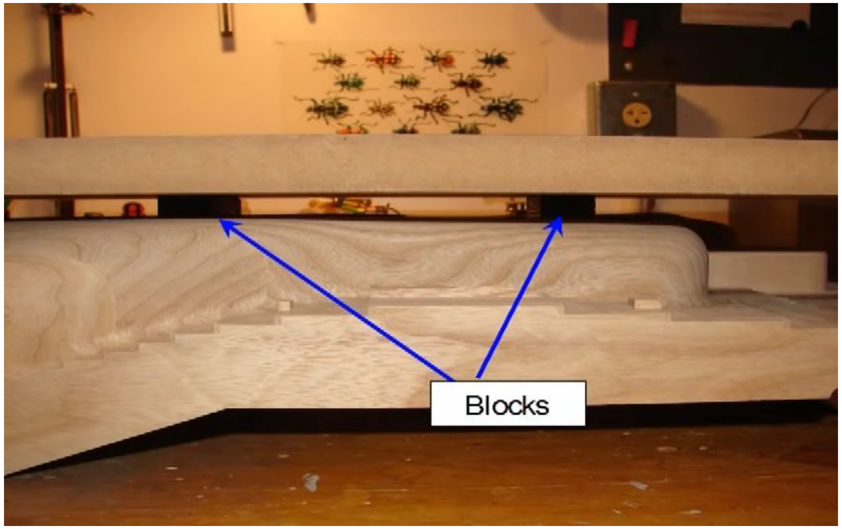


(F)
¼” dowel pin holes and screw mounting holes are machined on the neck area as well.

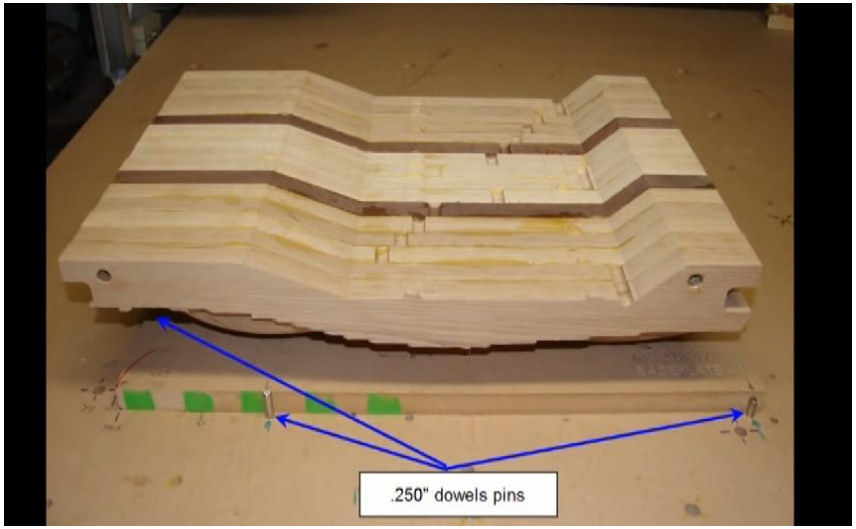


(G)
Two fixture blocks and a fixture plate are prepared with ¼" dowels and screw mounting holes.

(H)
The fixture blocks are mounted to the top side of the machined guitar body using the dowels.

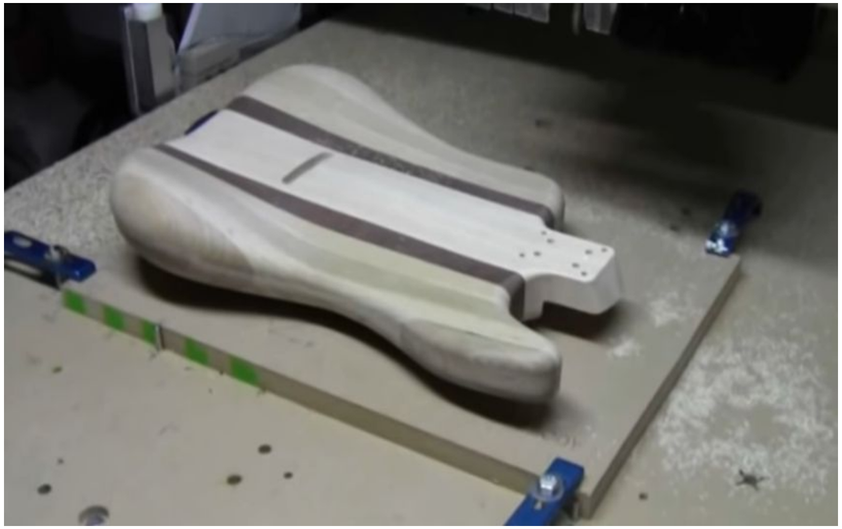


(I)
The fixture plate is mounted to the fixture blocks using the dowel pins for alignment.



(J)
The fixture plate is flipped over and aligned to the router bed using additional dowel pins.

(K)
With the fixture plate mounted, the back side of the guitar is machined. Roughing is shown



(L)
Here we see the fully machined guitar body ready to be removed from the fixture plate.

(M)
The completed guitar body top.

(N)
The completed guitar body bottom.

(M)
The Machine Zero: The dowel pin hole on the neck serves as the Work Zero for machining the top side. The same dowel pin location on the fixture plate is used to zero the machine for cutting the bottom side.

Hat's off to Jeff for designing the excellent "flip-machining" technique!

More Cool Designs from KOZM Guitars!

KOZM Guitars

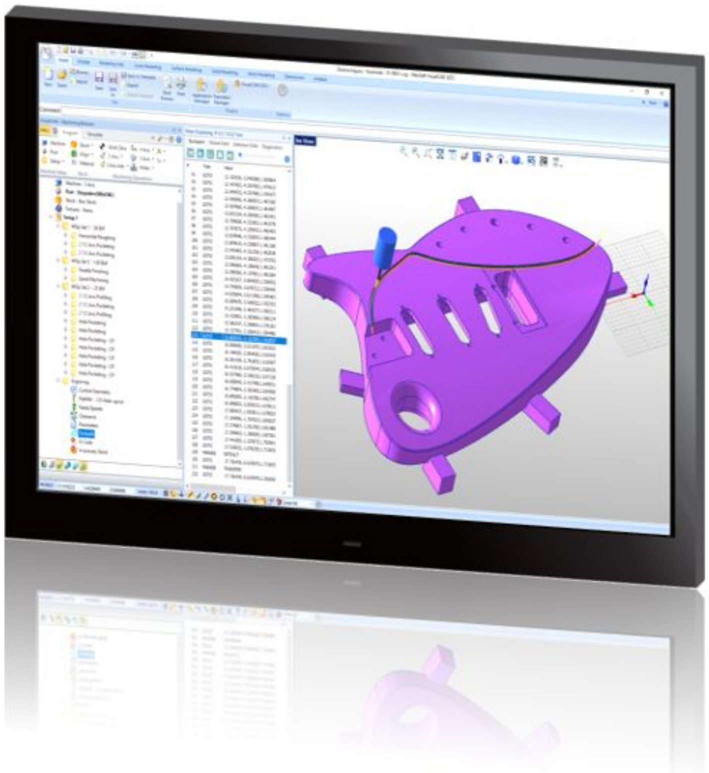
VisualCAD/CAM®

More about KOZM Guitars

You can learn more about Jeff Kosmoski and KOZM Guitars by visiting his website at www.kozmguitars.com. To learn more about Jeff's CNC processes you can visit his Digital Lutherie page. We want to extend a special thanks to Jeff Kosmoski for allowing us to showcase his work!

Cool project Jeff!
Thank you for allowing us to showcase your work!

More about VisualCAD/CAM



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

- **VisualCAD/CAM 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!
- **VisualCAD/CAM 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!

- **VisualCAD/CAM 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.
- **VisualCAD/CAM 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.
- **VisualCAD/CAM 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 VisualCAD/CAM - MILL Product Page: mecsoft.com/products/visual-cad-cam