

CREATING CURVED PROFILES ON THE TABLE SAW

INTRODUCTION

Recently I was pondering the design of an upcoming jewelry box project and decided I wanted to create the sides of the box as curved profiles. In my mind's eye, I had a perception of a possible profile, but I had no idea how I was going to create it. I don't have a router table or shaper, so I needed to come up with some alternate method to create the profile. I had heard of the cove cutting technique but had never pursued it because I had no requirement for cove moldings. But after viewing some online videos I was intrigued with the possibilities that cove cutting seemed to offer. Consequently, I decided to learn more about the process.

I discovered that cove cutting on the table saw is an old technique that is very well documented in magazine articles and online DIY videos. Sometimes the profiles created are called **Crown Molding**. I think the term "cove cutting" is too limiting, because this technique can be used to make a wide variety of **curved** profile shapes, but it seems to be the most used descriptive term.

Cove cutting on the table saw is not rocket science – it is a very simple process that carves a groove in the face of a board, passed across the table saw blade against a fence set at an angle to the blade. A curved profile is generated by making successive cuts, raising the blade in small increments until the desired profile depth is achieved. The **size** and **shape** of the profile are determined by the table saw setup.

PROFILE TYPES

Two types of profiles can be generated with this process: **Symmetric** and **Asymmetric**

Symmetric profiles have an identical curvature on each side of the centerline of the profile.



Asymmetric profiles are offset to one side of center such that the curvature is constantly changing from one end of the profile to the other:



Symmetric cove moldings can be easily visualized because the curvature of the profile is uniform from one end to the other. However, **Asymmetric** profiles are difficult to envision because the curvature of the profile is constantly changing from one end to the other.

In my mind's eye, I was visualizing some sort of **Asymmetric** curve for my virtual jewelry box component. I could understand how to establish the **Width** and **Depth** of the profile, but not the **shape**. This problem led me to conduct a series of tests to learn about the cove cutting process requirements and determine what combination of table saw settings would produce the curved profile I had envisioned.

The tooling and equipment required for cove cutting are readily available and can be as basic as one or two 2 x 4's clamped to your table saw top.

TABLE SAW

A table saw is a table saw, is a table saw, is a table saw.....! I would venture to say that almost any table saw could be used for cove cutting. In fact, I would bet that one could mount a portable saw upside down under a piece of plywood and clamp a 2 x 4 fence to the top surface, angled to the blade, and make perfectly acceptable curved profiles. It might not be very convenient to use but could be made to work!

My table saw is a **Ridgid R4511**, granite-topped model built by **Steel City** and marketed by **Home Depot**. After some re-engineering and modification to improve its usability, it currently looks like this:



This saw was used for all of the testing described in this document.

TOOLING

The tooling used to do cove cutting on the table saw is quite simple. Most of the tooling used for my cove cutting tests were items I already had or could be easily built in my shop:



Shop-made hinged fence



Digital protractor



Digital angle cube



Blades/Cutters

Other tooling items

Foam covered sanding pad – for use as a push block

Optional: Parallelogram Jig – in lieu of a protractor, a four-armed parallelogram jig, adjusted to the desired width of the profile, can be used to establish the required **Fence Angle**. Sometimes such jigs are constructed to also serve as a double-sided fence.

FENCE CONFIGURATIONS

There are two schools of thought about the fence configurations to be used for cove cutting – a **single fence**, or **two parallel fences**. I think the preference for the type of fence to be used is an individual one – both configurations will provide the same results.

Double Parallel Fence

Most of the articles and videos recommend using a double parallel fence. This fence configuration provides the best support for the part, which is especially important when making large cove moldings. However, the double parallel fence is usually clamped to the saw table, which would have been difficult on my saw.

Interestingly, the double parallel fence **Rockler** sells is unique in that it is attached to the saw table using expanding tee bars in the miter slots.



In my view, one of the drawbacks of the double parallel fence is that repositioning the part between passes requires the part to be dragged backward across the blade, increasing the likelihood of excessive cutter marks in the surface.

Note that drafting triangles, adjustable triangles, or other measuring tools can also be useful for setting **Fence Angles**.

Single Fence

Because my testing was performed on 4/4 (3/4") material with the total depth of cut limited to 1/2 inch, I decided this effort did not require the extra support of the double parallel fence.

Instead, I chose a hinged, shop-made, single fence clamped to my existing table saw fence for the following reasons:

- 1) My table saw has a solid granite top, with a cabinet extending out to the edges of the table, which doesn't lend itself to clamping auxiliary fences.
- 2) The hinged fence allowed me to easily and accurately set the fence angle over a range of values for testing, and to be able to use the original table saw fence scale for a location reference – useful for making a spare part, or for future duplication.
- 3) It also provided unobstructed view of the part contact with the fence and easy part repositioning for each subsequent pass without having to pass the part backward over the blade.

FENCE DIRECTION

The direction of the fence **relative to the blade** depends upon which way the blade can be tilted. When using the double parallel fence, the fence can be positioned on either side of the blade. However, when using a **single fence**, the fence should **always** be positioned

on the side **opposite** the direction of the blade tilt – i.e. for a **left tilt saw**, position the fence on the **right side** of the blade and vice versa for a **right tilt saw**. This ensures that the cutting forces will always be directed **toward** the fence.

PROCESS VARIABLES & TERMINOLOGY

The three familiar table saw settings used for normal table saw cutting also apply to cove cutting:

Blade Height – maximum height of the blade above the saw table

Blade Tilt – angle of the blade with the vertical

Fence Position – distance between the fence and the blade

Each of these settings affects the shape and size of the cove profile:

Blade Height determines the maximum **Depth** of the profile (also called the **Apex**).

Fence Angle determines the **Width** of the profile.

Blade Tilt produces the **Asymmetry** (skewing of the profile).

0° Blade Tilt produces a **Symmetric Profile**

Apex Offset is the distance between the highest point (**Apex**) of the profile and the centerline of the **Width** of the profile. The **Apex Offset** determines amount of **Asymmetry** (skewing) of the profile.

Fence Position determines the distance between the edge of the board and the profile, measured **perpendicular** to the fence. This is also called **Edge Margin**.

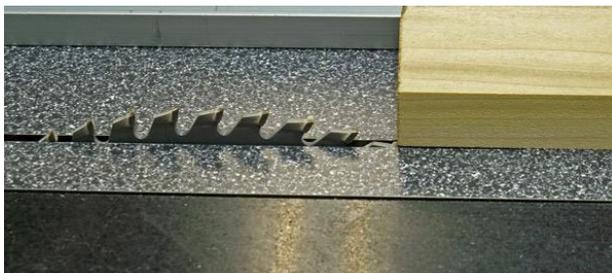
COVE CUTTING vs. NORMAL RIP AND CROSSCUTTING

I think it is important to understand the differences in the cutting action of the saw blade between normal rip or crosscutting and cove cutting.

Normal Rip or Crosscutting

Looking at the blade ready to make a **1/2-inch** deep rip cut, the length of **blade exposure** above the table is about **4 3/8 inches**.

When normal rip or crosscutting, the kerf material removal is performed by the **front edge** of the **blade teeth facing the operator**.



Using a 10-inch diameter blade, note that the cutting path is a 5-inch **circular radius** produced by the teeth on the **front side** of the saw blade. The teeth on the **back side of the blade beyond the centerline of the blade** are not doing anything – just coming along for the ride because the material in the kerf has already been removed by the **front teeth**. Since the blade rotation is toward the front of the saw, the cutting action is **downward** toward the top of the table.

Cove Cutting

By contrast, the cutting action when making cove profiles is quite different. To start with, the part is **passed across the blade at an angle**, instead of perpendicular to the edge of the blade. This angular feed travel direction causes the cutting path shape, viewed from the end of the part, to change from **circular** to **elliptical**.

The Symmetric cove profile is produced by making two converging, parallel cutting paths – one on each side of the blade centerline. The elliptical cuts on the half closest to the fence are made by the **downward facing blade teeth**; the cuts made on the other half of the profile are made by the **upward facing teeth, tending to lift the part off the table**. This is the reason that a uniform downward force must be exerted on the part during the cut to keep it in contact with the table.

The **two identical, parallel** cutting paths account for the uniform appearance of the profile on both sides of the centerline. This sample was made at a **10° Fence Angle**.



As shown in the graphic, **Symmetric** cove profiles made with small **Fence Angles** produce narrow cutting paths which may **not** converge, depending upon the table saw settings used. Clearly, there are **two Apexes** shown in the photo, defining the cutting paths. This phenomenon is not observed at greater **Fence Angles**.

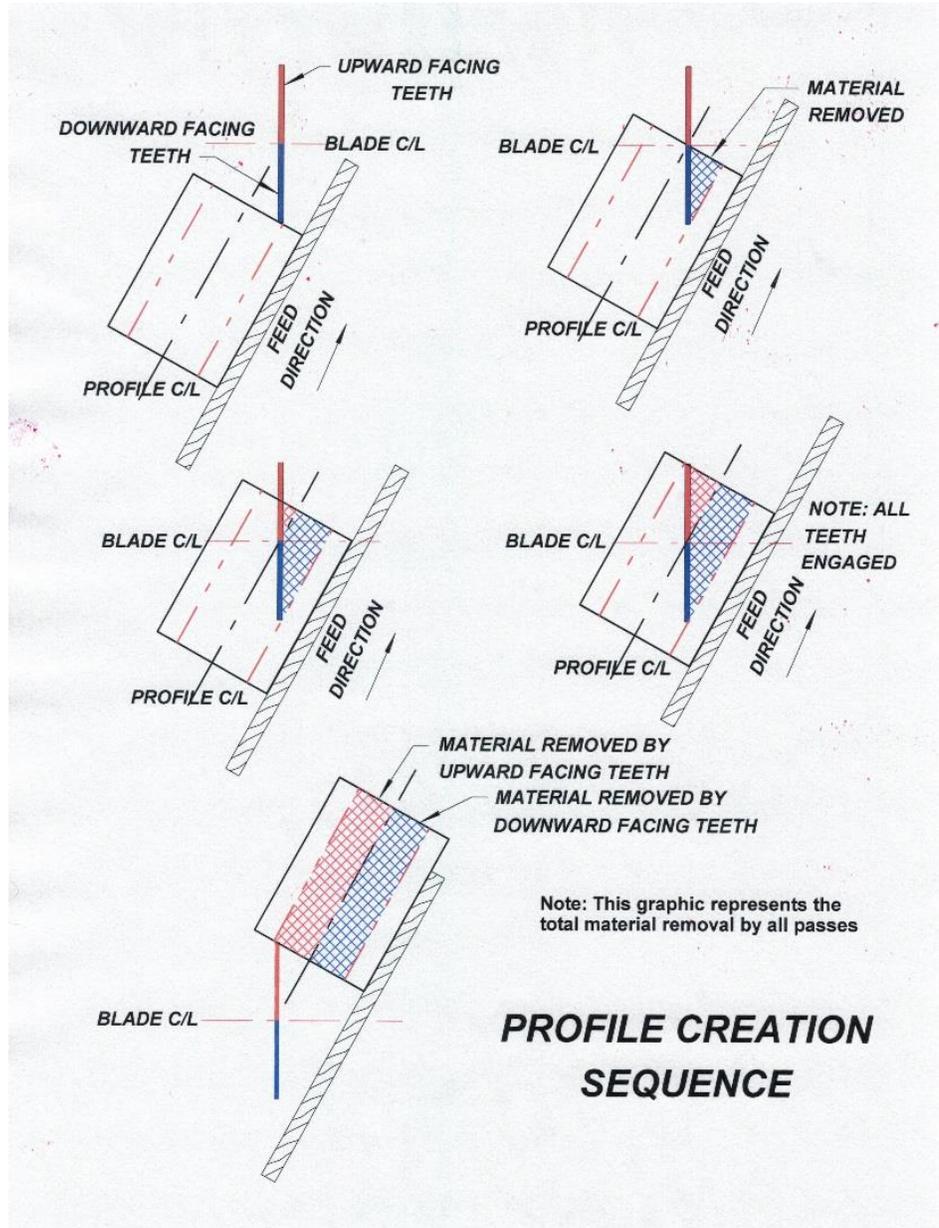
Increasing the **Fence Angles** widens the two cutting paths allowing them to converge at the **Apex** to form a smooth continuous profile.

Since the cuts are made on the bottom side of the part, it is not visually obvious that the complete profile is composed of two separate cutting paths. For typical cove profiles, the highest point of each cutting path is made when a blade tooth is at the top of the cut, the two cuts converge at that **Apex** point, merging them into a continuous profile surface.

Asymmetric cove cuts are also created by **two** cutting paths, which converge at the **Apex** of the cove profile, even though it is offset from the centerline of the profile (**Apex**

Offset). However, **each cutting path has a different curvature** caused by the effect of the **Blade Tilt** and **Blade Angle**. Some combinations of table saw settings prevent the two cutting paths from converging if the **Apex Offset** is too great. Fortunately, the online calculators disallow an excessive **Apex Offset** and warn the user of the issue. Because the **Apex** is offset away from the fence, more of the material removed to create the **Asymmetric Profile** is accomplished by the **downward cutting** blade teeth.

The cutting action when **Asymmetric** cove cutting is slightly different because the blade is tilted. This **Blade Tilt** causes the cutting path to change and the cutting action to occur on the **tips** of the saw blade teeth on the **back edge** of the blade. For this reason, the surface of the **Asymmetric** cove profiles may show more noticeable machining marks.



COVE CUT TESTING

The intent of this testing was to provide a visual record for future reference, using actual cross sections, to illustrate the effects of the table saw settings. The limits of my testing were designed to help define a curved profile **1/2" deep x 2 1/4" wide** in 1 x 4 (3/4" x 3 1/2") stock to be used for building an upcoming jewelry box. I would expect that the effects of the table saw settings would apply to other cove profiles in thicker material.

ONLINE COVE CUTTING CALCULATORS

Although the **Fence Angle** and profile **Width** can be determined by using a parallelogram jig to set up the saw, a much easier and more accurate way is to use the **online calculators** available from **Fine Woodworking** and **Woodpecker.net**, which are very easy to use. Configured similarly, each of the calculators require specifying the **Depth** and **Width** of the desired profile to enable calculation of the required **Fence Angle** and **Blade Tilt** settings. The calculators also specify the maximum achievable profile limits based upon the input data.

Blade Diameter (inches)	<input type="text" value="10"/>
Desired Cove Depth (inches)	<input type="text" value="0.5"/>
Desired Cove Length (inches) - max value: 4.358	<input type="text" value="2.25"/>
Desired Apex Offset (inches) - max value: 0.435	<input type="text" value="0"/>
Miter Gauge Midpoint Angle (0° or 90°)	<input type="text" value="0"/>
<input type="button" value="Perform Calculations"/> <input type="button" value="Reset Defaults"/>	
Fence Angle (Degrees): 61 Blade Tilt Angle (Degrees): 0 Verify Cove Length (Inches): 2.25 Verify Apex Offset (Inches): 0	

Blade Diameter (inches)	<input type="text" value="10"/>
Desired Cove Depth (inches)	<input type="text" value="0.5"/>
Desired Cove Length (inches) - max value: 4.358	<input type="text" value="2.25"/>
Desired Apex Offset (inches) - max value: 0.435	<input type="text" value="0"/>
Miter Gauge Midpoint Angle (0° or 90°)	<input type="text" value="90"/>
<input type="button" value="Perform Calculations"/> <input type="button" value="Reset Defaults"/>	
Fence Angle (Degrees): 29 Blade Tilt Angle (Degrees): 0 Verify Cove Length (Inches): 2.25 Verify Apex Offset (Inches): 0	

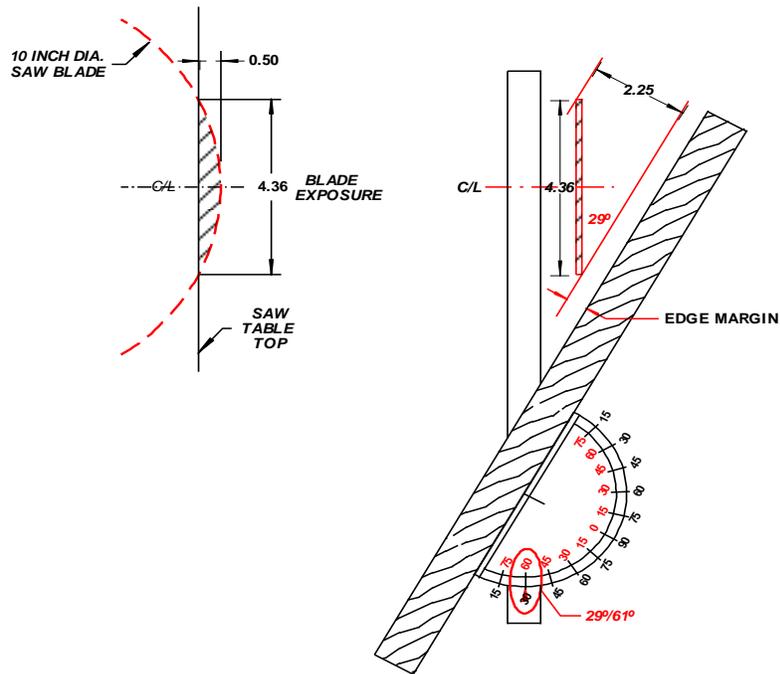
FINE WOODWORKING CALCULATORS

However, I found interpretation of the **Calculated Fence Angle** value to be very confusing because it is **based upon the CENTER POINT setting of a Miter Gauge**. **The fact that I was not even using a miter gage just added to the confusion**. As shown, both calculators require you to choose the configuration of the miter gage being used – specifying one with either a center point value of **0°** or **90°**.

Most miter gages provided with our shop equipment have **0°** center points. However, some after-market miter gages, such as the **Incra** models have dual scales for **both 0° and 90°** center points.



The following graphic illustrates the issue of the miter gage center point but also demonstrates how a miter gage could be used as a tool to establish the desired **Fence Angle** relative to the saw blade.

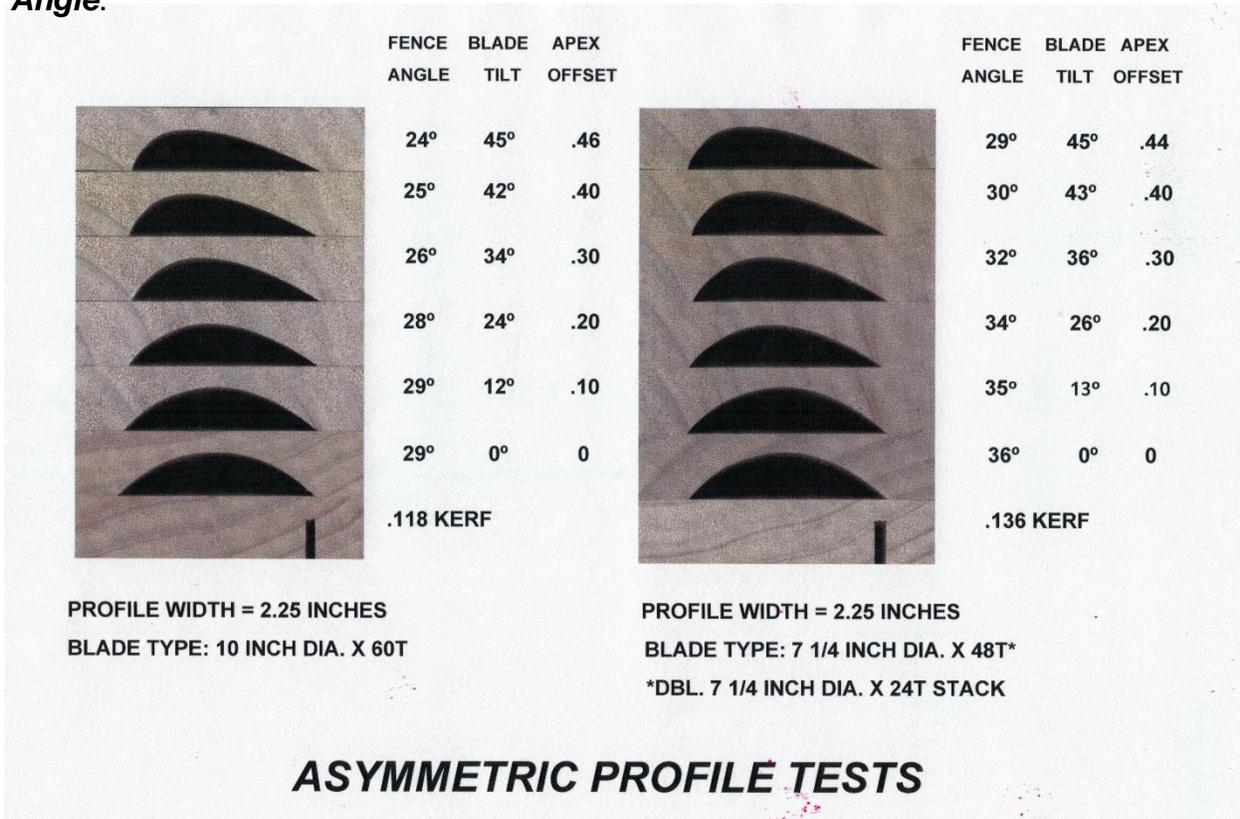


PROFILE CUTTING TESTS

Two sets of tests were conducted to illustrate the effects of **Fence Angle** and **Blade Tilt/Apex Offset** when making **Symmetric** and **Asymmetric Profiles**. Two different table saw blades were selected to demonstrate this cutter choice flexibility. The online calculator from **Fine Woodworking** was used to select the saw settings used in the tests.

	<p>FENCE ANGLE</p> <p>36°</p> <p>30°</p> <p>25°</p> <p>20°</p> <p>15°</p> <p>10°</p> <p>5°</p> <p>.136 KERF</p>		<p>FENCE ANGLE</p> <p>30°</p> <p>25°</p> <p>20°</p> <p>15°</p> <p>10°</p> <p>5°</p> <p>.118 KERF</p>
<p>MAX. PROFILE WIDTH = 2.25 BLADE TYPE: 7 1/4 X 48T* * DBL 7 1/4 X 24T STACK BLADE TILT = 0°</p>		<p>MAX. PROFILE WIDTH = 2.25 BLADE TYPE: 10 X 60T BLADE TILT = 0°</p>	
<p>SYMMETRIC PROFILE FENCE ANGLE TESTS</p>			

The **Symmetric Profile** configurations were created by simply varying the **Fence Angle** without **Blade Tilt**. As expected, the **Width** of the profile widened with increasing **Fence Angle**.



The second set of tests were designed to illustrate the effect of the amount of **Apex Offset** on **Asymmetric Profiles**. The selected **Apex Offset** determined the **Fence Angle and Blade Tilt** for each test to produce a consistent 2 1/4" wide profile. As can be seen, the profile became more **Asymmetric** (skewed) as the **Apex Offset** was increased.

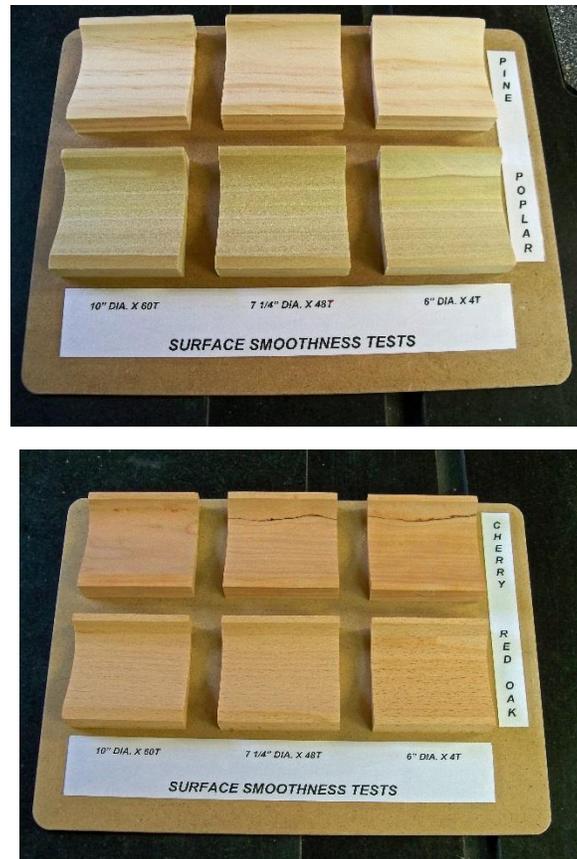
Note that although the profiles appeared to be very similar, the two different diameter blades produced profiles with slightly different curvatures.

SURFACE SMOOTHNESS

During my investigation, one of the common concerns registered by users was that the saw blade used to make the profile produced a rough surface that had to be smoothed by sanding or scraping. I am an unapologetic power tool guy who is **NOT** a fan of hand work, so I was interested in determining which blade produced the **best** surface finish, requiring the **least** post processing.

I noticed that there was very little information available about what saw blade or cutter configurations to use for cove cutting. Therefore, I made test cuts using two different blades to demonstrate the performance of the different cutters on four softwood and hardwood species with increasing hardness: **Pine, Poplar, Cherry, and Red Oak**. For comparison, I also made a set of test panels using a robust beading cutter having four,

1/2" wide, full radius carbide insert teeth. An **Asymmetric** profile was selected for the test panels to determine if the variable profile curvature would produce any significant change in the surface smoothness.



It should be noted that the material feed rate into the cutter has a decided effect upon the surface smoothness of the cut. Typically, the successive roughing cuts to remove the bulk of the profile material should be made by increasing the blade height in increments less than 1/8" using a moderate feed travel speed, which you can easily learn by experimentation. However, I found that making a very shallow (1/64" – 1/32") final pass at a much slower feed rate produced a much improved surface smoothness of the profile.

All of the test samples demonstrated surface finishes that I would consider acceptable, requiring only minor finish sanding. The **Poplar** samples exhibited some of the "fuzziness" characteristic of **Poplar**, although this was not present on the sample made with the four-tooth cutter. Minor machining marks occurred on some of the panels, but not deep enough to require such aggressive smoothing measures such as card scraping.

The best surface finish occurred on those samples produced with the **4-tooth beading cutter**. Due to the absence of pointed teeth on this cutter, there were no striations like those present in the other samples. Apparently, the shearing cutting action of the

generously radiused cutter teeth helped produce the improved surface finish, as was predicted by the tests that **Mathias Wandel** had conducted. (See References).

MISSION ACCOMPLISHED

As a final operation, I made an **Asymmetric** prototype profile from **Red Oak** which represents the one I will ultimately use on my upcoming jewelry box project! This sample, shown just as it came off the saw, was made with the **4-Tooth Woodline Bead Cutter**.



SUMMARY

Because so much detailed information about cove cutting on the table saw is available on the internet, my intent was to provide some of the underlying information that seems to be missing in the discussions/videos on the internet. By using actual cut profiles to illustrate the effects and interaction of the process variables, I hope this document will provide some useful background information and starting point setups to encourage the reader to explore this technique to create curved profiles for future projects.

REFERENCES

Though many more are available on the internet, I found the following references to be helpful during my investigation:

<https://www.youtube.com/watch?v=iKiwTkX4EhE>

Marc Spagnolo (The Wood Whisperer) provided an easy to understand explanation and demonstration of the cove cutting process.

<https://www.youtube.com/watch?v=YITLpXzTja8>

Brian Havens produced a very informative video which explains the effects of the process variables – **Blade Height**, **Fence Angle**, and **Blade Tilt** on the profile configuration.

<https://www.youtube.com/watch?v=ZqXyiYDmj34>

Gary Rogowski illustrates the process using an interesting **hinged fence design** which I adopted and modified to suit my table saw.

<https://www.youtube.com/watch?v=Qe5ZeSX-q0>

Mathias Wandel demonstrates tooling modifications to improve the surface finish.

<https://www.finewoodworking.com/2005/12/21/cove-angle-calculator>

This **2005 Fine Woodworking** article/calculator may require a subscription to ***Fine Woodworking***, but they provide a free trial use option.

<http://www.thewoodpecker.net/cove/cove.htm>

The **Woodpecker** calculator program provides similar information in both **Imperial** and **Metric** units, with **free** access.

<https://woodgears.ca/cove/calculate.html>

Mathias Wandel provided a table of values for profiles in **metric** units.

https://www.woodline.com/products/collections-saw-blades-page-2?_pos=110&_sid=643fddde3&_ss=r

This is the link to the **Woodline 4-Tooth Beading Cutter** used in these tests.

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All questions and comments are welcome. Please transmit them via email to

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I will endeavor to answer your comments and enquiries promptly.