Mathematics of Machine Cut Dovetails

When I was in school I had an engineering professor who told us there are two ways to approach a project. A) If you possess enough experience and aptitude you can guess at the parameters and be pretty close. After a little educated tweaking you'll hit the mark. B) Take ALL the variables into account, do all the pertinent mathematical analysis, build to the result without deviation and you'll also hit the mark. Any combination of the two techniques is largely a waste of time.

I have lived by that in much of my work and found it to be largely correct. Approach "A" seems particularly well suited to wood working, where feel and response to the medium play such a large part. But the following is an example of the latter technique applied to dovetail cutting using a simple jig. A brute force method if you will but useful nonetheless.

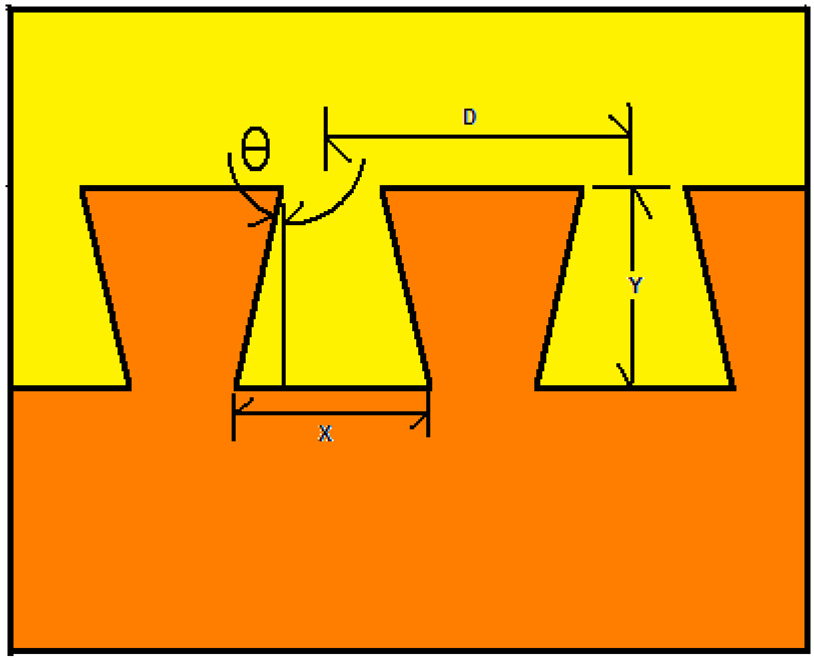
A long time ago I bought a dovetail jig for $30 from Harbor Freight. I set it up dutifully following the "destructions" and proceeded to make scrap wood. I threw it on a shelf intending to sell it in a lawn sale. 15 years later I unearthed it with renewed interest and curiosity, and maybe a little more patience born of age and tenacity.

I decided to approach it with a little more analytical perspective and determined that the instructions were absolutely wrong. You cannot possibly make symmetrical tails and pins with a ½" 14 degree router bit and a 1" pitch guide comb. It took me a while to stop doubting my math as I reviewed countless YouTube videos that seemed to jibe with the instructions. But neither did any of them explain the details of the geometry used in setting up the jig.

So I derived a simple, straight-forward equation that will allow me to calculate the depth and pitch required to cut symmetrical tails and pins for a given bit width and angle. If you have a fixed-pitch comb, as I do, the two variables are rigidly tied together. Jigs with movable fingers allow far more options for asymmetrical pins and tails but are beyond the scope of this article. It is suffice to say this is a practical rather than artistic view of the dovetail.

The goal here is symmetry , such that each pin matches each tail exactly in width, height and center to center distance, or pitch. The easiest way to explain how the math was derived is to imagine a square box joint. Now slide them together so there top and bottom widths remain unchanged but there sides have to tip. If we take a ½" box joint on 1" centers and slide them together ¼" we get ½" dovetails with roughly 14 degree sides. Too simple, right? Going the other way is not as simple. For instance, I have a ½" dovetail cutter with 7 degree side angles. What depth and spacing do I need to make symmetrical dovetails.? It turns out the following equation will answer that exactly. In fact, if you prefer to determine the depth based on a predetermined spacing, or vice versa, you can do that too. I have presented the equation several ways. I have also created a spreadsheet, which can be downloaded from my website, which displays a table of values for available bits and fractional spacing. You may enter your own values if you wish to fiddle. It is available at http://www.tinyurl.com/ka2qfx/dovetails.html"

Here’s the ugly part:



D = 2(x-tanθy)   Not very impressive is it?

Other versions are:

X = (D/2)+ tanθy and y =((D/2) – X)/- tanθ

Not pretty either, but it saves wood!

Examples:

Let’s say I have a 1/2”, 7 degree bit. What depth do I need to cut for a symmetrical dovetail using a 7/8” spacing?

Y = ((.875/2)-.5)/-tan7 = (.4375-.5)/-.12278… = .509” That’s reasonable.

Even simpler, my case, I have 1” spacing. Far a ½” deep route what size bit do I need for a 14 degree dovetail?

X = (1/2)+tan14*.5 = 5/8”   Great! A readily available bit size.

What if that were a 7 degree bit, what depth would I have to cut to correct the tail width?

Y = ((1/2)-.625)/-tan7 = 1.01” deep.   Good luck finding that bit.

Obviously, unreasonable numbers can result and force alternative combinations. As evidenced from the last calculation you can see that halving the angle required doubling the depth to maintain symmetry.

After playing with different combinations of bit size, angle and spacing it becomes obvious that there's a periodic nature to the results as shown in the table below. But having the equations to play with is a comfort to us left-brained types.

Symmetrical Dovetail Calculations

			3/8"	1/2"	9/16"	5/8"	3/4"	7/8"	1"	1-1/8"	1-1/4"	1-5/16"	1-3/8"
Width	Angle	Spacing->	0.375	0.5	0.563	0.625	0.75	0.875	1	1.125	1.25	1.313	1.375
0.25	14	Depth	0.251										
0.375	14			0.501	0.376	0.251							
0.50	14						0.501						
0.5625	14							0.501	0.251				
0.625	14							0.752	0.501	0.251			
0.75	14								1.003	0.752	0.501	0.376	0.251
0.25	7		0.509										
0.375	7					0.509							
0.5	7							0.509					
0.5625	7								0.509				
0.625	7									0.509			
0.75	7										1.018	0.764	0.509