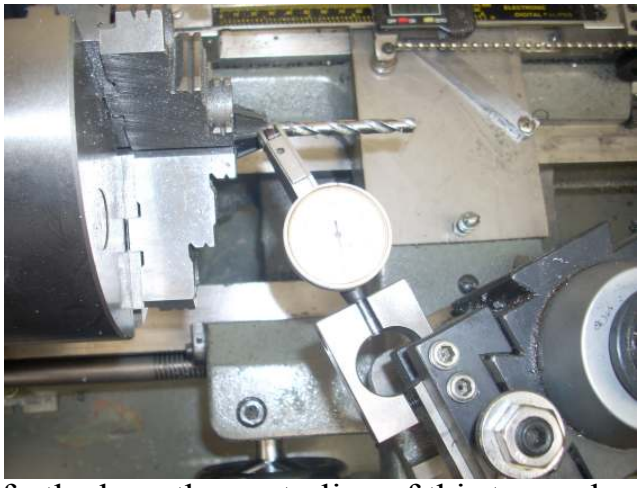
Using a Taper to set the Compound on a Lathe, Version 3

By R. G. Sparber



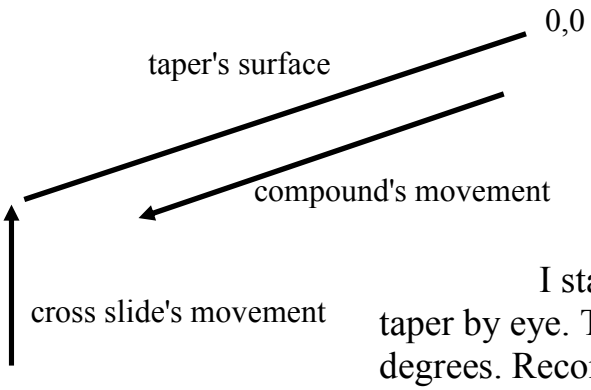
You are looking down on a lathe set up. On the left is my 3 jaw chuck. Held in the chuck is a drill being used as a mandrel. On the drill shank is a Jacobs Flex collet. Contacting the Flex collet is my Dial Test Indicator (DTI) which is clamped to a support that is fixed to my Quick Change Tool Post.

Only now can I explain what I'm doing. I'm running my DTI back and forth along the centerline of this tapered surface while adjusting the angle of my compound. My goal is to be able to move the DTI across this surface and have its needle not move. When this occurs, I have set my compound to the same angle as the taper. It will then be possible to cut this taper on stock held in the chuck.

I really hate doing tapers because it is so frustrating to repeat the "measure-adjust-measure" cycle until finally the DTI reads zero-zero. There has to be a better way. Well, I think I found it. Most likely this technique can be found in some old Shop Tricks book, but I've never seen it.

[1] You are free to copy and distribute this document but not change it.

My goal is to be able to read how many degrees I must rotate my compound in order to get the right taper. I will use my DTI as a means of reading a consistent touchdown point. This is really the best way to use a DTI anyway. It is only truly accurate when telling you that you are back to a preset point.



I start by aligning the compound to the taper by eye. This should get me within a few degrees. Record the angle shown on the collar of the compound**.**

Then I feed in on the compound and the cross slide until I read 0 on the DTI at the 0,0 point shown above. All subsequent readings of the dials are done by feeding in so as to avoid backlash error on the lead screws.

The cross slide is now backed out enough that the DTI does not hit the taper at the far end. I then feed in the compound and record the distance from 0.

Then plug these values into this nasty looking formula:

$$correction\ angle = \mathbf{sin^{-1}}\left\{\frac{cross\ slide\ distance}{compound\ distance}\ \mathbf{cos}(90° - compound\ angle)\right\}$$

Note that there is an arcsine (**sin**$^{-1}$) and a cosine (**cos**) operator in there. Some calculators give you a choice of angles in degrees or radians. Choose degrees.

Let’s try this out.

First I set my DTI, cross slide dial, and compound dial to zero at my 0,0 point. I back out my cross slide to prevent the taper from hitting the DTI finger.

I then move my compound 0.400".

I note that my compound angle is around 69°.

Next I feed in the cross slide until the DTI again reads zero. The cross feed dial tells me I am 0.010" in front of my zero point.

I calculated the correction angle using my nasty looking equation.

1. Subtract the compound angle from 90°. [90° - 69° = 21°]
2. Take the cosine of this value being careful to have my calculator set to degrees and not radians. [cosine of 21° = 0.934]
3. Multiply the result by the cross slide distance. [0.934 x 10 = 9.34]
4. Divide by the compound’s distance. [9.34/400 = 0.0234]
5. Take the arcsine of the result. [1.3°]
6. I now have the correction angle.

This tells me that my compound is 1.3º from the desired taper.

I back the DTI away from the taper, note the angle on the compound's collar, and unclamp the compound. Then I move the compound such that the DTI's finger moves closer to the taper. I stop turning when I have moved the number of degrees calculated. In my case I moved from around 69° to around 70°. Note that this is the compound angle and not the taper angle.

If the compound fed in past the zero point, then I would have needed to rotate the compound in the opposite direction.

I run the taper check again and find my cross slide moved 0.001" when the compound was fed in 0.400". This is an error of 0.15º. That is close enough for me to use the old measure-adjust-measure procedure.

I feed in the cross slide so the DTI showed the 0.001" rise. Then I unclamped the compound and gently tap the compound to rotate it until the DTI read zero.

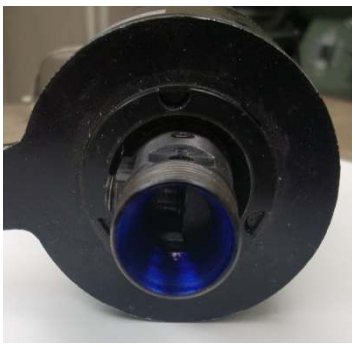
Reapplying the compound clamps did move me a little but the error was less than 0.0005".

Be careful when tapping the compound because there is backlash in the cross slide. You want the tapping to rotate the compound and not move the apron.

My educated guess is that the true taper angle is 20° (which equals 90° minus the compound angle of 70°).

Evaluation

So how good is this process? The best way I know to test it is by making a sample taper and fitting it to a known female taper with Hi-Spot® ink.



Here is the female taper that will receive the taper I will make. The inside surface has been lightly coated with Hi-Spot ink and will remain wet for a long time.

I then took a piece of scrap aluminum and turned a taper. I then pressed it into the female taper and Hi-Spot ink transferred. Be careful to just press it in and not turn it as that can smear the ink.

The goal is to have the taper evenly coated with ink. In my case, the surface finish was not that good so I had to run a file over it.

EdwinB suggests the following if you must file on a lathe:

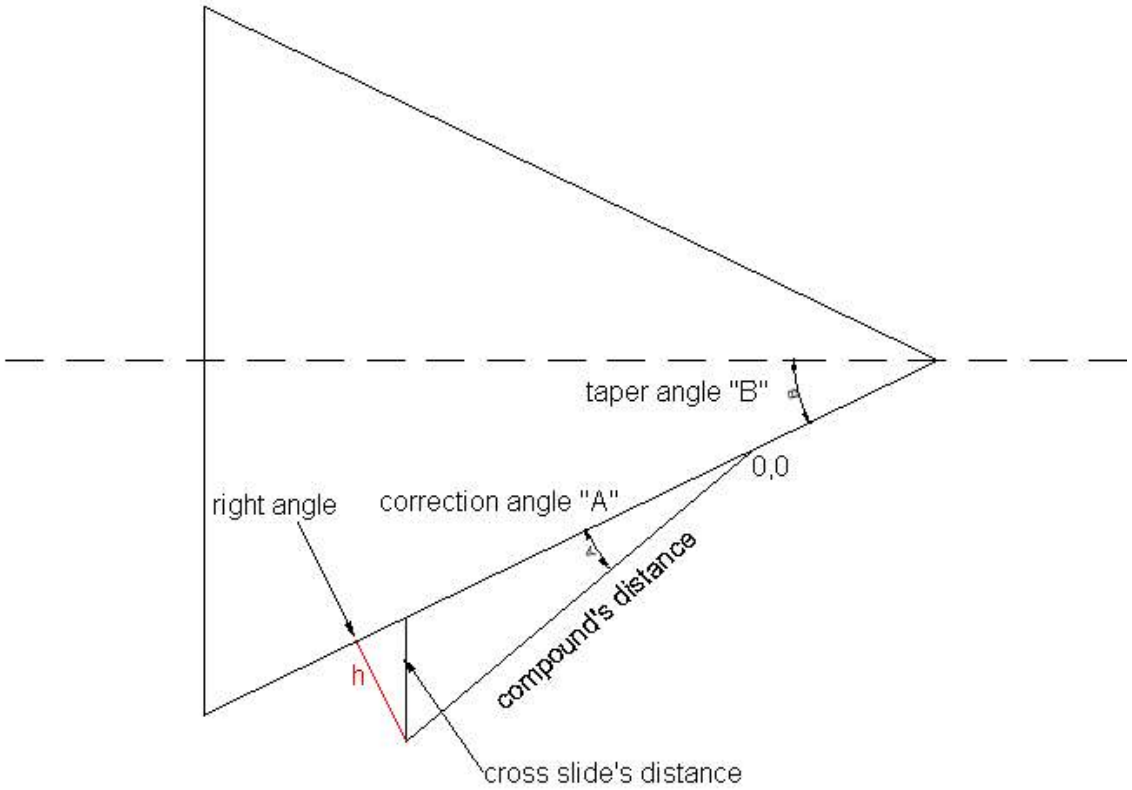
"The recommended technique is to pass the file under the work with the tang of the file passing between two fingers on the right hand. Fingers on the left hand press up on the bottom of the file (the left thumb does not touch the file).

If the file catches on the chuck, it will be forced away from your body, your right hand will be pushed away from the chuck, and your left hand should be pushed down (away from the chuck) and since you aren't grabbing the file, the left hand should not be drawn toward the chuck.

This technique does require that the operator reach over the work with his/her right hand, so he/she should ensure they have no jewelry or loose-fitting clothing (which is SOP when working around a lathe anyway).”

Before closing, I will explain the equation.

For the Math Geeks



Our goal is to adjust the compound's angle to match the taper angle. I have a fairly good idea what the taper's angle, B, is because I have adjusted the compound by eye to get close. The estimated taper angle equals 90° minus the compound angle.

For now, assume that I know the angle exactly. I also know how far I moved my compound and my cross slide. The compound's movement is the hypotenuse of a right triangle. But the cross slide's movement is not exactly the rise of this right triangle. What I really need is distance "h" shown in red. But note that the right triangle formed by h and the cross slide distance is *similar* to the triangle formed by our taper. This means that the angle of our little triangle equals our taper angle. I can then write:

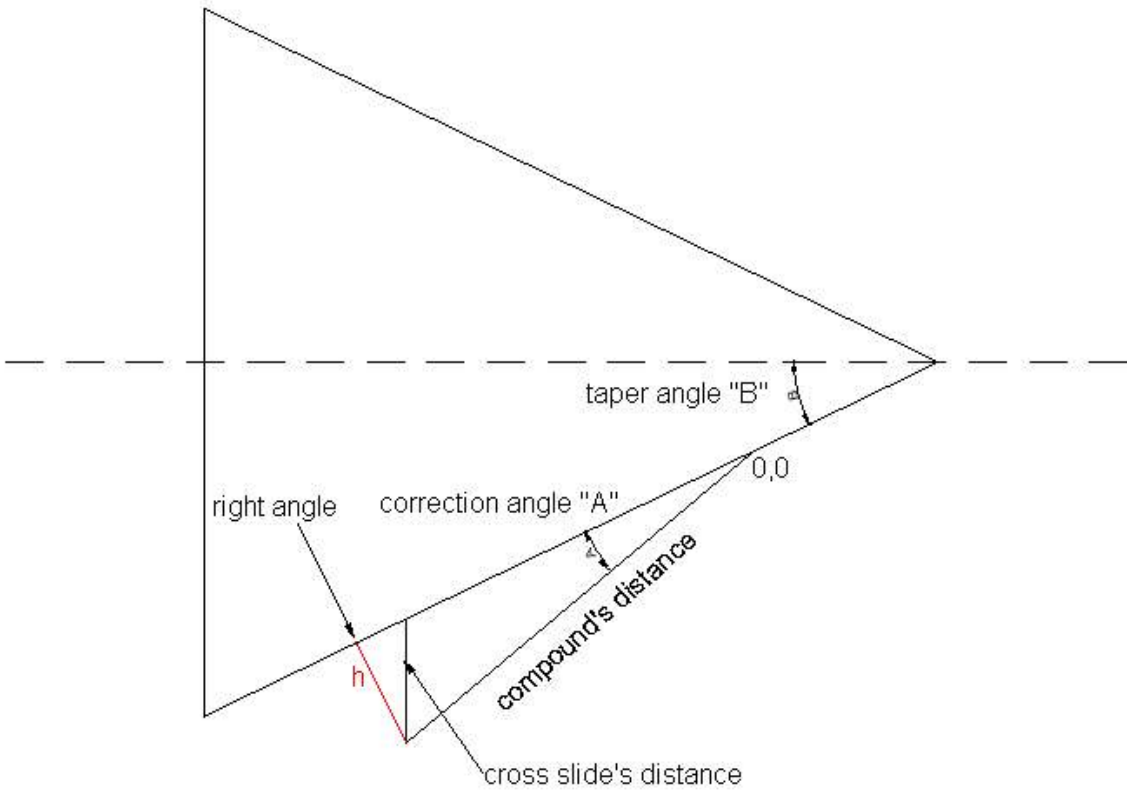
$$\frac{h}{S} = \cos B$$

Where:

h is the rise of our right triangle
S is the cross slide's distance
B is the taper angle

Solving for h to get

$$h = S \times \cos B$$



With h in hand, I can find my correction angle by noting that

$$A = \sin^{-1}\frac{h}{C}$$

Substituting in my equation for h gives

$$A = \sin^{-1}\left(\frac{S \times \cos B}{C}\right)$$

which can be written as

$$A = \sin^{-1}\left(\frac{S}{C}\cos B\right)$$

Where:

A is the amount you must move the compound to match the taper
S is the distance moved on the cross Slide

C is the distance moved on the Compound
B is the estimated taper angle which equals 90° minus the compound angle.

The reason for this odd correction in angle is due to how compounds are marked. They are showing what is called the compliment of the angle I define as my taper angle. This is a right triangle so one angle is 90° and the sum of all three angles in any triangle must equal 180°. So we end up with

$$180° = 90° + \text{the compound angle} + \text{the taper angle}$$

which can be rearranged to say

$$\text{the taper angle} = 90° - \text{the compound angle}$$

I did pull a fast one on you here. I assumed I knew the taper angle when in fact I only know it approximately.

It turns out that is OK because even moderate error in the taper angle estimate has a small effect on our answers. If I assume that I can know the taper angle within ±5°, my correction angle varies by no more than 0.1° independent of the taper angle.

Acknowledgements

Thanks to the following: Malcolm of the gingery_machines yahoo group for finding an algebra error; Pierre of this same group for finding a serious typo; toolmaker48 of the atlas_craftsman yahoo group for various insights; and to EdwinB also of the atlas_craftsman yahoo group for his advice on using a file on a lathe.

I welcome your comments and questions. All of us are smarter than any one of us.

Rick Sparber
Rgsparber@aol.com