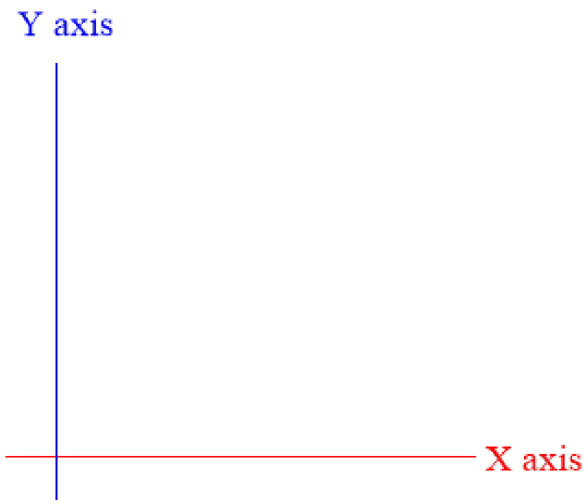
Aligning A Vise on a Mill, Version 1.1

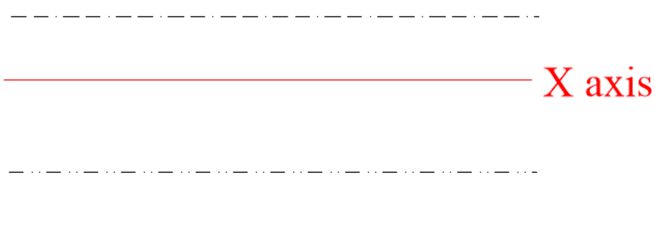
By R. G. Sparber

Here is a video that sums up what I will discuss.

At its essence, the vertical mill is a dead-simple device.

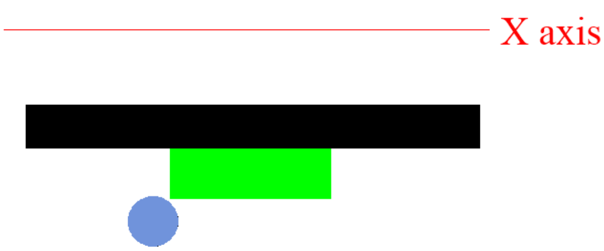


Looking down on the table, I have an X and Y-axis. By moving the table along one of these axes, the cutter will cut a straight line.

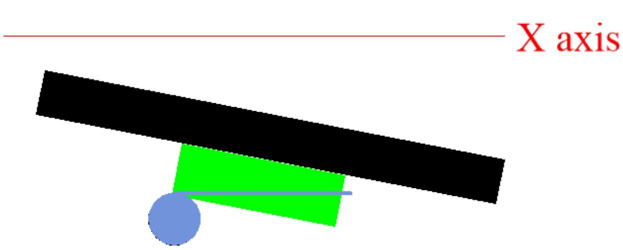


Thinking only about the X-axis, notice that it is an orientation, not a single line. Any path parallel to the X-axis is in alignment.

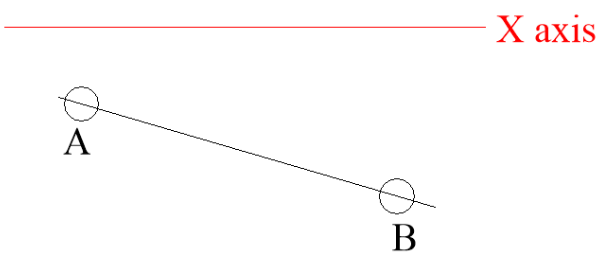
Have I put you to sleep yet?



The black rectangle is the fixed jaw on my ideal vise. Clamped to it is a piece of stock. The circle is my end mill. As the end mill moves across the face of the stock, it will cut a face that is parallel to the X-axis.

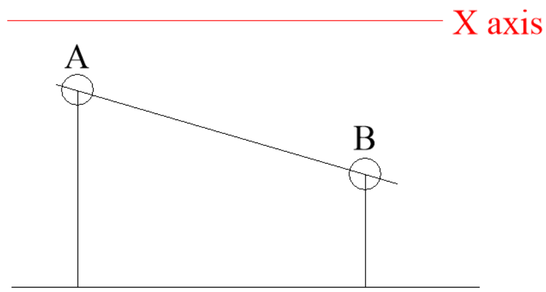


If the vise is out of alignment, the cutter will still follow the X-axis but the stock will be cut into a taper.

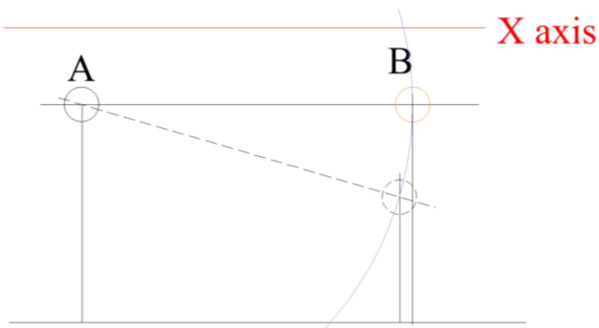


So how do we align the vise?

I can think of the face of the fixed jaw as a line. A line can be completely defined by two points, A and B.

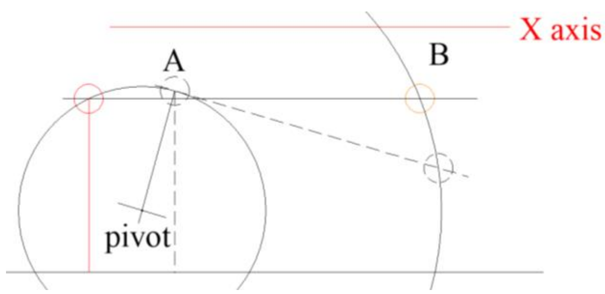


I can draw a line parallel to the X-axis and measure the distance to my two points.

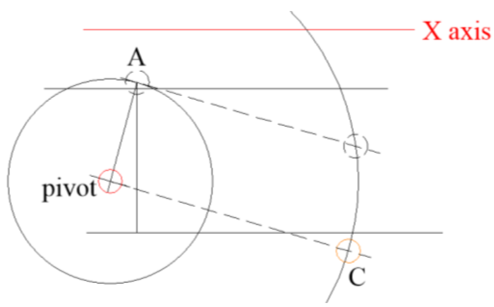


When these distances are equal, I know my vise jaw is in alignment.

Notice that I have fixed point A as a pivot. This enables me to focus on B as I rotate the vise. When the distance recorded from my line to A is the same as the distance to B, I'm done.



If I chose a pivot point, not on my vise jaw, the distance from it to my reference line would change as I rotated the vise. Compare the dashed vertical line to the red vertical line. This means I must move back and forth between A and B to know when they were equal. This is a royal PITA.

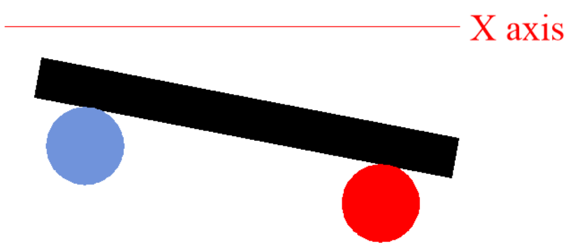


What if I tracked a new point, call it C that has the same offset? Ah, C is on a line that passes through my new pivot point so I'm back to my original configuration. I can measure my new pivot point distance and then only focus on point C.

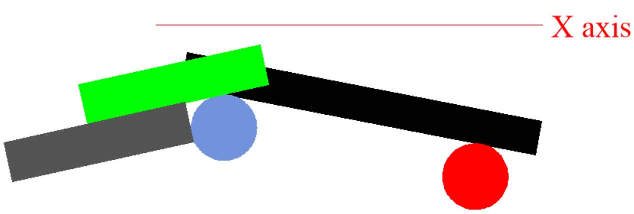
I realize this seems less than earth-shaking, but you will soon see its value.

It is time to return to my misaligned vise. We now understand that the easiest way to align the vise jaw is by first picking a pivot point on its face. Then rotate the vise until a second point, on its face, is at the same distance. Easier said than done. I have no such pivot point.

If I can't solve the problem, change the problem.

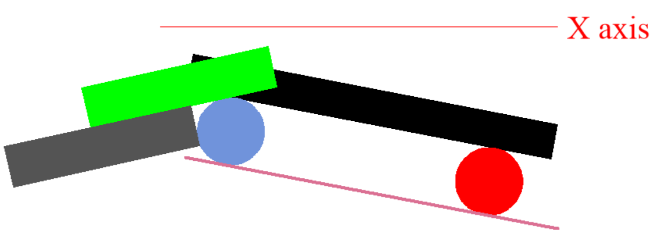


What if I clamped two rods, of the same diameter, to the face of the vise? My blue circle will be my pivot point.



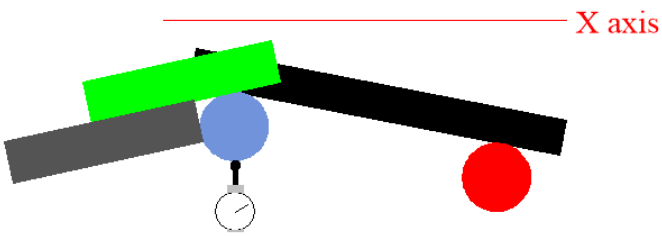
I can erect a bar (green) that hangs over the vise. It is tangent to the blue circle. Then I can clamp a block (gray) to this bar that also touches the blue circle. The angle of the green and gray bars doesn't matter.

These bars will constrain the movement of the blue circle so it can only rotate as long as they all stay in contact.

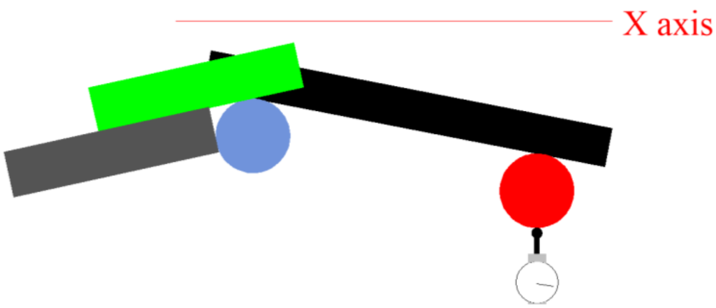


I can draw a line, tangent to my blue and red circles. When this line is parallel to the X-axis, my vise jaw must also be in alignment.

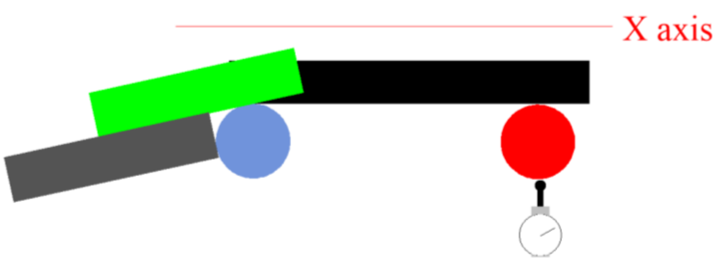
But accuracy depends on measuring right at the point where my tangent line contacts the circles. Isn't that hard to do? Nope.



I secure a finger Dial Test Indicator (DTI) to my spindle so it touches the pivot rod. Then I move the table along the X-axis and watch the needle rise and fall as it passes the rod's centerline. I record this value.



Then I move over to the red circle and stop at the point of maximum deflection.

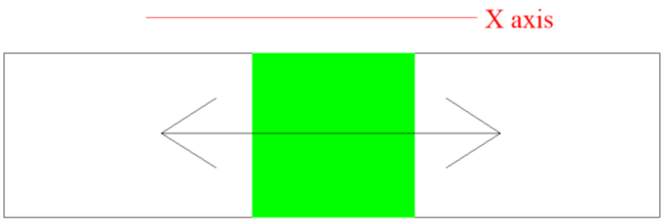


I gently pivot the vise while keeping the blue pivot bar touching my green and gray bars and stop when the DTI reads the recorded value. I then move the DTI back and forth along the X-axis over the red bar to verify I'm still at the maximum deflection since the pivoting does cause some X-axis movement of the rod relative to the spindle. The vise's fixed jaw is now parallel to the X-axis.

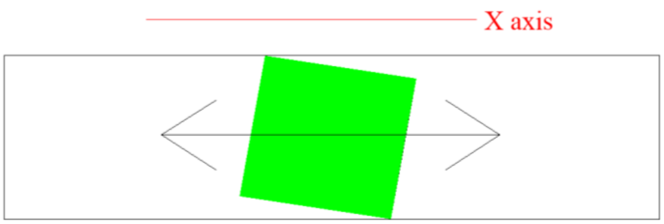
Confused? Maybe a second look at the video will help.

Unfortunately, reality creeps in to spoil the fun.

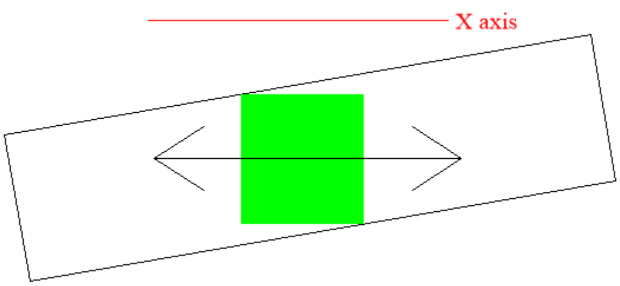
Ideally, my mill table moves along the X-axis. Therefore, if the vise is aligned to the X-axis, it will also move along this axis.



The table slides on ways, represented by the green square and the top and bottom lines of the black rectangle. If all surfaces are perfectly straight and parallel, the ways can be adjusted via a gib for perfect movement.

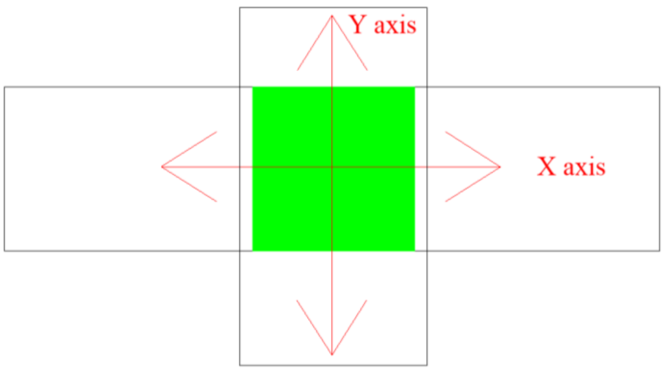


In reality, nothing is straight or parallel. If I tried to tighten the gib too much, it will bind up and the table will lock. Typically, this will happen at one or more points in the table's travel. The only solution is to back off on the gib and permit more play.



With a looser fit, the table is free to pivot.

Consider what this does to our perfectly aligned vise. You run through the procedure and attain a difference in DTI readings of less than 0.0005 inches. After tightening the hold-down bolts, you check your work and discover it is out by 0.002 inches. Crap! Yes, you can go back and do the alignment again and again, but it won't help. The problem is in the ways.



But wait, there is more to this depressing story. We also have the Y-axis. It has the same limitations with its ways and gib. The result is that the table will acquire play from both ways.

Now, before you go looking for a bridge to jump off of, consider what this means. First, we must adjust our X and Y gibs to minimize play without binding[2]. Then have confidence in the alignment procedure. Align the vise as close to perfect as possible. Then grab the table and turn it clockwise. Measure your vise alignment. Then turn the table counterclockwise and measure your vise alignment. This variation is the tolerance in your alignment.

For example, say I align my vise to zero-zero using my DTI that can resolve to better than 0.0001 inches. Then I twist my table clockwise and read an error of 0.001 inches. After twisting the table counterclockwise and I read – 0.002 inches. This is a swing of 0.003 inches.

But let's put this in context. This means that we can be out of square by as much as 0.003 inches over the distance between rods. In my case, 3 inches. The error is therefore 0.001 inches per inch or ± 0.0005 inches per inch. Maybe I won't jump.

Partway through this discovery process, I seriously considered junking my 35-year-old Enco copy of a new Kurt vise. I'm sure glad I didn't because it would not have made any difference. For significantly better accuracy, I would need to buy a better mill. Not likely.

I welcome your comments and questions.

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[2] To figure out which gib is the problem, put the DTI on the table referenced to the end of the apron. Then twist the table and record the change in readings. This play is due to the X gib. Repete with the DTI on the base referenced to the end of the apron. You are now reading the Y gib play.