# Total Indicated Runout, Version 2

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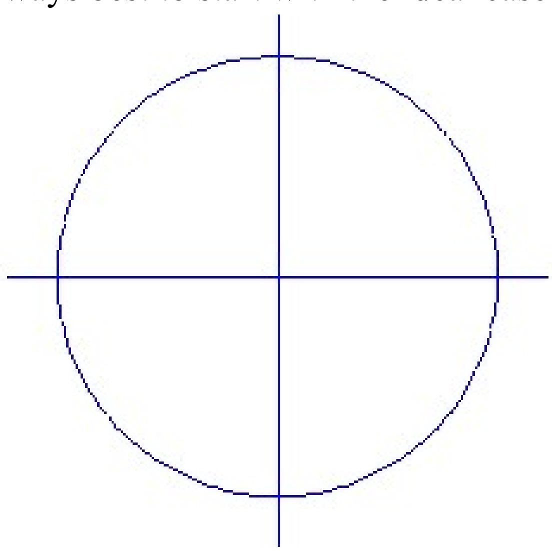
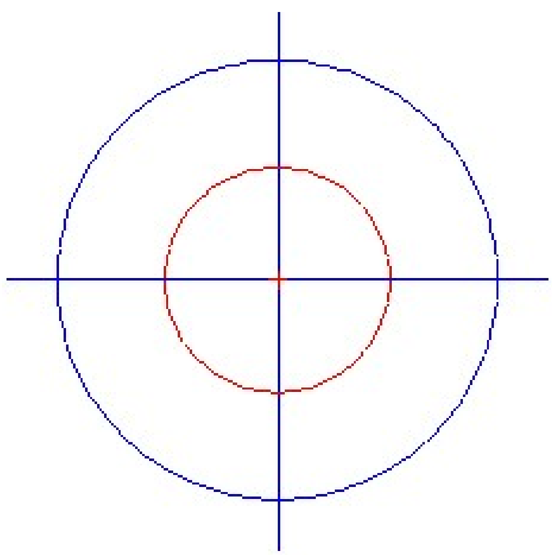
Maybe I'm just looking in the wrong place, but a quick search of the web did not turn up a clear explanation of Total Indicated Runout. I did learn that it is also called Total Indicator Runout. This article attempts to explain what TIR is and how it can effect things.

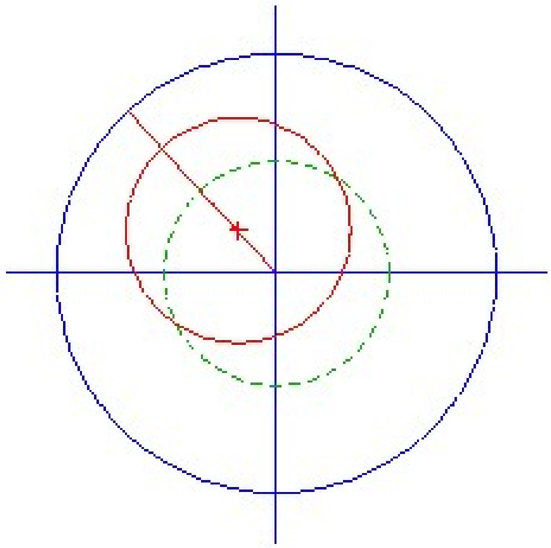
It is always best to start with the ideal case and then see how things go wrong.



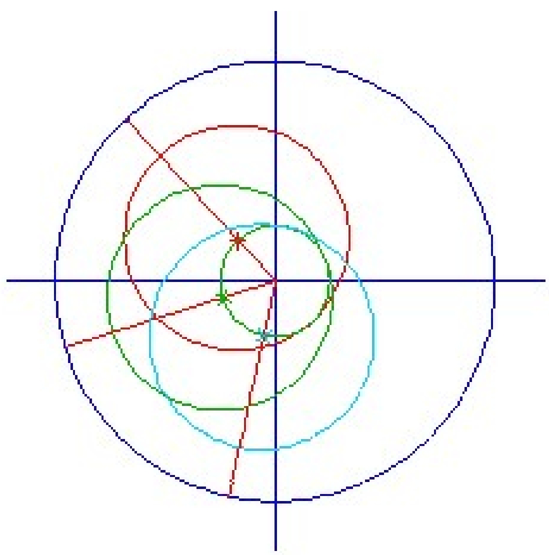
Here I have a circle centered on two perpendicular lines. If the circle rotated around the intersection of these lines, it would appear to not move. Not very exciting…



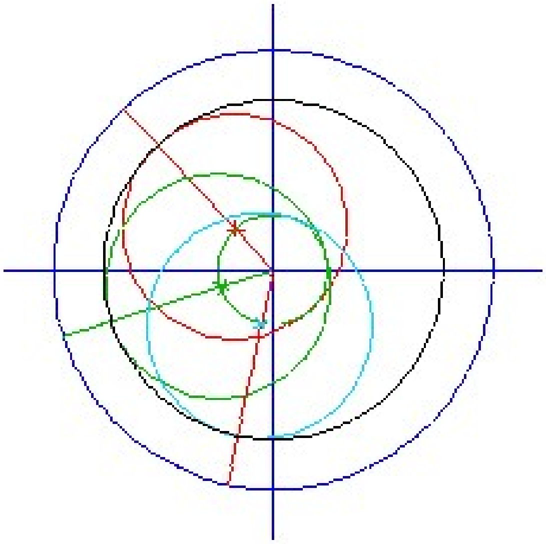
I have now added a second circle in red that shares its center with the larger blue circle. Say that the red circle is resting on the surface of the blue circle. As I turn the blue circle, the red circle will ride along. Since both circles share the same center point, the red circle will appear to not move as we turn it.



Look what happens if the red circle's center is not aligned with the center of the blue circle. The dashed green circle is its previous, ideal location and the red circle is the new location. The center of the red circle is marked with a red X. I can always draw a line from the center of the blue circle, through the center of the red circle, and out to the blue circle. This line will always be a radius.



Here is where it gets a bit messy. As I turn the blue circle with the red circle resting on it, note how the red circle turns. The original location of the red circle is shown with its red center point. Below it is this same circle but with the blue circle turned a bit counterclockwise. I changed the color to green. Below it is again the same circle but move a little further and in turquoise. As I turn the blue circle, the center of the red circle traces out a small circle shown in green. This green circle goes to zero diameter when the red circle's center is aligned with the center of the blue circle.



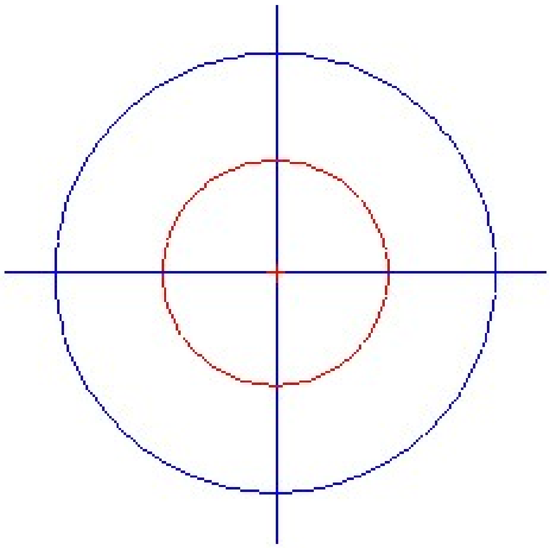
Time for a diversion to the practical. Say the blue line represents the spindle of a vertical mill as viewed by looking up. The red circle represents and end mill. A *really* bad collet holds the end mill so it turns way off center.

Note that as the spindle turns, the outer side of the end mill will define a circle shown in black. This black circle is the "effective diameter". See my web site for an article on this subject and how to directly measure it. I find it interesting that this outer part of the end mill does all of the cutting.

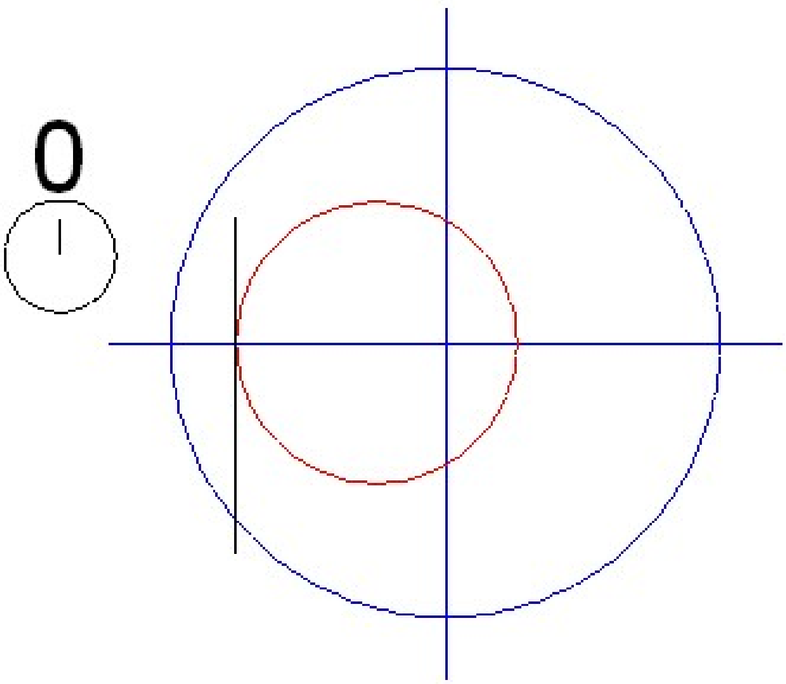
Another example is when you try to use a drill bit with a point off center. You will get a hole that is larger than what is stamped into the bit. Normally this is not good. In a few desperate cases, it might be just what you wanted.

A case where this offset is a good thing is when you are trying to tap an oversized hole. By flanking the tap with a length of hardwood or brass, you will force the tap off center and it will cut a larger than standard diameter.

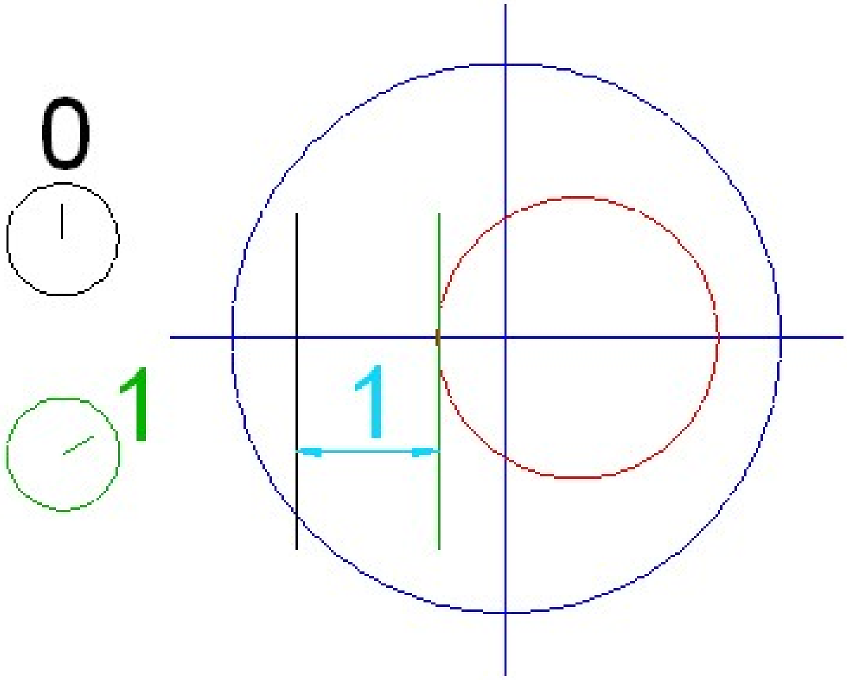

OK, back to theory. How do we measure how far off the red circle's center is from the blue circle's center? A common method is to use a Dial Test Indicator. A DTI is great at telling you when one spot is at the same position as another spot. See my web site for more information about DTIs.



If you placed a DTI on the red circle in the ideal case, the reading would be constant as the circle turned. When I get this result in my less than ideal world, it usually means the DTI is broken, hitting a stop, or not touching the circle.




Anyway, say the red circle is not centered. I can rotate the blue circle until the DTI reads a maximum. This must be the point where the center of the blue circle is on the same line as the center of the red circle. Say I set the DTI to read 0.

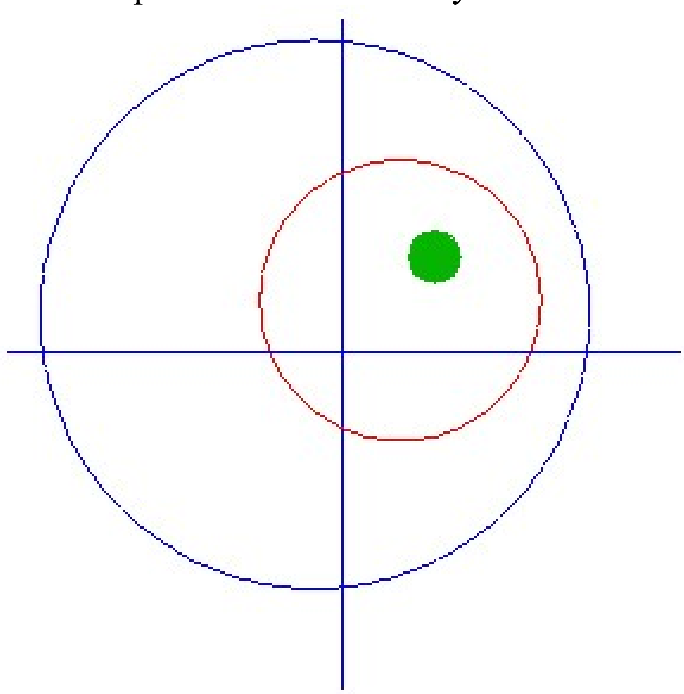



Now rotate the blue circle 180 degrees. The red circle will again have its center on the same line as the blue circle's center and the DTI's spot. The DTI will now read a minimum.

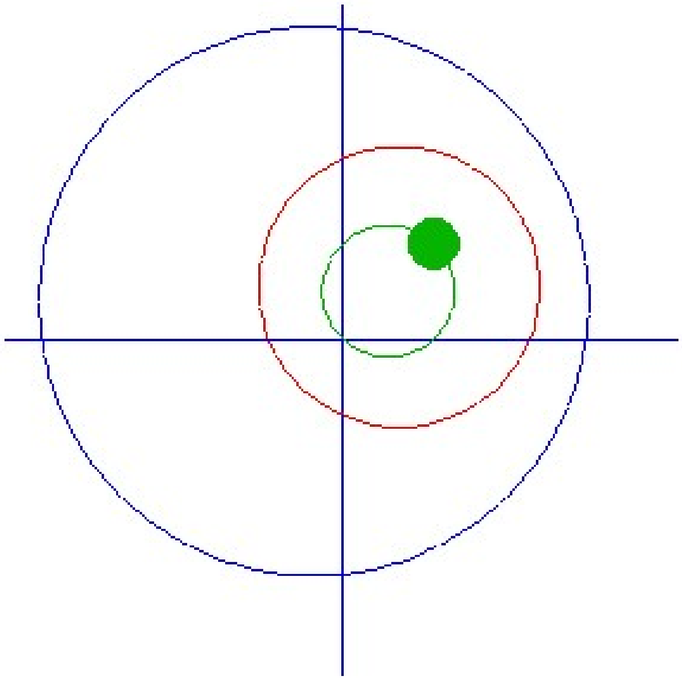
When we subtract the maximum DTI reading from the minimum DTI reading and take the absolute value, the result is our Total Indicated Runout.

The center of the blue circle is often the center of rotation as in the example with the end mill and its "effective diameter". In some cases, the red circle may have its own TIR. This can be the case for an Electronic Edge Finder.

An EEF has an outer body and a pin at the end. Ideally the pin and body are in perfect alignment. In practice, there will be a measurable TIR of the pin with respect to the EEF's body.



We then end up with a situation like this one. The blue circle is the spindle and its center is not on the center of rotation. The red circle is the body of the EEF. The green dot is the end of the EEF's pin. Nothing is lined up with the center of rotation. This case is not all bad because it enables us to reduce the total TIR.



As I rotate the body of the EEF represented by the red circle, the pin will trace out the path marked by the green circle. Note that there is a point on the green circle that lines up with the center of rotation. By turning the body of the EEF we can place its pin's center at the center of rotation and achieve zero TIR. We would then have a misaligned spindle holding a misaligned EEF with its pin perfectly aligned. I guess you could say that in this instance, two wrongs do make a right.

This technique can also be found on optical centering scopes and laser centering instruments. See my web site for the article "Tune In for Better Electronic Edge Finder Accuracy" which shows only the practical side of this procedure with no theory.

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

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