Measuring Lathe Centre Height

Every user of a lathe should know the centre height of the spindle. That is such an obvious fact that it doesn't need to be mentioned. Consequently it was never mentioned to me. As a result, I have owned quite a number of lathes over the years without ever knowing the actual centre height of the spindle. Approximate setting methods such as holding a shim between cutter and workpiece have sufficed. However, accurate knowledge of the centre height is also required for mounting critical boring work on the cross slide. It is only since I have taken a closer interest in the errors associated with machining, that the importance of having truly accurate settings has become clearer to me.

In determining the centre height, an initial approach is to mount a suitable piece of material in the chuck and face it off. Using a vernier height gauge, a line is then scribed across the face as near to centre height as can be judged. Next, the chuck is rotated by 180 degrees and a second line scribed parallel to the first with the height gauge at the same setting. Since each line is offset from the true centre by the same amount, the gap between the two lines is twice the value of the adjustment required on the height gauge. This approach is illustrated in Figure 1 where "h" denotes the amount of offset.

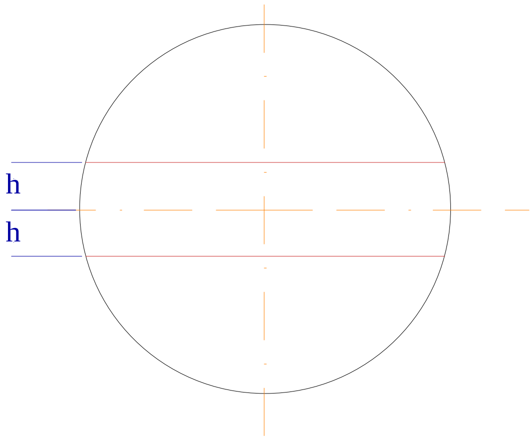

Figure 1. Using a pair of parallel scribed lines to determine the required height correction.

The operation sounds straightforward, but in the absence of some form of spindle indexing, it is extremely difficult to obtain absolute parallelism between the two lines. The situation is illustrated in an exaggerated way in Figure 2. On one side, the gap between the lines is slightly greater than it should be, while on the opposite side it is slightly smaller. The nominal separation should be 2h, as seen in figure 1, so on one side it can be regarded as actually being (2h + x) where x represents the error due to the lines not being parallel. On the opposite side it seems reasonable to expect the gap to be (2h - x). This observation provides a way forward. If the gap on each side is measured, the values obtained can be added giving (2h + x + 2h - x) = 4h. Now all that is required is to divide this figure by 4 to determine the adjustment required.

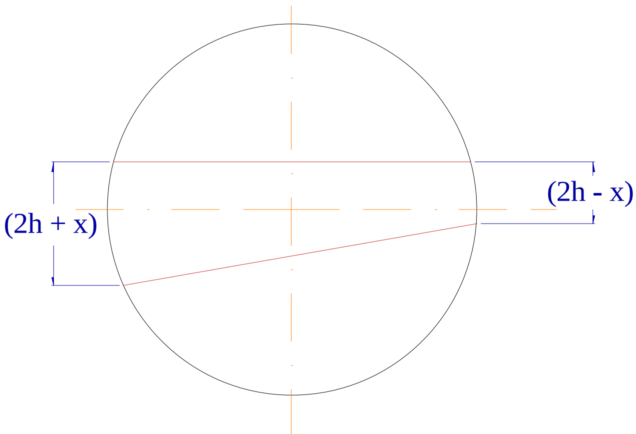

Figure 2. The effect of a failure to achieve perfect parallelism.

The approach suffers from the disadvantage that the gap between the lines has to be measured at each side. However, it appears that the amount by which the gap is smaller on one side is compensated by the increase in gap on the opposite side. If that is the case, it makes sense to arrange for the gap at the narrow side to be zero, causing the gap at the wide side to be equal to 4h. Then a single gap measurement will be sufficient and the result will be divided by 4 to determine the correction required for the height gauge reading.

The complete procedure requires a line A-B to be scribed across the workface, leaving the height gauge at the finish point B. The chuck is then rotated until the original start of the line A-B is coincident with the height gauge.

In this position, the first scribed line is lying at a slight angle to the horizontal as a result of the offset from the true centre. The second line A-C is then scribed in the opposite direction. Finally the gap G is measured and the adjustment calculated.

Setting to work, I faced off a suitable piece of metal. With the height gauge at the approximate centre height and the reading carefully noted, the two lines were duly scribed. The height gauge was then adjusted until it coincided with the final position of point B. Once more the reading was noted and the value of G determined. The adjustment was calculated and the height gauge reset accordingly. With the height gauge at the new setting, I repeated the exercise to confirm the accuracy of the result. It was a disappointment to discover that there was still a visible gap between the pair of lines, albeit much smaller than the first one. I could not understand what I had done wrong, but measured the gap as before and made a further correction. Carrying out the procedure once more, it was still evident that the scribed lines were not quite coincident, but the gap was too small to be measured. Reluctantly I accepted that I had reached the limit of my ability for the operation.

Subsequently I sketched a diagram of the procedure. It became obvious that the method itself was slightly flawed and the result obtained was an approximation. I wondered if this could explain my failure to obtain the correct adjustment at the first attempt. The situation is illustrated in figure 3.

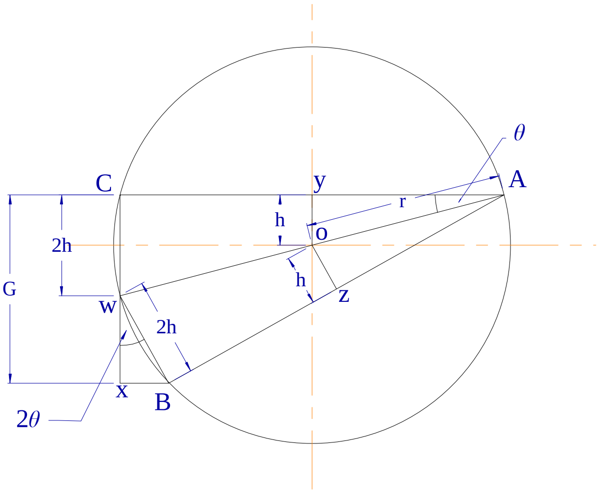

Figure 3. The vertical difference in height, G,
measured by the vernier is less than 4h.

The problem arises because the vertical offsets of the pair of lines A-B and A-C are not collinear. Consequently, reducing the vertical gap at one side does *not* produce an equal increase in the vertical gap at the opposite side. The actual value of G, is slightly less than 4h. Having recognised that the method was approximate, the next step was to determine how good the approximation would be in practice.

In Figure 3, the lines A-B and A-C represent the scribed lines. The line Aow represents the true diameter through A. The geometry shows that the gap is:-

$$G = 2h + 2h\cos(2\theta)$$

This can be simplified by means of trig identities to:

$$G = 2h + 2h\left[1 - 2\sin^2(\theta)\right]$$

Which becomes:

$$G = 4h\left[1 - \sin^2(\theta)\right]$$

From Figure 3, it can be seen that:

$$\sin(\theta) = \frac{h}{r}$$

So the value of G is given by:

$$G = 4h\left[1 - \frac{h^2}{r^2}\right]$$

Consequently the measured value of G is smaller than it should be by an amount:

$$\delta = \frac{4h^3}{r^2}$$

Assuming a radius of 1” and an initial offset of 0.020”, the actual height G works out to be 0.07997” instead of 0.080”. The difference is negligible showing that the approximation is an excellent one. Furthermore, the approximation improves as the offset is reduced. I had no excuse, and the problem I had encountered was undoubtedly due to my sloppy workmanship. On the other hand, trying to track down sources of error with a view to eliminating them appeals to me as one of the most interesting aspects of recreational engineering. Not only do I now understand the method, I have also satisfied myself that it is one in which I can have complete confidence. The technique can be applied to determine the height of any rotating spindle above a datum.

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