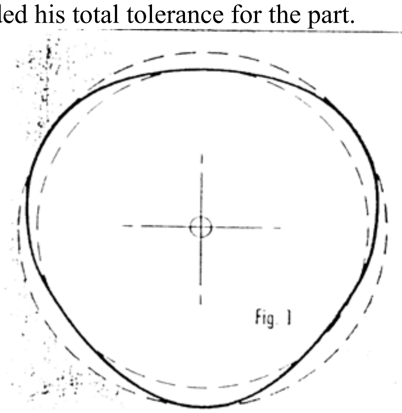
THE SHAPE OF THINGS TO COME

What do you do when you're doing everything right and it's still coming out all wrong? We had a case like this not too long ago, where a shop was making a spindle and bore assembly for a high precision application. The owner complained that while he was machining well within his specified -.0002 tolerance on the shaft, his parts were either causing excessive bearing loads, or worse, not fitting in the bores at all. "How can they be wrong," he said, "when everything measures right?"

What this fellow didn't realize was that there are more things which can go wrong with a part than dimension. Just as we cannot make parts perfectly to size, neither can we make them perfectly round or perfectly smooth. And, as we all move towards tighter and tighter tolerance machining, irregularities in shape and finish will have a greater and greater affect on our ability to make parts. This means we're all going to have to understand more about geometry and surface finish.

In the example above, analysis in our lab showed a consistent three-lobed out-of-round condition on the spindles which was making their effective diameters too large. Three-lobed out-of-round is very common when using centerless grinding, but it wasn't noticed in this case because: 1) the specs didn't call for any geometric analysis on the parts; and 2) the shop was only using a two-point dimensional gage which was incapable of detecting the problem.

Figure 1 illustrates the relationship between out-of-roundness and effective diameter on a three-lobed part. As you can see, any two-point measurement will yield a consistent diameter, because each lobe is geometrically opposed by a flat area. This measured dimension would fall somewhere between the inner and outer dotted circles. However, the <u>effective</u> diameter, or the amount of space this part would actually require to clear, would be the outer dotted circle, which encompasses all the lobes. In this case, because the tolerance was so tight to begin with, the increase in effective diameter caused by the roundness problem exceeded his total tolerance for the part.



So did that mean he had to invest in a lot of fancy lab equipment, or buy a new centerless grinder? Fortunately not. As noted, out-of-round conditions with an odd number of lobes are common with centerless grinding (the greater the number of lobes, the more closely you approach true round), and once understood, are easily compensated for. In this case, a simple V-block fixture was set up with the blocks at 60° to measure the effective diameter, and the grinder set accordingly. Without going through the math involved, other odd-lobed out-of-round conditions can be similarly detected, using V-block fixtures set at other angles (108° for five lobes; 138_ 40' for seven lobes; and so on).

Unfortunately, in this case (but not for this column!) out-of-roundness was not the only problem. There was also a problem with surface finish which, while specified, was not really being measured. The specs called for an average roughness (R_a) of no more than 4 µin., but when measured, the parts showed an R_a of between 15 µin. and 25 µin. Since the affect of roughness on overall tolerance is a factor of at least 8, and sometimes as much as 20 (see Fig. 2), the 25 µin. of roughness took up the entire .0002" tolerance range on these parts!

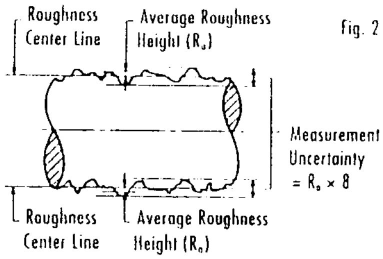


fig. 2

Again, the solution was not costly equipment -- surface finish gages are readily and economically available for shop floor use -- but an awareness of the problem and an understanding of the basic causes. A simple redressing of the wheel solved the problem here, and allowed our shopowner to resume his normal sleeping pattern at night.

But the lesson is an important one. A recent report by the National Center for the Manufacturing Sciences showed that machining tolerances have decreased by a factor of five within the last decade, and that even tighter tolerances are on the horizon. This means that things like geometry and surface finish are going to play an increasingly important role in machining operations. And we need to understand that role, if we are to continue to produce good parts. That's the shape of things to come.