AIR RINGS, CMMS AND SUPERMIKES

George Schuetz, Mahr Federal Inc.

A major aerospace customer complained that the air-ring gage we sold him was inaccurate. How did he know? I asked. Because, he said, he checked the measurements against a coordinate measuring machine and a super-micrometer he had in the shop. The CMM and the super-mike agreed with one another closely, while measurements on the air gage differed from them by as much as .0004", ergo...

"Send me a few samples," I told him "and we'll check them in our lab, where results are good to one millionth. Then we'll know exactly what size they really are, and which gage is at fault."

The lab identified at least part of the problem even before they put them on a gage. "Where are the witness marks?" they wanted to know. "Where, exactly, were these parts measured?"

"What difference does it make?" asked the customer. "They're simple OD cylinders."

In fact, it makes a lot of difference. If a part is slightly out-of-round, then the measuring method you choose will influence your measurement. A CMM, for example, will tend to average out errors of geometry and waveform. A super-mike might give you the min, the max, or somewhere in-between, depending upon precisely where the measurement is made. The performance of an air ring can also vary between min/max and average reading, depending upon the number of jets, the part's geometry and surface finish, and the position of the part in the gage. None of them are necessarily wrong.

In this particular case, all three gages were giving accurate readings, but each one was measuring different dimensions. In the lab, we found that the parts exhibited geometry errors of as much as .0003", in addition to a small amount of waveform error. By measuring at different locations on the parts, the manufacturer sometimes picked up on that variation, and sometimes missed it. Simply by measuring from a consistent datum, we brought the air gage readings to within 50 millionths of the other two gages.

Instead of asking "is it accurate?" we should be asking "is it appropriate?" Most gages are accurate as delivered from the manufacturer, but every gage embraces certain limitations and assumptions. When selecting a gage or a gaging method, it is essential to establish a clear objective: Do you want to account for, or ignore, variation due to geometry, waveform, and surface finish? Do want to know the maximum OD of a part, or the minimum OD, or the average OD?

The answer to these questions depends upon the application. As a hypothetical example, consider a spool valve assembly, in which the bore is a perfect cylinder, and the spool itself has a slight three-lobed condition. The overall (average) diameter of the spool may determine the efficiency of the valve, but its maximum diameter will determine whether the two parts can be assembled or not. It's up to the user to determine which is the critical measurement and then select the measuring tool most appropriate to the task.

Many gages offer a certain degree of flexibility. For example, it may be possible to specify the arrangement of jets in an air ring to automatically give the min/max, or average reading. Likewise, it may be possible to program a CMM to account for geometry factors, but before you can do either, you have to know what you want to measure.

Not surprisingly, this situation is paralleled by the factor of surface finish. Air gages tend to average, or ignore, surface roughness -- up to a point. A super-mike, measuring on the "peaks," will tend to maximize its effect, while a CMM will randomize peaks and valleys, generally giving an average. In the aerospace manufacturer's case, we found that surface finish accounted for the remaining difference in readings between the gages.

If that isn't complicated enough, here are two more factors you might want to consider: 1) The geometry of the gage's sensitive contact and holding fixture may affect measurements. 2) Masters are also machined parts that are subject to the influences of geometry and surface finish.

Why didn't we worry about this stuff before? Because even as recently as 10 years ago, tolerances were generally looser. As tolerances get tighter, variations in part geometry and surface finish exert proportionally more influence on our measurements.