

June 2008

## SPINDLE PROBING BENEFITS STACK UP

**BYLINE:** Cunnings, Moise.

By MOISE CUNNINGS, machining systems engineer at **TechSolve** Inc..  
([www.techsolve.org](http://www.techsolve.org))

**SECTION:** MACHINE TOOLS; Pg. 56 ISSN: 1041-7958

**LENGTH:** 1241 words

### ABSTRACT

To create secondary fixture offsets at key points of interest to minimize stack-up errors, machinists should continue to use the G54 coordinate system for the main setup, but use G55 to G59 coordinate systems for more localized datums. The areas for secondary coordinate systems or local fixture offsets are determined by tight tolerances relative to local datums. Examples of this could be a set hole pattern or features that have to mate precisely with another part in the assembly process.

### FULL TEXT

When manufacturers machine components, they follow a conventional protocol of establishing a work coordinate, or fixture offset, for parts per their prints. The benefit of this method is that it establishes datums early for determining fixture designs and NC program strategies.

However, the one drawback to this method is that datums - such as bolthole patterns, tightly toleranced pockets and concentric holes - that don't interact directly with fixtures are subject to several stack-up errors.

These stacked errors can include the metrology of the machine, the condition of the rough part stock and human error. Fortunately, though, setting up secondary fixture offsets at key points using spindle probing can minimize these stacked errors.

No machine tool is perfect. All have a certain amount of error due to squareness issues, twist, and bowing in the axes. In small areas, these issues may be present and error can be measured in microns, but in larger parts - 500 mm or larger - these errors can be magnified by five, ten or twenty times over the length of the axis. Combine these errors in all three axes and the degree of uncertainty in the rough stock geometry and work holding can make some machine tools falsely appear to be incapable of making the component in question.

Rough stock condition is a major issue when it comes to stack-up uncertainty.

Proper material cleanup is one of the basics for a machinist to ensure that there are no burrs, that all sides of the material are square, and that forged and cast surfaces are in alignment with the print.

Much like issues in the metrology of the machine, small errors at main datums can magnify and become unpredictable over the depth, length and width of a part.

Human error also contributes to localized alignment problems. Most workholding devices are designed to eliminate the human element by using positive stops, drawn down clamps and other poka-yokes, but the human element prevails in the form of happenstance, such as overlooked chips on datums and loose locators, among other things.

Ultimately, small discrepancies will become magnified and can cause any machining process to produce outof- print parts, especially in key areas of the part where the tolerances may become tighter and more crucial to an assembly process and part function down the road. The parts may not be able to be assembled or there could be premature wear and a shortened product life. In these instances, there are a lot of charges from returned material going back to the machine shop, altering parts on the line to force them to work and engineering reviews.

#### Fixture offsets

To make the machining process easier, the work coordinate system, also called the fixture offset, is set so that the machining process is in line with part prints. This keeps the designer and the machinist on the same page when referencing part features.

Fixture offsets provide a lot of flexibility for the machinist to perform several tasks with little effort. One example is to use different fixture offsets to make multiple parts. If a machinist has enough space on a fixture to machine six of the same part, then the program can be written by changing only the G54 command to G55, G56 and so on to G59, and establishing corresponding origins in the relative work volumes.

When using a spindle probe, also known as a touch probe, machinists can change, add and move a fixture offset simply and quickly using more of the machine's capabilities. A powerful use of a spindle probe is to establish a secondary fixture offset locally within a part and treating features local to that new origin as a part in and of itself based on the local datums.

This removes the uncertainty of the rough stock/fixture interface from the stack-up error and greatly reduces the influence of positional error of the machine. The only new uncertainty introduced is the spindle probe, which is significantly less than the ones that were eliminated. Also, spindle probe uncertainty can be calculated using ASME G5.54 or ASME B89.4 standards, and therefore, better understood.

#### Secondary fixture offsets

To create secondary fixture offsets at key points of interest to minimize stack-up errors, machinists should continue to use the G54 coordinate system for the main setup, but use G55 to G59 coordinate systems for more localized datums. The areas for secondary coordinate systems or local fixture offsets are determined by tight tolerances relative to local datums. Examples of this could be a set hole pattern or features that have to mate precisely with another part in the assembly process.

Machinists should use spindle probes to establish local work coordinate systems because these probes are capable of repeatabilities to 0.5 microns in many cases, and accuracies of less than one micron. This means that if a feature has to have an extremely precise position relative to machined datums, then it is possible to achieve

that positioning with a less-precise machine tool or with a less-than-perfect fixture setup because all of these features are being designed, machined and measured relative to the same machined surfaces as implied by GD&T practices.

as an example, consider a casting (below) that measures 500-mm long, 400-mm wide and 100-mm thick that is clamped in a classic 3-2-1 workholding pattern. This part also requires a 50-mm-diameter bored hole to be machined concentric to a pocket that is 100 mm in diameter and 20-mm deep, and both holes are located at the center of the workpiece. The bored hole must be concentric within 30 microns (0.030 mm) relative to the 100-mm pocket, which is datum A.

In the cast part scenario, the location of the smaller bore is subject to the stack-up errors of the casting, the workholding and the machine's positional accuracy, regardless of the fact that it was not designed with those uncertainties or inspected with those uncertainties. With a spindle probe, it is possible to establish a secondary fixture offset using the finished surface of the 100-mm pocket (datum A).

Since this new origin is established from the datum feature, the only uncertainty to its location will be the accuracy of the spindle probe and the positional accuracy of the machine, which in the case of newer machines, can be less than 0.5 microns. The same principle applied to this sample part would also apply to parts with multiple pockets or pockets that are off-center.

True, using a spindle probe to establish a local fixture offset will add a relatively small amount of cycle time and programming to the process. However, this increase in time is offset by the throughput that is created, and it helps increase the number of saleable parts a shop can produce by minimizing errors due to machine metrology and other conditions that would otherwise magnify the current small errors.

#### **SIDEBAR**

Secondary fixture offsets at key points can minimize stack-up errors when machining.

#### **SIDEBAR**

Establishing a local fixture offset