by Tim Heston, Managing Editor

Volumetric Error Correction: The Future of On-Machine Measurement?

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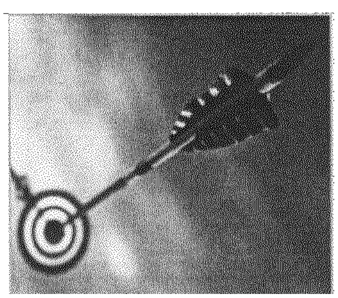
machine tool doesn't share the repeatability of a CMM - but industry would like to change that.

"The major objection to on-machine measurement is that the part is measured on the same machine that made it," states Charles Wang in his technical paper, *High Accuracy On-Machine Measurement with Volumetric Error Correction.* "Any positioning errors that occurred during machining are very likely to be repeated during inspection. Furthermore, measuring-machine accuracy should be at least four times more accurate than the parts to be measured."

Enter volumetric inspection. During the SME conference at this year's IMTS in Chicago, Wang introduced his vector measurement technique for measuring volumetric positioning errors.



On a machining center, displacement errors offer a special concern. Each linear axis has six degrees of error - three linear-displacement errors, pitch, yaw and roll.

As for squareness error, "the magnitude of this error grows as the machine travels away from the line of travel along which it was compensated for pitch errors," Wang says.

Guide surfaces aren't perfectly straight, either, and so "weight shifting and overhanging during axis travel may cause straightness errors," he says.

The sequential diagonal measurement Wang introduced at the conference measures vector errors, namely the displacement error and the vertical and horizontal straightness error. Using a laser beam, the measurement direction isn't parallel to linear-axis motion, and so measured displacement errors are sensitive to the errors both parallel and perpendicular to the direction of the linear axis.

With four setups, the method determines all three displacement errors, six straightness errors and three squareness errors. This method also generates a volumetric-positioning-error compensation table.

"It can be set up and run by a machine operator," he says, "and measures the volumetric errors in two to four hours for a working volume of about one cubic meter."

Here's how it works.

Sequential diagonal measurement, as the name implies, measures space diagonally across the work envelope, each axis (X, Y, Z), one after the other. **The method** uses a laser interferometer in conjunction with an alignment mirror. The interferometer moves diagonally (in the "body-diagonal direction") from the lower-left comer (X=0, Y=0, Z=0) to the upper-right corner (Xmax, Ymax, Zmax). On its way up through the work area, the tool moves alternatively along the X, then Y, then Z, and repeats -creating a "step-like" diagonal path through the work area, only with one added dimension (Z). Data is collected after each single movement.

Wang's company Optodyne, Inc. (Compton- Calif), introduced this method to process engineers at IMTS 2002 with its model MCV-500 laser interferometer, based on Doppler effect with a single aperture.

And what does volumetric-error correction mean?

"This volumetric error correction eliminates the inherent errors in machine-tool geometry and positioning, and accurate dimensional measurements can be achieved," Wang says. "Hence, with the volumetric-error compensation, a CNC machine tool becomes a high-accuracy CMM and satisfies the 4-to-1 ratio of gage accuracy."

That's big news.

"On-machine inspection becomes a viable process," Wang continues, "allowing a CNC machine to be used to verify the accuracy of a part it machined."

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