Laser Calibration Tightens Tolerances

As machine tool builders and their customers learn the connection between tighter tolerances and their potential to reduce costs such as those attributable to scrap, delayed assembly times, too frequent maintenance, and excessive warranties, the need for ensuring accuracy in production is accelerating.

Jobs S.p.A. uses Optodyne's patented volumetric laser calibration technology on its five-axis high-speed machining centers.

Jobs S.p.A. (Piacenza, Italy) has been manufacturing three-axis and five-axis high-speed standard and linear-motor-driven machine tools since 1980. Two years ago, jobs replaced its conventional laser calibration equipment with Optodyne's (Compton, CA) patented Laser Doppler Displacement Meter (LDDM)-based calibration equipment. Used in conjunction with a sequential step-diagonal measurement technique, also developed by Optodyne, LDDM calibration equipment enables Jobs to take precision measurements and detect problems before critical production runs. If parts are not ready, assembly and electrical departments may be idled. If parts are not machined to specified tolerances, assembly will take much longer to ensure the final machine can cut to published specifications.

"With the Optodyne volumetric laser calibration equipment, we obtain more complete data with fewer measurements in much less time. This provides us with a better understanding of machine errors, allowing us to correct them and deliver a better machine at a more competitive cost," explains Sandro Foletti, jobs manufacturing engineer.

The sequential step-diagonal measurement method collects 12 sets of data with the same four diagonal setups. Based on these measurement data, all three displacement errors, six straightness errors, and three squareness errors can be determined. The measured positioning errors can be used to generate a 3-D volumetric compensation table that is uploaded into the control for correcting any positioning errors and improving positioning accuracy.

"The Optodyne system and sequential step-diagonal measurement process require fewer measurements to obtain more data that clearly indicate the machine condition," Foletti explains. "As a result, we better understand such common problems as mounting errors, errors due to temperature, temperature change, and structural problems, and, without increasing assembly time, we are producing a better quality product.

"The sequential step-diagonal measurement method for volumetric calibration requires a maximum of seven measurements from which it is possible to understand the type and the dimensions of the most important errors," says Foletti. "We have validated it as an alternative to such traditional instruments used in assembly as the optical collimator, straightedges, and granite square."

Optodyne's LDDM technology utilized by Jobs employs the single-beam MCV-500 and dual-beam MCV-2002 to reflect a modulated laser beam off a movable target. The beam is detected and processed for displacement information, which is used to create the lookup table that enables the con-

Sequential step-diagonal measurement technique collects 12 sets of data with the same four diagonal setups from which all three displacement errors, six straightness errors, and three squareness errors can be determined.

trol to compensate for errors. Setups are quick because an offset for a return beam is not required as with conventional laser equipment. Only two components have to be aligned: the laser head with a single aperture for emitting and receiving the beam, and a flat mirror that acts as a target.

"The dual-beam MCV-2002 allows us to take position and straightness measurements at the same time without changing optics or realigning the laser beam," Foletti says. "The single-beam MCV-500 allows us to take advantage of the sequential step-diagonal measurement so that 3-D volumetric positioning errors can be measured with a minimum interruption of assembly and, therefore, much lower costs."

The laser and the flat mirror are mounted in the spindle and on the table, and moved along each axis separately and in sequence. The sequence alternates along the X axis, Y axis, and then Z axis, and is repeated until the opposite corner of the diagonal is reached. The diagonal positioning error is collected after each separate movement of all three axes. This technique collects three times the amount of data and allows the displacement error for each separate axis movement to be measured. The trajectory of the target is not a straight line and the lateral movement is quite large. A conventional interferometer does not tolerate lateral movements this large and cannot take these measurements. However the LDDM-based laser system uses a flat mirror target, so the laser beam is not displaced when moving parallel to the mirror and the distance from the source does not change. As a result, the measurements are not affected.

To measure the fourth axis (A) and fifth axis (B), the MCV-2002 with rotary calibration system is used. After each rotational movement, the table stops and settles for 3-5 sec, allowing automatic collection of angular data. The setup process is automated by utilizing the motorized programmable rotary table to eliminate the manual return movement. Automatic data collection minimizes operator error and reduces the time it takes to calibrate the rotary motion of a four or five-axis machine.

Setup and alignment are quick because angular measurement is not affected by runout, wobble, or parallelism of the rotary motion. A high degree of accuracy is achieved with this accessory and technique unlike the conventional comparative method, which compares a test device to known inaccuracies with an expensive master rotary calibrator.

A rotational angle of up to ±10˚ can be measured. The angular measurement range can be extended to 360°. Windows-based metrology ,software minimizes and corrects cosine and retroreflector rotational error.

In addition, the MCV-2002 provides automatic temperature compensation, using a platinum sensing element that is accurate to within ±0.1°. Up to four workpiece temperature sensors can be linked to the automatic temperature compensation unit. Automatic compensation is also provided for such environmental factors as air temperature, barometric pressure, and machine temperature to compensate for thermal growth.