Calibration Case Study-

Do-It-Yourself Laser Calibration Pays Off

A Code-One Flight Item Vendor Takes Laser Calibration In House.

As a Code-One Flight Item Vendor for over 40 years and an approved source for fracture-critical, Level 1/Sub-Safe and high-strength steel components, Scotts Valley, CA's Tapemation Machining, Inc. relies on laser calibration for ensuring the accuracy of its machining processes. But calibrating 5-axis machine tools and CMM is a difficult and expensive process, especially when the cost of machine downtime and outside services are considered.

"We were unable to find an outside service with the experience to calibrate many of our 5-axis machine tools and rotary tables," reports Tapemation president Bruce Erickson. "Finally we purchased our own laser calibration equipment. We were able to realize pay back in two years."

Large Components

Because it makes large precision-machined components for the aerospace, defense, medical, scientific, electronic, marine and petroleum industries, which require tight tolerances, laser calibration is somewhat of a competitive advantage for Tapemation. In its 50,000-sq-ft facility equipped with 22 major machines, including 5-axis Anayak, Mazak, SNK, Rambaudi and LeBlond-Makino machining centers, Tapemation boasts an internal quality control system that meets or exceeds MIL-1-45208A.

"Calibration isn't mandated by our suppliers," says Erickson, "it's mandated by the type of work we do. We don't include laser calibration as a part of our regular maintenance plan, except for our CMM. We calibrate the CMM at least once a year for ISO 2000 and 45208 inspection procedures. We calibrate the machine tools to ensure accuracy, so if we get a part that we have to hold flatness or position over a distance, we know the machine is capable."

Laser Calibration System

An Optodyne MCV 4000 laser calibration system was purchased with a dual beam laser head, dual channel processor and squareness optics for running linear, angular (pitch, yaw, straightness, flatness) and squareness

Data collection during calibration of Tapemations's large Brown and Sharpe MDL 3000 Validator CUM. The MCV 4000 laser head is shown at the left-rear corner of the CMM tabletop. Laptop stores data.

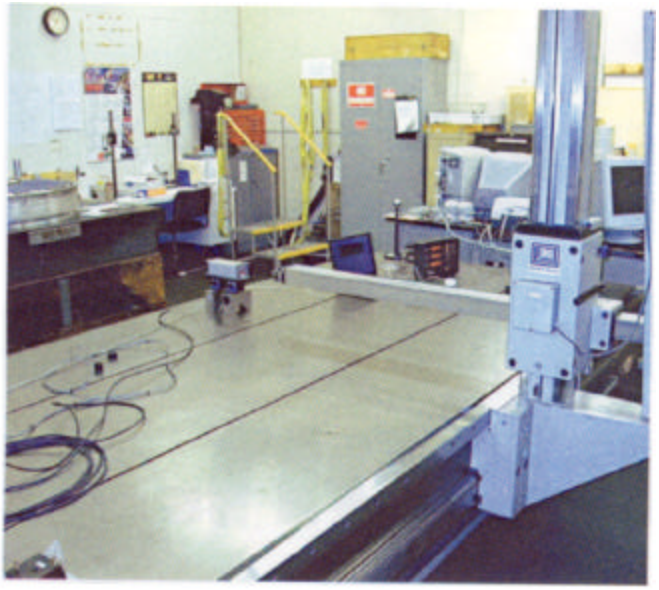
calibration. Optional accessories were purchased for calibrating tilting spindles and rotary motion for calibrating 5-axis machine tools. In addition to machine tools, the MCV 4000 is used for calibrating Tapemation's Brown & Sharpe MDL 3000 Validator CMM with travels of 132" X, 47" Y and 78" Z.

Most of the components machined at Tapemation are close tolerance, for example, ⌀0.001" over a 40 inch diameter or ±0.005" flatness over a 10-foot-long part.

Erickson: "Our QA manager, formerly a machinist, runs the calibration. Because we do 5-axis and rotary table calibration, his training required about a week to be proficient. Still, that's not bad when you consider the high cost when a machine is down waiting for an outside service to show up. Now we can schedule calibration when it's convenient to our schedule."

Easy Setup

Based on Optodyne's patented Laser Doppler Displacement Meter (LDDM) technology, the MCV 4000 reflects a modulated laser beam off of a movable target. The beam is detected and processed for displacement information used by the control to determine position. Expensive precision and special optics are not required and rotary tables are calibrated without the use of an indexing table. Because there are only two components to align, setups are very quick. The laser requires only a small percentage of the return beam, and a **retro-reflector.** Both components are machine mounted, which eliminates the need for a tripod and removing covers or dismantling the machine to run calibration.



A different view of the calibration process shows the MCV 4000 tracking the Y axis on Tapemation's Brown & Sharpe MDL 3000 Validator CMM. Tapemation builds large parts with very tight tolerances and requires a large-capability CMM for inspection.

The MCV 4000 features laser stability of 0.1 PPM, system accuracy of 1.0 PPM with resolution of 1 micro-inch (0.01 um).

"Most of the outside services we tried had to set the laser up on tripods off the machine," reports Erickson. "The MCV 4000 allows us to set the mirrors right on the machine. So we don't need to take covers off or dismantle the machine for calibration. It simplifies the process, saves time and potential problems."

The MCV 4000 enables a variety of 5-axis calibration methods to ensure precise positioning, including linear displacement, laser vector volumetric, sequential diagonal volumetric, flatness, squareness, static A and B axis rotational and dynamic A and B axes rotational calibration.

5-Axis Calibration

Typically, 5-axis calibration at Tapemation consists of checking linear displacement and running static measurement of the A and B rotational axes. Linear displacement and pitch/yaw angles are measured simultaneously, providing the performance of two laser systems. Setups for linear displacement are very quick, because only two optics must be aligned and both mount on the machine.

Data collection is manual, automatic or on-the-fly with a notebook computer. Information is processed to obtain plots and tables based on industry standard.

At Tapemation, the MCV 4000's velocity trigger is used for automatically recording position information, reducing operator errors. For example, the operator uses the control to move the table into position.

Since the system automatically senses table movement, data collection is triggered after a user-defined interval as the table starts to move and stop. This ensures measurements are taken at uniform intervals.

The rotational axes A and B are calibrated with a precision metal sphere mounted on the spindle and the laser head with focus lens is mounted on the table. A four-inch focal-length lens is used to center the laser beam on the surface of the sphere. With a large standoff distance and only two components to align, the laser head assembly and precision metal sphere, the system is very quick and easy to setup. The laser head is pointed in the X-axes direction and the sphere is aligned with the laser beam by moving the spindle. By rotating the A or B rotational axes, the distance variations between the laser head and the sphere surface are measured.

Rotary Table Calibration

The setup process for calibrating a rotary table is automated by utilizing the motorized, programmable rotary table to eliminate the manual return movement. 'Ibis reduces the time it takes to calibrate a rotary table and minimizes operator error.

With the rotary table calibration accessories and software, the rotary table platen stops and settles for three to five seconds after each rotational movement of the rotary table, then angular data is automatically collected. A rotational angle of up to +10 degrees can be measured. The angular measurement range can be extended up to 360° for calibration of rotary tables and stages.

Software minimizes and corrects cosine and retro-flector rotational error. A high degree of accuracy is achieved, unlike the conventional comparative method, where a test device is compared to known inaccuracies with an expensive master rotary calibrator.

The system provides resolution of 0.2 arcsec, accuracy of 1 arcsec and is calibrated and is NIST traceable.

"An outside service for just calibrating our CMM was charging us $6,500 year, two times a year. The service technician couldn't calibrate some of our other machines. And they had a very difficult time doing our 5-axis and rotary tables. We used to spend half the cost of the Optodyne system every year calibrating all our machines. A two-year ROI is a pretty good investment."

View of the MCV 4000 checking Z-axis motion on the Brown & Sharpe CMM. A mirror attachment is used for the purpose.