Laser Calibration Ensures Tie-Bar Accuracy

Calibration of lathes is crucial for positioning when turning tie bars for the clamping systems of plastic injection-molding machines and die-casting equipment.

"Turning tie bars is no small matter," explains Larry Green, plant engineer, Kelm Acubar (Benton Harbor, MI). "Tie bars can be up to 16" [406 mm] in diam, 20-35 [6-10.6-m] long and weigh as much as 32,000 lb [14,515 kg]. Often, customers specify tie bar tolerances of ±0.002" [0.05 mm] over 100" [2.54 m] or more," says Green.

"Holding precise tolerances is fairly routine now; we haven't had a reject in years," says Green. "Ten years ago, we were making tie bars with buttress grooves for a customer, but there were many discrepancies between what we measured and what our customer measured. Basically, there was no way to position or measure the buttress grooves as accurately as they wanted them. As many as 60 grooves could be specified and at that time we had difficulty measuring to determine if we were meeting the tolerances of 0.002" [0.05 mm] over 65" [1.65 m] on a set of four tie bars. The customer couldn't find anybody else who was doing better, and tried some of our competitors. They were unable to meet the specifications." Green says.

Tie bars, usually a set of four, apply force to the platen. If the clamping system is out of tolerance, the pressure exerted on the tie bars and platen will be unbalanced, and will cause one or more to carry an excessively high load. This situation causes many problems, including bar fracture. There are many tie-bar system designs; one is a multiple buttress-groove system composed of 50-100 (or more) buttress grooves extending sometimes in excess of 100" (2.54 m).

Green had looked at buying a laser-calibration system even before the tie-bar accuracy issue arrived, but its price tag was too high. Instead they opted to pay an outside service to calibrate and compensate the lathe. Yet the calibration and compensation service had no effect on the lathe's ability to hold tolerances.

"We heard about a laser calibration system from Optodyne Inc. [Rancho Dominguez, CA] that cost significantly less than other systems, and decided to see a demonstration," says Green. "The Optodyne rep set up the equipment in about five min. We took a 15-min warm-up break, and four min later the rep said the lathe had been compensated from the wrong side."

Green says that the only question Kelm Acubar had at that point was: "Would compensation from the correct side allow the lathe to hold the tolerances we needed to satisfy our customers?"

Optodyne's laser calibration system requires only two optics, a laser head and a retro reflector, which are mounted on the machine. This makes it easier to align, and therefore much fast to set up than other systems.

The Optodvne laser meets NIST traceability requirements and features a stability check of better than 0.1 ppm, accuracy of 1.0 ppm, and resolution to 1 µin. (0.00003 mm). Additionally, the system can automatically compensate for environmental factors, including barometric pressure, air temperature, and material temperature, to compensate for thermal expansion.

Based on Optodyne's patented Laser Doppler Displacement Meter (LDDM) technology, the system works by reflecting a modulated laser beam off a target. The beam is detected and processed for displacement information.

The reading head is sent to the bome position, and the operator specifies the measurement increment. When the system is activated, it automatically senses movement, and after an operator-defined interval, data collection is automatically triggered after the table stops. The process continues by stepping through multiple measurements along the full length of the lathe.

The deviations between the scale and the positions measured by the laser are determined, allowing calculation of a compensation table. In some cases, a single linear correction factor is used. In others, a nonlinear incremental correction can he applied.

"We bought the Optodyne system," says Green. "I compensated the lathe and then refined the measurements over a period of time. The lathe became extremely accurate, and our customers could no longer refute our findings. Typically we would send out a set of four bars having a tolerance of ±0.001 " [0.03 mm]. Of course, that stretched into other applications, and we calibrated our other CNC and manual machines. Our products got better and better, and we bought a second laser."

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According to Green, he checked the two lasers against each other, and they were right on. Still a little doubtful, he thought they needed a NIST traceable standard (National Institute of Standards and Technology); a 10' (3-m) long Invar bar calibrated to ±0.0002" (0.005 mm) seemed to be ideal. He presented the concept to a NIST metrology engineer who told him that it would cost a half-million dollars to calibrate such a bar, and that nobody in the industry would be maintaining (or even measuring) to the tolerances being achieved by Kelm Acubar.

"We have not had any measurement problems since we started using the Optodyne laser system," says Green. "When we run these programs that do long tie bars and other long bar applications, we put temperature compensation in the programs. The system allows us to input the temperature of the machine and the bar into the program. It puts in a correction to a millionth of an inch. Now, we're working on coming up with a laser function for other applications."

Optodyne's LDDM system is mounted on the machine at Kelm Acubar, where it has eliminated discrepancies between the company's measurements and those of its customers for critical tie bars used in die casting or plastic injection molding.