

CMM Monitoring, Calibration, and Correction

Modern technology maximizes volumetric accuracy – Audi AG case study

Stationary coordinate measuring machines (CMMs) of different designs and sizes form the backbone of quality assurance in modern automotive production – e.g. at AUDI AG, the worldwide leader with respect to body accuracy. The automotive manufacturer uses an innovative method made in Germany for monitoring, calibration, and correction of the coordinate measuring systems at their Ingolstadt plant: the LaserTRACER made by Etalon not only assumes standard-conform CMM monitoring, but also enables complete volumetric compensation of the CMM within shortest time. Thus, Etalon's system offers a scope of functions significantly larger than the ball bar commonly used for CMM monitoring.

The measurement uncertainty of a CMM should be five to ten times smaller than the tolerances to be monitored. This is a requirement for getting significant measurement results, and for assuring a reliably and economically controlled production process. However, coordinate measuring machines – particularly large ones – undergo geometric changes due to foundation drifts, collisions, or aging of machine components. This makes re-calibrations necessary.

"The importance of CMM monitoring and calibration has continuously increased in the last years, mainly due to increasingly tighter manufacturing tolerances," confirms Josef Mutsch, responsible for Measuring System Quality Assurance at Audi in Ingolstadt. "We must now be able to quickly and precisely analyze the geometric accuracy of our CMMs to assure dimensionally accurate production. Short response times are especially requested after collisions. We also focus on continuous calibration verification for our 'troublemakers', such as CMMs whose foundation is not fully stabilized."

Several double-column CNC coordinate measuring machines and manual CMMs is used in Quality Assurance at the Audi plant in Ingolstadt.

Periodic verification of this large number of CMMs can become a tough job – even without unexpected incidents. When Josef Mutsch heard about Etalon's LaserTRACER during an industry meeting, he quickly recognized the potential of this new technology compared to the ball bar previously used at Audi. "Extensive test series and individual development services by Etalon and Zeiss followed. The active exchange between the project partners allowed further development of the LaserTRACER to extend the application spectrum of Etalon's system to manual CMMs. Thanks to a customized interface, seamless handover of the measured data to the control software of the CMMs could be ensured," reports Josef Mutsch.

Side notes: Weaknesses of the ball bar

The ball bar is considered a proven aid for calibrating coordinate measuring machines. However, the artifact can easily reach its limits:

- In the case of large CMMs, the complete measuring volume cannot be captured without moving the device.
- The ball bar is susceptible to mechanical damage.
- Calibrating a CMM often requires a complete workday, even if done by experienced personnel.
- If a significant geometrical deviation is detected on a CMM, an external service provider must be commissioned for calibration.

Functional principle of the LaserTRACER

The LaserTRACER was developed by Etalon for calibration, monitoring and accuracy enhancement of measuring machines and machine tools. The self-tracking laser interferometer automatically tracks a reflector, and hence allows for the identification of geometrical deviations with highest precision.

In contrast to conventional measurement devices, the LaserTRACER features an unprecedented accuracy of the center of rotation thanks to a patented method: A sphere with a form deviation in the nanometer range is used as an optical reference for the interferometer. Therefore, the mechanical errors of the rotation and swivel axes are fully compensated.

The measurement

For measurement execution, the compact LaserTRACER is stationary placed at several different positions inside the working area of the machine without any special fine adjustment. Here, a reflector is mounted instead of a probe. In the following automated measuring process, the LaserTRACER tracks the actual path of the machine in its entire working area, and continuously acquires length changes with nanometer resolution.

By using the LaserTRACER together with the Trac-Check software, machine deviations can be determined with sub-micron accuracy according to the standard based on ISO 10360-2. Thus, it is possible to detect whether a measuring machine meets the specifications or whether a maintenance action must be performed. Simple compensation values for scale factor and squareness can be directly derived from the measuring results. The patented method for automatic alignment of the measuring beam significantly reduces the measuring time compared to the ball bar. Furthermore, the LaserTRACER is more portable than a ball bar and does not require a second employee for setup.

Significant increase of geometrical accuracy within the entire measuring volume

Mid 2013, the LaserTRACER was successfully integrated into Audi's Quality Assurance: Since the system has replaced the ball bar, Audi could reduce the CMM monitoring time by 50%.

"All CMMs are regularly checked using the LaserTRACER," explains Josef Mutsch. "Depending on the results outputted by Etalon's Trac-Check software, we define the way of proceeding: If all measured values are within the tolerance, there is no need for action. However, the LaserTRACER occasionally suggests a linear and angle correction that would increase the machine accuracy even more. Based on our experiences, the geometrical accuracy of the calibrated CMMs can be increased by another 15 percent, if we implement the correction suggested by LaserTRACER.

However, if a CMM operates outside the tolerance, there is urgent need for action. In this case, we use Etalon's Trac-Cal software to generate a correction field and transfer the volumetric compensation data to the control software of the CMM. Next, the LaserTRACER measurement is repeated to verify the new calibration. The complete volumetric compensation – including verification – is completed in one day. On average, the machine accuracy can be increased by 30 percent compared to the manufacturer's specifications, in exceptional cases by more than 50 percent."

Further advantages: Quick verification and quick response in the case of deviations

For Josef Mutsch, the advantages of the LaserTRACER are obvious: "Not only can we quickly and accurately say, how good or bad the CMMs are. This statement is of essential importance - mainly with respect to the requested production accuracies. The measuring results of the LaserTRACER are more safe and accurate than the results of the ball bar. In addition, we profit from the high degree of independence from third-party service providers we needed in the past for the generation of the correction field. By using the LaserTRACER, we can perform the volumetric compensation immediately. At the same time, the elastic deformation of the CMM column is recorded, which is a fundamental accuracy factor. This plus in flexibility, precision, and the possibility of fast responses to geometric deviations allows for an optimum interaction of tolerance and quality management."

Today, the LaserTRACER is also used for CMM verification at the Audi plants in Neckarsulm and Győr.