How to select a noncontact coordinate measuring machine

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A committee of the International Standards Organization has begun the process of rationalizing the performance assessment of optical measuring instruments.

Computer-aided design (CAD), manufacturing (CAM), and engineering (CAE) are essential tools for today’s industries. For example, in fabricating a new product, an engineer will draft a design using CAD. Then he might check its resistance to stress or heat using CAE. That information is fed back into the design, and the loop is repeated. Finally, the product is made and tested again by applying actual force and heat. However, manufactured products never have precisely the same shape as their design prototypes, and often fail to perform as expected. One solution to this problem is to base the CAE process on real manufacturing and measurement data, not CAD data. Consequently, since 1959, some hundred thousand contact coordinate measuring machines (CMMs) have been used in many fields of industry.

Contact CMMs work by having an electrical probe touch down at various points on the surface of a product and send back information about length and other geometrical parameters. CMMs are versatile and accurate instruments. But they are very slow. And because current products are elaborately designed and have complex, free-form shapes, the sparse, discrete points measured by contact CMMs are insufficient for CAE.

For this reason, in the last decade, noncontact (mostly optical) CMMs, which are capable of measuring several million points in an instant, have been overtaking conventional CMMs.

There are a number of types of noncontact CMMs, including a combination of stationary fringe projector and TV camera, and an illuminated laser-scanning system. For users, the challenge with these machines is selecting one, because manufacturing specifications for the instruments follow different formats. Makers use terms such as ‘resolution,’ ‘accuracy,’ and ‘uncertainty,’ arbitrarily. Gauges and testing volumes also vary, and sometimes there is no information at all concerning measurement accuracy. Because customers have no criteria for selecting instruments, they fall back on intuition, with the unhappy result that their choice may not meet their expectations. If the performance assessment of noncontact CMMs were standardized, buyers could at least compare instruments under the same conditions.

Some standards for checking the measurement performance of contact CMMs do exist, although they are not comprehensive. For example, a simple procedure that consists in making three repeated measurements for five gauge blocks of different lengths at seven different positions and orientations gives a total of 105 measurements. In principle, this standard could be applied to noncontact CMMs, but for various reasons it is impractical. For years now, we at the National Metrology Institute of Japan (NMIJ) have been receiving requests from makers and users to remedy the situation.

In 2003, at the encouragement of NMIJ, a number of companies voluntarily initiated a preliminary experiment. A ball plate (see Figure 1) and a ceramic cylinder (see Figure 2) were measured using various noncontact CMMs owned or sold by the participants. The findings convinced us that we could devise a
standard to evaluate the measurement performance of such instruments. Eventually we decided to create a consortium to establish both national and international standards.

The consortium currently consists of 17 company members and approximately 40 individual members. The first and most controversial point of discussion was the optical characteristics of the surface of the gauge to be measured. Both users and manufacturers are interested in linear dimensions. But users want to apply the measure to glittering surfaces, such as car bodies, which noncontact CMMs do not handle very well. For this reason, we concluded that length measurement and surface roughness should be tested separately. Because length measurement has already been defined for contact CMMs, we decided to make a gauge for assessing it easily in noncontact CMMs. Evaluating roughness will require a new test and will be addressed later.

We fabricated more than 50 balls with different finishes and coatings and measured them using a variety of noncontact CMMs. Titanium dioxide over a sandblasted surface turned out to be the easiest coating to measure. A ball bar consisting of several balls mounted on a carbon-fiber beam was constructed as a material standard of size (see Figure 3). The existing standard for contact CMMs evaluates length-measurement errors only. But in noncontact CMMs form-measurement errors are also important because the instruments are often used to measure free-form surfaces. In addition to the procedure using the ball bar, form measurements of a ball and a plane were stipulated. Detailed activities of the consortium are available elsewhere.

A draft Japan Industrial Standard has already been compiled by NMIJ and is in the process of being deliberated by the Japanese Industrial Standards Committee. As members of the working group on coordinate measuring machines of the International Organization for Standardization (ISO/TC 213/WG 10), Japan and Germany have drawn up a so-called new work item proposal ballot that will be voted on at the next meeting of the group in Berlin in January 2009. As in many international bodies, the ISO standardization process generally moves slowly. But we are confident that an impartial standard will be published in the not-too-distant future and that users will finally be able to effectively compare noncontact CMMs.

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References