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SOME ASPECTS OF THE ROUNDNESS MEASUREMENT WITH CMM

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Abstract: In the article, the form deviation (roundness) measurement with the Coordinate Measuring Machine has been discussed. The influence of the measuring points number and the type of the roundness deviation on the result (since different fitting elements are used) has been presented. The obtained investigation results prove that minimal number of points is not enough for measurement, while the too large number does not improve the measurement, as well. The recommendation on the measuring points number have been given.

Keywords: coordinate measuring technique, roundness.

1. INTRODUCTION

As the manufacturing technologies are continually improved, and the quality requirements are constantly risen, it becomes necessary to perform the metrological analysis in order to gain the complex knowledge on the manufactured detail. So, it is necessary to apply flexible and accurate measuring devices like Coordinate Measuring Machines. Those devices ensure the needed speed and flexibility of the measurement with high accuracy.

Coordinate measurement is based on the calculations of the measuring points defined in 3D coordinates. The more is the number of those points, the higher is the accuracy of model. In the roundness measurement the calculated characteristics of the circle are its radius (diameter) and coordinates of its center.

Industrial practice indicates that pulse CMM measurements are mostly performed with the minimal number of points needed to describe the fitting element. However, it is not enough for metrological purposes, which was proved by many researchers (see fig. 1).

2. FACTORS AFFECTING THE ACCURACY OF ROUNDNESS MEASUREMENT

The result of the roundness measurement is influented by the number of measuring points, their distribution and the fitting element. Besides of it, the accuracy of measurement may be influented by the characteristics of the measured detail like roundness deviation model and tolerances, as well as the accuracy of the CMM applied.

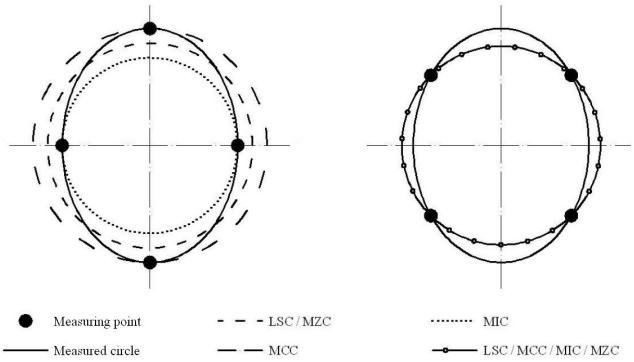

Fig. 1. The results of roundness measurement influented by the distribution of the measuring points and different fitting methods

The Standard ISO 6318 accepts four fitting methods for circle: Least Square Circle (LSC), Minimal Circumscribed Circle (MCC), Maximal Inscribed Circle (MIC) and Minimal Zone Circle (MZC). The most commonly the LSC method is applied. However, in many cases it is inappropriate, e.g. when the moving joint with small tolerances is measured. The Gaussian method leads to obtaining a "mean" form which may differ considerably from the actual one. In such case, the orifice should be measured using the maximal inscribed circle and the shaft using the MCC method. This way the true coordinates of the center are obtained, and above all the actual diameters of cooperating details is calculated properly and the information on assembling and further work is known.

3. WHY THE MINIMAL POINTS NUMBER IS NOT ENOUGH?

The minimal number of measuring points given for fitting purposes may cause a large error during the measurement of the diameter and the location of center of the circle. When the roundness deviation is ovality, minimal number of 4 points gives completely different measuring results (Fig. 1, fig. 2).

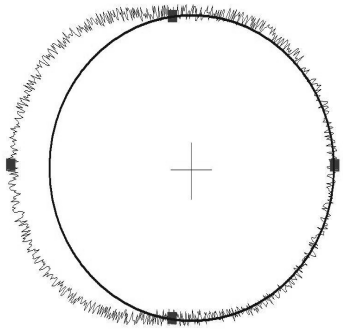

Fig. 2. Measurement of the circle with ovality deviation usin 4 points

In the extremum, the measurement of such a circle with 4 points only gives a large error of the ceter location. When the points are distributed like in the fig. 2, the maximal inscribed circle is based on 3 points, as it is shown. The larger is the ovality deviation, the larger is the center location measurement error. The maximal error occurs when the measuring points are located on the extremal surfaces of the oval (fig. 3).

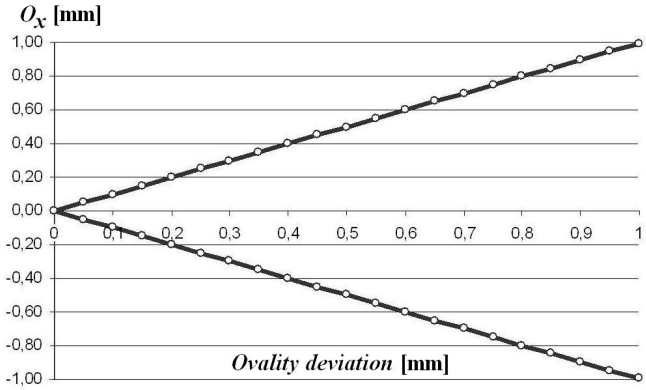

Fig. 3. The circle center location O_x (in *x*-axis) versus the value of ovality deviation

The error occurs both in the direction of positive coordinates and negative ones. The result is highly influeted by the inaccuracy of the Coordinate Measuring Machine.

4. THE INFLUENCE OF THE FITTING ELEMENT AND POINTS NUMBER ON THE MEASUREMENT OF THE CIRCLE WITH FORM DEVIATION

The number of measuring points should be different for different diameters, different models of form deviations and fitting methods. The increase of the number of points ensures higher accuracy. However, in the pulse measurement it requires more time. When the large number of points should be collected, the scanning head should be applied. However, scanning heads and their software are much more expensive.

So it appears to become crucial to work out the recommendations on the appropriate point number choice dependent on the expected form deviation and the applied fitting method. The accuracy of the Coordinate Measuring Machine and the tolerances of measured detail are of great importance, too.

The measurement of the circle should be carried out in the CNC mode ensuring the steady distribution of the measuring points on the surface of detail, the contact in normal direction and the measurement with the constant force of the head contact with the surface of measured detail.

The results of investigation prove that the measurement of the circle using the minimal number of points is inappropriate. At the same time, too large number of points is not necessary, because after the certain number of points is reached, the further improvement of measuring accuracy is no larger than the accuracy of the CMM itself, both for the radius and the center coordinates. The results shown in fig. 4 prove that even 16 points is not enough for the appropriate diameter measurement. In order to perform the metrologically correct measurement (accuracy no less than 0.1T), minimum 128 points should be collected. However, when it is enough to perform measurement with 0.2T accuracy, the measurement with 32 points may meet this requirement (fig. 4).

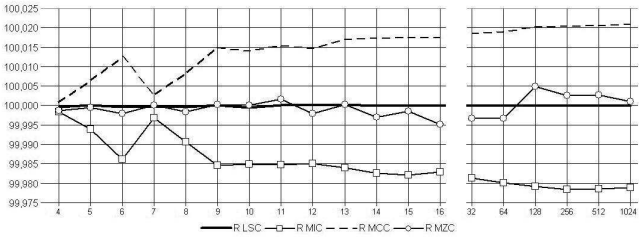

Fig. 4. The influence of the number of measuring points on the obtained radius of the measured circle for different fitting methods. MPE_E = ± 2,5 [µm]

5. CONCLUSION

Coordiante Measuring Technique is widely applied in industrial measurements. It combines the flexibility, swiftness and accuracy of the measurement. In many cases those characteristics allow the replacement of the specialized measuring devices with the Coordinate Measuring Machines.

In case of the roundness measurement, the pulse measuring heads are recommended for the determination of the center location and the circle radius. However, when the form deviation should be analysed, considerably larger number of points should be collected. Such measurement may require the continual measurement with the scanning head.

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