Roundness Deviation Measuring Strategy at Coordination Measuring Machines and Conventional Machines

Lenka Ocenasova, Bartosz Gapinski, Robert Cep, Linda Gregova, Branimir Barisic, Jana Novakova, and Lenka Petrkovska

***Abstract*—**Today technological process makes possible surface control of producing parts which is needful for product quality guarantee. Geometrical structure of part surface includes form, proportion, accuracy to shape, accuracy to size, alignment and surface topography (roughness, waviness, etc.). All these parameters are dependence at technology, production machine parameters, material properties, but also at human, etc. Every parameters approves at total part accuracy, it is means at accuracy to shape. One of the most important accuracy to shape element is roundness. This paper will be deals by comparison of roughness deviations at coordination measuring machines and at special single purpose machines. Will describing measuring by discreet method (discontinuous) and scanning method (continuous) at coordination measuring machines and confrontation with reference method using at single purpose machines.

***Keywords*—**Coordinating Measuring Machines (CMM), Measuring Strategy, Roughness Deviation, Accuracy.

I. Introduction

AT current competition, producers offer higher part for lower price, because would like to be keep at marketplace. On base of this, company must develop their products at technological (production) and quality (metrological) aspect. At this paper was chosen problems of roundness deviation measurement. It has big meaning at bearing rolls production and it is one of most monitoring parameter of surface quality. Together with surface roughness affects vibration and quality of whole device. High attention is dedicated to valuation of measuring methods and using of measuring devices [1, 10, and 11].

Self measuring and evaluation do not quantify deviation value, but obtain information usable at surface creation – machining with goal of correct and improve technological processes [2, 12]. For roundness deviation measuring are usable different methods and measuring equipments, from universal up to very special measuring devices [3, 4]. Universal and special measuring equipment are differs by uncertainty, price and measuring time. Special apparatus are quick, but they can measure only one deviation (parameter). Universal devices can measure many parameters, but with low uncertainty. Big advantage is that we can measure other properties (size, shape, surface, etc.).

Big care is about coordination measuring machines (CMM) today. These machines have wide usability and they are quick and precise. On basis of that we can assert that CMM can measure together with production [5].

II. Current State Analysis

Coordination Measuring Machines (CMM) performs measuring at plane or space. Basis of geometrical data calculate are position data. From these positions are determine substitute part geometry. For all elements are determine minimal number of points which is necessary for alternative geometry generation. There are two standard measuring methods are using at roundness deviation: continuous (scanning) and discontinuous (discrete). Continuous method is individual mode, where results are position data values consecutive at measuring surface [7]. Measuring provides more detail information about workpiece and measuring surface. There is shorter distance between points at continuous method (Fig. 1), like at discontinuous method. But measuring time is longer. This method has advantage in equivalent results at repeatable measuring and during change position of measured part. At discontinuous method are points reading separately at measuring surface (Fig. 2). Results are relatively inaccurate and do not provide full information's about shape and size of measured surface. Requirement of right measuring is right set up of measured part. Repeatable measuring of workpieces with shape mistakes and carried with low point numbers leads to various results [9].

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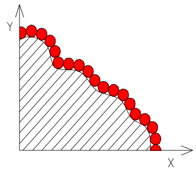

Fig.1 Point scanning by continuous method

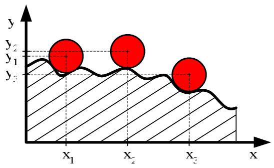

Fig. 2 Point scanning by discontinuous method at CMM [8]

Results of roundness measuring are affection by next factors: number of measuring points, distribution of points and choice assembling element. Standard ISO 6318 provides next four assembling elements: Least Square Circle (LSC), Minimal Circumscribed Circle (MCC), Maximal Inscribed Circle (MIC), and Minimum Zone Circles (MZC).

III. Experimental Set Up

Measuring of roundness deviation was realization by continuous and discontinuous method at CMM and was compare with continuous method at special device Talyrond 73 from Taylor Hobson. Results from Talyrond 73 will be reference measured roundness deviation.

Measuring by Continuous Method at CMM

Roundness deviations were measured at coordination measuring machine DEA Global – IMAGE clima (Fig. 3) from DEA company and was using measuring probe SP 25M-1 (Fig. 4). Measuring was realized at Poznan University of Technology, Institute of Mechanical Engineering, Poland.

Fig. 3 DEA Global – IMAGE clima

Fig. 4 Measuring probe SP 25 M-1

Measuring Conditions

Accuracy of CMM at 18–20°C, max 1 K/h: MPEE = 1,5+L/333 μm ; (L is in mm), MPEP = 1,5 μm;
Temperature: 20°C; software: PC DMIS CAD++;
filter: GAUSS;
Reference circles: LSC, MZC, MIC, MCC;
diameter of measured part: ϕ 44,5 mm;
Diameter of measuring contact: ϕ 5 mm;
measuring part: cylinder.

Measured workpiece was equal by 5 cuts. Measuring was carried at radial cut at z = 10,36 mm from parts front. Roundness deviation was measured by continuous (scanning) method for LSC, MZC, MIC, MCC. Number of scanning point on mm: 1point/mm, 5points/mm, 10points/mm, 20points/mm at arc measure 30 times and measured results was statistical processing by standard uncertainty type A. Results are at Fig. 5.

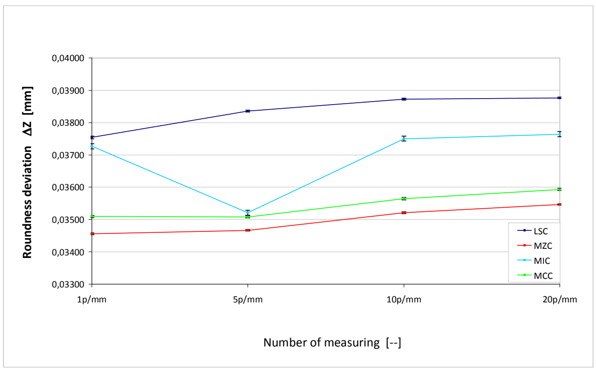

Fig. 5 Comparison of roundness deviation for - 1b/mm, 5b/mm, 10b/mm, 20b/mm(for LSC, MZC, MIC, MCC)

During measuring by continuous method are roundness deviation increase in depended of point numbers on 1 mm. There is progress of deviations at different numbers of point is on Fig. 7. There is valid, that with increasing point numbers are better measuring and roundness deviation is more objectively.

Measuring by Discontinuous Method at CMM

Roundness deviations were measured at the same CMM but were usage measuring probe TP 200.

Accuracy of CMM at 18–20°C, max 1 K/h: MPEE = 1,5+L/333 µm ; (L is in mm), MPEP = 1,7 µm;

Diameter of measuring contact: ϕ 4 mm;

There were increasing numbers of measuring points at workpiece. Measuring were at 4, 8, 16, 32, 64, 128, 256 points 30 times and measured results were processing statistically for standard uncertainly type A. Results are at Fig. 6.

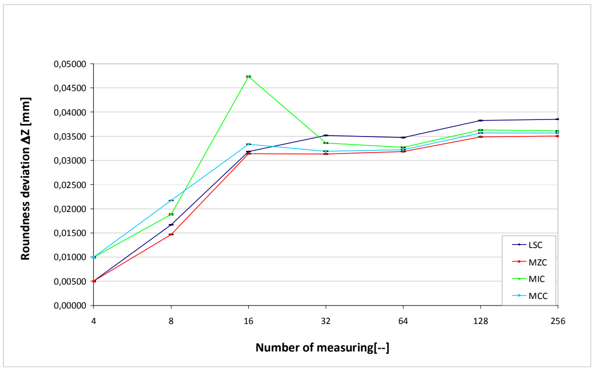

Fig. 6 Comparison of roundness deviation for 4 ÷ 256 points (for LSC, MZC, MIC, MCC)

We can see that up to 16 point was measured deviation with more intensity. After that is increasing slower and with more stability. Of course with increasing numbers of points is roundness deviation higher and decreasing result dispersion. With increasing number of measuring are higher time and price costs. From measured results we can see that most effectively is measuring at 32 points where roundness deviation at the same value and time charge is relatively low.

Continuous (Scanning) Measurement Methods for Special Equipment

Roundness deviation was measured on a special measuring device - Talyrond 73 from Taylor-Hobson (Fig. 7). For measuring device was roundness deviation measured of continuous - the absolute method. The device works on the principle of turning the spindle. Measurement is done in a laboratory of 3D measurement at the Department of machining and automation and the Department of design and machine element, Faculty of mechanical engineering - University of Zilina in Zilina, Slovakia. Component was measured 30-times in the same place of cut as in previous cases.

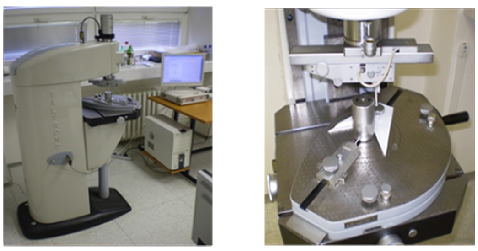

Fig. 7 Measuring device Talyrond 73 and measured part

Conditions of Measurement

accuracy of the device u_P: 0,02 µm;
ambient temperature: 21°C;
software: ROFORM;
filter: GAUSS, 2-10000;
fitting elements according ISO 6318: Least Square Circle (LSC), Minimal Circumscribed Circle (MCC), Maximal Inscribed Circle (MIC), Minimum Zone Circles (MZC).

The results were statistically processed - according to the standard uncertainty of type A. In Table I are reported results roundness deviations for the continuous method of the fitting element: LSC, MZC, MIC, MCC. The most commonly used fitting element is the Least Square Circle, which is inappropriate in many cases, especially for moving joints with narrow tolerance. The Gaussian method gives the „mean" shape of the measured detail. When the measured circle is to cooperate in narrow tolerance, the measurement with Minimal Circumscribed Circle (MCC) or Maximal Inscribed Circle (MIC) should be performed. [10, 11]

TABLE I
THE AVERAGE VALUES OF ROUNDNESS DEVIATIONS FOR CONTINUOUS MEASUREMENT

Evaluation Method:	LSC	MZC	MIC	MCC	Number of measuring	Units
The arithmetic average ΔZ :	37,2	33,9	33,9	34,6	30	[mm]
Uncertainty u_A :	0,028	0,047	0,047	0,063	30	[mm]

On the based of measured results can be state that the roundness deviation in the individual positions are not significantly different. The results roundness deviations are considered as reference values of the fitting elements: LSC, MZC, MIC, MCC.

Comparison of Measurement Methods

The results of the measurements for the evaluation of roundness deviations for continuous and discontinuous methods to the coordinate measuring machine, and continuous method for special equipment have been processed statistically. From the statistical processing of data is made according to the chart roundness deviations from number of scanned points of the fitting elements: LSC, MZC, MIC, MCC (Fig. 8). Individual measurements are arranged so that the values of roundness deviations in the graph in a row followed by the number of scanned points on the parts.

In all methods of statistical evaluation showed that an increasing number of measured points in all methods roundness deviation increases (Fig. 8) and it is found the value of roundness deviation objective. The measured component of the above graph shows that in the interval of measured points 256 for non CMM and a method for measuring ÷128 20b/mm÷interval points 1b/mm the continuous method for the CMM, are almost all the results of the measurement methods are very similar. Variations of these methods compared to the CMM of coupled method - measuring device Talyrond 73, which is considered as the reference, are minimal. When comparing the non circularity deviation method with a benchmark the number of measured points 4 and 8, the measure can be in terms of accuracy and probability theory be 16 points sensed linear curve is÷considered relevant. In the interval from 8 rising and beginning to stop at the border until 32 to 64 points may be noted that the measure is not linked to this area of sensed points for measurement of effective and not just time but also in economic terms. This applies to the case, which was stripped in the article; would examine the other cases.

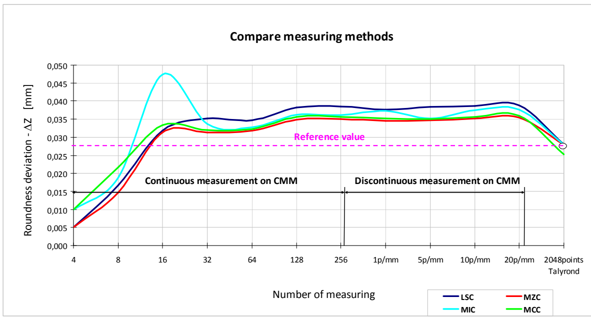

Fig. 8 Graph of the deviations scanned points (for LSC, MZC, MIC, MCC)

IV. Conclusion

Present production process put demands on quality and production of manufactured parts, therefore there is important to deal with quality and fast evaluation of roundness deviation. One of the solutions is a coordinate measuring device, which replaces special equipments if the appropriate software is selected and suitable strategy of measurement is chosen [9]. There are used two ways of scanning in case of CMMs: continuous and discontinuous measurement. In the continuous (scanning) method, the accuracy of the reference method is satisfactory, the results were just the same, the advantage is that you can use the diversity of measurement - stepping up 20b/mm (3108 points) depending on the diameter of parts and thus affect the measurement economy. In case of discontinuous method, however, there are important number of scanned points, profile shape, part diameter and diameter of measurement contact, and even more required accuracy. Compared to the reference measurement, it was showed that the number of sensed points were mostly in the range from 64 to 128 points, which can not generalize. For less accuracy, it is sufficient to capture the number of 32 points; it is valid for this particular case. By the given analysis of continuous and discontinuous measurement on CMM compared with reference value, this analysis confirmed that improperly selected number of sensed points leads to doubtful assumptions about the correctness of the result. Based on this analysis, we can assume that the deviation of circularity seems to be more suitable when application of continuous method. Based on the results achieved in the work we can conclude that co-ordinate measuring machines are suitable for measuring roundness tolerances. It is desirable to keep working on this issue.

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