RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

NUMBER OF POINTS FOR ROUNDNESS MEASUREMENT – – MEASURED RESULTS COMPARISON

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Abstract

Paper deals with filtering roundness. It presents experimental results measured for roundness turning and cylindrical grinding. Roundness was measured using Prismo Navigator 5 coordinate measuring machine. Evaluation was done by four methods: Minimum zone reference circles (MZCI), Least squares reference circle (LSCI), Minimum circumscribed reference circle (MCCI) and Maximum inscribed reference circle (MICI). The filters used were: Gauss, Spline and no filter.

Key words

roundness, reference circle, filter, measurement, evaluation methods

Introduction

It is impossible to produce ideal parts. Deviations are a natural result of production. These deviations should be determined. Standards STN EN ISO 1101: 2006 [1] does not define the term tolerance. It introduces the term "tolerance zone", which is defined as a circumscribed area by one or more geometrical exact lines or surfaces. This tolerance zone is characterized by a linear dimension which is called "tolerance" [2].

Standard STN EN ISO 1101: 2006 [1] defines "roundness tolerance" as follows: the tolerance zone is delimited by two concentric circles with their radial distance equal to value „t" at under consideration cross section. That means the entire extracted (real) circumferential line of random cross section of cylindrical or conical surfaces must be found between two complanationary (that are inboard one plane) concentric circles with their radial distance that is specified by tolerance on mechanical drawing.

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Roundness plane is perpendicular to the roundness axis within the full extent of the feature. Measured is real surface of a workpiece, which is an integral feature part of real surface of a workpiece limited by the adjacent real (integral) features. Thus, roundness profile which is defined as extracted circumferential line (digital representation of the intersection of the real surface and the roundness plane) intentionally modified by a filter can be determined.

Circle that is faced with measured profile is called "reference circle". This is defined as an associated circle fitting the roundness profile in accordance with specified conventions, to which the deviations from roundness and the roundness parameters are referred. Reference circle can be:

1. *Minimum zone reference circles MZCI:* two concentric circles enclosing the roundness profile and having the least radial separation (see Fig. 1):
   - *outer minimum zone reference circle:* outer circle of the minimum zone reference circles;
   - *inner minimum zone reference circle:* inner circle of the minimum zone reference circles;
   - *mean minimum zone reference circle:* arithmetic mean circle of the minimum zone reference circles.

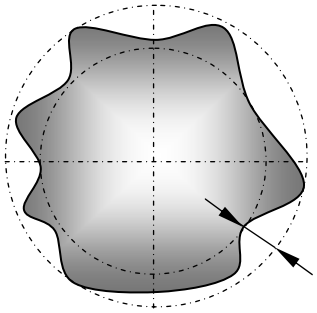


Fig. 1 *Minimum zone reference circles MZCI*

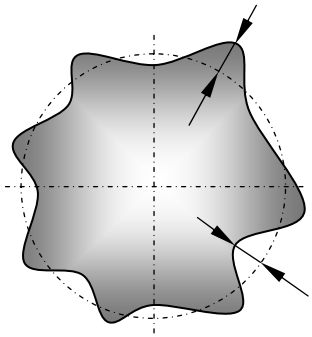


Fig. 2 *Least squares reference circle LSCI*

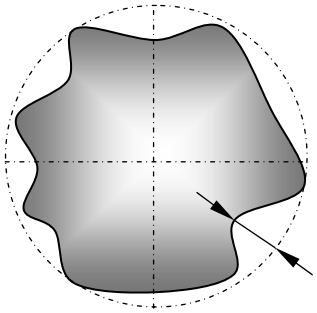


Fig. 3 *Minimum circumscribed reference circle MCCI*

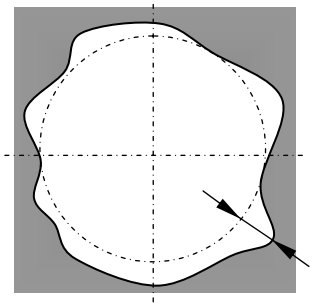


Fig. 4 *Maximum inscribed reference circle MICI*

2. *Least squares reference circle LSCI:* circle such that the sum of the squares of the local roundness deviations is a minimum (see Fig. 2).

3. *Minimum circumscribed reference circle MCCI:* smallest possible circle that can be fitted around the roundness profile (see Fig. 3).
4. *Maximum inscribed reference circle MICI:* largest possible circle that can be fitted within the roundness profile (see Fig.4).

Roundness measuring methods

Basic roundness measuring manners are presented in Fig. 5. Experimental work was carried out by Prismo Navigator 5 coordinate measuring machine using a multi-point method (Fig. 6). Measurements were made with 8, 16, 32 and 64 points and scanning with 500, 1000, 2000 and 4000 points. Measured was the turned and grinding surface.

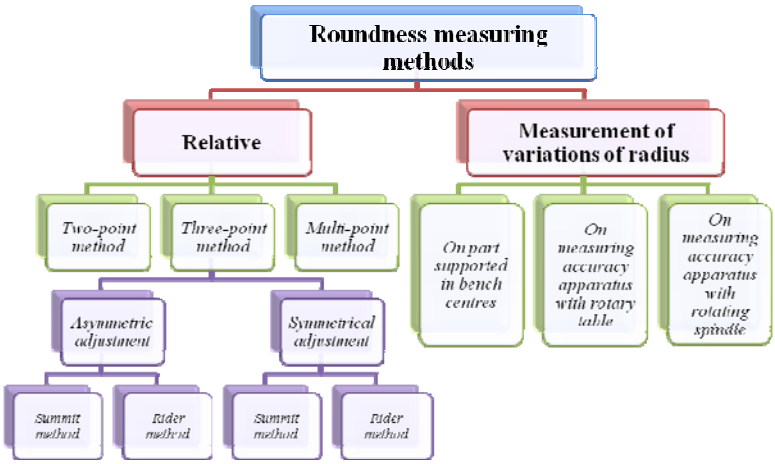


Fig. 5 *Basic roundness measuring manners [3]*

Fig. 6 *Prismo Navigator 5*

Filtering data

To evaluate deviations of form, data are filtered. Via a suitably chosen touch (e.g. large diameter balls), it is possible to eliminate the roughness element. Sensor is used as a mechanical filter. This arises through the form and radius of the sphere which is replicating the workpiece surface. Other harmonic components need to be eliminated by filtering [2]. Filtering can be simply called the smoothing of the recorded profile, as it removes undesirable elements (in this case, data or points). Evaluation Software offers several filters. It is not possible to specify clearly the best one. The most common ones include:

2RC filter (RC - Resistor and Capacitor) - This type of filter was taken from the filtering of sound waves and is the oldest of the methods.

Gauss filter is newer than 2RC and used more often than 2RC. It solved the problem of non-linear phase of the 2RC and could be implemented digitally quite easily. Commission for approval of ISO standards introduced Gauss filter for filtering the measurement data of 2D profiles as a standard [4].

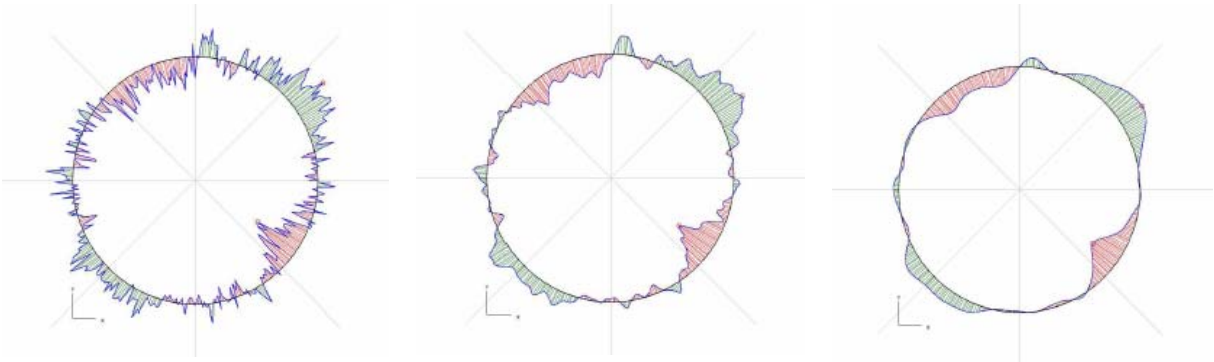
Spline filter is the latest method of filtering. When compared with the Gauss filter, it has better results. It was approved as an ISO standard in 2006. It eliminates two problems associated with Gauss filter: edge distortion and poor results achieved in measuring larger parts [5].

In case of roundness, the value is set up to display the harmonics components (UPR - undulations per revolution). Waves with high frequency (short period) represent the surface roughness, mid-frequency - waviness and low frequency - form of profile. All the harmonic components together create the primary profile. To view harmony, the following filters are used:

Low-pass - filtered harmonic components with high frequencies. It usually filters roughness, while waviness remains. An example is presented in Fig. 7.

Height-pass - is the opposite of low-pass filter. Long wave (waviness) is filtered and short wave (roughness) remains unchanged.

Band-pass - is a combination of low-pass and high-pass filters. Filtered harmonic components in that range (waviness and roughness).



a) without filter b) low-pass filter to 50 UPR c) low-pass filter to 15 UPR

Fig. 7 *Filtered profile [6]*

Results of experimental work

Results of measured roundness are presented in Fig. 8:

- for turning and grinding surfaces,
- for different numbers of points,
- for Gauss filter, spline filter and without filter,
- for MZCI, LSCI, MCCI and MICI methods.

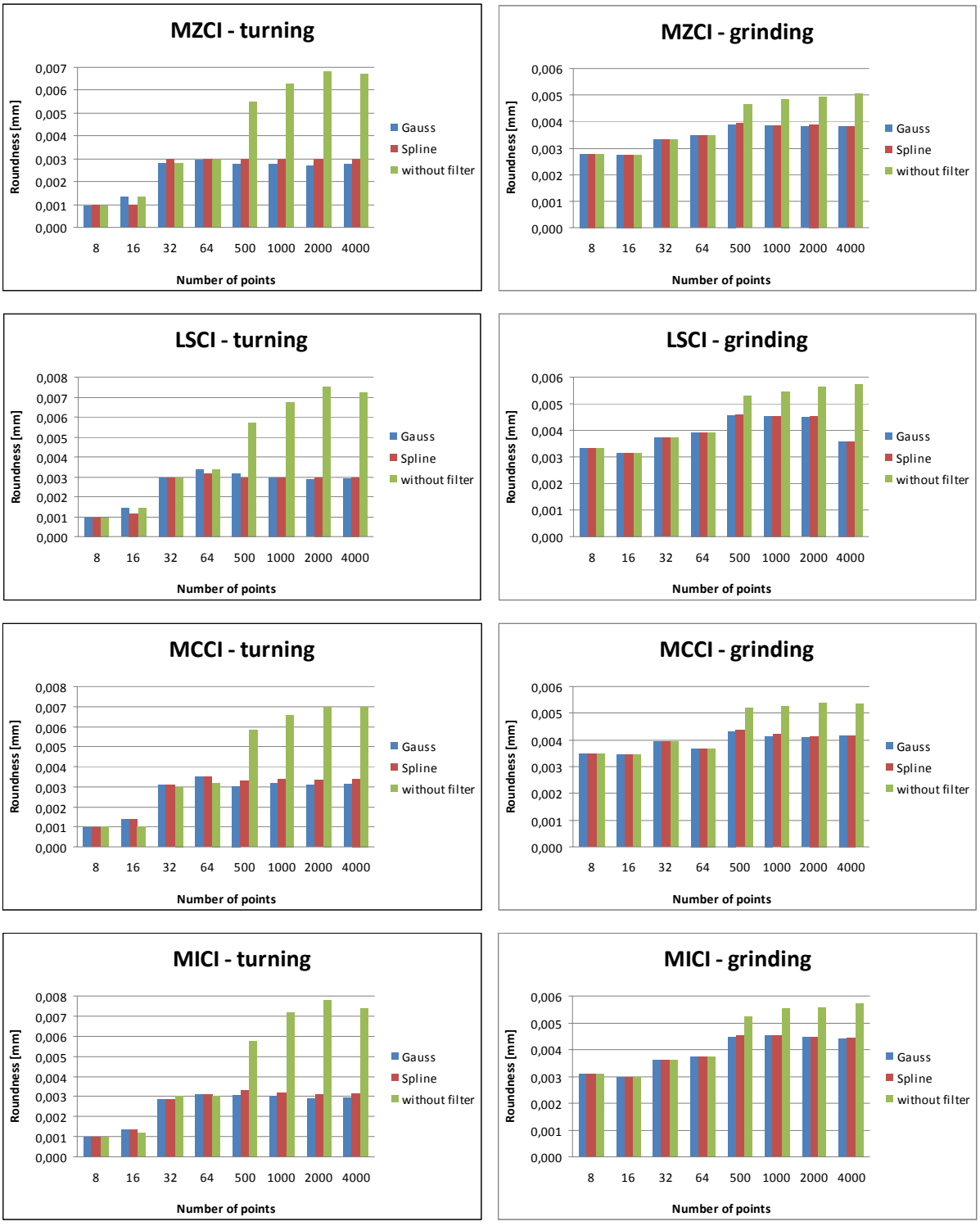


Fig. 8 *Roundness turning and grinding surface – MZCI, LSCI, MCCI and MICI methods*

Conclusion

Results of the measured roundness indicate the following:

- In turning area, the number of points 8 and 16 is inadequate (for all methods - MZCI, LSCI, MCCI and MICI). Results there were smaller. With higher number of points, roundness varied a little.
- In grinded surface, the values measured with 8, 16, 32 and 64 points were smaller than those measured by scanning.
- When using 8, 16, 32 and 64 points, the roundness was similar for all filters.
- In scanning without filter, roundness is significantly higher than when using Gauss and Spline filters.

In conclusion we can say that, when measuring roundness, it is appropriate to use scanning and filter data.

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