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EVALUATION OF MEASUREMENTS SYSTEMS AND METHODS

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ABSTRACT
Production metrology is an extremely dynamic field of mechanical engineering, its historical development can be divided into 5 stages. All those stages brought on novel and improved ideas compared to the previous ones. However, the question arises: how great a development has truly been achieved? The best method to answer this question is to analyze the capabilities of the metrological systems and compare the results measured using these systems. System capability analysis is best performed on a specific task.
This paper will analyze the measurings of a single geometrical feature – roundness, and through this the system capability analysis will also be carried out on the various metrological systems and methods for determining those. Following the analysis, the results will be represented in numerical form based on a point system, which will make comparison easier. Evaluation happens by ranking based on the given points.
The paper will offer conclusions of the evaluation based on the achieved results.
Key words: roundness, CMM, measuring

1. INTRODUCTION

Modern metrology is the science on measurings, methods, and means of ensuring their units and modes of achieving the necessary accuracy. This work will analyze a single geometrical feature – roundness, and through this analyses of various measuring systems and methods for determining measuring systems will be conducted. The given task will be realized based on the principles of current methodologies for research and scientific work, with the application of statistical methods. Due to space limitations this work will show the results in the form of tables, these results were achieved after having conducted measurings and studies on the applied systems and methods. The applied methods and measuring systems are as follows:

a) Measuring in a prism (measuring on the outer surface of the cover of the measuring-control object with three points of contact),
b) Measuring on the Abbe measuring machine (measuring on the interior surface of the cover of the master rings with two points of contact),
c) Measuring on the coordinate measuring machine (by scanning the measuring surfaces), and
d) Measuring on special measuring machines for measuring roundness (Roundtest – Mitutoyo).

Based on the achieved results, and taking into consideration some other, significant circumstances the used methods were ranked. This ranking was done by simply categorizing the methods based on various criteria. These criteria are described in detail below.

2. DESCRIPTION OF CRITERIA FOR EVALUATION AND PRESENTATION OF SOME PARTICULAR RESULTS OF THE RANKING

a) Accuracy of the results

The most important criterion of the ranking is the size of the expected accuracy of the result, i.e. the degree of uncertainty. This criterion is taken on the basis of the technical information of the applied measuring device. Naturally, the question arises as to the authenticity of these data received from the manufacturers of the measuring instruments, however, based on the conducted measurings and comparative analysis it can reliably be stated that the data are within the scope of reality (see Table 1.).

Table 1. Ranking based on the criterion of accuracy of results

Ranking of the method	I	II	III	IV
Measuring in a prism		X		
Measuring on the Abbe measuring machine			X	
Measuring on the CMM				X
Measuring on the Roundtest machine	X			

b) Overall output values of the measuring

This criterion evaluates the amount of included details in the measuring report. Actually, the more details are included in the report, then, the more parameters suitable for analysis, the more relevant parameters, the easier it is to reach a final conclusion even based on a smaller number of measurings. This criterion is vital in manufacturing conditions, as the time factor is one of the most important ones that has a direct influence on the manufacturability of the machining system (see Table 2.).

Table 2. Ranking based on the criterion of overall output values of the measuring

Ranking of the method	I	II	III	IV
Measuring in a prism				X
Measuring on the Abbe measuring machine				X
Measuring on the CMM		X		
Measuring on the Roundtest machine	X			

The other criterions will be presented without explanations, only with the table of results of ranking.

Table 3. Ranking based on the criterion of the possibility of different representations of results

Ranking of the method	I	II	III	IV
Measuring in a prism				X
Measuring on the Abbe measuring machine				X
Measuring on the CMM		X		
Measuring on the Roundtest machine	X			

Table 4. Ranking based on influence of the subjective factor of the operator of the measuring results

Ranking of the method	I	II	III	IV
Measuring in a prism			X	
Measuring on the Abbe measuring machine			X	
Measuring on the CMM	X			
Measuring on the Roundtest machine	X			

Table 5. Ranking based on the duration of the measuring

Ranking of the method	I	II	III	IV
Measuring in a prism			X	
Measuring on the Abbe measuring machine				X
Measuring on the CMM		X		
Measuring on the Roundtest machine	X			

Table 6. Ranking based on the applicability of the method for determining various types of dimensions

Ranking of the method	I	II	III	IV
Measuring in a prism				X
Measuring on the Abbe measuring machine				X
Measuring on the CMM	X			
Measuring on the Roundtest machine		X		

Table 7. Ranking based on the required degree of expertise of the operator

Ranking of the method	I	II	III	IV
Measuring in a prism	X			
Measuring on the Abbe measuring machine		X		
Measuring on the CMM			X	
Measuring on the Roundtest machine			X	

Table 8. Ranking based on the cost of the applied measuring device

Ranking of the method	I	II	III	IV
Measuring in a prism	X			
Measuring on the Abbe measuring machine		X		
Measuring on the CMM				X
Measuring on the Roundtest machine			X	

Table 9. Ranking based on the criterion of the capability of applying the method for extremely different overall dimensions

Ranking of the method	I	II	III	IV
Measuring in a prism				X
Measuring on the Abbe measuring machine				X
Measuring on the CMM	X			
Measuring on the Roundtest machine				X

Table 10. Ranking based on the repeatability of the measurings

Ranking of the method	I	II	III	IV
Measuring in a prism				X
Measuring on the Abbe measuring machine				X
Measuring on the CMM	X			
Measuring on the Roundtest machine	X			

In the tables shown above the ranking was based on the logic of technological and economic laws and requirements, meaning that the methods with the more suitable characteristics were ranked higher.

3. EVALUATION OF THE METHODS

Based on the results of the rankings of methods according to given criteria shown in the table above the final evaluation table can be drawn up. Table 3.1 presents the final scores of each method as a sum of the points scored according to the separate criteria. As the points actually represent placements in the ranking, this means that the highest amount of points is also the best placement.

Table 11. Table showing the results of the ranking

RESULTS OF THE RANKING					
Ranking of the method	I. times	II. times	III. times	IV. times	Sum of points
Measuring in a prism	2	1	2	5	***30***
Measuring on the Abbe measuring machine	0	2	2	6	***34***
Measuring on the CMM	5	2	1	2	***20***
Measuring on the Roundtest machine	6	1	1	2	***19***

4. CONCLUSION

The results of the final evaluation of the methods does not only concern roundness but much wider aspects. This ranking is a summary of all technological, economic and other aspects of machine construction and its narrower segment, metrology. The listed criteria may not include all relevant factors for analysis but the most important ones are certainly included. Naturally, this list can be expanded.

The scores give a clear view of the capabilities and possibilities of the analyzed methods. Modern methods, as expected, are higher ranked that conventional methods. However, what deserves special attention is the almost equal placement of the coordinate measuring machines and the special machines Roundtest. This statement lends proof for the hypothesis that the CMM's are sufficient in a manufacturing system to ensure roundness control, even though at the point of uncertainty they lag behind the rival Roundtest machine.

5. REFERENCES

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