EXPERIMENTAL MEASUREMENTS OF SHAPE DEVIATIONS OF MACHINE COMPONENTS

LUBA BICEJOVA

Technical Universtity of Kosice
Faculty of Manufacturing Technologies with a seat in Presov
Department of Technical Systems Design and Monitoring
Presov, Slovak Republic

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e-mail: luba.bicejova@tuke.sk

The paper deals with the analysis of shape deviations, causes of their origin and offers their brief overview. At the same time it points out the methods and possibilities of measurement of shape deviations by means of contact and contactless techniques. The paper focuses also on errors which might influence the measurement results. The main aim of the presented paper is practical measurement of shape deviations by means of the most frequently employed measuring devices. It provides the overview of the particular measured values and presents the view of effectiveness, simplicity and accuracy of the individual measuring methods and devices.

KEYWORDS

tolerance, measurement errors, deviations

1 INTRODUCTION

Measurement of geometrical deviations represents in practice rather significant line of measurement. Such measurements represent 90% of all measurements performed in engineering industry. Demands regarding the employed measuring instruments and procedures are constantly increasing due to continual increase of production tolerances [Mascenik 2014a].

At the same time demands laid on surface quality of products increase. Geometrical tolerances currently range within the scope of micrometric and nanometric values. To assure such qualitative requirement the specialized measuring devices have been credited high prominence which through connection with a computer station offer extensive possibilities of simple and fast evaluation of surface quality. Uncertainty of measuring by these special measuring devices reaches micrometers and therefore it represents the first-rate yet adequately expensive group of measuring devices[Gaspar 2013].

The presented paper is devoted to analysis of shape deviations in component check and to characteristics of contact and contactless measuring methods as well as to errors influencing the measuring results [Bicejova 2013a]. Special attention is paid to practical measurement and evaluation of the measured shape deviations. The paper presents determination and comparison of the measured values of geometrical deviations with diverse measuring devices and methods[Salokyova 2016a].

2 ANALYSIS OF SHAPE DEVIATIONS IN COMPONENT CHECK

Surface of each component constitutes of functional and free areas. Dimensions determining the functional areas must be tolerated to assure correct function of storing or assembly. Dimensions of free areas lime and determine the component shape yet its observation can be significant from the point of view of function. Magnitude of tolerances of the dimensions is selected to assure their observation under standard production and measuring conditions. These tolerances are determined by means of a joint drawing record[Salokyova 2016b].

Prerequisites of general tolerances and method of their prescription in the drawings are specified by the following standards:

STN ISO 2768 standard – 1,includes permitted deviation values regarding the following:

- length dimensions,
- interrupted edges,
- angle dimensions.

STN ISO 2768 standard – 2, specifies general geometrical tolerances regarding the following:

- straightness,
- flatness,
- perpendicularity,
- symmetry,
- circumferential flapping[Halko 2013].

Produced parts cannot be ideal as to accuracy. As to product geometry the shape of actual surface of a workpiece differs more or less from the shape of nominal surface. In fact, dimensions prescribed by the drawing are only theoretical. In production of parts occurred inaccuracies are caused by selected production technology, by production process and by human factor. The actual dimension of the part differs from the ideal one in certain respects. Differences from the nominal shape are referred to as deviations. Prescription of limits and of inaccuracies acceptable in production of parts is determined by tolerances, Tolerances determine just the deviation of actual characteristics from its prescribed nominal dimension [Mascenik 2012].

Each measurement result is error bound. The errors can be expressed as the absolute or the relative ones. The *absolute* error represents the difference between the measured and actual value of the measured quantity [Bicejova 2016a]. Ratio of absolute error and appertaining conventional actual value of the measured quantity is *relative* error. The measurement error represents a total value involving a number of partial errors, some of which occur systematically or randomly.

2.1 Sources of Measurement Errors

The most significant sources of measurement errors include the following:

- *device* errors: refer to errors stemming from imperfection of the applied measuring devices. Some of the errors occurring in production are eliminated; a producer indicates the values of other errors in the form of correction curves; the rest of the errors are indicated by the producer as the maximal permitted ones,
- *installation* errors: refer to errors stemming from demerits of connection, storage and setting of the measuring instruments and from mutual influence of measuring instruments, etc.,
- errors of *method:* refer to errors stemming from imperfection of the employed measuring methods,
- *observation* errors: refer to errors caused by imperfection of an observer,
- *calculation* errors: refer to errors occurring by processing of the measured values.

3 CONTACT METHOTS OF MEASUREMENT DEVIATIONS

3.1 Measured sample

Figure 1 shows the model of a machine part in case of which measurements of geometrical tolerances were performed. The sample was employed in measuring of collinearity between areas 1-2; 3-4;2-6; 1-5 and perpendicularity between areas 1-4[Mascenik 2016a].

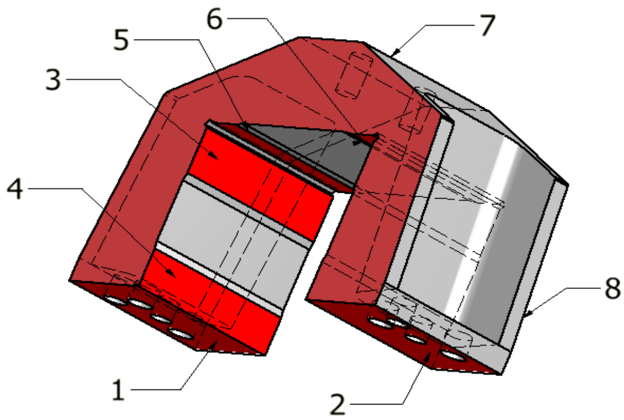

Figure 1. Model of a measured sample

The measurements were carried out with different measuring devices: SMS Rapid Thomet and contourgraph MarSurf XC 20. Their principle is based on contact measurement. These devices use contact sensors, but their accuracy is different due to principle of activity and to used measuring method [Bicejova 2016b]. The devices use different software for measured value evaluation. The first used measuring device was a 3D coordinate measuring machine Rapid by THOME Präcision, which is a portal SMS for high-speed scanning. It is recommended for measuring of specific elements, in many positions and under various angles. It is characterized by high accuracy, robustness and low demands for maintenance[Bicejova 2013b].

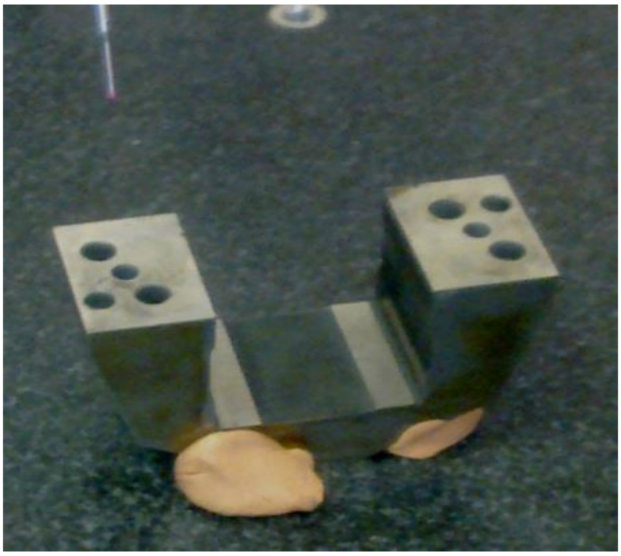

Figure 2. Measured sample

Figure 3. Coordinate Measuring Machines Rapid

The first used measuring device was a 3D coordinate measuring machine Rapid by THOME Präcision, which is a portal SMS for high-speed scanning. It is recommended for measuring of specific elements, in many positions and under various angles. It is characterized by high accuracy, robustness and low demands for maintenance [Smeringaiova 2016].

Type	**Rapid Thomet**
Measuring features	Scanning geometrical shapes – circle, cylinder, cone, plane
	Scanning of curve and common area curves
	Self-centering scanning of grooves, holes and hollows
Resolution	0.0005 mm
Measurement uncertainty in accordance to ISO 10360-2	2.2 + (L/350) µm, L – measured length in mm

Table 1. Features of Rapid device

The measuring device SMS Rapid, which was used for measurement, was equipped with a measuring software Metrolog XG [Mascenik 2011]. This software requires simple operation and extended graphical menu enables quick and effective measuring even to not trained users after couple of days.

Figure 4. Contourgraph Mar Surf XC 20

The other used measuring device was a countourgraph MarSurf XC 20, which is suitable for quick and simple evaluation of contours, components, tools or jigs. The moving part PCV 200 with replaceable measuring arm enables movement in X-direction (direction of feed) and movement in Z-direction (direction of scanning). In the direction of feed the measuring is done by an incremental sensor and in direction of scanning by an inductive sensor of high accuracy and linearity [Murcinkova 2013].

Scanning force (Z-axis)	1 mN – 120 mN
Resolution (Z-axis) related to sensor tip	0.5 mm with measuring arm 350 mm long
Resolution (Z-axis) related to measuring system	0.04 µm
Positioning accuracy (both X and Z axes)	1 µm
Sensor tip radius	25 µm

Table 2. Features of MarSurf XC 20

Evaluation and operation is carried out by software MarWin which enables to set scanning parameters as the measuring arm automatic dropping and rising, scanning speed, positioning before and after measuring as well as standard and segment profile scanning[Mascenik 2016b].

4 EVALUATION OF THE MEASURED DEVIATIONS

The first step taken in the measuring was calibration of instruments in order to determine accurate values. Consequently, by means of a scan head of the measuring device Rapid three points in the area 1 and 4 were scanned. The three points were selected to allow the device to define the plane by means of points in Cartesian coordinate system. The software was employed in selection of the geometrical deviation which should be measured – perpendicularity. The measurement result is a measurement record containing the deviation values evaluated by measuring software[Bicejova 2016c].
Collinearity deviation of areas 3 and 4 represented other measured deviation in this case (Fig.5). Deviation value is of 0.001 mm and falls within the tolerance field.

		Real	Rated	ISO	Tol-	Tol+	Var.	Trend	Out of tol.
✔	02	0.001	0.001		-0,050	0.050	0.000		

Figure 5. Deviation values of collinearity measured by the Rapid device (3-4)

By using the measuring device Rapid similar measurement was employed in determination of values of collinearity and perpendicularity of other areas in question. The following measurement was focused on determination of the values of geometrical tolerances of the same areas yet with application of different device – MarSurf XC 20[Bicejova 2013c]. The analogous method of determination employed in determination of collinearity value between areas 3-4 by the Rapid device was applied in measurement of collinearity by the device of MarSurf XC 20. The deviation value is of 0.002 mm yet figure 4 shows evaluation of measurements in degrees as well. Contrary to area 4 the area 3 tends to increase by 0.02°C in measured length [Mascenik 2016c].

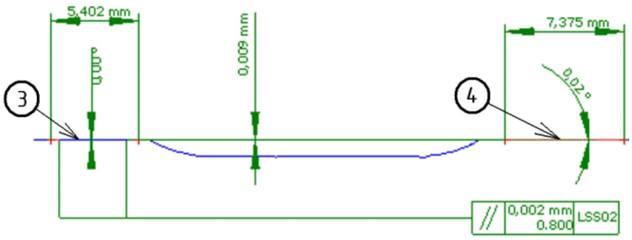

Figure 6. Deviation values of collinearity measured by MarSurf CX 20 (3-4)

Each of the geometrical deviations was measured by two measuring devices and contact methods of measurement were applied. The results of all measurements are summed up in the following Table 3 [Puskar 2012].

Measured geometrical deviation	Rapid	MarSurf XC 20
perpendicularity 1 - 4	0.011 mm	0.01 mm
collinearity 2 -6	0.005 mm	0.002 mm
collinearity 1 - 5	0.005 mm	0.002 mm
collinearity 1 -2	0.014 mm	0.010 mm
collinearity 3 - 4	0.001 mm	0.002 mm

Table 3. Overview of the values of measured geometrical deviations

5 CONCLUSIONS

The measured values of the shape deviations have proved that even in case of diverse types of measuring devices and different measuring methods observed can be negligible measurement deviations which might be the consequence of applied measuring method, of human factor, of environment influence and of measuring period. The term "measuring time"refers to measurement prior to or after calibrations of the respective measuring device [Mascenik 2014b]. The aim of the paper was to point out the alternative measurement of perpendicularity and comparison of the measurement results in case of randomly selected component.

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REFERENCES

[Bicejova 2013a] Bicejova, L., Pavlenko, S., Mascenik. J. Abrasive Granularity Impact on Water Jet Technology Head Vibrations during Cutting Steel. Applied Mechanics and Materials, 2013, pp. 304-309. ISSN 1660-9336

[Bicejova 2013b] Bicejova, L. Water jet technology head vibration generation due to selected technology parameters fluctuation effect during alloy cutting. Applied Mechanics and Materials, Vol.308, 2013, pp. 81-86. ISSN 1660-9336

[Bicejova 2013c] Bicejova, L. Abrasive kind and granularity changes affects to water jet technology head vibration during cutting HARDOX material thickness alternation process. Applied Mechanics and Materials, Vol. 308, 2013, pp. 75-79. ISSN 1660-9336

[Bicejova 2016a] Bicejova, L., Pavlenko, S., Mascenik, J. Measuring, processing and evaluating of technology head water jet vibration signal. Key Engineering Materials: Operation and Diagnostics of Machines and Production Systems

Operational States 3, Vol. 669, 2016, pp. 205-211. ISBN 978-3-03835-629-5, ISSN 1013-9826

[Bicejova 2016b] Bicejova, L. and Pavlenko, S. Experimental investigation and determination of abrasive granularity change impact to technology head vibration generating during awj technology steel cutting. Key Engineering Materials: Operation and Diagnostics of Machines and Production Systems Operational States 3, Vol. 669, 2016, pp. 220-227. ISBN 978-3-03835-629-5, ISSN 1013-9826

[Bicejova 2016c] Bicejova, L. and Pavlenko, S. Influence of selected technological parameters on cutting surface roughness in material laser cutting. MM Science Journal, Vol. 2016, No. September, 2016, pp. 973-976. ISSN 1803-1269, DOI: 10.17973/MMSJ.2016_09_201645

[Gaspar 2013] Gaspar, S., Pasko, J. Influence of technological factors of die casting on mechanical properties of castings from silumin, 2013. In: Lecture Notes in Electrical Engineering. Vol. 240, pp. 713-722. ISSN 1876-1100

[Halko 2013] Halko, J. and Mascenik, J. Differential with an integrated, newly - developed two-stage transfer. Applied Mechanics and Materials: Materials Engineering for Advanced Technologies ICMEAT 2013, Vol. 510, 2014, pp. 215-219. ISSN 1662-7482

[Mascenik 2011] Mascenik, J. and Gaspar, S. Experimental Assessment of Roughness Changes in the Cutting Surface and Microhardness Changes of the Material S 355 J2 G3 after Being Cut by Non-Conventional Technologies. Advanced Materials Research, Vol. 314-316, 2011, ISSN 1022-6680

[Mascenik 2012] Mascenik, J. The evacuation of pressure moulds as progressive developments of die casting process, 2012. Acta Technica Corviniensis: Bulletin of Engineering, Vol. 5, No. 3, 2012, pp. 25-26. ISSN 2067-3809

[Mascenik 2014a] Mascenik, J. and Pavlenko, S. Aspects of alternative dispute creating bolted joint technology flowdrill. Applied Mechanics and Materials: 2nd International Conference on Mechanical Structures and Smart Materials, 2014, Kuala Lumpur, Malaysia. Vol. 680, 2014, pp. 186-189. ISSN 1660-9336

[Mascenik 2014b] Mascenik, J. and Pavlenko, S. Determining the exact value of the shape deviations of the experimental measurements. Applied Mechanics and Materials, Vol. 624, 2014, pp. 339-343, ISSN 1660-9336

[Mascenik 2016a] Mascenik, J. Experimental determination of cutting speed influence on cutting surface character in material laser cutting. MM Science Journal, Vol. 2016, No. September, pp. 960-963. ISSN 1803-1269, DOI:10.17973/MMSJ.2016_09_201639

[Mascenik 2016b] Mascenik, J., Pavlenko, S., Bicejova, L. A device designed to monitor new belt types with application of diagnostic system. MM Science Journal, Vol. 2016, No. September, 2016, pp. 931-934. ISSN 1803-1269, DOI: 10.17973/MMSJ.2016_09_201624

[Mascenik 2016c] Mascenik, J. and Vojtko, I. Experimental monitoring and diagnostics of belt gears in testing device. MM Science Journal, Vol. 2016, No. September, 2016, pp. 964-968. ISSN 1803-1269, DOI: 10.17973/MMSJ.2016_09_201641

[Murcinkova 2013] Murcinkova, Z. and Krenicky, T. Implementation of virtual instrumentation for multiparametric technical system monitoring. In: SGEM 2013: 13th International Multidisciplinary Scientific Geoconference: Informatics, geoinformatics and remote sensing, 2013, Bulgaria - Sofia: STEF92 Technology, pp. 139-144. ISSN 1314-2704

[Puskar 2012] Puskar, M. and Bigos, P. Method for accurate measurements of detonations in motorbike high speed racing engine. Measurement, Vol. 45, No. 3, 2012, pp. 529–534. ISSN 0263-2241

[Salokyova 2016a] Salokyova, S. and Krenicky, T. Analysis of the effects of factors in relation to vibration of technological head during the splitting of construction steels through hydro-abrasive splitting. Key Engineering Materials, Vol. 669, 2016, pp. 216-219. ISSN 1013-9826

[Salokyova 2016b] Salokyova, S. Measurement and analysis of mass flow and feed speed impact on technological head vibrations during cutting abrasion resistant steels with abrasive water jet technology. Key Engineering Materials, Vol. 669, 2016, pp. 243-250. ISSN 1013-9826

[Smeringaiova 2016] Smeringaiova, A. and Smeringai, P. Dynamic model of the test station for gear drives dynamic tests. Key Engineering Materials: Operation and Diagnostics of Machines and Production Systems Operational States 3, Vol. 669, 2016, pp. 434-442. ISBN 978-3-03835-629-5.ISSN 1013-9826

CONTACTS

M.Sc. Luba Bicejova, PhD.
Department of Technical Systems Design,
Faculty of Manufacturing Technologies with a seat in Presov,
Technical University of Kosice, Presov, Slovak Republic
Bayerova 1, Presov, 080 01, Slovak Republic
+421 51 772 6313,e-mail:luba.bicejova@tuke.sk