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The Issue of Contactless Setup before Measuring Process

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Abstract

Increasing demands on productivity of measurement and control processes deal with high demands on speed, reliability and repeatability of all the preparatory steps that precede the measurement itself. These activities are still productivity needed and the productivity effect is multiplied by a technological downtime carrying them considerable economic impact, direct value added product. A typical case is the initial adjusting of the turntable of roundness instrument and measurement of the surface parameters in a hole with small diameter. This title deals with these issues.
It describes the issue of compensation contact setting of roundness machine by contactless method including performance model and philosophy of determining measurement uncertainty. The initial proposal will be modified for specific task of CNC measuring parameters in the small diameter holes.

Keywords: Initial setup; contactless measurement; measurement uncertainty

1. Introduction

The increasing demands on productivity of measurement and control processes deal with high demands on speed, reliability and repeatability of all the preparatory steps that precede the measurement itself. These activities are still productivity needed and the productivity effect is multiplied by a technological downtime carrying them considerable economic impact, direct value added product. A typical case is the initial adjusting of the turntable of roundness instrument. It is known to be based on an air bearing and adjustable in two axes, while more sophisticated systems allow even vertical axis tilt. Before using of roundness instrument in the measurement process must first be measured in part centered the rotary table, which is in the majority of cases dealt with by appropriate folding table and using special products.[11] More difficult preparatory work is the precise setting of the rotary table. Currently is

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even on high-end measuring machines common to use measuring ruby stylus contact method adjusting before the main measuring process. See Fig. 1.

The method has high accuracy, despite the many disadvantages. One of the most important is the enormous demand for quality and purity of tactile surfaces used etalons ring. It is difficult to achieve even in a clean laboratory environment.

Nomenclature

u_A	uncertainty A
u_B	uncertainty B
u_C	uncertainty C
S_y^2	sample variance
$X_1 ... X_n$	measured values
X_{1e}, X_{2e}	averaged values
U_1, U_2	measured voltage
UWB	University of West Bohemia

The situation is complicated by the need for regular calibration standard preservation by grease or similar products. The result often is an imperfect cleaning of the etalon ring, which leads to unsuccessful initial setting of the machine. It is therefore the need for the process be repeated the initial settings several times. This is by duration of one cycle in the order of several tens of minutes on the machine in the price in the order of several millions more than side. These are obvious reasons for the replacement of the conventional contact method by modern noncontact method [1, 2].

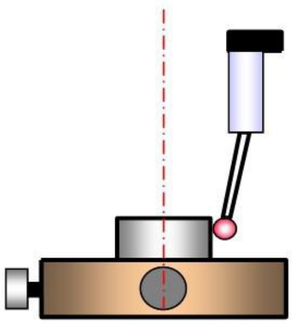


Fig. 1. Contact method.[10]

2. Experimental analysis

2.1. Experimental equipment for the establishment of contactless sensors

During a validation analysis in 2011 was introduced automatic test equipment that issue of initial setup aptly demonstrated and provided important initial data for functional and statistic evaluation methodology. The test set consisted of several parts; the most important was the Sensoric head that integrates laser scanner and accurate inductive sensor. Brain of devices working fully automatic mode has a basis in LabVIEW [9]. Use of technical equipment can be fully automated start-up in the correct position, thus eliminating the cumbersome and lengthy process of establishing a touch sensor. The proposed experimental device operates on a fully automatic cycle, which reduces the time required to set up and eliminates errors classical principle.

An experimental device (see Figure 2) was used for determining the exact location of the axis of rotation while changing the position of the axis of rotation of parts during the rotation of which is then detected roundness.

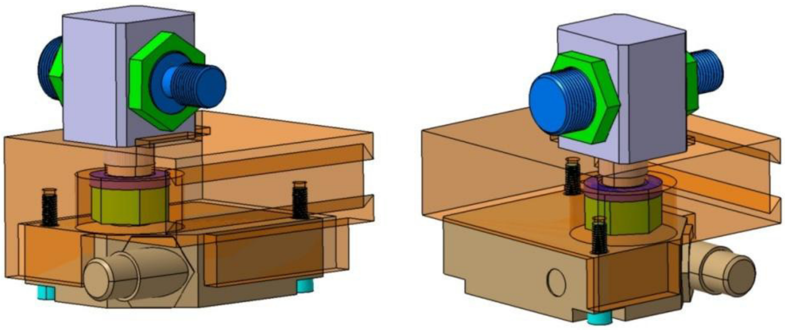


Fig. 2. Experimental testing equipment – Sensoric head.

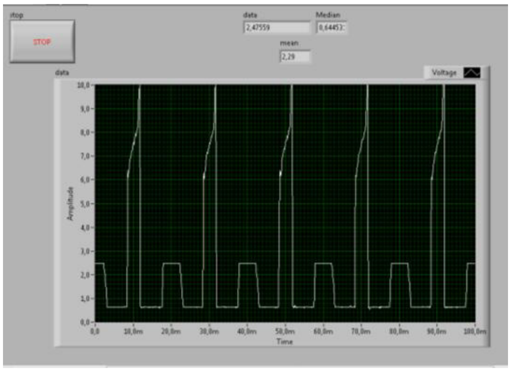


Fig. 3. Example of measured signal from the sensors.

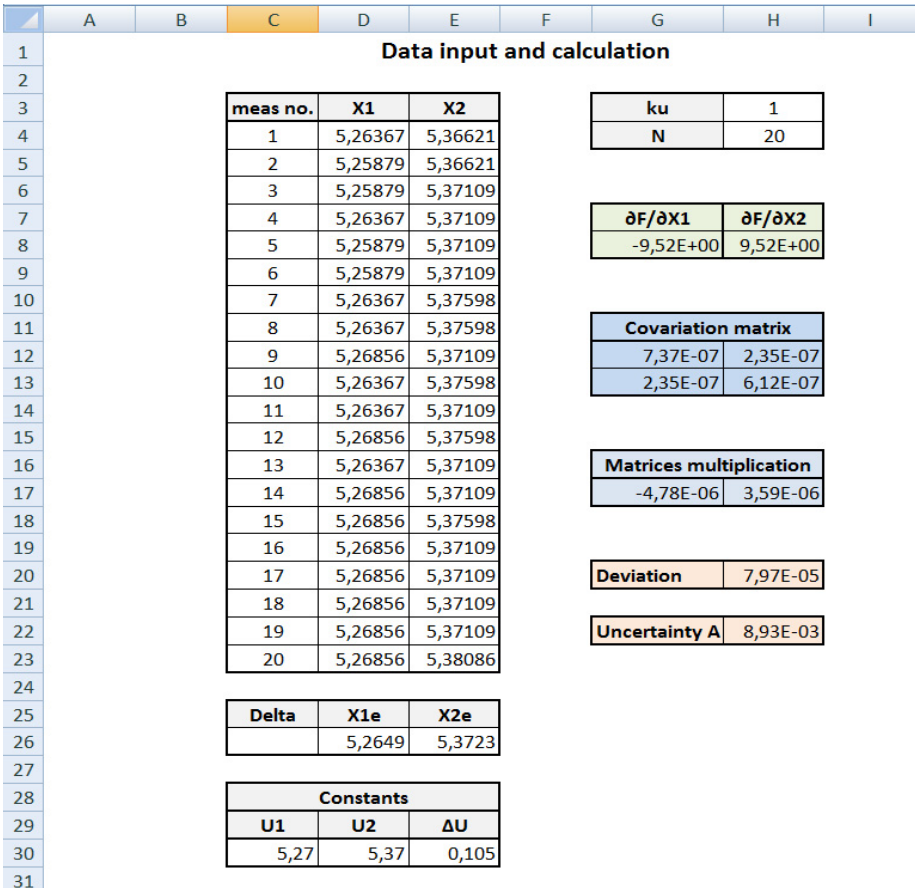
2.2. Uncertainty evaluation

The methodology for evaluating model device uncertainty of type A was determined in matrix form:

$$S_y^2 = \left(\frac{\partial f}{\partial x_1}, \frac{\partial f}{\partial x_2}, \dots, \frac{\partial f}{\partial x_m}\right) \begin{bmatrix} s_{\bar{x}_1}^2 & s_{\bar{x}_{1,2}} & \cdots & s_{\bar{x}_{1,m}} \\ s_{\bar{x}_{2,1}} & s_{\bar{x}_2}^2 & \cdots & s_{\bar{x}_{2,m}} \\ \vdots & \vdots & \ddots & \vdots \\ s_{\bar{x}_{m,1}} & s_{\bar{x}_{m,2}} & \cdots & s_{\bar{x}_m}^2 \end{bmatrix} \begin{pmatrix} \frac{\partial f}{\partial x_1} \\ \frac{\partial f}{\partial x_2} \\ \vdots \\ \frac{\partial f}{\partial x_m} \end{pmatrix} \qquad [8,7,3] \qquad (1)$$

To increase productivity of the methodology evaluation and to prevent of errors in the calculation process a macro for MS Excel was established. Standard uncertainty was determined from the experimentally measured values of the output voltage of the ΔU. [6]

Before determining the standard uncertainty of type B, it was necessary to verify the correlation of sources of measurement uncertainties, which was again realized with the help of statistical support MS EXCEL. An example of calculation is shown in Fig.4. [5,7]



Data input and calculation

meas no.	X1	X2
1	5,26367	5,36621
2	5,25879	5,36621
3	5,25879	5,37109
4	5,26367	5,37109
5	5,25879	5,37109
6	5,25879	5,37109
7	5,26367	5,37598
8	5,26367	5,37598
9	5,26856	5,37109
10	5,26367	5,37598
11	5,26367	5,37109
12	5,26856	5,37598
13	5,26367	5,37109
14	5,26856	5,37109
15	5,26856	5,37598
16	5,26856	5,37109
17	5,26856	5,37109
18	5,26856	5,37109
19	5,26856	5,37109
20	5,26856	5,38086

Delta	X1e	X2e
	5,2649	5,3723

Constants		
U1	U2	ΔU
5,27	5,37	0,105

ku	1
N	20

∂F/∂X1	∂F/∂X2
-9,52E+00	9,52E+00

Covariation matrix	
7,37E-07	2,35E-07
2,35E-07	6,12E-07

Matrices multiplication	
-4,78E-06	3,59E-06

Deviation	7,97E-05
Uncertainty A	8,93E-03

Fig. 4. Example of uncertainty calculation done in MS Excel.

For evaluation of uncertainty B statement it is necessary to determine the correlations between elements of measurement device. The correlations are shown in table 1. With respect to formula $uC = \sqrt{uA^2 + uB^2}$ were subsequently Combined uncertainty determined, which is equal to 206μm. Although this is the value for the use model in practice unacceptable, but it provides regard to the nature of device, the basic data set for the progressive improvement of the model. [4,5]

Table 1. Uncertainty correlation of used sensor .

Correlation	Inductive sensor	Laser sensor	Reference standard
Inductive sensor	1	-0,210413967	-0,158580527
Laser sensor	-0,210413967	1	0,380138003
Reference standard	-0,158580527	0,380138003	1

3. Device modification

The entire device has been extensively tested and successively modified for other metrological tasks. During 2013 the Department of Machining Technology has solved the evaluation of surface parameters inside the hole with a small diameter. See fig.5. For this issue, of course, the device of 2011 is not applicable and therefore it was necessary to radically modify the process. The actual detection parameters is performed on Roughness/Contour Hommel-ETAMIC T8000, which is capable of in a controlled environment to detect and measure the parameters in the accuracy of fully meeting the requirements of aerospace and automotive industries.

This equipment as well as other manufacturers' equipment provides measurements in only two axes and a possible shift the third axis is solved by manually or CNC controlled table, which can be obtained from the manufacturer in the supplementary equipment of machine.

Unfortunately, even this does not solve the accessories fully current issue for several reasons:

- Manual table allows for universal adjustment of third axis but unfortunately the lack of scale and an adjustment is quite slow and the operator after a certain time and laborious.
- CNC controlled table although working in automatic mode, but its purchase is financially quite challenging and, in addition, this solution does not provide for our case such an important safety system against manufacturing errors measured piece.

The way out of this situation is shown positioning device of new design that would combine the advantages of automatic operation cycle of CNC table and also stood in the "eyes of the operator" for precise positioning of roughness device in the hole. This is achieved by a new design of the positioning table in connection with significant innovated sensor system.

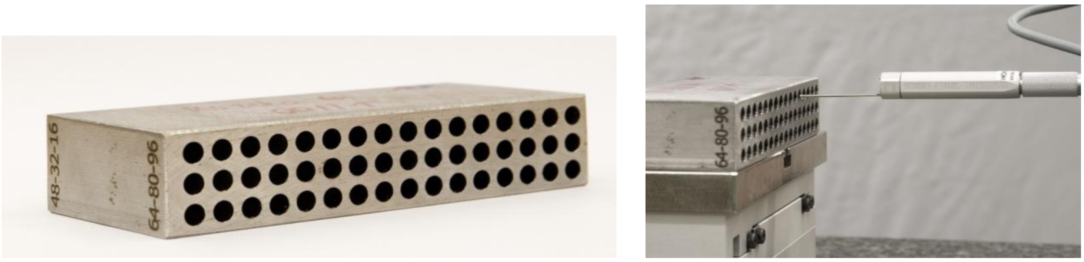


Fig. 5. (a) Measured piece with 96 holes (b) Roughness sensor approaching the hole for measurement.

4. Conclusion

Based on the experimental simulations it was found that the above described device provides an effective way to initial setup of the third axis of the roundness instrument. Because exerted contactless nature of the methodology and the resolution of HD camera, we obtain high accuracy while keeping a significant increase in the success of initial setup cycle. This is achieved substantial productivity gains the control processes. Also, the value of standard uncertainty remains at the same level as touch setup. Advantage, the decreased cost of the non-contact components compared to standard method based on the manual or CNC table, savings in labor time and expense-consuming machines, to which the contactless setup realized, as there is no need to operator surveillance over the process because of the anti-collision procedure. The proposed device is therefore a significant improvement and streamlining the setup process.

The model devices provides good results for both applications described above so the next step will be preparation next gen. of these models and their applications by using high precision machines by support of Regional Technological Institute (RTI-UWB). RTI under research project cooperate with many companies, which allows the usage of the devices and procedures in the reality of industrial sector.

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