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VERIFICATION OF THE MEASUREMENT SYSTEM IN A PRODUCTION ORGANIZATION

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ABSTRACT

Monitoring the accuracy of meters by qualified workers and managers is a preventive measure of every organization. The paper focuses on monitoring the accuracy of measuring devices and proposes preventive and corrective actions. The discussed measurement device was tested for accuracy using accuracy indexes C_g and $C_{gk.}$ The identified deviations in measurements showed that the meter was not fully efficient. Consequently, actions were taken to ensuring that the measurement device is accurate.

Introduction

The concept of quality is one of the most important factors in the field of contemporary production, as the competition in engineering is harsh. Clients choose products according to their quality, both visual and functional. Through quality verification, failures in production and complaints from customers can be prevented. Quality governs the production process, production workers, and quality controllers (Bujna and Beloev, 2015) and must always be managed by standards in force.

Quality controllers perform random quality tests during the production process (Žitňanský and Polák, 2019). They verify the quality of purchased parts as well as output control before the product is handed over to the customer. Authorized personnel inspect products based on measurements (Borovička et al., 2005).

Quality controllers measure products using meters, which must always have a valid calibration. The measurement device must always be tested for possible damage, correct set up in the standby mode, otherwise the meter could indicate true values (Petrík, 2004).

Accuracy of measurement devices is determined based on several elements. Based on deviations, it can be determined whether a measurement device is accurate, or not (Čech et al., 2005). Statistical methods are important in engineering practice, and include the analysis of measurement accuracy, as well as production equipment and process accuracy. These tools are an active part of process measurement in the application, development and continuous improvement of quality system effectiveness. Measurement is defined as the assignment of numbers to tangible matters to represent the relationships between them with respect to specific properties (Baráth et al., 2020). Data can be used for a variety of purposes in organizations. When a process is statistically unmanaged, the factors affecting the process are identified and corrective action is taken. These factors need to be classified according to their impact on the process and managed to achieve a steady state of the process (Kelemenová and Dovica, 2016). As long as the quality of the measured data is high, the quality of the measured data yields a high effect. Therefore, before determining the accuracy of the production equipment, the accuracy of the measurement instruments is assessed (Holub et al., 2018).

The objective of the paper was to find out the accuracy of measurement device in the specific organization by repeatedly measuring of the given product. Another objective is to find out the reason if the given measurement device shows deviations of the measured values. It is therefore important to determine the corrective measures and then determine the accuracy of the measurement device (Vicario and Pennecchi, 2020).

Material and methods

Quality in an organization nowadays is one of the most important factors. Thanks to quality we can resist competition on the market. Under quality we understand control, measurement and process of the whole production in an organization (Paulová, 2013). Measuring and controlling products allows preventing faulty products and ultimately, cutting operational costs in the organization. This is done by:

– calculating accuracy indexes of measuring devices C_g, C_{gk},
– calculating the percentage value of product repeatability and reproducibility.

The presented measuring device (Fig. 1) controls the quality of welded products, while evaluating the height and distance of the welded part to the product. It identifies whether the overall length, side distance, height and top distance of the welded product component is correct (Kuchtová, 2020).

The device consists of a bridge and an extension for the welded side part. It contains deviation meters, which are used to determine the differences between the welded piece and the sample piece. Deviation meters must always be checked for damage and looseness before measurement (Polák et al., 2016). It is important that the meter is always zoroed according to the standard before the measurement.

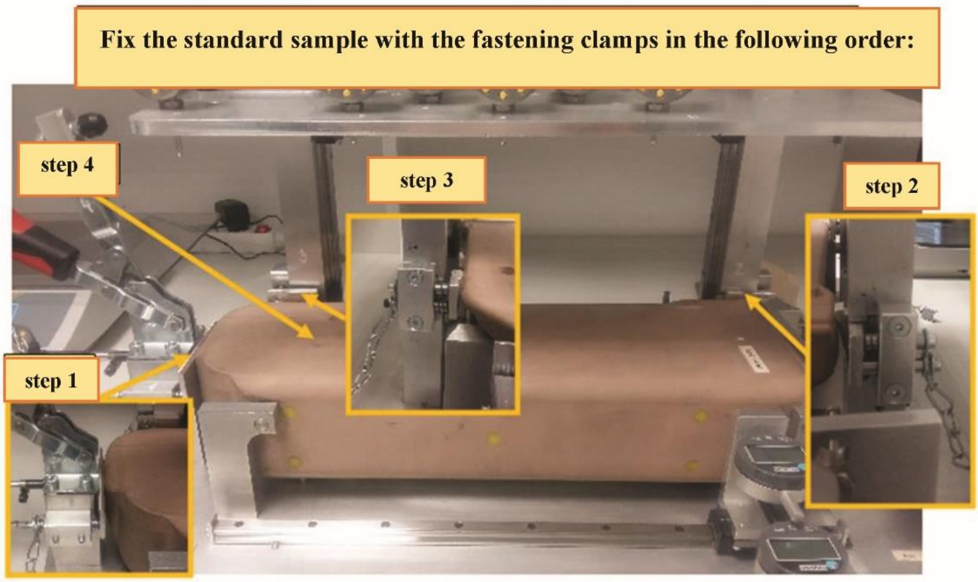


Figure 1. Measurement equipment

Indexes of accuracy C_g and C_{gk}

The prerequisite to identifying mean indexes of accuracy is to perform a measurement of the standard in the same order as the actual measurement. The measurement must always beperformed in the same place.

First, arithmetic mean and standard deviation must be calculated:

$$\bar{x} = \frac{1}{n}\sum_{n=1}^{n} x_i \tag{1}$$

$\bar{x}$ – arithmetic mean,
n – subgroup scope,
x_i – i-measured value.

$$\sigma_g = \sqrt{\frac{1}{n-1}\sum_{k=0}^{n}(x_i - \bar{x})^2} \tag{2}$$

σ_g – standard deviation of measured values

$$C_g = \frac{0{,}2(USL-LSL)}{6.\sigma_g} \tag{3}$$

C_g – index of accuracy of the measuring device,
USL – upper tolerance limit,
LSL – lower tolerance limit.

$$C_{gk} = \frac{0,1.(USL - LSL) - (X_r - \bar{x})}{3.\sigma_g} \quad (4)$$

C_{gk} – corrected index of accuracy,
X_r – adopted reference value of the standard

Results

Test equipment for the meter

As part of the conducted calibration of the studied measuring equipment, it was found out that the material is not solid and deviates in contact with the tips. To prevent it, metal points were made to measure, to be located in places of contact with the deviation meter.

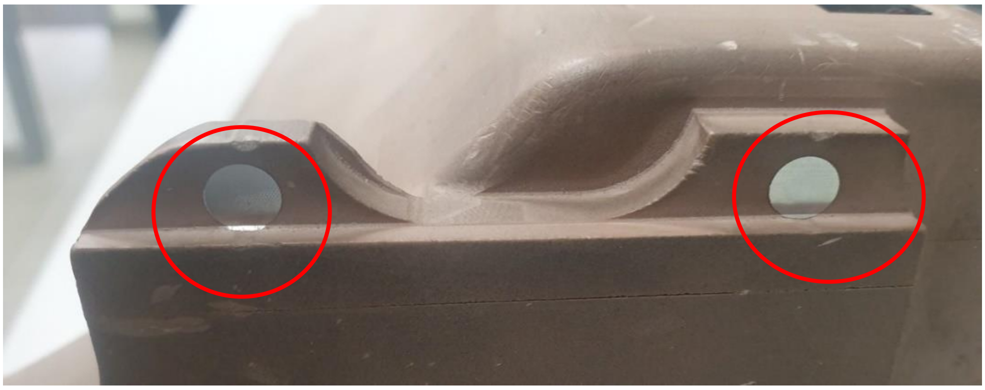


Figure 2. Details of metal tips on the standard

The measurement was stabilized, but in four places it was not possible to make metal markings on the standard, to allow determining corrective measures, namely the replacement of tips on the standard. The tips (Fig. 2) were replaced with other tips (Fig. 3) to avoid discrepancies in measurements. It was necessary to replace them with tips with a larger contact area, so that the contact with the product is more stable (Kuchtová, 2020).

The individual tips on the deflection gauges proved stable and the measurement did not show a discrepancy. Replacement of the tips on the deflection gauges with tips with a smaller diameter of contact was to ensure that the contact with the product is stable.

After exchange of tips, the accuracy test of equipment was repeated, in which we found that the deviation meters showed a discrepancy again. The deviation meter for measuring the height and the deviation meter for measuring the upper distance of the welded part came into collision with each other (Fig. 4) and thus it was not possible to measure all deviations at the same time. The average of tips was too large, which caused us time losses and extended the total measurement time. It was inevitable to set up new corrective measures.

The deflection gauge for height measurement and the deflection gauge for measuring the top distance of the welded part collide with each other and thus it was not possible to measure with all deflection gauges simultaneously. The diameter of the end pieces was too large, which caused time losses and increased the total measurement time.

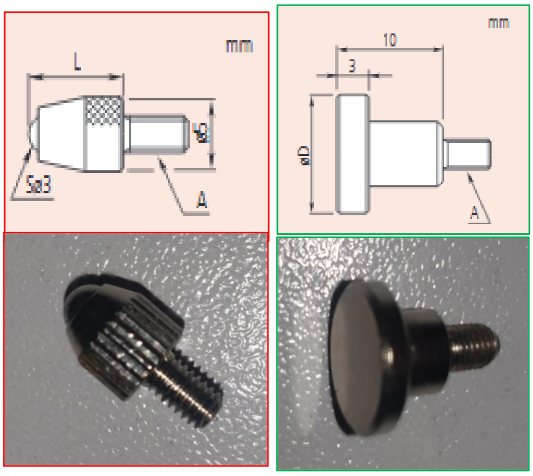


Figure 3. Metal tips

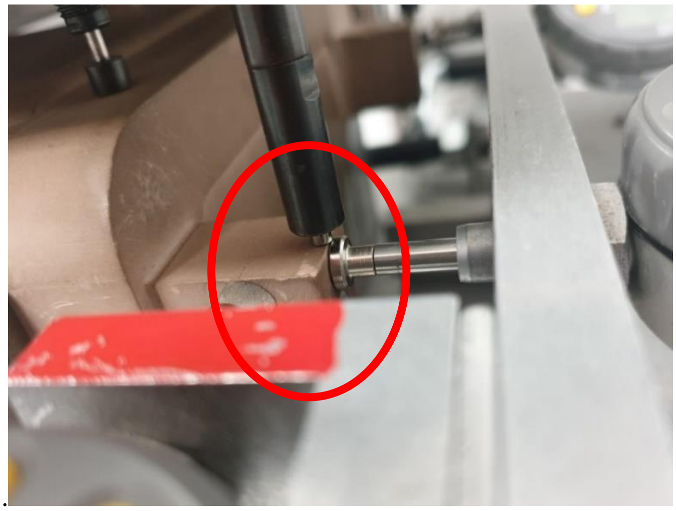


Figure 4. Collision display

The accuracy of the test equipment was performed for deviators used to measure the height and the upper distance of the welded part.

When it was determined that the test equipment is unfit for further measurement (Tab. 1), it was necessary to determine corrective measures with a deadline for the implementation and retest of the test equipment so that we could continue to use the gauge for quality control in series production as soon as possible.

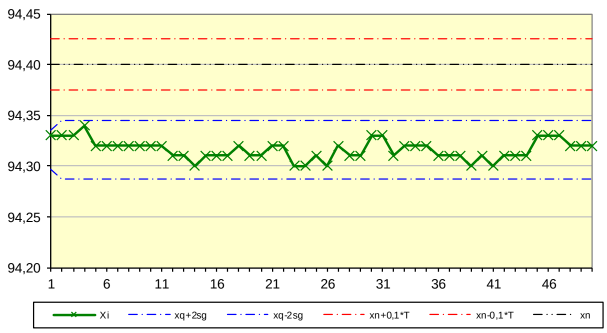
Table 1.
Form for "uncertainty of measurement" and index of accuracy C_g and C_{gk}

Process of control – method 1
"uncertainty of measurement" and index of capability C_g and C_{gk}

Date:	17.01.2022	Measure:	XYZ	Tried point:	height/left
Created by:	Kuchtová	No. of measure:	XYZ	Tolerance:	0,25
No. of product:	XYZ			Resolution	
Controler:	Prístavka			X Normal	94,40
	The confidence interval for calculating Cg and Cgk is 99,73% which corresponds to 6 s of the measuring instruments				6 s

Measurement	X_i
1	94,330
2	94,330
3	94,330
4	94,340
5	94,320
6	94,320
7	94,320
8	94,320
9	94,320
10	94,320
11	94,320
12	94,310
13	94,310
14	94,300
15	94,310
16	94,310
17	94,310
18	94,320
19	94,310
20	94,310
21	94,320
22	94,320
23	94,300
24	94,300
25	94,310
26	94,300
27	94,320
28	94,310
29	94,310
30	94,330
31	94,330
32	94,310
33	94,320
34	94,320
35	94,320
36	94,310
37	94,310
38	94,310
39	94,300
40	94,310
41	94,300
42	94,310
43	94,310
44	94,310
45	94,330
46	94,330
47	94,330
48	94,320
49	94,320
50	94,320

n	50	R	0,040000
xq	94,316	1 x s	0,010
max.	94,340	6 x s	0,058
min.	94,300		



C_g	=	0,2 * T / 6 x s Measure	=	**0,860**
C_{gko}	=	(Xq Normal + 0,1 x T) - xq Measure / 3 x s Measure	=	**3,750**
C_{gku}	=	xq Measure - (X Normal - 0,1 x T) / 3 x s Measure	=	**-2,030**
C_{gk}	=	Lower value from C_{gko} and C_{gku} is value of C_{gk} (minimum requirements C_g, C_{gk} > 1,33)	=	**-2,030**

Note:

Evaluation: Test equipment not capable

Signature

Note: Other indications for measurement uncertainty: (VDA 5) are repeatability (Q-DAS); repeatability (MSA-QS 9000)

Determining corrective actions

Corrective measures were performed in the following order:

1. Replacement of tips on deviation meters
2. Research and proposal of new tips
3. Implementation
4. Re-testing accuracy of the test equipment

Based on the results, the authors proposed an exchange of tips on deviation meters for tips with smaller contact area. At the same time, it must be ensured that these tips are not in stable contact with the product (Fig. 5).

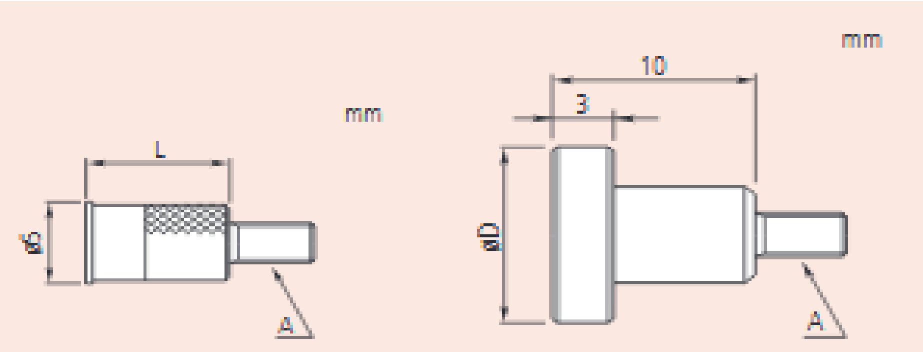


Figure 5. New tips on deviation meters

After exchange of tips we found put that between deviation meters there is no collision (Fig. 6).

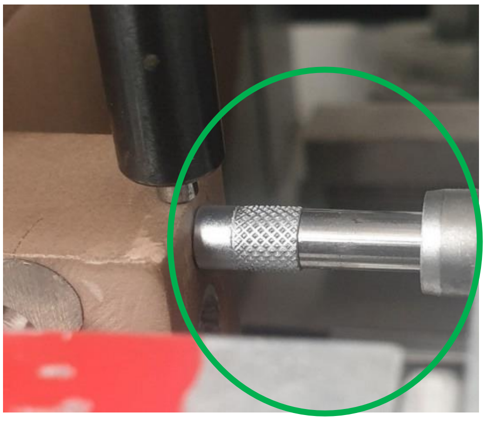


Figure 6. Between deviation meters there is no collision

The measurements were repeated to determine the measurement uncertainty (Tab. 2) and the suitability of the test equipment. The deflection gauges were used to measure the height and top distance of the welded part.

Table 2.
Form for "uncertainty of measurement" and index of accuracy C_g and C_{gk}

Process of control - method 1 "uncertainty of measuremnt" and index of capability C_g and C_{gk}

Date:	19.02.2022	Measure:	XYZ	Tried point:	height/left
Created by:	Kuchtová	No. of measure:	XYZ	Tolerance:	0,25
No. of product:	XYZ			Resolution	
Controler:	Prístavka			X Normal	94,40
	The confidence interval for calculating Cg and Cgk is 95% which corresponds to 4 s of the measuring instruments				6 s

Measurement	X_i
1	94,410
2	94,410
3	94,410
4	94,410
5	94,410
6	94,410
7	94,410
8	94,410
9	94,410
10	94,420
11	94,420
12	94,420
13	94,410
14	94,410
15	94,410
16	94,410
17	94,410
18	94,420
19	94,410
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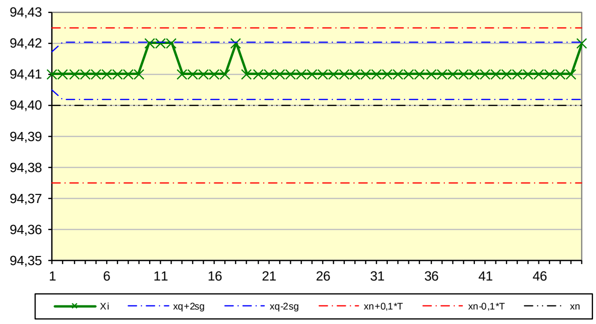
37	94,410
38	94,410
39	94,410
40	94,410
41	94,410
42	94,410
43	94,410
44	94,410
45	94,410
46	94,410
47	94,410
48	94,410
49	94,410
50	94,420

n	50		R	0,010000
xq	94,411		1 xs	0,003
max.	94,420		6 xs	0,018
min.	94,410			



C_g	=	0,2 * T / 6 xs Measure	=	**2,750**
C_{gko}	=	(Xq Normal + 0,1 x T) - xq Measure / 3 xs Measure	=	**1,540**
C_{gku}	=	xq Measure - (X Normal - 0,1 x T) / 3 xs Measure	=	**3,960**
C_{gk}	=	Lower value from C_{gko} and C_{gku} is value of C_{gk} (minimum requirements C_g, C_{gk} > 1,33)	=	**1,540**

Note:

Evaluation:	**Signature**
Test equipment is capable	

Note: Additional indications for measurement uncertainty: (VDA 5) are repeatability (Q-DAS); repeatability (MSA-QS 9000)

The method for determining the accuracy of a meter, which was used in the case of the single-purpose device in question, is of a general nature. It can also be used for other types of meters, whether single-purpose or general meters in serial or single-purpose production.

Conclusion

Determining the suitability of a measuring device using statistical methods is universal and can be used on a number of instruments and in a variety of processes. The effort and costs associated with the maintenance, calibration, or purchase of new and quality measuring equipment will multiply the organization's profits from quality products. A quality management system supports the organisation in keeping production under control and stabilizes the relationship between supplier and customer. Therefore, the use of measurement equipment in the production process should be a standard procedure and, as a rule, should be followed to check and determine whether the measuring equipment is fit for purpose.

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ANALIZA SYSTEMU POMIAROWEGO W PRZEDSIĘBIORSTWIE PRODUKCYJNYM

Streszczenie. Monitorowanie sprawności mierników to działanie prewencyjne każdej organizacji. Pracownicy działów jakości oraz osoby odpowiedzialne za kontrolę i pomiary wyrobów końcowych są zobowiązani do ciągłej kontroli sprzętu pomiarowego. W artykule skupiono się na monitorowaniu dokładności przyrządu pomiarowego oraz zaproponowaniu działań zapobiegawczych i korygujących. Dokładność przyrządu pomiarowego określono za pomocą wskaźników dokładności C_g i C_{gk}. Stwierdzono, że odchylenia w pomiarach świadczą o tym, że miernik nie jest w pełni sprawny. W związku z tym podjęto działania naprawcze, które zapewniły sprawność przyrządu pomiarowego.

Słowa kluczowe: sprawność przyrządu pomiarowego, powtarzalność, odtwarzalność