**DETERMINING THE TOTAL DISPERSION ZONE
FOR MICROMETER S_M MEASURING EQUIPMENT**

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Abstract

The aim of the total dispersion zone for measuring equipment S_M is to define if three workers A, B, C can achieve the same values of measurement using the same measuring equipment. Before estimating the total dispersion zone for measuring equipment S_M , the calibration of the micrometer was carried out. The values were obtained by measuring the width of clip anchor. It is necessary to calculate the average values $\bar{X}_A, \bar{X}_B, \bar{X}_C$ and to calculate standard deviations $s_{\Delta A}, s_{\Delta B}, s_{\Delta C}$ for three workers. Finally, the total dispersion zone S_M will be calculated and the results will be interpreted.

Key words

measuring equipment, average value, standard deviation, dispersion zone

Introduction

Requirements for quality have been lately widened to such a degree where they become a significant factor in company management. To manufacture some quality products, it is necessary to detect not just the capability of processes or the production facilities but also the capability of the measuring equipment.

The aim was to prove the capability of a micrometer and to meet the given requirement for the measuring system of the pressing process.

The capability of measuring equipment predicates of the operational capability of measuring tools and considers also the influence of the operators and the place of use [1].

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The functionality of measuring tools is expressed by indexes C_{gm} and C_{gmk}

- Index C_{gm} is the ratio $0.2 \times \text{sign tolerance } T$ to six times of standard deviation repeated measurements s_w ,
- Index C_{gmk} is the ratio $0.1 \times \text{sign tolerance } T$ to three times of standard deviation s_w , taking into account the position $\bar{X}_a$ measured by the tools.

Implementation:

The examination of measuring tools has to be done on the assumed place of use. Before the examination, it is necessary to calibrate the measuring tools. Normally the measurement has to be performed in the same place and the same position. At least 25 repeated measurements have to be done; the values are recorded in a form.

Defining the total dispersion of measuring tools S_M

Procedure:

Before the examination, the operator has to calibrate the measuring tools. Ten serial manufactured products, which have to be numbered, and measured twice, in the same order and place like before, have to be used. The measurement will be done by the operator A; 10 equivalent products will be measured by operators B and C. Values are recorded in the form. The differences between lines 1 and 2 will be calculated.

Materials and methods

As requested by MEVIS Slovakia s.r.o., Insize micrometer was used for total dispersion zone of measuring equipment S_M . The monitored feature – the width of the clip anchor with dimensions 7.5 ± 0.2 mm – was measured using this measurement tool. Three workers conducted the measurements, each of them measured 10 products, while the measurement was conducted twice.

Identification of measuring tool: Micrometer INSIZE 3104-80

Range of measuring tool: 50 - 80 mm

Product name: LEGRAND

Measured feature: width of handles

Feature value: 7.500 mm

Tolerance: $USL = 7.700$ mm

$LSL = 7.300$ mm

Real value: $X_r = 7.500$ mm

Operating staff: 3 workers

The amount of measured products: 10.

Before starting the examination of total scatter S_M it is necessary to prove the capability using the index C_{gmk} , the value of which has to be $C_{gmk} \geq 1.33$ [3]. If the index $C_{gmk} < 1.33$; afterwards will be proposed corrective measures, which will eliminate the cause of the detected non-compliance or other unwanted situations (changes in the surrounding temperature, adjust production equipment, collection of products, used material, human factor...).

$$C_{gm} = \frac{0.2.T}{6.s_w} \quad (1)$$

C_{gm} = lower value from

$$C_{gm} = \frac{(X_r + 0.1.T) - \bar{X}_a}{3.s_w} \quad (2)$$

or

$$C_{gm} = \frac{\bar{X}_a - (X_r - 0.1.T)}{3.s_w}, \quad (3)$$

where: s_w - standard deviation,

$\bar{X}_a$ - average value,

X_r - conventional true value,

T - sign tolerance.

Evaluation according to the methods s

Average values $\bar{X}_A, \bar{X}_B, \bar{X}_C$ and standard anomalies $s_{\Delta A}, s_{\Delta B}, s_{\Delta C}$ for each operator will be calculated.

Total scatter area S_M will be calculated as follows:

- average standard deviation of the measuring device

$$\bar{s}_\Delta = (s_{\Delta A} + s_{\Delta B} + s_{\Delta C}) \left(\frac{1}{3} \right), \quad (4)$$

$$\bar{s} = \frac{\bar{s}_\Delta}{\sqrt{2}}, \quad (5)$$

- standard deviation s_v caused by the operators and calculated from of three average values $\bar{X}_A, \bar{X}_B, \bar{X}_C$
- total scatter zone of the measuring device S_M :

$$S_M = \sqrt[6]{\bar{s}^2 + s_v^2}, \quad (6)$$

$$S_M \% = \frac{S_M}{T} \cdot 100, \quad (7)$$

where: T – sign tolerance.

We regard $S_M\%$ as follows:

$S_M\% = 0$ to 20 %	good.
$S_M\% = 21$ to 30 %	limited usable.
$S_M\% =$ more than 30 %	unacceptable [2].

EVALUATION OF THE TOTAL DISPERSION ZONE S_M (according to method s)

Table 1

MEVIS SLOVAKIA, s.r.o.	Form for evaluation of total dispersion zone S_M (according to method s)						Method 2		
							Level Nr: 1/1		
Nr. of facility M 13458	Measuring equipment MICROMETER INSIZE 3104-80				Year of production				
Data about product			Data about normal line			Data about product			
Name: Legrand			Name: standard			Cgm: 1.93			
Sign: width of clip anchor			Nr: 15			Cgmk: 1.87			
Real value: 7.500 mm			Real value: $X_r = 7.500$			Prepared: Kudičová			
USL = 7.700 LSL = 7.300						Date: 20.02.2011			
Measurement conditions:									
Measuring data : Measure: mm Value deviation:									
Worker	A			B			C		
Product	Line 1	Line 2	(1-2)	Line 1	Line 2	(1-2)	Line 1	Line 2	(1-2)
1	7.499	7.498	0.001	7.499	7.501	0.002	7.500	7.499	0.001
2	7.497	7.498	0.001	7.499	7.500	0.001	7.499	7.499	0.000
3	7.501	7.499	0.002	7.498	7.498	0.000	7.497	7.498	0.001
4	7.498	7.498	0.000	7.500	7.500	0.000	7.499	7.499	0.000
5	7.496	7.497	0.001	7.501	7.500	0.001	7.501	7.500	0.001
6	7.498	7.499	0.001	7.501	7.500	0.001	7.500	7.501	0.001
7	7.500	7.501	0.001	7.497	7.499	0.002	7.498	7.499	0.001
8	7.500	7.500	0.000	7.497	7.498	0.001	7.499	7.498	0.001
9	7.502	7.499	0.003	7.499	7.499	0.000	7.498	7.497	0.001
10	7.502	7.501	0.001	7.500	7.501	0.001	7.498	7.498	0.000
$s_{\Delta A} = 0.000831$ $s_{\Delta B} = 0.0007$ $s_{\Delta C} = 0.000458$ $\bar{X}_A = 0.0011$ $\bar{X}_B = 0.0009$ $\bar{X}_C = 0.0007$									
1. Average standard deviation of measuring equipment $\bar{s}$: Average standard deviation of difference Measure: mm $\bar{s}_\Delta = (s_{\Delta A} + s_{\Delta B} + s_{\Delta C}) \cdot (1/3) = 0.000662973$ $\bar{s} = \bar{s}_\Delta / \sqrt{2} = 0.000468793$									
2. Standard deviation s_v of average values $\bar{X}_A, \bar{X}_B, \bar{X}_C$ (handling effect) $s_v = 0.0001632993$									
3. Total dispersion zone of measuring equipment S_M $S_M = 6 \cdot \sqrt{\bar{s}^2 + s_v^2} = 0.079180207$ $S_M \% = (S_M / T) \cdot 100 = \mathbf{19.79 \%}$									
4. Results	S_M 0 – 20 % (good)			21 – 30 % (delimited)		> 30 % (deficient)			
Remark:	Date: 20.02.2011		Department: Q		Name: Kudičová				

Results and discussion

The first worker performed two consecutive measurements of one screw and then measured other nine products in the same way. Other two workers measured the same ten pressings in the same way as the first worker.

Revised screws were numbered and each worker carried out the measurements in the same order and the same place in the production hall. Measured data ($s_{\Delta A}$, $s_{\Delta B}$, $s_{\Delta C}$) were recorded in Table 1 for evaluation of the total dispersion zone of the measuring equipment S_M . Twenty values were measured for each worker. From these values were calculated: medium values $\bar{X}_A = 0.0011 \text{ mm}$, $\bar{X}_B = 0.0009 \text{ mm}$, $\bar{X}_C = 0.0007 \text{ mm}$ and further standard deviations for each worker $s_{\Delta A} = 0.000831 \text{ mm}$, $s_{\Delta B} = 0.0007 \text{ mm}$, $s_{\Delta C} = 0.000458 \text{ mm}$. Basically were calculated average medium standard deviations $\bar{s} = 0.000468793 \text{ mm}$ and handling effect deviation $s_v = 0.0001632993 \text{ mm}$. Finally, the total dispersion zone for micrometer $S_M = 19.79 \%$ was calculated. If this value was in the zone from 0 to 20 %, the measuring equipment was qualified as good. All measured data as well as the calculated values are shown in the form for the evaluation of the total dispersion zone S_M in the Table of the total dispersion zone S_M (Table 1).

Summary

Determining the total dispersion zone for measuring equipment S_M according to the method s proved that the measuring equipment can be qualified as good because the value was in the zone from 0 to 20 %. ($S_M = 19.79 \%$).

Similarly, the values of capability indexes $C_{gm} = 1.93$ and $C_{gmK} = 1.87$ proved that the measuring equipment, a micrometer, is capable. Based on these data, we can calculate their capability indexes and evaluate the process capability. This information signals the organisation a necessity of quality improvement, and simultaneously provides an evidence for a customer about the stability of production conditions.

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