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Monitoring the Manufacturing Process in the Selected Organization

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Abstract: *The goal of the article was to determine the capability of the manufacturing process of turning component „the turbine hub." The subject of the practical part is to measure 4 specific parameters on 100 collected samples. Measured results have been evaluated according to the specified methodology. It was being determined whether the variability and average of the process are in the statistically mastered state. The second parameter of the process did not complied with this requirement in three cases. Identified results of each four parameters are: first: P_p=1.803, P_{pk}=1.886. The process is capable when $P_p / P_{pk} \geq 1.67$. Production process was fully capable.*

Keywords: *quality management, production process, monitoring the capability of the manufacturing process, process capability index.*

INTRODUCTION

At present, the world market is full of organizations that seek to attract and, above all, maintain customers. Their goal must not only be the production of any kind of products. Their products must have a high level of quality so they can take on a potential customer because today's customers can choose what they buy and therefore it's their right to be demanding [1,6,13]. Therefore, it is necessary for the organization to constantly strive to be competitive. The right way is to introduce statistical control methods into the processes. One of these methods is to determine the capability of the production process. The ISO 9001 standard even requires and specifies the requirements for the quality management system and includes methods that help keep the production process in a stacked state. When these methods are applied correctly in practice, the quality of the process increases as well as the product quality and customer satisfaction [7,9].

Nowadays, it is essential for the organization to ensure that its products exhibit the highest possible quality. It depends on its survival in the market where there are a number of other competitive organizations. In this regard, one of the important tools for the organization is the use of statistical methods to control processes, which contribute to process, improvement, and make the final products meet the required quality [2,5,8]. The aim of the article was to apply statistical methods in quality management. In this paper, we investigated the short-term capability of the turbine cartridge turning process. This component is used in a four-speed hydrodynamic torque converter [4,16].

MATERIAL AND METHODS

In the given organization, we collected 5 parts of the components during 20 shifts. Sampling was done by random selection. About 100 samples were collected. On each of them, we measured the specified parameters and wrote down in the table, from which we subsequently produced the measured value card [17,18,20]. The measured data was divided into 20 subgroups of 5 measurements, which were processed according to the formulas given in the methodology [1,19,23]. The necessary values were recorded in the X-card and R card, which helped to determine whether the process is in a stacked state. If proven, we continued to investigate the process capability [10,22].

Evaluation of measured values

– *average range in subgroups*

$$\overline{X}_i = \frac{1}{n}\sum_{j=1}^{n} X_{ij} \tag{1}$$

i= 1,2,... k j = 1,2, ... n,
X_{ij} – measured value in i- subgroups
j –serial number of measured value in i- subgroups
k –number of subgroups
n –file size

− *interval in subgroups:*

$$R_i = MAX(X_{ij}) - MIN(X_{ij}) \tag{2}$$

i = 1,2,...k and j = 1,2,... n,
$MAX(X_{ij})$ a $MIN(X_{ij})$ maximum and minimum *measured value in i- subgroups*

− *calculation of equivalent span* $(\overline{R})$ *and average process* $(\overline{\overline{X}})$*:*

$$\overline{R} = \frac{1}{k}\sum_{i=1}^{k} R_i \tag{3}$$

− *average process:*

$$\overline{\overline{X}} = \frac{1}{k}\sum_{i=1}^{k} \overline{X}_i \tag{4}$$

$R_i, \overline{X}_i$ interval and averages in i- subgroups (i = 1,2,....k).
$\overline{R}$, $\overline{\overline{X}}$ in regulations diagrams produce central lines (CL).

− *calculation Specification limit:*

$$UCL_R = D_4.\overline{R} \tag{5}$$

$$LCL_R = D_3.\overline{R} \tag{6}$$

$$UCL_{\overline{X}} = \overline{\overline{X}} + A_2.\overline{R} \tag{7}$$

$$LCL_{\overline{X}} = \overline{\overline{X}} - A_2.\overline{R} \tag{8}$$

D_4, D_3, A_2: constant factor which is being changed by range of subgroup, in our case for 5 measured   rates in a choice $D_4 = 2.114, D_3 = 0, A_2 = 0.577$

Qualification of a process

Before counting of indicators of process qualification, a standard deviation should be estimated:

$$\hat{\sigma} = \frac{\overline{R}}{d_2} \tag{9}$$

$\overline{R}$ - average range in subgroups

d_2 - constant factor which is being changed by range of subgroup, in our case for 5 measured   rates in a choice **d_2=2.326**

− *capability process index* C_p *:*

$$C_p = \frac{USL - LSL}{6\hat{\sigma}} \tag{10}$$

USL – Upper Specification limit
LSL – Lower Specification limit

– *corrected Capability process index* C_{PK}*:*

$$C_{pk} = \frac{USL - \overline{\overline{X}}}{6\hat{\sigma}} \tag{11}$$

$$C_{pk} = \frac{\overline{\overline{X}} - LSL}{6\hat{\sigma}} \tag{12}$$

Component characteristics

Turbine charge is a component used in most cars and light and heavy trucks. It is located between the brake drums or wheels and the drive axle. On the axle side, it is mounted from the chassis to the holding console.

This component is part of a four-speed hydrodynamic torque converter. It is supplied as a semi-finished product that has a deformed outer and inner diameter [7].

Fig. 1 Component before trimming

Fig. 2 Component after trimming

Examined parameters

− 5.7 mm ± 0.05 mm lenght parameter, important feature.

Important feature – this dimension must be manufactured as precisely as possible, or it may cause problems in the future assembly of the component (in conjunction with the other components in the system). Labeling of the important features is determined after the design has been done in the production / assembly drawing, and the character is given in a rounded frame [11,12].

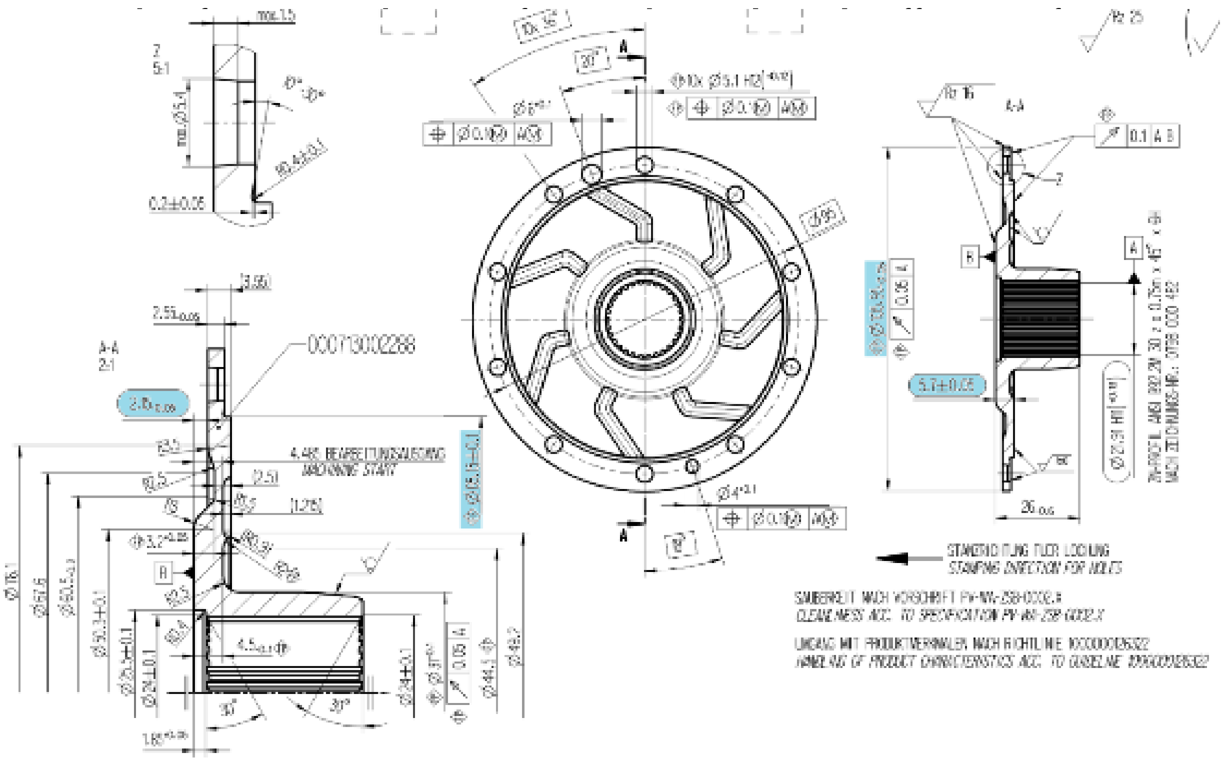

Fig. 3 The drawing of the component and the examined parameters

From a technological point of view, trimming is considered as the basic machining method. It is versatile, it can be machined by various external and internal surfaces.

Gauges

Examined component dimensions are controlled objectively by means of gauges (fig. 4). In these cases, a comparative measurement is performed using numerical deviations, in which the deviations are directly measured from the set dimension. It is determined if the dimensions are within the prescribed limits, which guarantee the assembly of the components without further modifications [7,15].

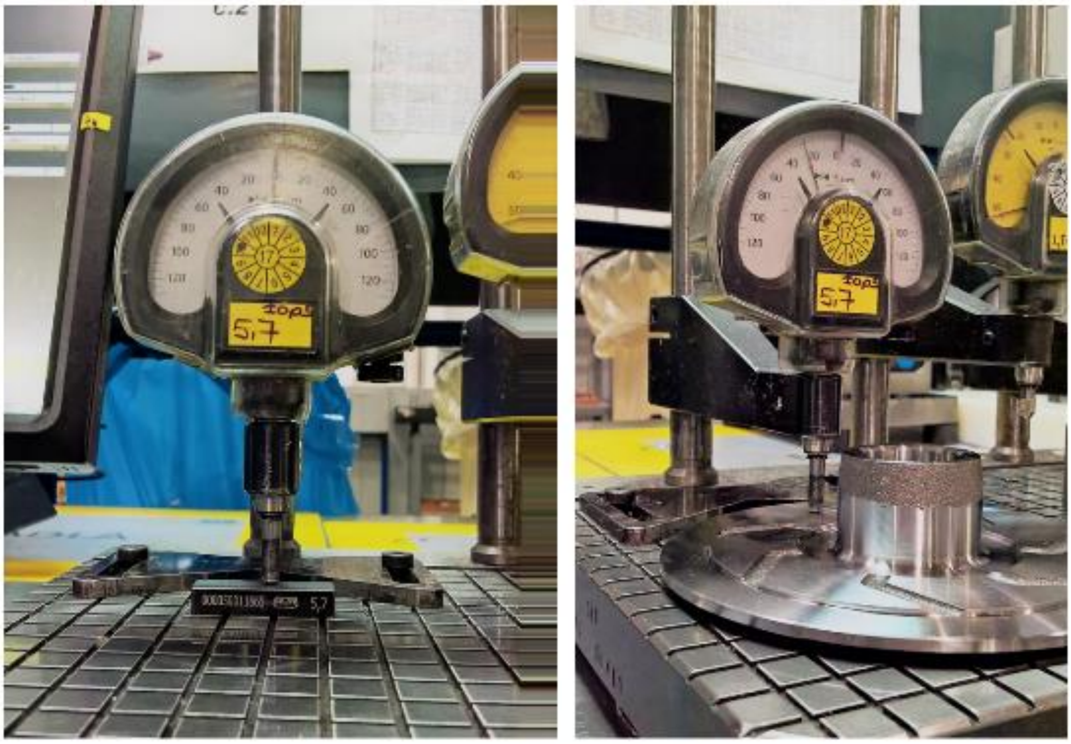

Fig. 4 Gauger for the dimension 5.7 mm ± 0.05mm

Evaluation of measured values

From each parameter, 100 values were collected, which were processed into 20 subgroups with 5 values. The collected data is graphically displayed in the measured values tab [7,14,21].

Determination of limit values

We calculated the mean value of the feature in the subgroup $\overline{X_i}$ the span in the subgroup R_i and the process diameter $\overline{\overline{X}}$ and the average span $\overline{R}$.

$$UCL_{\overline{X}} = 5.712 + 0.577\ x\ 0.0182 = 5.723 \tag{13}$$

$$LCL_{\overline{X}} = 5.712 - 0.577\ x\ 0.0182 = 5.702 \tag{14}$$

$$UCL_R = 2.114\ x\ 0.0182 = 0.0386 \tag{15}$$

$$LCL_R = 0\ x\ 0.0182 = 0 \tag{16}$$

The values were processed into $\overline{X}$ card and R card. They are analyzed individually. In the $\overline{X}$- card there are six points out of the regulatory limits. This process parameter is statistically unmanageable. There is no point in the R card outside of the regulatory limit. The process parameter is in a stacked state.

Parameter 5.7 mm ± 0.05mm

Tab. 1 Table of measured values divided into 5 subgroups for parameter 5.7 mm ± 0.05mm

5.7 mm ±0,05mm							
P.č.	X_1	X_2	X_3	X_4	X_5	$\overline{Xi}$	R_i
1	5.710	5.705	5.710	5.715	5.710	5.710	0.010
2	5.705	5.725	5.710	5.695	5.700	5.707	0.030
3	5.710	5.730	5.730	5.715	5.715	5.720	0.020
4	5.705	5.710	5.695	5.690	5.695	5.699	0.020
5	5.690	5.685	5.720	5.720	5.705	5.704	0.035
6	5.685	5.680	5.710	5.695	5.695	5.693	0.030
7	5.720	5.715	5.710	5.710	5.715	5.714	0.010
8	5.720	5.725	5.725	5.710	5.710	5.718	0.015
9	5.730	5.730	5.730	5.730	5.735	5.731	0.005
10	5.705	5.710	5.715	5.715	5.715	5.712	0.010
11	5.710	5.710	5.695	5.690	5.695	5.700	0.020
12	5.720	5.720	5.720	5.730	5.730	5.724	0.010
13	5.710	5.710	5.705	5.710	5.695	5.706	0.015
14	5.705	5.710	5.695	5.710	5.710	5.706	0.015
15	5.715	5.725	5.710	5.705	5.725	5.716	0.020
16	5.725	5.730	5.730	5.725	5.730	5.728	0.005
17	5.710	5.725	5.710	5.705	5.715	5.713	0.020
18	5.720	5.730	5.730	5.710	5.710	5.720	0.020
19	5.705	5.720	5.720	5.725	5.710	5.716	0.020
20	5.715	5.710	5.695	5.685	5.720	5.705	0.035
						$\overline{\overline{x}} = 5.712$	$\overline{R} =$ 0.0182

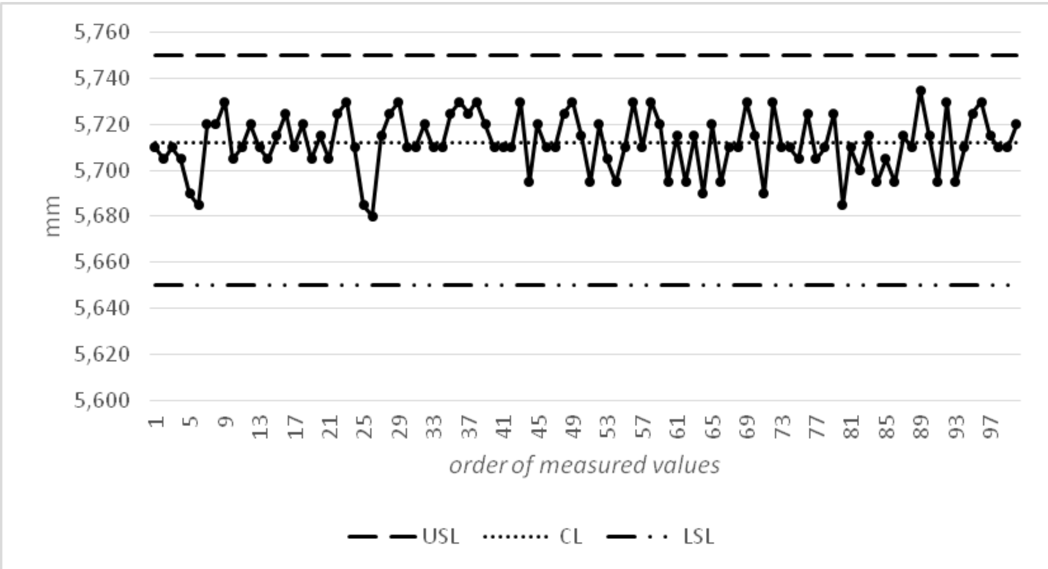

Fig. 5 The measured value card for the parameter 5.7 mm ± 0.05mm

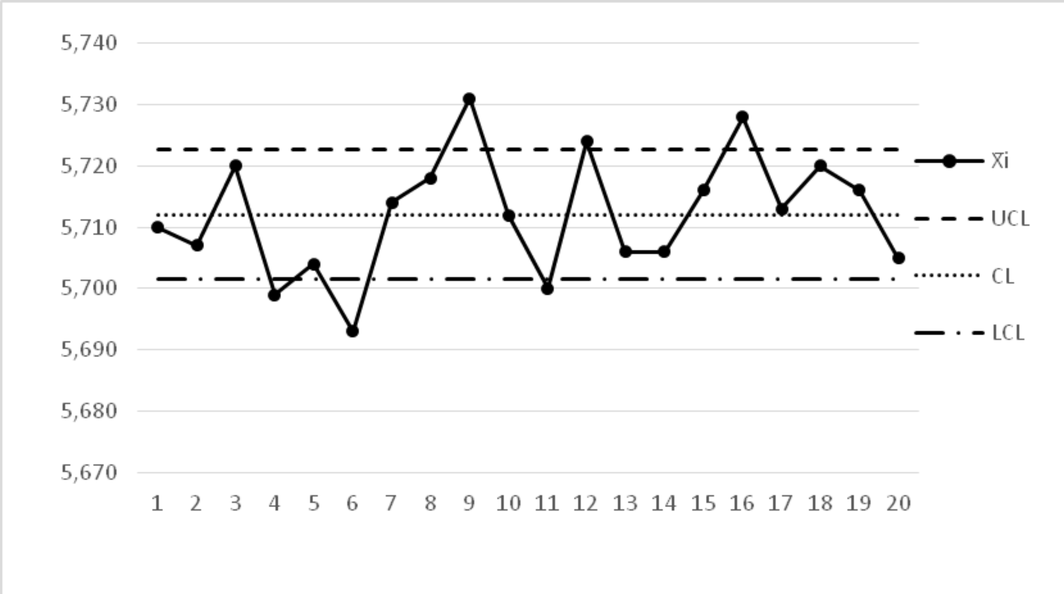

Fig. 6 X – card for parameter 5.7 mm ± 0.05mm

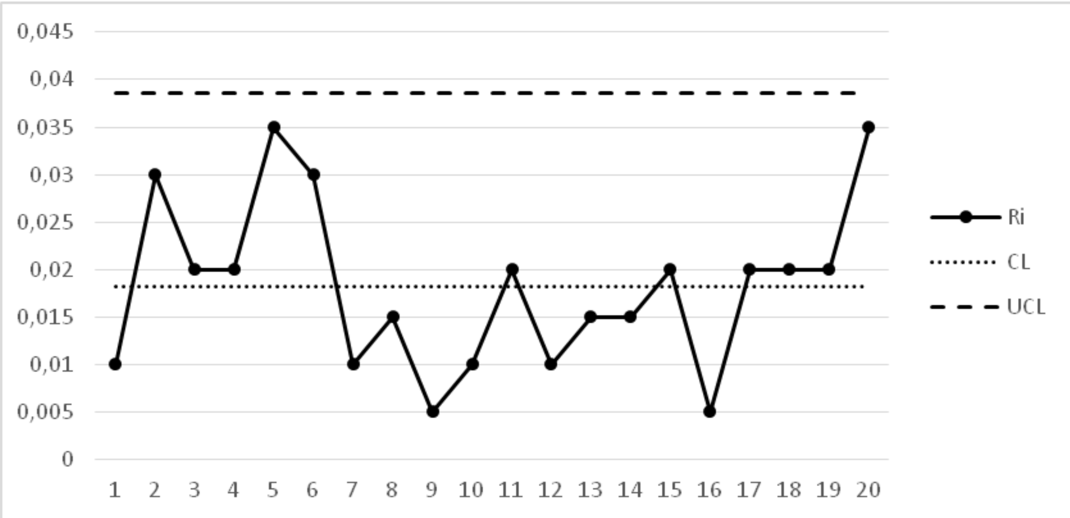

Fig. 7 R – card for parameter 5,7 mm ± 0,05mm

Process capability

Before calculating process capability indices, it is necessary to determine the standard deviation, with the constant d_2 = 2.326

We have calculated the Pp and Ppk indices, taking the lower value in the evaluation into account.

$$\hat{\sigma} = \frac{0.0182}{2.326} = 0.00785 \quad (17)$$

$$P_p = \frac{0.1}{6\ x\ 0.00785} = 2.124 \quad (18)$$

$$P_{pk} = \frac{5.750 - 5.712}{3 \ x \ 0.00785} = 1.610 \qquad (19)$$

$$P_{pk} = \frac{5.712 - 5.650}{3 \ x \ 0.00785} = 2.638 \qquad (20)$$

This process is conditionally eligible.

CONCLUSION

If an organization is interested in being able to compete with other organizations at present but mostly in the future, it needs to take certain measures. Their capability must be periodically inspected to avoid unwanted disturbances and if they occur to be quickly identified and removed. Therefore, it is appropriate to introduce statistical methods for process control.

In the article we applied statistical methods in the turbine turning process. The goal was to examine the short term capability of this process using the P_p a $P_{pk.}$indices by means of the parameters of this component. The necessary values were recorded in the X-card and the R-card, from which we determined if the process diameter and the process variability are in a statistically controlled state. Variability was statistically mastered in each process. The process average did not meet this requirement. The manufacturing process has proved to be conditionally capable. From the acquired findings about these processes, it may be concluded that corrective actions need to be taken to eliminate undesirable effects, that means stabilize processes. An appropriate measure already carried out by the organization is the input control of the semi-product when taking on from the supplier by means of a check sheet.

Among the causes that influence the process, the parameter settings in the machining process can be considered. To improve the process, for example, it is advisable to use cutting blades with the longest possible life. They will ensure the most accurate dimension of the component. During the process, it is also important to use a suitable coolant to monitor the machining temperature.

In addition, it is necessary to regularly check the condition of the lathe and take care of the correct maintenance method. It is therefore important to train staff involved in the inspection, maintenance and operation of the machine.

The results of the process could also be adversely affected in the component parameter measurement phase. The causes that can affect the measuring area include the ambient temperature at which the component parameters were measured. When using high precision instruments, changing ambient temperatures may cause measurement deviations. Therefore, it is necessary to ensure conditions for measurement at a suitable ambient temperature without any deflections.

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