International Journal of Engineering, Science and Mathematics
Vol. 6Issue 8, December 2017,(Special Issue)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

ANALYSIS OF PROCESS CAPABILITY ABOUT TURNING CENTER

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Abstract

Analysis of process capability convinces that processes need to be according to manufacturing industry specification, while reducing the process variation and improving the product quality characteristic. The aim is to verify the performance of the process and also the ability of the machine to achieve within the tolerance limit specified.100 sample shafts were turned on the turning center with subgroup size being ten. The performance needs to be within the control limits and also capable of meeting up to specification. Further, the capability index (Cp) measured in this case is greater than 1. Also, the machine capability (Cpk) for this manufacturing application is also greater than 1, thus making the process capable.

Keywords:

Turning center;
Control charts;
Process capability;
Machine ability.
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1. Introduction

Nowadays, most of the manufacturing companies spend a lot of money for machine tools with advanced technology such as CNC tools and automated machine tools. These will help to improve the quality and dispatch time of the products that they produced. The investors require that the machines they purchase have high flexibility, good running condition and highly precision-oriented turning centers. In the manufacturing sector, the accuracy of parts is very important because the accuracy of the finish part helps in evaluating the machine's accuracy that produces the particular part. In the early 1970s the concept of process capability was introduced by Juran, an expert in world quality. Subsequently, for almost 40 years many accepted indices such as Cp, Cpk and Cpm were developed to measure the performance of the respective process [1]. The measure of the uniformity of performance is process capability. Variability of the process output is measured by its uniformity in process product. The relative deviation in the product specification and requirements is nothing but variability in process product. Process capability analysis is a technique applied in many stages of the product cycle. This includes product design, manufacturing planning process and production in machines for each operation. This technique helps in determining the ability for achieving the engineering values and manufacturing parts within the tolerance limits.

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The long term performance level of a process which is brought under statistical control is called process capability. Statistical process control is a quality assurance tool which is used to improve the quality of manufacture and helps in scoring the end-customer satisfaction [2]. The ability of the combination of the equipment to produce a product which will meet the design requirements and the expectation of the customer is process capability. The analysis makes sure that the processes are fit for industrial specification. Further, for achieving product quality characteristics it is important to limit the process variation [3]. Discussion related to computational framework used to control the machining system capability is done in [4]. Process capability indices are effective for the improvement of productivity, managerial and quality decisions [5]. Process capability indices of the turning operation could be evaluated towards measuring the process performance. The capability index could be further put to use for comparing controlled process outputs to the required specification limit.[6&7]. It can be define as a numerical summary which analogizes the behavior of a process/product characteristic to the specifications in engineering [8&9].

2. Process Capability Analysis

The process is the combination of several different input parameters like men, machine, method, material and environment. These parameters together form a product output. The process capability is defined by the total variation that comes from common causes, that is the minimum variation that can be achieved after all special causes have been eliminated. Variation and errors can arise from two kinds of causes. i.e. Assignable and random causes. provided that the process remains in statistical control. If this happens, it will continue to produce the same proportion of out – of specification parts [10].

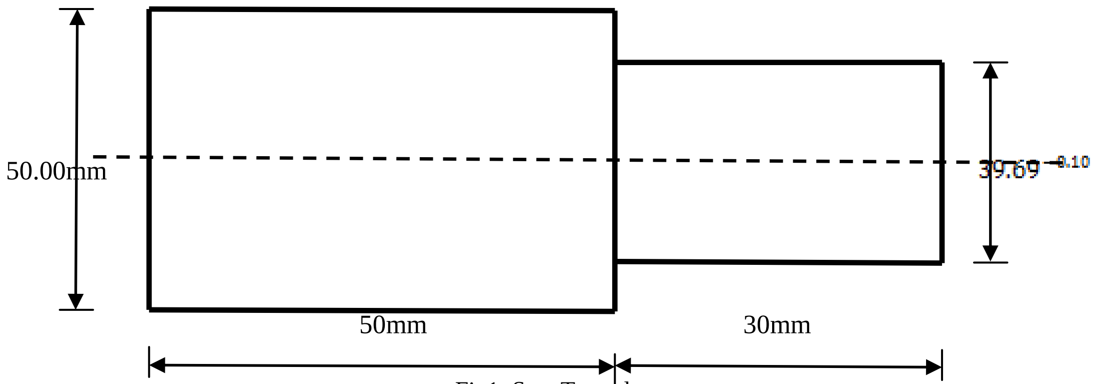

Fig1: Step Turned component

To improve the process ability so that it meets specifications consistently, it is necessary for the organization actions to reduce the difference from common causes. Lower natural tolerance limit(LTNL), Upper natural tolerance limit(UNTL).The specification of a turned component is39.69/39.59 as shown in Fig1. UNTL-LNTL=6σ

Case-1: Control Chart for Process is not capable (USL-LSL < 6σ).

In this case, more than 100% of the tolerance band is used by the process. Non-conforming units in large number will be produced. The specification limit is to be widened and for its improvement, we have to increase the tolerance limit and /or reduce the dispersion by making fundamental changes in the production methods and machines used, as shown in Fig2.

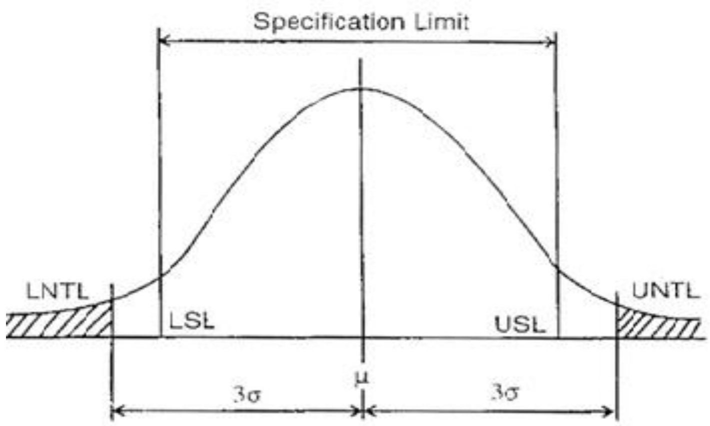

Fig2: Control Chart for Process is not capable (Source.[11] Balasudhakar,et.al. 2011)

Case-2: Process capability ratio is equal to unity (USL-LSL = 6σ)

The process uses the entire tolerance band and the process will produce more non-conforming units even if there is a slight deviation in mean value. as shown in Fig3

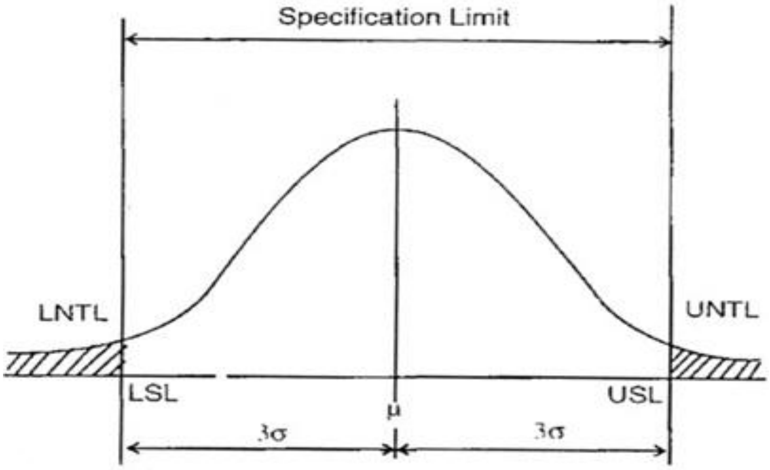

Fig3: Control Chart for Process is in Normal (Source: Balasudhakar 2011)

Case 3: Process capability ratio is greater than unity (USL-LSL > 6σ)

This process will produce very few non-conforming units because the natural tolerance limit falls well within the specification limit. So it is not necessary to take action. The process uses much less than 100% of the tolerance band.as shown in Fig4.

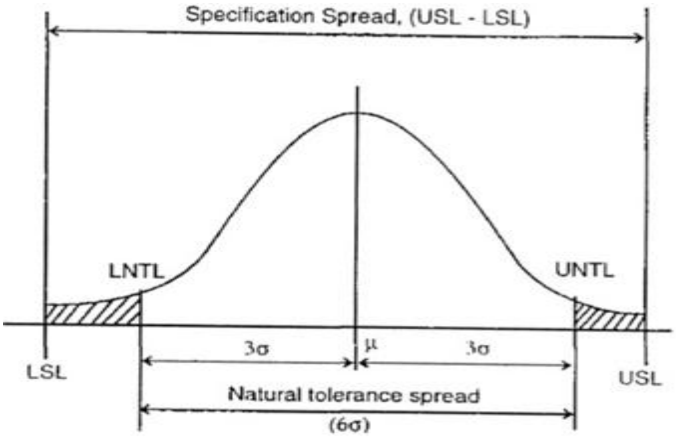

Fig4: Control Chart for Process is Capable (Source: Balasudhakar,et.al 2011)

Formulae used in Process capability Analysis.

Arithmetic mean $\overline{X} = \frac{X1+X2+X3+\cdots+Xn}{n}$ ------------------------- 1

Average of Range $\overline{R} = \frac{R1+R2+R3+\cdots+Rn}{n}$ -----------------------2

Average of Averages $\overline{\overline{X}}$ = = $\frac{X1+X2+X3+\cdots+Xn}{N}$ ------------------- 3

<u>For $\overline{X}$ Chart</u>

Upper Control Limit (UCL) = $\overline{\overline{X}} + A_2 \overline{R}$

Lower Control Limit (LCL) = $\overline{\overline{X}} - A_2 \overline{R}$ --------------- 4

<u>For R Chart</u>

$$\left.\begin{aligned}\text{Upper Control Limit (UCL)} &= D_4\overline{R}\\ \text{Lower Control Limit (LCL)} &= D_3\overline{R}\end{aligned}\right\} \quad \text{----------------- 5}$$

$$\text{Standard Deviation } (\sigma) = \frac{\overline{R}}{d2} \quad \text{----------------------------- 6}$$

$$\text{Process Capability } (6\sigma) = \frac{6\overline{R}}{d2} \quad \text{----------------------------- 7}$$

$$\text{Specification Limit} = \text{USL-LSL} \quad \text{-------------------- 8}$$

$$\text{Process Capability Ratio } (C_p) = \frac{\text{Specification Limit}}{6\sigma} \quad \text{-------- 9}$$

$$\text{Process Capability Index } (C_{pk}) = \text{Min}\left(\frac{USL-\overline{X}}{3\sigma}, \frac{\overline{X}-LSL}{3\sigma}\right) \quad \text{---- 10}$$

Table No:1 Data collected for 10 hours production

SAMPLE NO	1st Hour	2nd Hour	3rd Hour	4th Hour	5th Hour	6th Hour	7th Hour	8th Hour	9th Hour	10th Hour
1	39.6	39.65	39.63	39.62	39.64	39.66	39.65	39.61	39.61	39.65
2	39.61	39.66	39.62	39.63	39.61	39.64	39.65	39.65	39.64	39.63
3	39.65	39.62	39.63	39.62	39.66	39.64	39.64	39.62	39.65	39.64
4	39.62	39.63	39.64	39.61	39.66	39.65	39.62	39.63	39.63	39.65
5	39.62	39.64	39.62	39.66	39.65	39.64	39.64	39.64	39.61	39.63
6	39.63	39.64	39.65	39.62	39.64	39.64	39.64	39.65	39.62	39.65
7	39.62	39.61	39.63	39.65	39.62	39.63	39.62	39.64	39.63	39.64
8	39.63	39.62	39.64	39.65	39.62	39.62	39.63	39.61	39.65	39.65
9	39.64	39.63	39.63	39.64	39.65	39.64	39.64	39.61	39.64	39.66
10	39.62	39.64	39.65	39.63	39.63	39.63	39.62	39.63	39.62	39.61

Table No: 2 Average and Range values as per Data Collected

SAMPLE NO	1st Hour	2nd Hour	3rd Hour	4th Hour	5th Hour	6th Hour	7th Hour	8th Hour	9th Hour	10th Hour	**AVERAGE $\overline{X}$**
1	39.6	39.65	39.63	39.62	39.64	39.66	39.65	39.61	39.61	39.65	39.632
2	39.61	39.66	39.62	39.63	39.61	39.64	39.65	39.65	39.64	39.63	39.634
3	39.65	39.62	39.63	39.62	39.66	39.64	39.64	39.62	39.65	39.64	39.637
4	39.62	39.63	39.64	39.61	39.66	39.65	39.62	39.63	39.63	39.65	39.634
5	39.62	39.64	39.62	39.66	39.65	39.64	39.64	39.64	39.61	39.63	39.635
6	39.63	39.64	39.65	39.62	39.64	39.64	39.64	39.65	39.62	39.65	39.638
7	39.62	39.61	39.63	39.65	39.62	39.63	39.62	39.64	39.63	39.64	39.629
8	39.63	39.62	39.64	39.65	39.62	39.62	39.63	39.61	39.65	39.65	39.632
9	39.64	39.63	39.63	39.64	39.65	39.64	39.64	39.61	39.64	39.66	39.638
10	39.62	39.64	39.65	39.63	39.63	39.63	39.62	39.63	39.62	39.61	39.628
											$\overline{\overline{X}}$ = 39.634
RANGE	0.04	0.05	0.03	0.05	0.05	0.04	0.03	0.04	0.04	0.05	**$\overline{R}$ = 0.042**

From table of control charts

n =10 A2 = 0.31 D3= 0.22 D4 =1.78 d2 = 3.078

<u>$\bar{X}$ – Chart Calculation</u>:

UCL = $\bar{\bar{X}} + A2 * \bar{R}$ = 39.634+0.31*0.042= 39.647
LCL = $\bar{\bar{X}} - A2 * \bar{R}$ = 39.634-0.31*0.042 = 39.621

R- Chart Calculation :
UCL = D4*$\bar{R}$ =1.78*0.042 = 0.0748= 0.08
LCL = D3*$\bar{R}$ = 0.22*0.042 = 0.0092=0.01

σ = $\bar{R}/d2$ = 0.042 / 3.078 = 0.0136
$C_p = \frac{USM-LSM}{6\sigma}$= 0.01/6*0.0136=1.226
UCL= USL-$\bar{\bar{X}}$)/3σ= (39.69-39.634)/3*0.0136=1.373
LCL= $(\bar{\bar{X}} - \mathrm{LSL})/3\sigma$= (39.634-39.59)/3*0.0136=1.078
C_{PK}= min [(USL-$\bar{\bar{X}}$/3σ), $\overline{(X - LSM/3\sigma)}$)]
C_{PK}= MIN(1.373,1.078)= 1.078

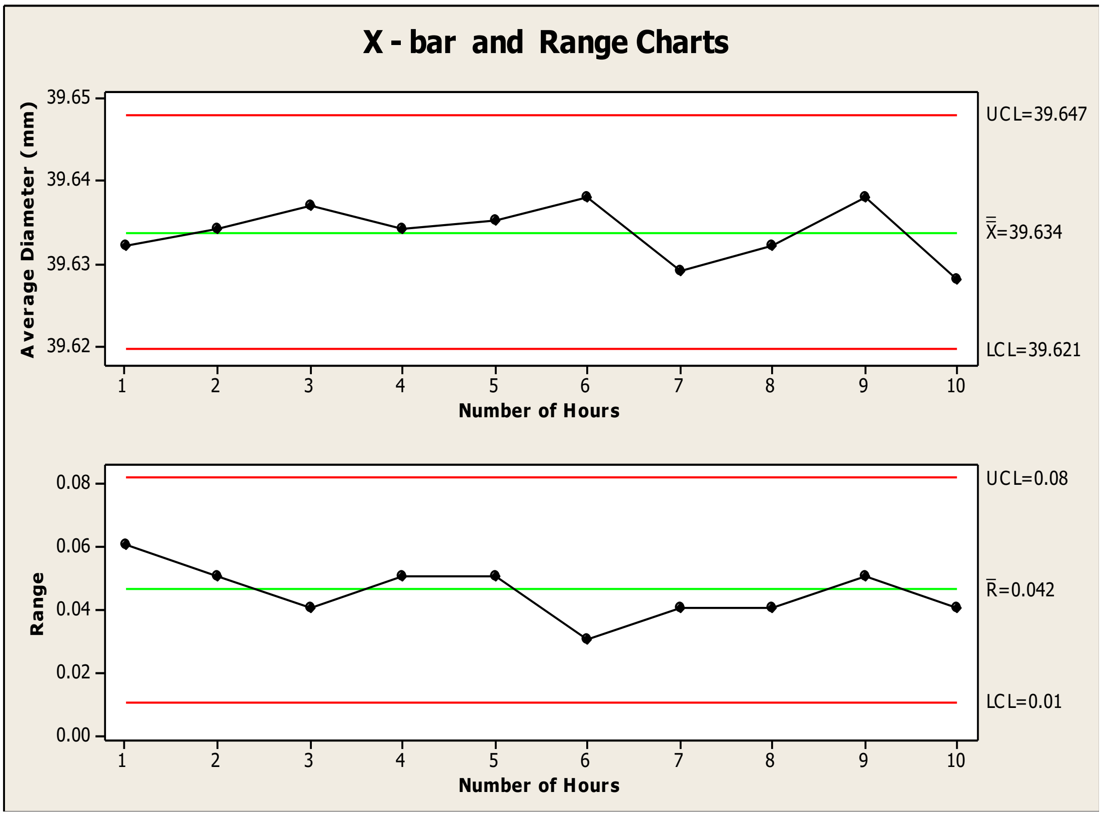

Fig 5. Control Charts: plotted control charts with the help of Minitab-14 software.

3. Results:

UCL = 39.647
LCL = 39.621
Average Range= 0.042
Process Capability= Cp= 1.126
Upper process Capability CPU= 1.373
Lower Process Capability cpl= 1.078
CPK= Minimum (CPU, CPL)= 1.078

Conclusion:-
The results of analysis of the data collected indicates that, the process is capable of consistently maintain

the diameter of the job well within the customer's satisfaction, and also machine is capable doing that job.

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