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Statistical Analysis of Process Capabilities to Reduce Cost - A Case Study At Kiran Machine Tool Jalgaon. (M.s.)

Shri. Bhushan Nimbaji Saner Mechanical Department, S.G.D.Polytechnic, Jalgaon

ABSTRACT *A measurement control systems ensures that measuring equipment and measurement processes are fit for their intended use and its important in achieving products quality objective. Process capability indices are intended to provide a single number assessment of the consistency of a manufacturing process relative to the engineering specification limits on quality characteristics.*

In this paper, an attempt has been made to highlight the methodology of statistical tolerance limits and its applicability for estimating the process capability. A case study conducted at Kiran Machine Tool Jalgaon. The control valve cylinder head OP-20 affected by various cutting parameters such as speed of machine; feed rate and depth of cut etc. The process for normal conditions are in statistical control but there is a scope for optimization of process costs by improving the, capability indices (nearly equal to 1.67). As process capability indices improve, it gives the direct effect on the production rate and less scrap. Enhancement of Process Costs Through Process Capability Measurement. Process Capability measurement is an inseparable part for the success of an organization.

KEYWORDS : - Quality Cost, Process Capability Indices, Six Sigma, and Process Cost.

INTRODUCTION

The implementation of statistical process control involves achieving two related (but different) targets. The first target is to achieve a state of 'statistical control'. A statistically controlled process is a process that displays a consistent amount of variability about a constant mean. In practical terms, the process basically operates in the same fashion over time. Statistically control is often demonstrated by using X and R chart techniques. Once achieved, this state of statistical control does not necessarily imply that the process is operating well enough to meet customer requirements. Control only tells us that no unusual process variations are being observed. The second target is to achieve 'Capability'. A capable process is one that is able to meet customer requirements or product specification. When both of these targets have been met, the process consistently meets customer requirement.

Process Capability refers to the inherent ability of a process to produce similar parts for a sustained period of time under a given set of conditions when operating in a state of statistical control Process Capability Indices are used to provide a numerical measure of whether a production a process is capable of producing items satisfying the quality requirement in the factory.

Measurement of process capability is determine by total variation caused by random reasons influencing the process. Variation is caused by variability of the measured quality values that are not connected to the measurement conditions and must be excluded. Process costs can be reduced by improving the process capability indices. Economical savings represent the direct impact possibility for better setting of the production process; decreasing of the number of non-conforming products and resulting the increased production efficiency.

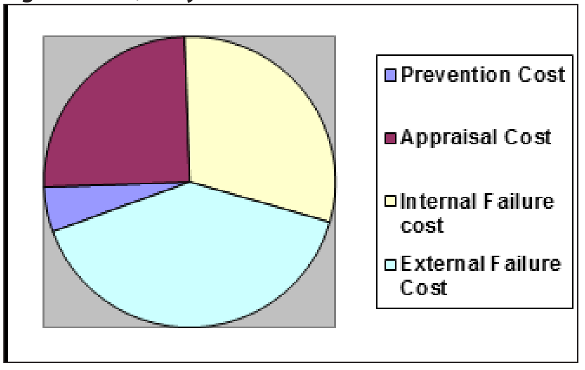
QUALITY COSTS :

Quality is conformance to a given requirement or specification on a product or service. The quality statement or specification should be based on what the existing process can produce with reasonable control.

Quality is measured by the cost of quality, which is the expenses of non – conformance. Quality costs are the costs associated with preventing, finding and correcting the defective work. These costs are huge, running at 20% - 40% of sales. Many of these costs can be significantly reduced or completely avoided. One of the major important role of Quality Engineer is the reduction of the total cost of quality associated with the product.

Cost of quality can be comparable in importance to labour costs, engineering costs and selling costs. Quality costs are budgeted by departments used in major capital investment decision and are the part of significant business determination. In modern industries striving to maintain and improve their competitive position.

Fig . 1 Total Quality Costs.



ECONOMICS OF MACHINING :

The aim of any engineering industry is to achieve either a minimum costs of production or a maximum production rate in machining These two criteria are closely interrelated with the choice of cutting conditions like speed, feed and depth of cut. The optimization of these conditions depends and must be related to the machinability characteristics of the materials. It becomes necessary to relate the available engineering raw materials and semi finished products to specific machinability rating. For accessing the machinability of a material is governed by the type of machining operations. For e.g. roughing, a primary consideration is maximum removal of metal which is directly influenced by the cutting speed which should be optimum speed. In case of finishing operations, surface finish is more important

CONCEPT OF CAPABILITY STUDIES :

Process capability is a measurement with respect to the inherent precision of a manufacturing process.

As a definition – 'Process capability is a quality performance capability of the process which given factors and under normal, in control conditions.' Two significant element in this concept of a process capability are –

Process Factors
Process Conditions

Process Factors : A process is made up on number of distinct factors, these factors include raw material , machine or equipment; the operators skill, measuring devices and the measures skill. A chance in one or more of these factors may change the process capability

Process Conditions: It involves the condition of a process for a process capability study to be meaningful, the process being analyzed should be one that has measurements normally

USES OF PROCESS CAPABILITY INFORMATION :
Process capability information serves multiple purposes-

1. Predicting the extent of variability that process will exhibit such capability information, When provided to designers, provides important information in setting realistic specification limits.
2. Choosing form among competing process that are most appropriate to meet the tolerances.
3. Planning the inter relationship of sequential processes.
4. Providing a quantified basis for establishing a schedule of periodic process control checks and readjustments.
5. Assigning machines to classes of work for which they are best suited.
6. Testing theories of causes of defect during quality improvement programme.
7. Serving a basis for specifying the quality performance requirements for purchased machines. These purposes account for the growing use of the process capability concept.

STANDARDIZED FORMULA :
The most widely adopted formula for process capability is,

Process capability = $\pm 3\sigma$(a total of 6 σ)

where, σ is a standard deviation of the process under a statistical control i.e. under no drift and no sudden changes If the process is centered at the nominal specifications and follows a normal probability distribution, 99.73% of production will fall within $\pm 3\ \sigma$ of the nominal specification. Some industrial process operate under a state of statistical control. For such processes the computed process capability of 6 σ can be compare directly to specifications limits and judgments of adequacy can be made. However the most of the industrial process exhibit both drift and sudden changes. These departure from the ideal are a fact of life, and practitioner must deal with them.

METHODS OF CALCULATING PROCESS CAPABILITY :

1. *Standard deviation method* : By this method process capability study may be made by gathering the required data- at least 50 observation and preferably 100 or more if possible - and computing the standard deviation of this data by using the relation.
2. *The average range method* :The average range method is preferred for process capability analysis for the following reasons-
   (i) It is easier to calculate , no square root is involved.
   (ii) Trends occurring in the study or other abnormal conditions can be detected.
   (iii) When the average range method is used the capability study can be serve as a base.
3. *Single range method* : A rough estimate of process capability may be obtained by this method. Take a certain number of observations and then find the difference between the largest and smallest readings. Based on certain confidence level we can predict the percentage of the products (depending upon the number of observations) that will be within the observed range of the sample. This method is variable when used in conjunction with the average range method.

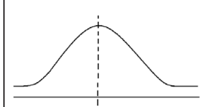
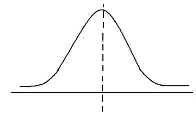
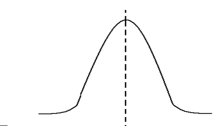
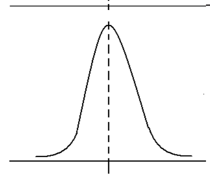
PROCESS CAPABILITY STUDY STEPS :
The general process Capability study steps are-

(1) Select critical parameters.
(2) Collect data .
(3) Establish control over the process.
(4) Analyze process data
(5) Analyze sources of variation.
(6) Establish process monitoring system.

Assumptions in Process Capability Study : The interpretation of capability indices such as Cp and C_{pk} rests on a base of several assumptions.

(i) The process is in a state of statistical control
(ii) Sufficient data are collected during the capability study to minimize the sampling error for capability indices
(iii) The data are collected over a sufficient period of time to ensure that the process condition present during the study are representative of current and future conditions
(iv) The parameters analyzed in study follows a normal probability distribution otherwise the percentage of product associated with values Cp and C_{pk} are incorrect In the real world, assumption are never fully meet, but the assumption stated above should not be taken lightly.

POSSIBLE RELATIONS BETWEEN PROCESS VARIABILITY AND SPECIFICATION LIMITS AND THE LIKELY COURSES OF ACTION FOR EACH

Sr. No.	Process	Cp	Total amount of outside limits	Action to be taken
A)		<1.0	>=5.0 %	Heavy Process Control; sorting
B)		1.0	0.3 %	Heavy process control; and inspection
C)		1.33	64 ppm	Reduced inspection; selected use of control charts.
D)		1.63	1 ppm	Spot checking; selected use of control charts

SIX SIGMA CONCEPT OF PROCESS CAPABILITY :
The six Sigma approach is really a strategy for improvement. For some processes, shifts in the process average are so common that they should be recognized in setting acceptance values of Cp. In some industries, shift in the process average of ± 1.5 standard deviation (of individual values) are not unusual. To allow for such shifts , high values of Cp are needed. For example if specification limits are at $\pm$ 6 σ and if the mean shifts $\pm$ 1.5 σ , then 3.4 parts per million will be beyond specification limits. The Motorola company's six sigma approach recognizes the likelihood of these shifts in the process average and uses a variety of quality engineering techniques to change the product, the process or both to achieve a Cp of at least 2.0.

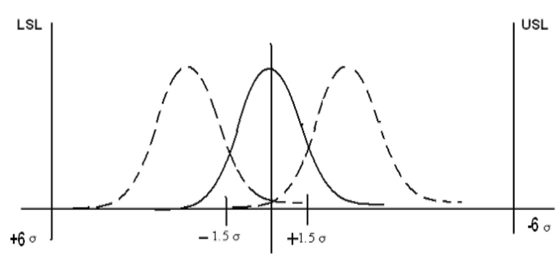


Fig . Six Sigma Process Capability

Sigma Level	Centered Process		Shifted ($\pm 1.5\sigma$) Process	
	Cp	ppm*	Cpk	ppm
3	1	2,700	0.5	66,803
4	1.33	63	0.833	6,200
5	1.67	0.57	1.167	233
6	2	0.002	1.5	3.4

Sigma Levels and Defect Levels

Figure Shows capability indexes and defects levels in parts per million (ppm) for a centered process and for a process with the mean shifted 1.5 σ. At the 3 σ level with a entered process , the defect level is 2700 parts per million (or 0.27%) ; with a shift of 1.5 σ the defect level is 66,803 parts per million (6.68 %). These calculations apply to a single product or process characteristic. In reality, many products or processes have numerous characteristic, and thus the overall yield decreases with this complexity.

The six sigma approach to improvement is a strategy that assumes process shifts of 1.5 σ (in practice a realistic assumption for many processes). This use of term six sigma is quite different from the classical standardized formula for process capability as ± 3σ or a total of 6 σ.

CASE STUDY :

Kiran Machine Tool Jalgaon is one of the vendor of BOSCH Chassis Systems India Ltd. Jalgaon. The rejection level below 0.18 to 0.35% which is less than allowable 2%. The selection of component (C.V. Cylinder Head) is based on critically and the quality norms achieved. Application of C.V. Cylinder Head in valve body assembly for creating adequate pressure for lifting. After the study of component, the external diameter 76.15± 0.025 plays an important role. The machining (LTC) process OP-20 is affected by three parameters such as speed of machine , depth of cut and feed rate of tool. The data is recorded in inspection check sheet , which gives the parameters and dial snap gauge which is to be used for measurement.

Terminology and Notations :
USL = Upper Specification Limit
LSL = Lower Specification Limit
Tolerance (T) = Specification width = S

$$\overline{X} = Mean = \frac{\sum X}{n}$$

$\overline{X}$ = the average of Subgroup average is the overall process average

Range = R = Highest Value – Smallest Value

Calculate the grand average $\overline{X}$ and average of range $\overline{R}$ after calculating the average and range of each subgroup.

$$\overline{\overline{X}} = \frac{\sum \overline{X}}{N}$$

Where ,

$\overline{\overline{X}}$ = Average of averages.

N = No. of Sub groups.

$$\overline{R} = \frac{\sum R}{n}$$

calculate standard deviation = σ = $\overline{R}$ /d2

For the upper control limit (UCL $\overline{X}$),

UCL $\overline{X} = \overline{\overline{X}} + A_2 . \overline{R}$

Lower Control Limit (LCL $\overline{X}$),

LCL $\overline{X} = \overline{\overline{X}} - A_2 . \overline{R}$

Where,

$\overline{\overline{X}}$ = Grand average

$\overline{R}$ = Average of sample ranges.

A_2 = Constant found from table.

Control limits on sample range are,

USL $\overline{R} = \overline{R} . D_4$

LSL $\overline{R} = \overline{R} . D_3$

Where ,D_4 and D_3 are constants found in table.

N	A_2	D_3	D_4	d_2
2	1.830	0	3.268	1.128
3	1.023	0	2.574	1.693
4	0.729	0	2.282	2.059
5	0.577	0	2.114	2.326
6	0.483	0	2.004	2.534
7	0.419	0	1.924	2.704
8	0.373	0	1.864	2.847
9	0.337	0	1.816	2.970
10	0.308	0	1.777	3.078

Cp- It is the simple process capability index. It is the process width divided by 6 times sigma : is estimated within subgroups standard deviation, where process width is difference between upper specific limit minus lower specific limit.

$$Cp = \frac{USL - LSL}{6\sigma}$$

$$Cp = \frac{Tolerance}{6\sigma}$$

If Cp<1 – Process is wider than specific limits and not capable to producing all in specification products.

If Cp> 1- Bad parts could be still being produced if the process is not centered . thus there is a need of capability index, which takes process centering into account.(Cp_k)

Index, k= {2 (D-X)/s}

Cp_k = It is capability index which accounts for process centering. It relates the scaled distance between the process mean and the closest specification limit to half the total process spread.

Cp_k = (1- k) Cp.

OBSERVATIONS :

The data collection for case 01 , 02 and 03 for OP-20 when conditions of process are i) Speed of machine = 650 rpm , ii) dept of cut = 0.3mm iii) Feed rate =0.18 mm/rev.

Case-01

S.NO.	1	2	3	4	5
1	76.145	76.146	76.145	76.146	76.146
2	76.148	76.145	76.148	76.145	76.145
3	76.146	76.145	76.146	76.145	76.145
4	76.144	76.143	76.144	76.153	76.153
5	76.146	76.142	76.146	76.146	76.151

Case-02

S.NO.	1	2	3	4	5
1	76.146	76.145	76.145	76.146	76.146
2	76.145	76.148	76.148	76.145	76.145
3	76.145	76.146	76.146	76.145	76.145
4	76.153	76.144	76.144	76.153	76.153
5	76.151	76.146	76.146	76.152	76.151

The data collection, case-04, 05 after improving the capability indices when the condition of process :-i) Speed of machine =750rpm,ii) Feed rate =0.25mm/rev,iii) Depth of cut = 0.6mm

Case-04

S.NO.	1	2	3	4	5
1	76.145	76.153	76.145	76.146	76.146
2	76.148	76.145	76.148	76.145	76.145
3	76.146	76.145	76.148	76.145	76.145
4	76.144	76.153	76.145	76.153	76.153
5	76.146	76.162	76.148	76.162	76.162

Case-05

S.NO.	1	2	3	4	5
1	76.148	76.148	76.145	76.146	76.146
2	76.146	76.146	76.145	76.145	76.145
3	76.144	76.144	76.153	76.145	76.139
4	76.146	76.146	76.152	76.153	76.145
5	76.141	76.146	76.146	76.152	76.152

Conclusion :

There are many industrial applications which may important for optimization of process cost. Once of the benefits from the process is the capability of large area of processing which can reduce production cost significantly. The measurement of process capability (Cp and Cpk) provides a useful assessment for enhancement process costs. Process capability indices can help process engineer to assess the potential of given process condition as well as providing a useful for comparing the process costs. By improving the value of process capability indices (near to 1.67), the effect is that large saving in inspection cost , labor cost and tool cost. The overall effect is that large a0ount of saving in total production cost for mass production.

It may conclude that it is not necessary to maintain high value of process capability indices, we can get high production rate if we maintain the value of Cpk nearly equal to 1.67

REFERENCES

1.Layth. C.Alwan ,'Statistical Process Analysis', 2000, McGraw- Hill Higher Education, Pp. 567-627. | 2. J.M.Juran and Frank. M. Gryna, 'Quality Planning and Analysis', 2002 , Tata McGraw-Hill, New Delhi, Pp 42-45 and 392- 393. | 3. Armand. V.Feigenbaum, 'Total Quality Control', 1998, McGraw-Hill International ,Pp 778-781 | 4. Suresh Dalea and Saurabha,'ISO 9000,A Manual For Total Quality Management',1997, S.Chand and Co.Ltd.,New Delhi, Pp406- 435. | 5. Dr.Brijendra Singh, 'Quality Control and Reliability Analysis', 2003, Khanna Publication, New Delhi , Pp 16-41. | 6. M.S.Mahajan, 'Statistical Quality Control', 2002, Dhanapat Rai and Co. Pvt. Ltd., New Delhi , Pp178-230. | 7. Joseph. M.Juran,Frank.M..Gryna ,Richard .C.H.Chua, Joseph.A.Defeo, 'Juran's Quality Planning and Analysis For Enterprise | Quality', 2008, Pp 667-715. | 8. Sanjaykumar Saxena, 'Process Capability', 2006 , © Sanjaykumar Saxena, Pp 1-4.