RESEARCH STUDY OF PROCESS CAPABILITY

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ABSTRACT
Determining the process capability is one of the easiest way to control production quality statistically and prediction of production failure within batch. This research study gives analytical as well as practical areas regarding process capability and its implementation benefits with steps for calculating Cpk.

KEYWORDS: *process capability, process capability indices, statistical control of production, standard variation*

I. INTRODUCTION

"Quality is the ability of product or service to fulfill customer's requirements." So every industry tries to seek on quality. There are many principles followed by every industry like "SQC (Statistical Quality Control), 5MT Conditions 5S, KAIZEN KANBAN, POKA-YOKE, FMECA, DMAIC" etc. Process capability analysis can determine how the process performs relative to its requirements or specifications, where an important part is the use of process capability indices (Cp, Cpk etc.)

This paper contains information under the following heading:

1. Importance
2. Importance of knowing capability of our process.
3. Importance of knowing the capability of the suppliers process.
4. Process capability precautions
5. Steps to study the process capability
6. Process capability index
7. Analysis of process capability by using 5M techniques
8. Future scope
9. Results from discussion
10. Conclusion.

II. IMPORTANCE

It allows one to quantify how well a process can produce acceptable product. As a result, a manager or engineer can prioritize needed process improvements and identify those processes that do not need immediate process improvements. Process capability studies indicate if a process is capable of producing virtually all confirming product. If the process is capable, then statistical process controls can be used to monitor the process and conventional acceptance efforts can be reduced or eliminated entirely. This not only yields great cost savings in eliminating non-value added inspections but also eliminates scrap, rework and increases customer satisfaction. The benefits of performing process capability studies are certainly worth the effort in the long run.

III. IMPORTANCE OF KNOWING THE CAPABILITY OF OUR PROCESSES

Process capability measurements allow us to summarize process capability in terms of meaningful percentages and metrics. To predict the extent to which the process will be able to hold tolerance or customer requirements. Based on the law of probability, you can compute how often the process will meet the specification or the expectation of your customer. You may learn that bringing your process under statistical control requires fundamental changes - even redesigning and implementing a new process that eliminates the sources of variability now at work. It helps you choose from among competing processes, the most appropriate one for meeting customers' expectation. Knowing the capability of your processes, you can specify better the quality performance requirements for new machines, parts and processes.

IV. Importance Of Knowing The Capability Of The Supplier's Processes

To set realistic cost effective part specifications based upon the customer's needs and the costs associated by the supplier at meeting those needs. To understand hidden supplier costs. Suppliers may not know or hide their natural capability limits in an effort to keep business. This could mean that unnecessary costs could occur such as sorting to actually meet customer needs. To be pro-active. For example, a Cpk estimation made using injection molding pressure measurements during a molding cycle may help reveal a faulty piston pressure valve ready to malfunction before the actual molded part measurements go out of specifications. Thus saving time and money.

V. Precautions for process capability

The indices for process capability discussed are based on the assumption that the underlying process distribution is approximately bell shaded or normal. Yet in some situations the underlying process distribution may not be normal. For example, flatness, pull strength, waiting time, etc., might naturally follow a skewed distribution. For these cases, calculating Cpk the usual way might be misleading. Many researchers have contributed to this problem. Readers are requested to refer to John Clements article titled "Process Capability Calculations for Non-Normal Distributions" for details.

The process / parameter in question must be in statistical control. It is our experience that there is tendency to want to know the capability of the process before statistical control is established. The presence of special causes of variation makes the prediction of process capability difficult and the meaning of Cpk unclear.

The data chosen for process capability study should attempt to encompass all natural variations.

For example, one supplier might report a very good process capability value using only ten samples produced on one day, while another supplier of the same commodity might report a somewhat lesser process capability number using data from longer period of time that more closely represent the process. If one were to compare these process index numbers when choosing a supplier, the best supplier might not be chosen.

The number of samples used has a significant influence on the accuracy of the Cpk estimate.

For example, for a random sample of size n = 100 drawn from a know normal population of Cpk = 1, the Cpk estimate can vary from 0.85 to 1.15 (with 95% confidence). Therefore smaller samples will result in even larger variations of the Cpk statistics. In other words, the practitioner must take into consideration the sampling variation's influence on the computed Cpk number. Please refer to Bissell and Chou, Owen, and Borrego for more on this subject.

Generally, the final solution of the process capability is specified either in the form of calculations or histograms.

VI. Steps For Process Capability Study

6.1 Select Critical Parameters:- Critical parameters need to be selected before the study begins. Critical parameters may be established from drawing, contracts, inspection instructions, work instructions etc. critical parameters are usually correlated to product fit and or function.

6.2 Collect Data:- Data collection system needs to be established to assure that the appropriate data is collected. It is preferable to collect at least 50 data values for each data parameter. If this is not possible, correlation can be made to adjust for the error that is introduced when less than 50 data values are collected. Significant data should be the number of significant digit required as per the specification limit plus one extra significant digit to assure that process stability can be evaluated.

6.3 Established Control Over the process:- A distinction between product and process should be made at this point. The product is the end result from the process. The product may be physical item or service. One may control the process by measuring and controlling the input to the process. It is ultimately desirable to establish control over the process by controlling the process inputs. On the other hand process capability indices are always performed using the critical parameters of the product.

6.4 Analyze Process Data:- To calculate the process capability indices, estimates of the process average and dispersion (standard deviation) must be obtained from the process data. In addition, the formulas for process capability indices assume that the process data came from a normal statistical distribution. It is important that one prove that the data is normally distributed prior to reporting the process capability indices because errors in misjudgment can lead to the same undesirable effects.

6.5 Analyze Sources Of variation:- Study of the component sources and their magnitudes may range from simple statistical tests to complex experimental designs carried out over long period of time. If possible, tests should be kept simple. Analyzing sources of variation involves determining what process factors affect the natural process spread and the process centering. With this knowledge, it may be possible to improve the process capability.

6.6 Established Process Monitoring System:- Once the process capability indices indicate a capable process, a routine process control technique should be employed to assure that the process remains stable. This may be done by a variety of methods such as establishing a statistical process program. The process capability indices should also be periodically recalculated to assure the process mean and spread has not significantly changed.

VII. PROCESS CAPABILITY INDEX (CPK)

Cpk is the distance from the process mean to the nearest specification limit divided by three times standard deviation. So in this case you calculate Cpu and the Cpl and the minimal of these two were the process Cpk.

Process capability index indicates that the process actual performance by accounting for a shift in the mean of the process toward either the upper or lower specification limit. It is often used during the pilot production phase and during routine production phase. Cpk tells about the positioning/location of the curve.

$$C_{pk} = \text{minimum of} \left\{ \frac{\text{USL} - \bar{\bar{\text{X}}}}{3\sigma}, \frac{\bar{\bar{X}} - LSL}{3\sigma} \right\}$$

Cpku – Cpk (Upper Specification Limit)

Cpkl – Cpk (Lower Specification limit)

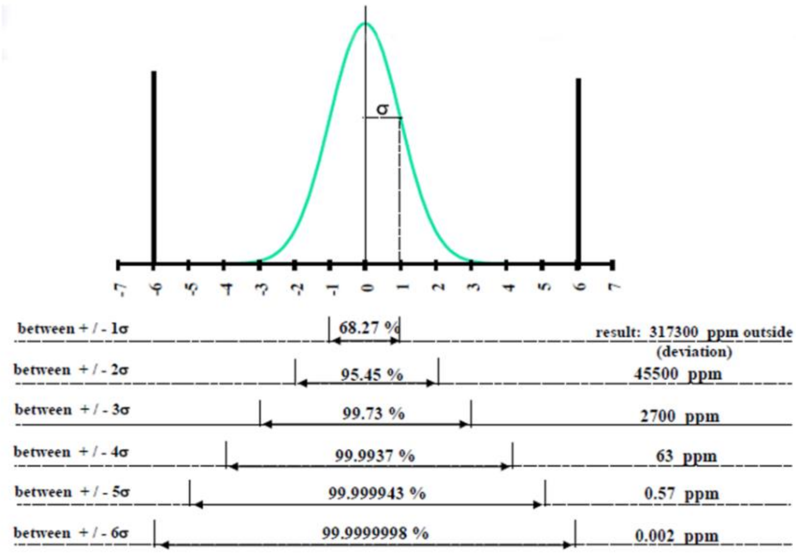

Figure 1: 6sigma & ppm relation diag.

Above figure shows relation between capability index, potential capability and the six sigma. By reducing the value of variation (standard deviation) i.e. reducing variability by reducing the process the acceptance of product may increases. If the previous specifications, USL and LSL, were at due to reduction in value of deviation .

Using process capability indices it is easy to find out how much of product is falling beyond specification. The conversion curve presented here can be a useful tool for interpreting Cpk with its corresponding defect levels. The location and

Now let us see some conditions for process capability and the defect rate.

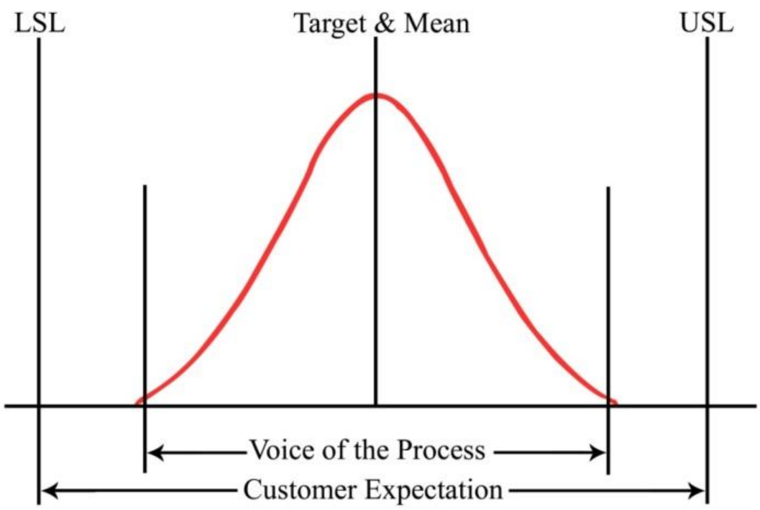

Figure 2: Specification limit & mean relation with product variation distribution diag.

Look at the above distribution shown by figure we see that USL – LSL is more than six times sigma (i.e. 6σ), so we can conclude that the Cp is greater than 1 (CP > 1). Also as the process is centered because Cp = Cpk. The process is centered and all the measurements are within the acceptable specification limits. So this process is highly capable.

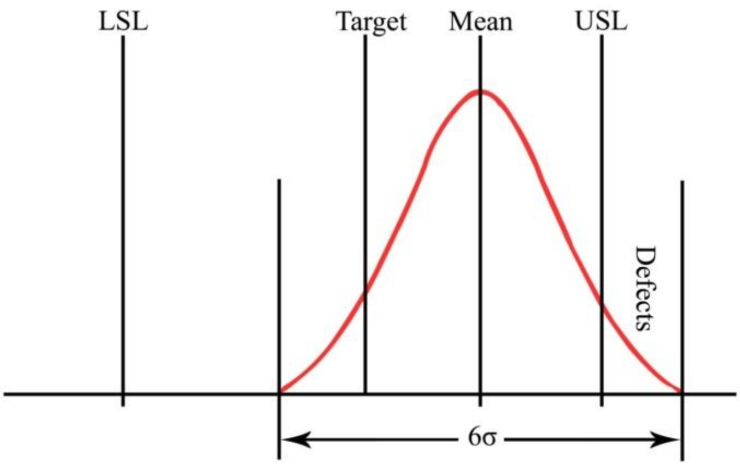

Figure 3: Specification limit and 6 sigma relation with product variation distribution diag.

Now see above distribution in this case Cp is more than 1, since the difference between USL and the LSL is more than 6σ. However in this case Cpk is less than Cp, so the distribution curve is shifted from target value. As the process has potential capability more than 1 but because of Cpk process can produce defects. So this process is barely capable.

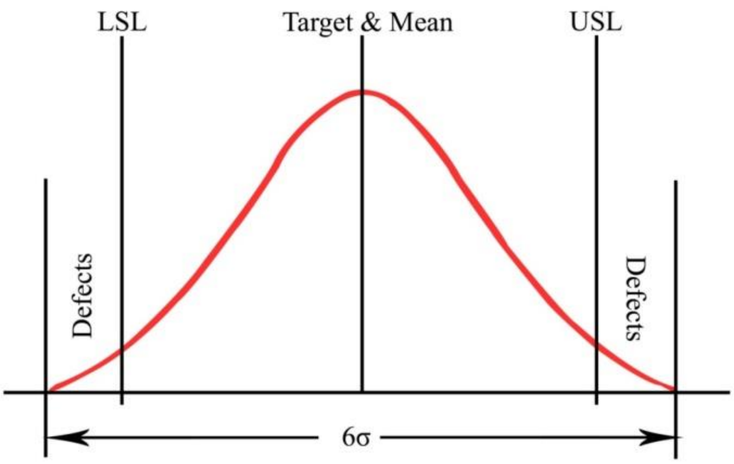

Figure 4: Specification limit, 6 sigma and mean relation with product variation distribution diag.

Now look at this figure here we can see that the difference between USL and the LSL is lesser than 6σ, since Cp < 1. Also the capability index is equals to Cp, as the distribution is centered. Hence we conclude that the process is centered but still it is producing defects, since there is area outside the specification limits. So this process is incapable. This process is able to produce nonconforming parts per million larger than 2699.9344.

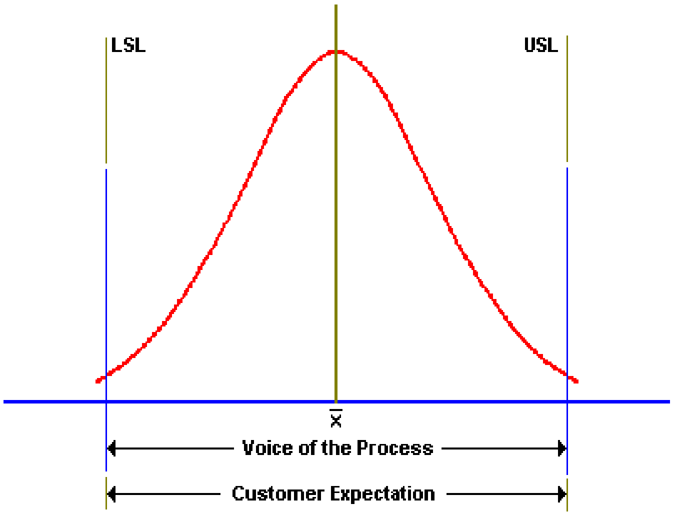

Figure 5: Product variation & customer expectation distribution diag.

Now let us see above normal distribution here the total tolerance is equals to 6σ, so here Cp is 1 and as curve is centered the Cpk is equals to 1. Hence this is barely capable process. So we conclude that the process is having 2699.9344 parts per million rejections.

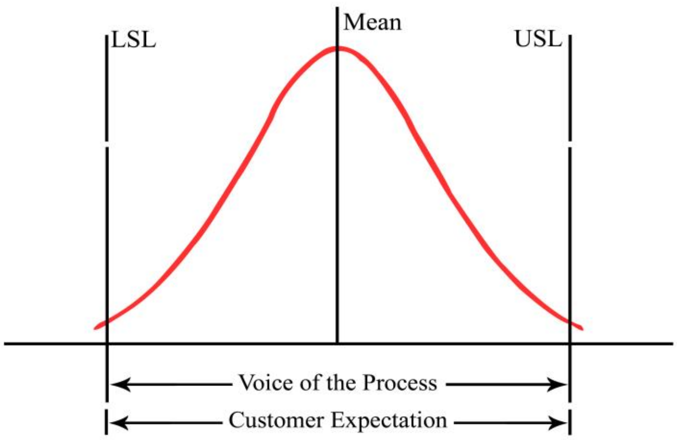

Figure 6: Product variation & specification limit diag

From above figure we can conclude that capability potential (Cp) can affect the ppm calculations. As the capability potential is equals to 1 then rejection produced by process parts per million may be of 2699.796. As the Cp increases process tends to produce less rejections per million. Hence it is advised to avoid rejections produced by process, it should be needed to maintain the process capability potential (Cp) must greater than 1, and also process capability index (Cpk) equals to potential capability (Cp) to maintain process centered.

VIII. ANALYSIS OF PROCESS CAPABILITY BY USING 5 M TECHNIQUES

Whenever the process capability indices, indicates that the process is not capable to meet the customer expectations. This is always because of process variations. Then the analysis is done to reduce these process variations. Where roots and causes of various affecting parameters and ways to reduce or eliminate them are found out. While we seek for reductions in variation we needs some programs or techniques or effective ways. So there is one way to achieve this goal is the "5MT Conditions" program. The 5M is a technique used to explore the cause-and-effect relationships underlying a particular problem. The primary goal of the technique is to determine the root cause of a defect or problem, which points toward a process which is not working well or does not exist. The technique was originally developed by Sakichi Toyoda and was used by Toyota Motor Corporation as it evolved its manufacturing methodologies. It is now used within Kaizen (continuous improvement), lean manufacturing, and Six Sigma process capability.

To explore the 5M condition fishbone diagram is used. This fishbone diagram is also called as Ishiqawa diagram as it is originally developed by Prof. Ishiqawa. This 5MT condition includes following points.

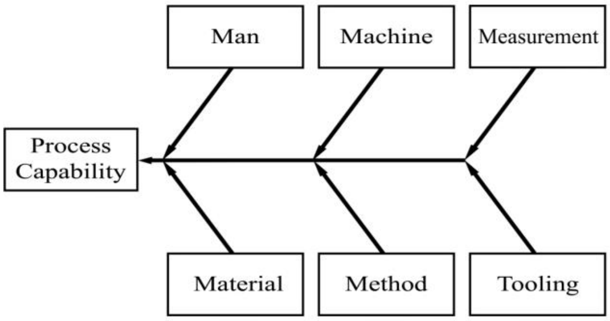

Figure 7: 5MT fishbone analysis diag.

IX. RESULTS WITH DISCUSSION

Let us now discuss the above described points in details.

Man is considerably affecting parameter on the variation on product specifications. Attitude to see process, Physical and educational limitations, Experience for specific process, Skill and knowledge, Understanding of process of new products, Training and Motivation Knowledge about measurement equipments are the points falls under man heading.

Machine is second parameter responsible for variation in product size. Accuracy and sensitivity, Maintenance after specific period, Calibration, Additional systems used for process, Environment, Vibration these all matters for the variation.

Measurement is third concluded parameter from the results responsible for variations in product size. Accuracy and precision, Repeatability and Reproducibility (R&R), Proper assembly of product, Product geometry, Digits after decimal point falls under heading of measurement. Material also contributes for variations and following points falls under it.

Physical properties (Hardness), Chemical properties (chemical stability), Defects in attribute data of raw material, Previous process done to product. Methods also causes variations as they may have Defective program, Sequence of operations of tool, Measurement technique, Method of providing inputs to machine. In tooling Tool wear, Feed, Spindle speed, Depth of cut these lead to the product variation.

X. FUTURE WORK

Properties of PC index, suggested by various researchers are examined under different distributional assumptions. The obtained results offer a useful approach for measuring process capabilities on the basis of quantitative aspects. Often a quality of process is determined by several correlated univariate variables. Our objective to study the therotical as well practical areas of the process capability indices.

XI. CONCLUSION

To maintain process capable, checked product specification must be 1/3rd of the tolerance limit. According to Cpk, we can conclude about how long the process will be capable? Under the heading of

5MT's i.e. Man, machine, material, measurement, method and tooling various sub-parameters makes large affect on the process capability index.

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