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Statistical Process Control in the Automotive Industry

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Abstract- **Variability in method performance typically ends up in waste and process. For improvement in quality and productivity method variation must be reduced. Several techniques square measure obtainable for quality improvement. Applied math method management (SPC) is one such TQM technique that is wide accepted for analyzing quality issues and raising the performance of the assembly method. Applied math method management (SPC) is methodology mistreatment management charts for helping operators, supervisors, and managers to observe the output from a method to spot and to eliminate the reason behind variations. SPC may be a established technique for deciding {the method the method} capability and predicting the yield from a process. In trade, supplier's square measure needed to produce proof of applied math method management to their customers. Survivors in extremely competitive markets are going to be those companies that may demonstrate their quality capability. During this paper want of SPC, varieties & procedure of plotting management charts and method capability confirmation by SPC as a top quality management tool is mentioned.**

Index terms- **Statistical Process Control, Quality Control, Decision Analysis, Automotive Industry, Quality improvement**

1. INTRODUCTION

The management and quality improvement has become one among the core ways of business for various organizations, fabricants, distributors, transporters, financial, health and state service organizations. Quality could be a competitive advantage and any given organization that satisfies its customers through quality improvement and management will prevail over the competition.

The increasing economic process and also the increment of automotive production capability stimulate the fight of automotive plants. For the automotive business the standard is expressed in terms of customers' satisfaction in reference to the merchandise and offered services. a solution to the current increasing demand is that the SPC – a group of tools for method management and for determination and observance of the standard of a corporation final outputs. It's additionally a method for rising capability through the reduction of variability of merchandise, deliveries, processes, materials, attitudes and instrumentality. the proper implementation and use of the Statical method management will result in selections supported facts, to a growing perception regarding quality in the slightest degree levels, to a scientific methodology regarding downside resolution, to a gathering of expertise and to all or any reasonably improvement. preponderantly in producing and regarding quality, SPC is that the most generally used technique and once fittingly applied, will improve operational and money advantages.

Control charts square measure wont to check the method stability. during this context, a method is alleged to be "in applied math control" if the likelihood distribution representing the standard characteristic is constant over time. If there's any modification over time during this distribution, the method is alleged to be out of management. In distinction, associate degree out of criterion signals the presence of transferrable or special cause variation within the distribution. this kind of variation should be known and eliminated so as to bring the method to a state of applied math management.

Depending on the kind of knowledge collected, there square measure variable and attribute management charts. Variable management charts square measure supposed to manage method or product parameters that square measure measured on an eternal measure scale like pounds, inches, millimeters, etc. instead of amount defective. For a producing method, the foremost common management charts in use square measure mean and variance that has to be monitored collectively to make sure prime quality yield. Joint Shewhart the and R (or s) management charts are wont to management the method mean and variance

for an extended time. The attribute management charts classifies processes in terms of fine or unhealthy, settle for or reject, etc. Amongst all the attributes management charts, the p chart is additional appropriate for showing the variable sample size and are used wide in industries to manage the method fraction unorthodox p, since it's outlined because the quantitative relation of variety the amount the quantity of unorthodox units during a population to the full number of units in this population.
Cp-capability index indicates whether or not ths method is capable of manufacturing product to specifications. The capability index is calculated exploitation specifications limits and also the commonplace deviations solely.
CPk- performance chart indicates whether or not the method is capable of manufacturing among specifications associate degreed is additionally an indicator of the power of the method to adhear to the target specification.
method capability analysis has become a major and well-defined tool in applications of SPC to an eternal improvement of quality and productivity. Following this, the power of the method to satisfy specifications is assessed through calculation of 1 or additional capability indices. the foremost simply understood of those is that the proportion of things created by the method that square measure among specification.
This paper aims to contribute to unravel a high quality downside, significantly within the improvement of a method quality exploitation varied applied math tools. A qualitative analysis methodology is employed, so as to look at the readying of the SPC and its impact on company's success. Moreover, per the reached results, it's thought of the chance to counsel doable enhancements relating to the utilization of SPC.
This paper is organized as follows. once the introduction a literature review on Section one offers a general summary of the subject - the state of art, the objectives, the paper organization and also the study methodology. Section two presents the outline of the supposed industrial unit and also the analysis of the method, knowledge assortment and utilised management charts; the results and its details square measure then given in section three. In section four is created associate degree analysis of identical results and also the discussion of them. The paper concludes in Section five with general conclusions and proposals.

2. METHODOLOGY

The methodology is a general framework used in research work and addresses a more practical perspective, referring to tangible paths used to better understand the involved certainties.
A case study can make an important contribution to scientific development and such research is not simplistic at all since requires adequate theoretical basis, expertise, dexterity and time availability. Certain situations and processes run the risk of going undetected in studies of larger proportions while analysing cases, even unusual cases, can be illustrative of critical conditions for systems and organizations.

3. THE INDUSTRIAL UNIT AND THE PROCESS

The case study is an automotive plant belonging to an industrial group founded in the 1983. This plant produces various automobiles, which is the the leading manufacture of Four-Wheeler automobile in South Asia. Suzuki Motor corporation of Japan holds a majority Stake of the company. It was the first Indian company to mass produce and sell more than one million cars. Maruti 800 till 2004, was the India's largest selling compact car ever since it was launches in 1983.
This case study has a diversified production launching over 39 different models to the market. This factory is characterized by different processes of manufacturing automobiles. The production process of each product follows a specific flow, as each requires a specific tool.
For such processes and in order to have better quality control at various stages the case study plant has implemented a wide range of Statical Process Control tools. . During the production process of engine parts the statistical control is required. Therefore, there are features of each conceived part, almost all dimensional, which must be controlled, as required. Some parts are quite complex because they contain some significant features than the rest which requires to be controlled with the important support of the control charts.
This case study is confined to the study an analysis of statistical process control applied to one part

reference by analysing variables control charts for the most produced parts by the plant, and also the example of an attribute control chart for of the same part if so is needed.

Thus, the study is based on these two types of control chart, each corresponding to production process of two references to the same part, omitting the study of remaining parts since the references are not very similar between each other and control method varies from one another.

3.1THE PROCESS

Being in mind the main objective of this study, a process that justifies the use of both, variables and attribute control charts is analysed. Firstly a detailed analysis of the process of a specific produced part named "Cylinder Head" is performed.

As can be seen several steps are involved in the production process of "Cylinder Head". These steps are described below:

Stages of Manufacturing

Casting > Machine shop > Machining > Inspection > Engine Shop>Assembly

- Step 1 –Raw material enterence is given to the machine shop which is provided by casting, which are unloaded, which came after the inspection from the casting shop and then loaded on machine for machining.
- Step 2 – After being loaded on machines, various operations are performed on the element such as grinding, drilling, threading, etc.
- Step 3 –After every operation the process is checked by the operator manually with the help of various instruments like blow holes, unwanted scratches, wrong operation, etc. if an of the piece is found faulty it is marked with red paint.
- Step 4 –The finished product is now passed through the degreasing process. The degreasing is required to remove the coolant (mixture of oil and water) used during the operation in machines.
- Step 5 –Randomly the finished products are now brought to the inspection room to check its dimensions on computerized machine with the accuracy of micrometer µm.

3.2 COLLECTION OF DATA

The collection of data related to Cylinder Head necessary to perform the qualitative analysis and measurement is made as described in step 5. According to the technical drawing given by the R&D department, there are around 6 critical dimensions. The other dimensions are not significant and do not require constant monitoring, however are also important. The statistical process control is made for all 6 critical dimensional characteristics as required by the factory. The collection frequency for measurement and inspection is established on a sample of 25 parts per shift and there is four shift daily, resulting in one sample for measurement. The variables measurement of the dimensions is carried out by a CMM machine when data are required for a sample of 25 parts to complete variables control charts. The fixture is used after Step 5 for data collection to detect a fraction of defective products or non-conforming products with a variable sample of pieces per shift, this requires attribute control charts. The non-conformities identified are recorded, and follow a pattern identified with the problem as well as the nomenclature of the problem or defect. This standardization permits doing a question of the information collected and also the analysis of the most mechanical system issues, epidemic downside identification and also the prioritization of corrective actions for more elimination.

3.3CONTROL CHARTS

As mentioned previously, the sampling frequency is 25 pieces per shift and since there are four per day, four point in the control chart is daily recorded. There are two types of control charts used for the existing process, one by variables and one by attributes and along this paper will be studied a control chart of each type.

In the Figure 2, it is possible to see an illustrative image of a variable control chart (,). This chart is divided in two big parts, with 25 samples each. The variables control chart is composed by the following sections: 1) Identifying data of the chart and of the process; 2) Statistical control chart; 3) Data table in which all measurements are introduced; 4) Result section, one being the Capability Index; 5) Histogram; 6) Normal Probability chart; 7) Kolmogorov-Smirnov Test; 8) PPM (Parts per million).

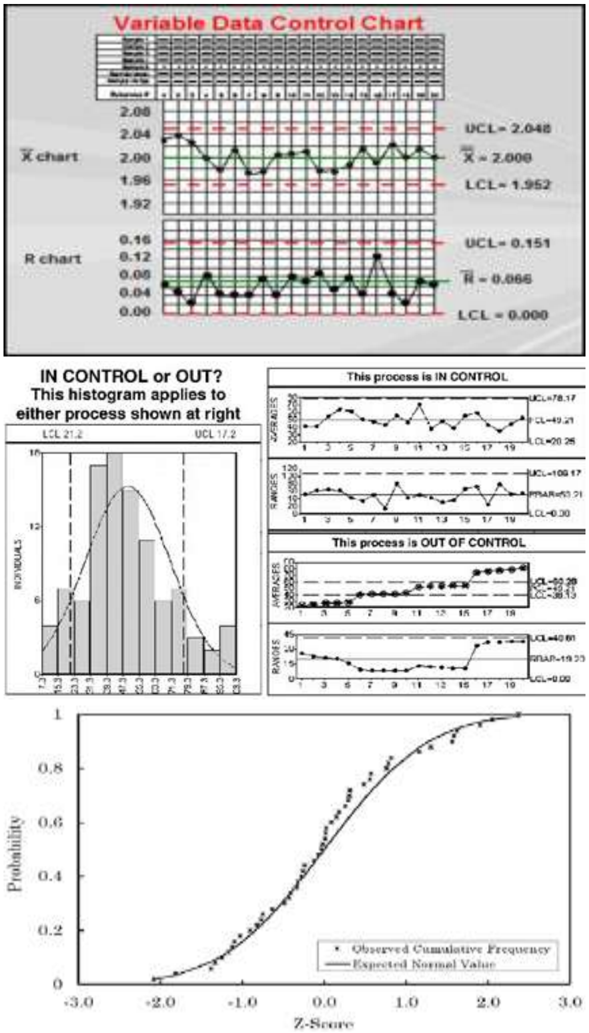

Figure 2. Variables control chart.

The p attribute control chart it is made by less sections, which are: 1) Identifying data of the chart and of the process; 2) Statistical control chart; 3) Data table in which all measurements are shown; 4) Result section, one being the Capability Index; 5) Note that this control chart has a lack of several statistical tools present in variable control charts such as normality test and histogram.

3.4RESULTS OBTAINED FROM(R) CONTROL CHART

For "studying the dimensional feature of the cylinder head journal certain control charts are employed being defined as target the dimensional feature of dia 23.0mm with a tolerance of 0-21µm. The daily collected sample of 25 pieces comes from Step 3 of the process.

In the Figure 2, it is shown the sample data. Also is to be noted that this table gives info on dates, average and range.

After filling the data slots with collected measurements, the graphic marks start to appear. In the Figure 2, the result of the collected data is revealed. It is possible to observe the behaviour of the graphic by following the dots connected line and it is possible to see the control limits and also the average as well as the small boxes above the charts containing the value of the average, range and control limits.

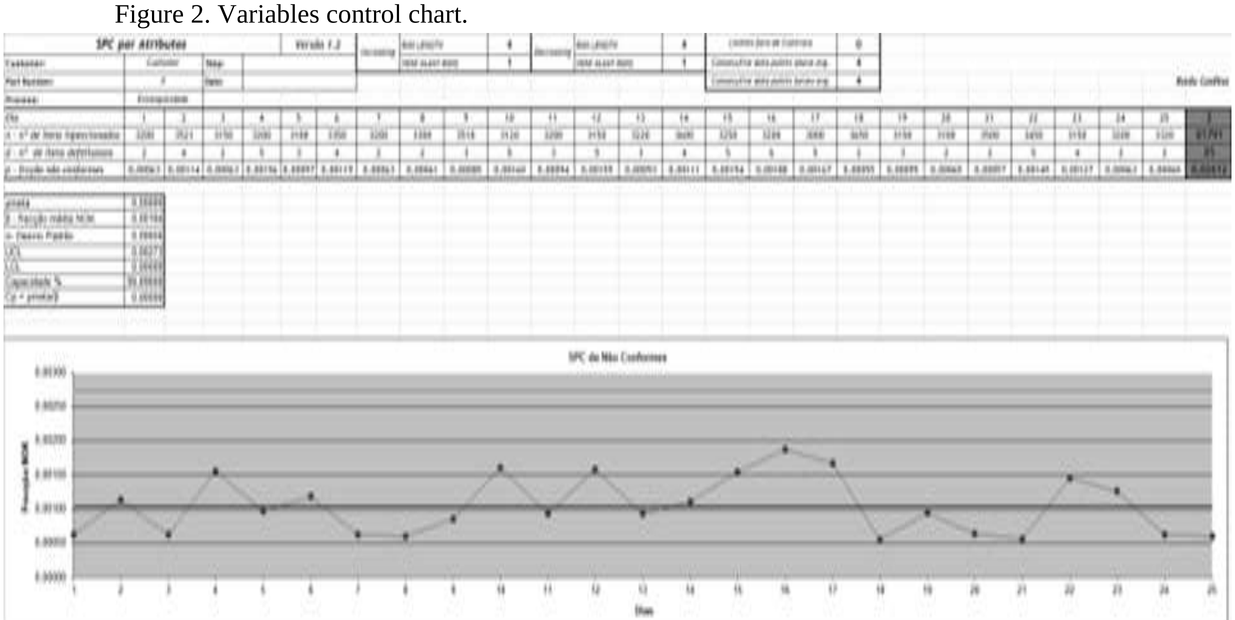

Figure 3. *p* attribute control chart

The interpretation and the obtained results from this control chart are discussed further in the paper.

The numbers of inspected items are the numbers of pieces that are tested by the control fixture.

In Figure3 the sample data is presented, which is divided into 25 subgroups and it can be seen the inspected items row, the number of defective items and non-conforming fraction.

After filling the data slots with collected measurements, the graphic marks start to appear. It is possible to observe that the behaviour of the graphic by following the dots and the connecting line, also the vertical lines, the control limits and the average are shown.

The interpretation and the obtained results from this control chart are going to be discussed further in the paper.

4. RESULT ANALYSIS

After the data insertion in control charts and after making the observation of graphs' shape it is possible to deduce some indices, like capability index, in order to better understand the obtained results. The capability calculation was done by Excel®™ software that analyses the tendencies and the process' Capacity index.

Also with another statistical tool in case of variable control charts, for instance the normality test a better understanding of the acquired results can be reached.

4.1 CONTROL CHART OBTAINED RESULTS ANALYSIS

4.1.1 Calculations for process capability index

1 Standard deviation (σ) by the following method σ = Rbar/d2

Where d2 = 23.007 for n = 25

Where Rbar is the average of sub group ranges

2 Calculate the process capability: Process Capability Cp = (USL – LSL)/ 6σ = tolerance / 6σ

Process Capability Index Cpk = Minimum of Cpl,

Cpu Cpl = (Xbar – LSL)/ 6σ Cpu= (USL – Xbar)/3σ

σ = Standard Deviation X bar = Mean find in the X bar chart

USL =Upper specification Limit LSL= Lower Specification Limit

4.1.2 Process Capability index

For the process in control satisfactorily Cp and Cpk≥ 1By convention, when a process has a Cp less than 1.0, it is considered as incapable of meeting specification requirements. Conversely, when a process Cp is greater than or equal to 1.0, the process has the chances of being capable. By convention, If the Cpk is less than one, the process is considered to as incapable. When the Cpk>=1, the process is considered capable of producing a product within specification limits. In a Six Sigma process, the Cpk= 2.0. The value of Cp should be as high as possible. The higher the Cp, the lower the variability wrt the specification limits. In a process qualified as a Six Sigma process (i.e., one that allows plus or minus six standard deviations within the specifications limits), the Cp>= 2.0.

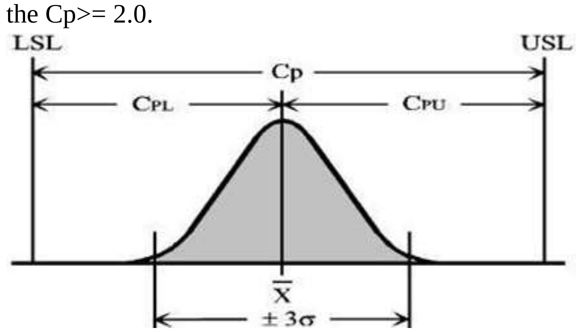

FIG. Relation between Cp and Cpk

Table 1. Process capability analysis

Number of readings (Journal J1)	25
Lower spec limit (LSL)	23mm
Nominal	23mm
Upper spec limit (USL)	23.021mm
Average readings (X)	23.007
Maximum	23.015
Minimum	23.002
Readings below LSL	0
Readings above USL	0
Average Range (R)	0.013
Upper capability index (Cpu)	1.41
Lower capability index (Cpl)	1.41
Capability index (Cp)	1.41
Capability ratio (Cr)	0.71
Process Capability Index (Cpk)	1.41

The collected data from the Table 1 can give some conclusions. After computing all the data the process capability index Cpk is 1.41. This plant as many others uses as a standard of quality goal of Cpk > 1,33 ensuring that the specification contemplates 6σ of the process. However as 1.41> 1.33 it can be concluded that the process is capable. Also the potential capacity of the process is calculated and the Cp index assessed, reaching a value of 1.41, which is greater than 1.33, so the process is potentially capable.

4.2 P CONTROL CHART OBTAINED RESULTS ANALYSIS

By placing the data into the control charts and after viewing the shape reached by the control chart it is possible to deduce the capacity rate, to better understand the results. By examining the p control chart and by searching for pattern recognition and counting the obtained points it was filled up the Table 3:

Table 4 shows that there is no non-random pattern since it is not verified the occurrence of seven or more consecutive points to follow a trend or consecutive data points above or below average. The data required to obtain the capability of the process from the p control chart is in Table 5:

Table 5. Process capability analysis

p_ goal	0.00000
p - Average Fraction NOK	0.00104
σ- Standard Desviation	0.00056
UCL	0.021
LCL	0.00000
Capacity %	99.89608
Cp = p_goal/p	0,00000

Table 5 provides the information on the capacity percentage which is related to the expectations and goals of the management. With the help of this data the capacity index (Cp) is computed. When Cp = 0 and Cp < 1, this means that the management must act on the process.

Attending the analysis of p control chart this process does not present satisfactory results of stability and capability. However, because of customer requirements, the use of this type of control chart was abandoned. As the customer demanded 0% of defective pieces, management decided to give up of this method of control and implemented a 100% control, i.e., a unitary control at the end of Step 5.

5 CONCLUSIONS AND RECOMMENDATIONS

Briefly, the development of this work led to a deepening of knowledge around the management method or a set of tools for managing processes - the statistical process control-SPC with respect to its scope, its embracement and its implementation in the real time.

The main objective of this paper is to present the application of a systematic approach to the use of Statistical Process Control (SPC) across the several stages of production of a specific “Cylinder Head” in a plant with the purpose of improving the quality in its manufacturing processes.

Using the control charts this approach, allows the identification of problems into the company’s production process. By applying this model, it was possible to increase knowledge and learning through the difficulties and challenges encountered in each step of application of the statistical process control. Thus, it is possible to show that depending on each case the researcher should develop alternatives to make Statical Process Control (spc) applicable to different kind of companies since they could have different processes, routines and particularities, requiring specific adaptations. Although the analysis of the results of attribute control charts have demonstrated that the process is not capable of producing 100% of the specified piece within required specifications, it can be seen that, through these information it the manufacturing process of the Cylinder Head can be better understood and the analysis of the results and the application of corrective actions and improvement are facilitated.

By preparing the case study its possible to apply this solution to the reality of an industrial unit within all its complexity.

Regarding the results of attributes control chart, became unsatisfactory since it cannot guarantee 0% defects and some nonconforming parts eventually reach the customer. The solution chosen by management was the 100% unit control output in Step 5. Although it is a more expensive and requires more hand labour, guarantees 100% leaktightness of the Cylinder Head, as requested by the customer.

Choosing the right steps for using this method it is very important since it allows better control of the process in its various stages of production and creates the possibility of identifying some problems at the root and not only detect them at the end of the process.

By analysing the results obtained in the case study, it is believed that the application of the proposed model, with the necessary adaptations, can help other companies to achieve high levels of quality, resulting in gains and in meeting the expectations of final customer that may contribute in a crucial way to the growth of the company's image, which is its greatest asset.

The approach proposed can be applied at other stages of the process, contributing significantly to the reduction and/or elimination of failures in the production process, allowing the fulfillment of the quality targets set by the management company to other ones. This demonstrates that continuous improvement is a necessity that must be born from the product design or new processes, making it possible to gain time and resources, not forgetting that the company is working preventively and not correctively.

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