Implementation of Statistical Process Control Techniques in Industry: A Review

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Abstract **- Excessive variability in process performance often results in waste and rework. For improvement in quality and productivity process variation needs to be reduced. For this Statistical Process Control techniques are used. SPC uses statistics to detect variations in the process so that it can be controlled. Control charts are used in SPC for measuring the variation in the process and that can be continuously improved by the different techniques used in the SPC such as 7 QC tools. This paper shows applicability of the statistical process control techniques in different manufacturing industries. In this research paper various research articles and the case studies on the implementation of the Statistical Process Control Techniques in the manufacturing industries are selected for the review.**

Keywords **- Statistical Process Control, Control charts, 7QC Tools**

I. INTRODUCTION

Success in the global market depends on quality. Companies don't design poor quality; it is usually the result of a variation in some stage of production. The concept of variation states that no two products will be perfectly identical even if extreme care is taken to make them identical in some aspect [17]. Therefore, product quality depends on the ability to control the production process. This is where Statistical Process Control- SPC, comes in [2]. Statistical Process Control (SPC) applies statistical methods to monitor and control a process to operate at full potential. Statistical process control is a collection of tools that when used together can result in process stability and variance reduction. Control charts are used in SPC for measuring the variation in the process and that can be continuously improved by the different techniques used in the SPC such as basic 7QC tools. 7QC Tools are called Basic because they are suitable for people with little formal training in statistics and they can be used to solve the vast majority of quality-related issues [18].Management involvement and commitment to the quality improvement process are the most vital components of SPC's potential success. A team approach is also important, as it is usually difficult for one person alone to introduce process improvements [1]. The objective of an SPC-based variability reduction program is continuous improvement on a weekly, quarterly, and annual basis.

A. Control charts-Origin of SPC

Concern over variation in manufactured products produced by the Western Electric Company and studies of sampling results led Dr. Walter A. Shewhart of the Bell Laboratories to the development of the control chart as early as 1924 and the concept of a state of statistical control. There have been many extensions and modifications of the basic control charts of Shewhart over the years. They are the principal tools of statistical process control (SPC) [1]. The control charts are the base for the continuous improvement of any product quality. In any production process, regardless of how well designed or carefully maintained it is a certain amount of inherent or natural variability will always exist. The variation in the quality of product in any manufacturing process results because of two reasons namely, Chance cause and Assignable cause. A process that is operating with only chance causes of variation is said to be in a state of statistical control. A process that is operating in the presence of assignable causes is said to be out of control [17].

A typical control chart has control limits set at values such that if the process is in control, nearly all points will lie within the upper control limit (UCL) and the lower control limit (LCL) [1].

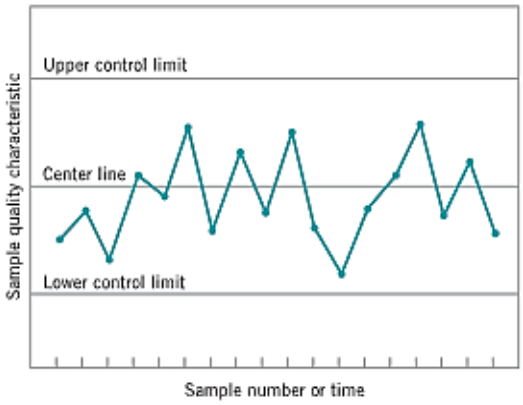

Fig.1 control chart

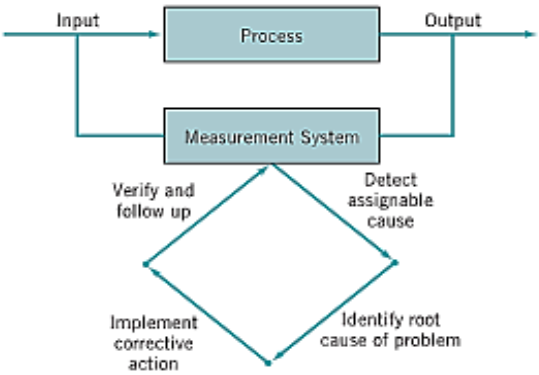

Fig.2 Process improvement by chart

Types the control charts:

1. Variable Control Charts for the Continuous data

2. Attributes Control Charts for the Discrete data

The control chart is an important tool for process improvement. Processes do not naturally operate in an in-control state, and the use of control charts is an important step that must be taken early in an SPC program to eliminate assignable causes, reduce process variability, and stabilize process performance. To improve quality and productivity, we must begin to manage with facts and data, and not simply rely on judgment. Control charts are an important part of this change in management approach. Control charts are widely used to establish and maintain statistical control of a process.

B. Basic 7 QC tools

1. Check Sheet
2. Histogram
3. Pareto Chart
4. Cause and Effect Diagram
5. Flow Chart
6. Control Chart
7. Scatter Diagram

1. Check Sheet: Check sheets are simply charts for gathering data. They are easy to understand and very clean to read.
2. Histogram: A histogram is a snapshot of the variation of a product or the results of a process. It often forms the bell-shaped curve which is characteristic of a normal process. The histogram helps to analyse what is going on in the process whether the data is falling inside the bell-shaped curve and within specifications.
3. Pareto Chart: The Pareto chart can be used to display categories of problems graphically so they can be properly prioritized. Pareto chart is a vertical bar graph displaying rank in descending order of importance for the categories of problems, defects or opportunities.
4. Cause and Effect Diagram: The Cause and Effect Diagram display the relationships between different causes for the effect that is being examined. The major categories of causes are put on major branches connecting to the main line, and various sub-causes are attached to the branches.
5. Flow Chart: Flow chart breaks the process down into many sub-processes. Analysing each of these separately minimizes the number of factors that contribute to the variation in the process.
6. Control Chart: As discussed above they are used to monitor the process.
7. Scatter Diagram: A Scatter plot is used to show how a pair of variables is related and the strength of that relationship. It is constructed by plotting two variables against one another on a pair of axes.

C. Manufacturing Industries

In order to survive in a competitive market, improving quality and productivity of product or process is a must for any company. To make improvement in the company strong commitment from the top management is required [3]. Furthermore the critical success factors are training and education, awareness of statistical methods, adequate measurement system etc. [4]. According to Prof. J.A. Doshi, J.D. Kamdar, Prof. S.Y. Jani, and Prof. S. J. Chaudhary for taking proper decision Cause and effect diagram is very helpful to the management. It is important to focus on the critical causes [15]. However, Laura M.M. Ribeiro and J.A. Sarseld Cabral found some misuse of the control chart that cannot help to remove the assignable causes of variation [16]. The 7QC tools are found the base for implementation of the quality management system in industry. Also for the data collection, analysis, measuring and decision making the tools are found very essential [10]. Edgardo J. Escalante has given the relationship among variation, quality, and defects. Also he has identified the common and special causes of variation & defects and derived benefits from reducing variation & non-conformities [17]. In six-sigma, for analyze, measure and control phase SPC tools are very useful and play the vital role for finding causes [22].

II. RESEARCH METHODOLOGY

This paper aims to explore the benefits and the applicability of the SPC tools and techniques in the manufacturing industries of different products. The different case studies and research articles are collected where the SPC has been successfully implemented in the manufacturing industries. Here the industries are from the different products and they have applied the SPC for their need. The case studies are from registered journals and publications. Total 12 case studies are taken from global industries. These case-studies are presented and their benefits and result are discussed as mentioned below.

III. TITLE OF THE PAPER AND PUBLICATION

Table-1 contains list of case studies with the title, authors, the publication journals with year of published and the manufacturing firm-product. These case studies are from global industries with the different products.

Table: 1 Research Summary

Sr. No.	Title	Authors	Journal, Year	Manufacturing Firm
1	Improving quality with basic statistical process control tools: A case study	Jafri Mohd. Rohani & Chan Kok Teng	Jurnal Teknologi, 2001	Injection plastic mould lenses
2	A case of implementing SPC in a pulp mill	JukkaRantama ¨ki,Eeva-LiisaTiainen,TuomoKa¨ss	International Journal of Lean Six Sigma,2013	Pulp mill
3	Quality improvement using statistical process control tools in glass bottles manufacturing company	Yonatan Mengesha Awaj,Ajit Pal Singh, WassihunYimer,Amedie	International Journal for Quality Research,2013	Glass bottles
4	Implementation of SPC Techniques in Automotive Industry: A Case Study	Dr. D. R. Prajapati	International Journal of Emerging Technology and Advanced Engineering, 2012	Shock Absorbers/ Rod Seals
5	The use of Statistical Process Control Technique in the Ceramic Tile Manufacturing: a Case Study	AliMostafaeipour, Ahmad Sedaghat, Ali Hazrati, MohammadaliVahdatzad	International Journal of Applied Information Systems ,2012	Ceramic Tile
6	Investigation and analysis of cold shut casting defect and defect reduced by 7 quality control tools	Prof B.R. Jadhav, Santosh J Jadhav	International Journal of Advanced Engineering Research and Studies ,2013	Automobile cylinder block of grey cast iron Grade FG150
7	Process variability reduction through Statistical Process Control For quality improvement	B.P. Mahesh M.S. Prabhuswamy	International Journal for Quality Research,2010	Soap manufacturing
8	Quality Tools to Reduce Crankshaft Forging Defects: An Industrial Case Study	Pankaj Chandna, Arunesh Chandra	Journal of Industrial and Systems Engineering ,2009	Crankshaft(697 integral counter weight)
9	An Integrated Model for Manufacturing Process Improvement	Winco K.C. Yung	Journal of Materials Processing Technology, 1996	Printed Circuit Board
10	On the Use of Quality Tools: A Case Study	Fábio A. Fernandes, Sérgio D. Sousa, Member, IAENG and Isabel Lopes	Proceedings of the World Congress on Engineering, 2013	Leather components
11	Statistical Process Control Tools: A Practical guide for Jordanian Industrial Organizations	Rami HikmatFouad, Adnan Mukattash	Jordan Journal of Mechanical and Industrial Engineering ,2010	Steel
12	Implementation of Statistical Process Control for manufacturing performance improvement	Farzana Sultana, Nahid Islam Razive, Abdullahil Azeem	Journal of Mechanical Engineering,2009	Cigarette

IV. OBJECTIVE AND TOOLS USED

For achieving higher profit we have to improve quality and this can be done by reducing the defects. Most of the case studies have similar objectives i.e. to reduce the defects as shown in Table: 2. Table: 3 indicate different tools and techniques used to achieve the objective. This comparison helps us to analyse which of the 7QC tools are mostly applied to in the engineering organization to achieve the goal.

Table: 2 Objective of the paper

Sr. No.	Objective of the paper
1	To reduce the defect rate from 13.49% to 10%.
2	To implement SPC in the control phase of six sigma
3	To create awareness to quality team how to use SPC tools in the problem analysis
4	To reduce the 9.1% rejection of Shocker Seals.

5	To reduce unwanted ceramic tile defects and wastages
6	To analyse and minimise casting defect Cold shut
7	To improve the Quality by reducing the variability in the process
8	To Reduce Crankshaft Forging Defects
9	To implement the spc in plant to monitor process
10	To use quality tools to improve the level of quality management
11	To train quality team on how to held an effective Brainstorming session and exploit these data in cause and effect diagram construction
12	To minimize machine breakdowns.

Table: 3 Comparison of Tools and Techniques used in paper

Tools and Techniques	1	2	3	4	5	6	7	8	9	10	11	12
Check sheet	Yes	yes	yes			yes					yes	
Histogram					yes					yes	yes	
Pareto Chart	Yes		yes		yes	yes	yes	yes	yes		yes	yes
Cause and Effect Diagram	Yes	yes	yes	yes		yes	yes	yes	yes	yes	yes	
Flow chart												
Control chart	Yes		yes	yes	yes		yes			yes	yes	yes
Scatter Diagram											yes	
Brainstorming			yes			yes					yes	
PDCA										yes		
Six-pack charts					yes							

V. BENEFITS AND RESULTS GAINED BY THE INDUSTRIES

In the Table: 4 the benefits/Results/Conclusion is given. After implementing SPC tools the organization has definitely gained the benefit in form of reducing the defects.

Table: 4 Benefits/Results/Conclusion of the paper

Sr.No.	Benefits /Results/Conclusion of the paper
1	Improved quality by reducing defects from 13.49% to 7.4%
2	It is used as a part of implementing six sigma in control phase
3	The pressure failure defect reduced from 23.44% to 13.51%. Blistersdefect reduced from 3.14% to 2.51%. The total gain annually due to reduction in pressure failure is 15391.2 Birr
4	The rejection of shock seal is reduced from 9.1% to 5% and process capability is 0.953 is achieved
5	From the Pareto chart about 61% of problems occur only due to types of cracks
6	The total rejection from cold shut was reduced to 6.6 % from 12.3% which is nearly 50% reduction
7	Increased the process Cp and Cpk
8	Reduced the rejection rate from 2.43% to 0.21% and rework from 6.63% to 2.15%
9	Scrap and rework rates have been reduced while quality yield is improved significantly
10	Reduced 29% in the number of nonconformities in the most problematic section. Average number of nonconformities reduced 50%.
11	The steel tensile strength is the vital few problem and account for 72% of the total results of the problems
12	The frequencies and time duration of cigarette making machine breakdowns and major causes of breakdowns are found

VI. CONCLUSION

From the above study of the different case studies it can be concluded that to survive in the competitive market companies need to produce the quality products. And quality can be achieved by using the SPC tools and techniques. From the study it reveals that SPC techniques can give the significance improvement to the quality. These tools and techniques are simple to implement and it needs the top management involvement and employee support. The SPC knowledge is important to the implementation and proper guidance is required. In this paper it has found that the SPC tools can be applied to different product for reducing the defect. Thus the SPC techniques are used globally to improve quality. Although SPC seems to be a collection of statistically based problem-solving tools, there is more to the successful use of SPC than learning and using these tools. SPC is most effective when it is integrated into an overall, companywide quality improvement program.

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