A Systematic Review of SPC Implementation in the Manufacturing Industry

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Abstract— This paper is a systematic review of the literature on statistical process control (SPC) implementation in the manufacturing industry. Using systematic searches across two decades of publications, 14 case studies were selected for the review. These case studies are from various journals and publications. These case studies were executed in the different industries produces different products. This paper focuses on the objectives of the case studies, various techniques used to fulfil the objectives and benefits gain by industries after implementing the quality tools.SPC involves measurement of process performance that aim to identify common and special causes of variation and maintain process performance within the limits. This paper will outline the 7QC tools and their vital role in increasing the productivity volume with the constraints of resources available and products cost.

Key words: SPC, 7 QC Tools, Common and Special Causes of Variation

I. INTRODUCTION

Statistical process control (SPC) is a method of quality control which uses statistical methods. SPC is applied in order to monitor and control a process. Monitoring and controlling the process ensures that it operates at its full potential. At its full potential, the process can make as much conforming product as possible with a minimum (if not an elimination) of waste (rework or scrap). SPC can be applied to any process where the "conforming product" (product meeting specifications) output can be measured. Key tools used in SPC include control charts; a focus on continuous improvement; and the design of experiments. An example of a process where SPC is applied is manufacturing lines. SPC must be practiced in 2 phases: The first phase is the initial establishment of the process, and the second phase is the regular production use of the process. In the second phase, a decision of the period to be examined must be made, depending upon the change in 4 - M conditions (Man, Machine, Material, Method) and wear rate of parts used in the manufacturing process (machine parts, jigs, and fixture). The preparatory phases of SPC involve several steps, using a number of different tools. Seven quality tools are available to help organizations to better understand and improve their processes. The essential tools for the discovery process are Check Sheet, Cause-and-Effect diagram, Flow Charting, Pareto Chart, Scatter Diagram, Histogram or probability plot and Control Charts. Check sheets are simply charts for gathering data. When check sheets are designed clearly and cleanly, they assist in gathering accurate and pertinent data, and allow the data to be easily read and used. Cause-and-Effect or Fishbone diagram are also called Ishikawa diagrams because Kaoru Ishikawa developed them to search the root causes of problem. The fishbone chart organizes and displays the relationships between different causes for the effect that is being examined. This chart helps organize the brainstorming process. The major categories of causes are put on major branches connecting to the backbone and various sub-causes are attached to the branches. Flowcharting breaks the process down into its many subprocesses. Analyzing each of these separately minimizes the number of factors that contribute to the variation in the process. The Pareto chart can be used to display categories of problems graphically so they can be properly prioritized. The Pareto chart is named for a 19th century Italian economist who postulated that a small minority (20%) of the people owned a great proportion (80%) of the wealth in the land. The Scatter plot is another problem analysis tool. Scatter plots are also called correlation charts. A Scatter plot is used to uncover possible cause-and-effect relationships. It is constructed by plotting two variables against one another on a pair of axes. A Scatter plot cannot prove that one variable causes another, but it does show how a pair of variables is related and the strength of that relationship. The probability plot is a graph of the cumulative relative frequencies of the data, plotted on a normal probability scale. The purpose of this plot is to show whether the data approximates a normal distribution. 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. Control charts are an essential tool of continuous quality control. Control charts monitor processes to show how the process is performing and how the process and capabilities are affected by changes to the process. This information is then used to make quality improvements. Control charts are also used to determine the capability of the process. They can help to identify special or assignable cause for factors that impede peak performance. The Control charts may be classified: (i) control charts for variables and (ii) control charts for attribute. The control charts based on variable data that can be measured on a continuous scale i.e. weight, volume, temperature etc. are known as control charts for variables. The control charts based on discrete data i.e. counted as present or not are called control charts for attributes.

II. RESEARCH METHODOLOGY

The objective of this paper is 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. Different products were produced by the different industries and they have applied the SPC for monitoring and improving the manufacturing processes The

case studies are from registered journals and publications. Total 14 case studies are taken from global industries.

III. LITERATURE CITED

The case studies relevant to the objective of this paper were selected from registered journal and publications and reviewed deeply to find out the various techniques used to tackle the problems associated with the quality of the firm's product. These case studies are then put in a tabular form containing 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 and are shown below in table 1.

S.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	Jukka Rantama ¨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	Yonatan Mengesha Awaj,Ajit Pal Singh, WassihunYimer,Amedie	International Journal for Quality Research,2013	Glass bottles
4	The use of Statistical Process Control Technique in the Ceramic Tile Manufacturing: a Case Study	Ali Mostafaeipour, Ahmad Sedaghat, Ali Hazrati, Mohammadali Vahdatzad	International Journal of Applied Information Systems ,2012	Ceramic tile
5	Process variability reduction through Statistical Process Control For quality improvement	B.P. Mahesh M.S. Prabhuswamy	International Journal for Quality Research,2010	Soap manufacture
6	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 co weight)
7	An Integrated Model for Manufacturing Process Improvement PCB	Winco K.C. Yung	Journal of Materials Processing Technology, 1996	Printed Circuit Board
8	Statistical Process Control Tools: A Practical guide for Jordanian Industrial Organizations	Rami HikmatFouad, Adnan Mukattash	Jordan Journal of Mechanical and Industrial Engineering ,2010	Steel
9	Implementation of Statistical Process Control for manufacturing performance improvement	Farzana Sultana, Nahid Islam Razive, Abdullahil Azeem	Journal of Mechanical Engineering,2009	Cigarette
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	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
12	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
13	Statistical process control: an approach for continuous quality improvement in automotive SMEs - Indian case study	Jigar A. Doshi, Darshak A. Desai	International Journal of Productivity and Quality Management, 2016	Automotive SMEs
14	Quality enhancement through first pass yield using statistical process	Sukrut Nataraj, Mohammed Ismail	International Journal of Productivity & Quality	Inner tubes used in bikes

	control		Management 2017	

Table 1:

These case studies were reviewed and it was found that the objective of all these studies directly or indirectly is to increase the productivity of the components by improving its quality through the elimination of the special causes of variation. In the next table we will see the various techniques that are used in these case studies to improve the manufacturing processes.

IV. TOOLS AND TECHNIQUES USED

Tools and Techniques	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Check sheet	✓	✓	✓					✓			✓			
Histogram				✓				✓		✓				
Pareto Chart	✓		✓	✓	✓	✓	✓	✓	✓		✓			✓
Cause and Effect Diagram	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓		✓
Control chart	✓		✓	✓	✓			✓	✓	✓		✓	✓	
Scatter Diagram								✓						
Brainstorming			✓					✓			✓		✓	
PDCA										✓			✓	
Six-pack charts				✓										

Table 2:

V. BENEFITS AND RESULT GAINED BY THE INDUSTRIES

S.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%.
4) From the Pareto chart about 61% of problems occur only due to types of cracks
5) Increased the process Cp and Cpk
6) Reduced the rejection rate from 2.43% to 0.21% and rework from 6.63% to 2.15%
7) Scrap and rework rates have been reduced while quality yield is improved significantly
8) The steel tensile strength is the vital few problems
9) The frequencies and time duration of cigarette making machine breakdowns and major causes are found.
10) Reduced 29% in the number of nonconformities in the most problematic section
11) The total rejection from cold shut was reduced to 6.6 % from 12.3%. The rejection of shock seal is reduced from 9.1% to 5%.
12) Continuous improvement is achieved.
13) Customer satisfaction with the product increases.

VI. CONCLUSION

In conclusion the company should seek for the execution of SPC tools for quality improvement. SPC implementation is significant as can be seen from the results of the above case studies. From the above study of the different case studies it can be concluded that to survive in today's era of competitive market, companies need to produce the quality products. And quality can be achieved by using the SPC tools and techniques. The study reveals that SPC techniques can give the significant improvement to the quality. These tools and techniques are simple to implement and needs the top management involvement and employee support. The SPC knowledge is important for 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 SPC techniques are used globally to improve quality.

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