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Impact of Statistical Process Control and Six Sigma.

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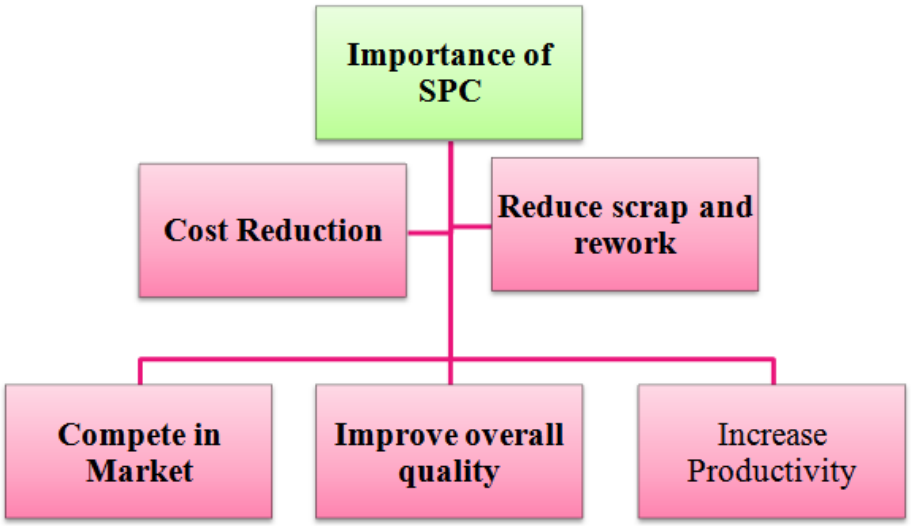
ABSTRACT
SPC techniques are used to reduce variations in process performance which gradually results in waste and reworks. Reduction of variations in process generally results in improvement of quality and productivity identification of the importance of SPC implementation can affect quality and firm performance empirically and statistically. SPC basically uses statistical techniques and methods to detect variation in the process so that it can be controlled. The quality control tools can be used to continually identify the causes of variation and work on it to keep the process under control. The impact of successful implementation of SPC is lacking due to some factors being neglected such as involvement of top management, ineffective training , role of quality department, team work & process focus and so on. This paper shows the impact of SPC techniques and Six Sigma in various industries. In this research paper various articles on the successful implementation of SPC & impact of Six Sigma are been selected and reviewed.

I. INTRODUCTION:

The use of statistical techniques to control a process or production method is known Statistical Process Control (SPC).The tools and procedures of Statistical Process Control (SPC) is used to monitor the process behavior discover various problems in internal systems, and find effective and efficient solutions for production issues .Statistical process control is often used interchangeably with Statistical Quality Control (SQC).

In any process, whether if is a manufacturing process or service process, or any transactional processes, there will be variations as it is bound to be happen it's an inherent part of the process .So how to control that variation? SPC is known as one of the popular method of controlees the process it helps to detect small changes in processes, so one can take corrective actions and in certain cases we can take preventive actions. It also helps to identify whether a process is stable/unstable or in a state of statistical control.

1.1 Why SPC ?



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- Reduce scrap and rework - SPC can minimize the variation in the process which will result in meeting the target production effectively and efficiently.
- Cost reduction - SPC helps to minimize the cost of the processes by keeping a track of the small changes occurring in the process.
- Improve overall quality- SPC can help to improve the overall quality by meeting the target production in time and minimizing all the variations in the processes.
- Customer satisfaction- SPC helps to improve the quality,hence results in customer satisfaction.
- Increase productivity- Installation of SPC will result in higher productivity as it helps to monitors all the change in the processes.
- Compete in today's world market- If product quality is not good, customer are not satisfied, repeat orders are less, rejections, cost of production is high competing in market is tough.

1.2 Types of variations:

Two types of variations occur in all manufacturing processes-

- Natural Cause Variation : Includes the variation which are in here not in the process as it is designed.Includes variations in raw materials, electricity etc.
- Special Cause Variation : It involves causes such as defect in the system or method.

'In Control' & 'Out Of Control'

A process is said to be 'In Control' & stable -> when the natural cause is the only type of variation that is in the process. A process is said to be 'In Control' & stable.

A process is said to be 'Out Of Control' & unstable -> When special cause of variation exists within the process.

Causes of variation

W.A. shewhart identified that a process contains two types of variation. The variation in a process due to random causes(common causes) and assignable causes(special causes)

* Variation exits everywhere

*Process displaying only common causes variation are stable, predictable, within statistical limits.

* To enhance the process improvement special causes variation should be eliminated.

1) Common Cause Variation :- Occurs due to random causes it is an inherent part of every process. Generally the effect of this type of variation is minimal and under control.

2) Special Cause Variation :- Occurs due to assignable causes and it is not an inherent part of the process. This type of variation shows something unusual occurring with in the process which are created by factors that are not a part of process design, to enhance the capability of process identifying and eliminating this special causes are very necessary.

1.3 Tools of SPC:

Basically there are seven basic tools of SPC which are also known as 7QC tools. It was originated in Japan as the country was undergoing major quality revolution. These tools are basically compromised of simple statistical & graphical techniques which were very useful in solving critical quality related issues.

The tools of SPC are also known as Seven basic tools of quality as these tools can be implemented by any individual with a very basic ideas and training in statistics and one can easily apply it to solve quality related problems.

The common used tools are as follow :

- Control Charts- It also known as Shewhart chart named after Walter A. Shewhart is generally a statistical chart which determines whether a process is within control and capable to meet customer's satisfaction. It determines whether a process is stable or not within correct condition.

In Control Chart data are plotted against time in X-axis. Control charts have a central line (mean), an upper line for the upper control limit and a lower line for the lower

- Control Limit- These line are usually drawn from historical data By comparing current data to these lines. Experts can predict or draw conclusions that whether the process is in control or stable or is out of control and predictable.

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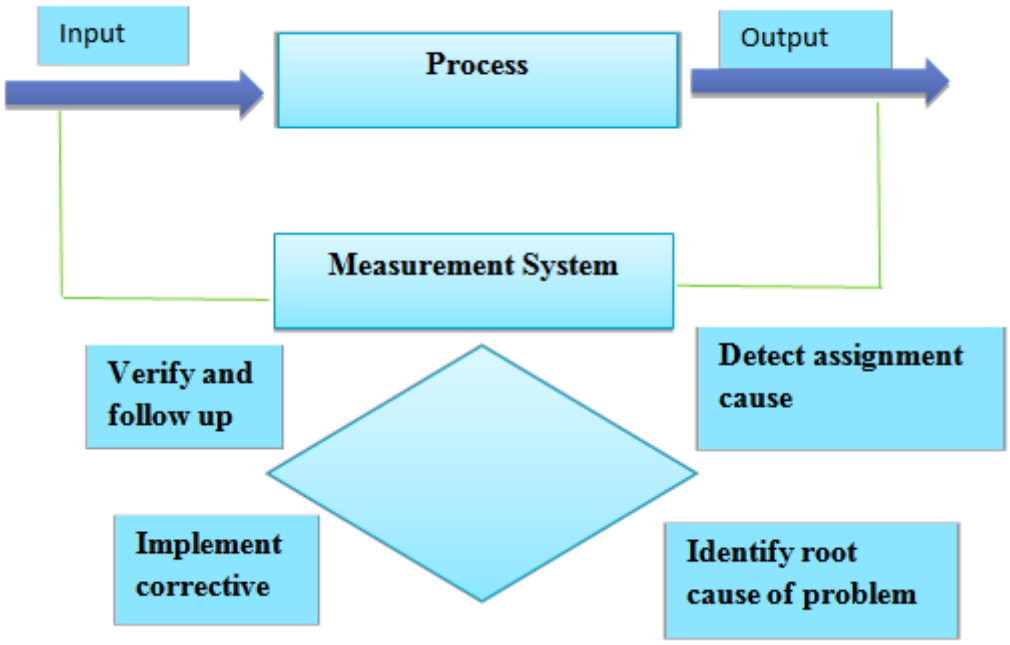
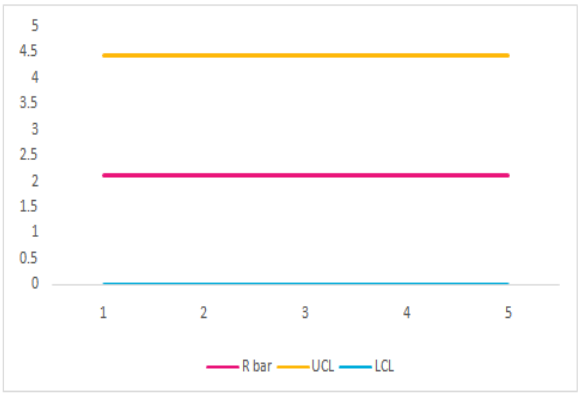
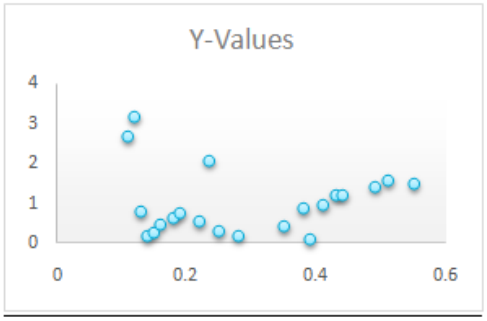


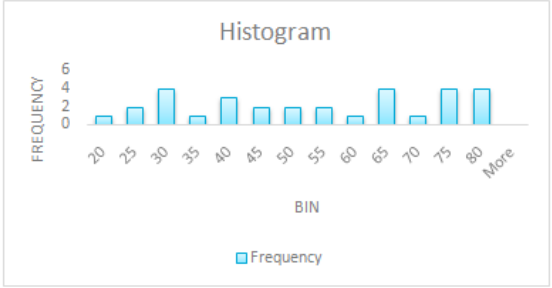


- Scatter Diagram- Is also known as Scatter Plot is generally a statistical tool that represent dependent variable on X-axis and independent variable on Y-axis, which are plotted as dots on their Common intension points. Any existing relationship among the variables can be highlighted by simply joining the dots. Scatter diagram is used to establish a relationship between problem and the causes which are generally affecting it.



- Histogram- A bar graph representing the frequency distribution on each bars was introduced by Karl Pearson.

Histogram helps to designate factors and identify the areas which needs to be considered the most. It also helps to identify the destiny of data of a given distribution.



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- Tally Sheet (Check Sheet) -It can be a form or structured table used for collecting information through counting and observation. The information collected is basically quantitative in nature.

1.4 Six Sigma :

It was just introduced by American engineer Bill Smith in 1986 while working at Motorola. Six Sigma is a set of management techniques that provides organizations tools to enhance the capability of business process improvement by greatly reducing the possibility that an error or defect will occur .The purpose of Sin Sigma is reducing variations in a process and providing consistently good product or service, reducing defects and re-works. Six Sigma process allows only three point four defects per million opportunities that is why it's a program aimed for elimination of defects from every product process and transaction.

Overview of Six Sigma:

- Six Sigma as a statistical tool- It focuses on maintaining three point four defects per million opportunities.
- Six Sigma as a process- It focuses on D Mac approach of process improvement (DMACC or DMAIC) i.e. define, measure, analyze, improve and control.
- Six Sigma as a philosophy- Sin Sigma implies that defects costs money, thus understanding processes and working on the improvement is the most effective and efficient way to achieve desired results.

To implement Six Sigma in organization the management need to consider few key issues.
What should be the rate of implementation?
How will it fit into their existing program?
How it can be controlled and monitored?

Role of Six Sigma:

An organization should understand before any improvement what is important to their customers and work on those parameters which tends to enhance customer satisfaction, reduce defects and meet customer specifications.

- Reducing Defects- DPMO is targeted while the implementation of Sin Sigma i.e. defects per million opportunities.
- Reducing Variation- Variation is the most important factor effecting quality, thus improvements within the process should attempt to minimize those variations.

Basically there are two types of improvement processes in Six Sigma-

- DMAIC- We find, Measure, Analysis, improve & control. It's basically used for improving an existing process.
- DMADV- Measure, Analysis,Design & verity. It's basically used for establishing a new process.

How does six sigma work?

- Identifying Business Problem:- First of all business problem is defined, questions such as wgat, when, where are mentioned in a problem statement, then project scope is identified.
- Identifying Statistical Problem:- After the identification of the business problem those are

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transformed into statistical problems using hypothesis testing methods.

II. LITERATURE REVIEW

(Er. Harpreet Singh Oberoi, 2016)- The paper briefly illustrates the process capability index, the different types of control charts and how they can be plotted in order to find out the control limits of the process .The research is based on secondary data .In this paper it has found that the use of different control charts (X bar-R bar) ,process capability index are simple to implement and it needs to top management involvement. Through this paper the researchers have concluded that SPC is an effective and efficient tool of process and quality control not only in manufacturing industry but in all type of industries where quality and customer satisfaction is the vital concern.

(Jose Carlos de Toledo, 2017)- The objective of the paper is finding out difficulties in the implementation and maintenance of SPC in a chemical plant .This was basically overcome by paying attention to the critical success factors (CSF) during of planning and implementation of control charts .The factors which affect the implementation of SPC involves technical and organizational factors which have been considered critical for successful implementation. The research method is based on primary data with help of operational staff and technical support of the chemical processing unit .Through this paper the researches have concluded an effective implementation and sustained used of control charts. The actions implemented during the research helped to change the culture and behavior of the plant operators.

(Fabino Rodrigues Soriano, 2017)- The paper illustrates the benefits from implementation of statistical process control .The use of SPC,specially of the control charts helps to stabilizing the process by identifying the causes of variations and work on minimizing those. Implementing SPC in organization is a difficult & complex task, the main reasons for its failure are related to the organizational, managerial, cultural & social factors such as lack of top management commitment and support teams, as well as poor understanding about the control charts and various statistical tools also resulted in its failure, the research is based on primary **data through a cross-section survey samples and data.**

(Oakland, 2007)- SPC is a tool that estimates & realizes quality control, helping managers with a wide range of industries potentials to take appropriate actions for business success. Research based on actual client work from an array of industries, latest computer methods and Minitab software being used .It serves as a text book for both students & employees about the understanding and implementation of the modern statistical process control techniques.

(Vaughn, 2000)-The main objective of the paper is related to the efficiency of project execution, the role of Cost Performance Index(CPI) and the Schedule Performance Index(SPI). The study mainly focuses on "Can a project be completed if it continues programming as it has? This paper expands the area of application, it represents an approach for Software Production Management (i.e. cost & schedule control). Through this paper the researchers have concluded that improvement of common cause entities reducing variability of a process; Understanding the implementation of SPC is process improvement.

(Pranay S Parmar, 2014)- The main objective of the people is the use of Control Charts for measuring variations in the process, so that it can be managed and the use of 7QC(Quality Control) tools effectively and efficiently .This research is based on secondary data(case studies from registered journals & publications). Through this paper the researchers have concluded that companies don't design poor quality products, it is basically due to the variation in some stage of production it happens. Implementation of SPC tools & techniques in the control phase of Sin Sigma can be an effective & efficient way of quality control.

(Hailu, 2013)- This paper objective is to enhance market share through the applicability of SPC. This paper is concerned about the quality control tools, identification and analysis of existing quality problems and to propose a better quality control method. The aim of this paper is implanting the simple statistical tools used for problem solving, collecting data, analyzing data, identification causes of variations and measuring the results.

(Arshad Rashid, 2016) - Primary goal of this paper is to identify the application of SQC tools in construction industry. The research is based on primary data which was collected by a construction company. SQC helps to analyze characteristics of a output by deduction of samples from the output. The Analysis of SQC helps to ensure the process remains in control. The aim of this paper is adoptions of derived plans statistically for materials and job compliance in order to increase the productivity and process improvement.

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(James Wilson Parsons Jr.):- The primary goal of this paper is identification of statistical quality control of a non-manufacturing nature. This paper defines the problems of SQC in non-manufacturing nature such as accounting and clerical problems. The researcher have analyzed a local industrial organization inventory procedure, primary data involved in the research. The conclusion drawn by the researcher was a need of some type of control action to reduce the excessively high error rate between the perceptual inventory, records maintained by the stores personnel and the physical inventory taken by the internal auditor.

(Gejdos, 2015)- This paper briefly illustrates the continuous quality improvement with the help of SPC tools and the DMAIC model, which was confirmed with shewhart control charts, capability index, Histogram. The DMAIC model i.e. (define, measure, analyze, improve and control had been clearly explained. Statistical Process Control can be defined as a very effective tool in ensuring process capability and stability. Through the combination of SPC tools and DMAIC model desired objectives of quality improvement can be achieved and can provide solutions to the tasks and problems that occurs in the process of quality improvement.

(Sung, 2011)-The primary goal of this paper is to reduce quality cost in food industries manufacturing process by applyingSix Sigma methods. DMAIC process solves problems systematically, applying it phase by phase helps to manage issues occurring in the quality improvement process effectively and efficiently. It identifies the extra quality cost consistently and various measures are taken into action in order to reduce or eliminate it.

OBJECTIVE OF THE STUDY

- To predict, prevent, and control defect in a process.
- To achieve sustainable quality through process improvement.
- To reduce the elements of wastages in a process.
- To understand the variations in a process.

III. RESEARCH METHODOLOGY

It involves specific techniques or procedures which are used to identify, select, process and analyze information about a topic. In a research paper, the methodology section illustrates the critical evaluation of the study's overall capability and reliability.

This Paper briefly illustrates the benefits and the applicability of the statistical techniques to control a process or production method through the effective and efficient implementation of Statistical Process Control and its various tools. Through Six sigma management techniques the possibility that an error or defect will occur can be greatly reduced as six sigma process only allows three point four defect per million opportunities which greatly enhance the product quality and process improvement.

The Different research articles are collected where the impact of SPC can clearly demonstrated. The research papers are from registered journals and publications which basically Shows the impact of using SPC and its tools for quality improvement and reduction of variations in process. The data is basically used here is secondary data which emphasize the impact of SPC plays in any industry whether it's a manufacturing or service industry, to meet customer expectations and quality improvement SPC and Six sigma is a necessary action to be successfully implemented.

IV. DATA ANALYSIS

Here, the data being analyzed have numbers involved in it thus it's a Quantitative data. A process by which numerical data is analyzed refers to quantitative analysis, it basically involves the use of statistical modelling such as mean, median and standard deviation. The purpose of data collection, analysis and interpretation is to gain usable and useful information and to make the most effective and efficient decisions possible.

Data Analysis for the compressive test of cement

X-bar Chart and R-Chart have been concluded out. Standard deviation have been calculated, the Upper control limit (UCL) and the lower control limit (LCL) have been demonstrated in the figure 4.3. First of all samples have been collected and the average X-bar then X-Dbar have been found out the Upper control limit(UCL) and the Lower control limit(LCL) is then calculated as shown in the table 4.2 and at last standard deviation have been calculated.

To form the Control chart (X-chart)

The Average X bar, X-Dbar, UCL, LCL have been demonstrated clearly through the use of different color lines in the Fig.4.3. A control chart is a graph used to study how a process changes over time, data here are plotted in time order. A control chart always have a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit, these lines are determined from historical data. By

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comparing current data to these lines, One can draw conclusions whether the process variation is under control or out of control.

Standard Deviation - 1.245604271

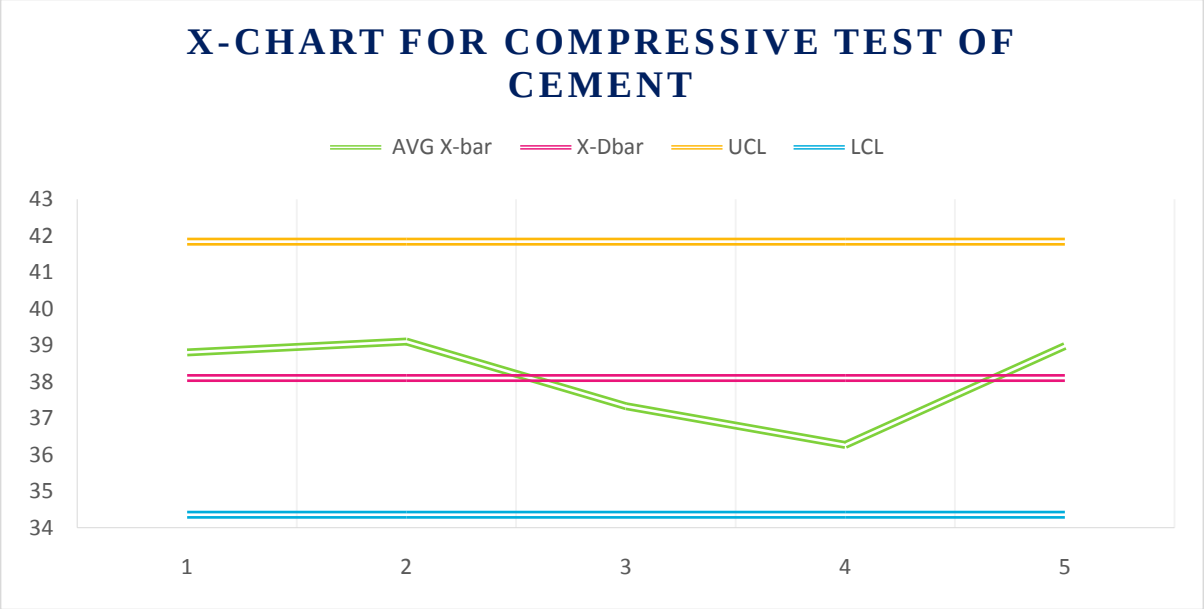
Table 4.1

Truck No	Sample Taken					AVG X bar	Range
	X1	X2	X3	X4	X5		
1	38.25	40	38.5	38.25	39	38.8	1.75
2	39	38.75	39.5	39.5	39	39.15	0.75
3	36	36.5	37	39	38.15	37.33	3
4	35	38	35.65	36.55	36.15	36.27	3
5	38	39	38.75	39.15	40	38.98	2

Table 4.2

Sample No	AVG X-bar	X-Dbar	UCL	LCL
1	38.8	38.096	41.83281	34.35919
2	39.1	38.096	41.83281	34.35919
3	37.33	38.096	41.83281	34.35919
4	36.27	38.096	41.83281	34.35919
5	38.98	38.096	41.83281	34.35919

Fig 4.3



To form R-Chart

For sample size less than 5 value of Upper control limit will be 2.11 and the value of Lower control limit will always be 0.

From the table 4.4 the samples taken are from the compressive test of cement, the Range and R bar is calculated the UCL , LCL values are as mentioned above. The Fig 4.4 show the actual control chart(R-

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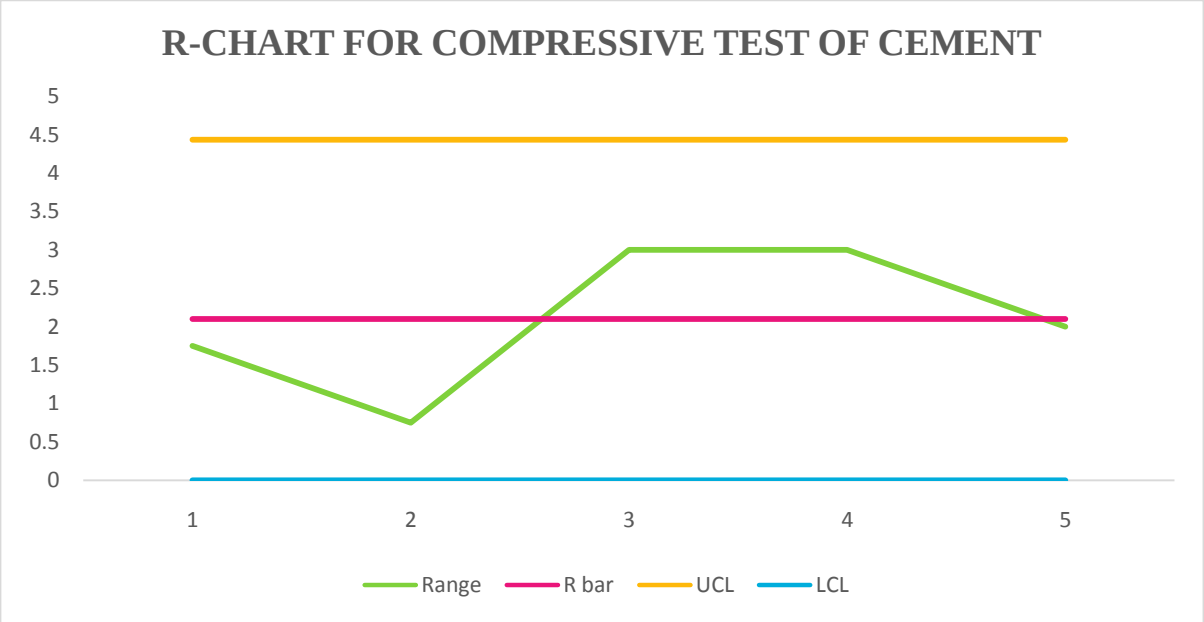
chart), where the UCL, LCL and the central line is shown clearly and the Range line is also been demonstrated. By interpreting the Fig 4.5 we can say the variations within the process is under control.

Table 4.4

Sample No	Range	R bar	UCL	LCL
1	1.75	2.1	4.431	0
2	0.75	2.1	4.431	0
3	3	2.1	4.431	0
4	3	2.1	4.431	0
5	2	2.1	4.431	0

Fig 4.5



Taking another Example from the research paper of HaftuHailu - Application of Statistical Quality Control (SQC) for Enhancing Market Share

To form P-Chart

From the table 4.6, we can see 25 samples have been taken of different lot sizes, sample size(n) are shown and the number of defectives are also clearly demonstrated. The values of P, control limits(CL), UCL_p, LCL_p are also been calculated in the table 4.7 as per the data the control chart(P-Chart) have been drawn. In the Fig 4.6 the blue line expresses the range i.e. the value of p in the diagram, the red line expresses the control limits(CL), the green line(UCL) and the purple line expresses(LCL) as shown above in the diagram.

Table 4.6

Lot size	Sample size, n	Number of defectives, np	Fraction defective (p)	Central Line (CL)	UCL_p	LCL_P
2850	125	10	0.08	0.00064	0.007426	-0.00615
1860	125	5	0.04	0.00032	0.005119	-0.00448
4385	200	12	0.06	0.0003	0.003974	-0.00337
970	80	3	0.0375	0.000469	0.007729	-0.00679
2568	125	8	0.064	0.000512	0.006582	-0.00556

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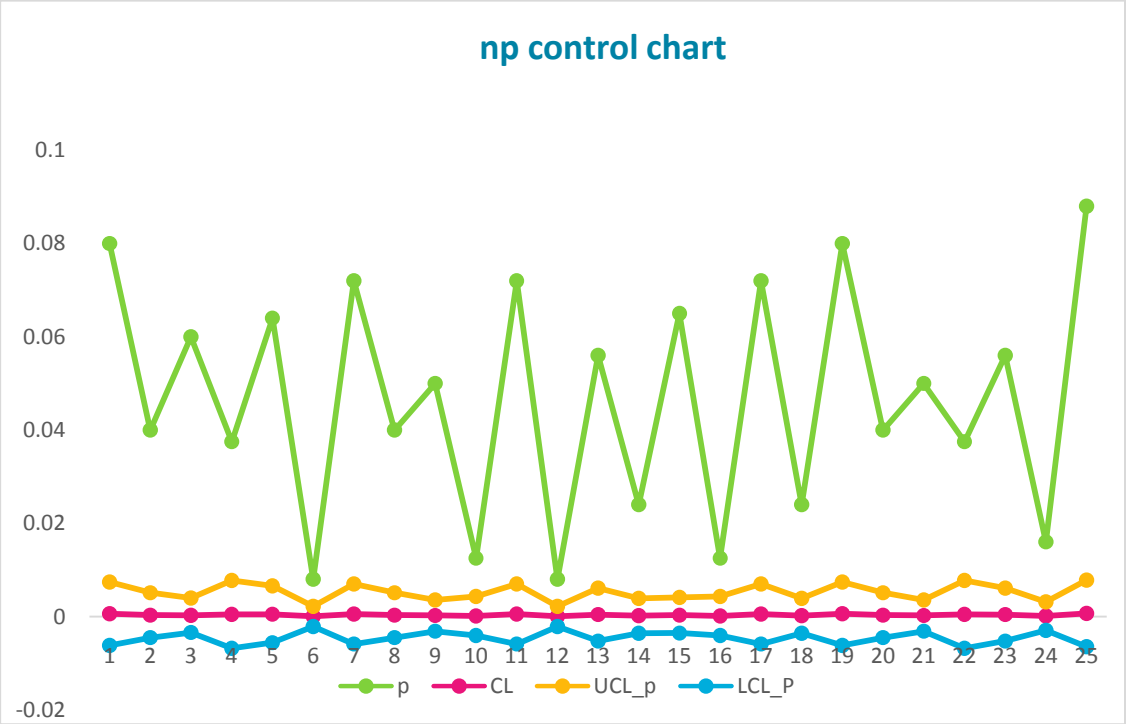
480	125	1	0.008	0.000064	0.002211	-0.00208
2850	125	9	0.072	0.000576	0.007014	-0.00586
1860	125	5	0.04	0.00032	0.005119	-0.00448
4385	200	10	0.05	0.00025	0.003604	-0.0031
970	80	1	0.0125	0.000156	0.004349	-0.00404
2568	125	9	0.072	0.000576	0.007014	-0.00586
480	125	1	0.008	0.000064	0.002211	-0.00208
2850	125	7	0.056	0.000448	0.006126	-0.00523
1860	125	3	0.024	0.000192	0.00391	-0.00353
4385	200	13	0.065	0.000325	0.004149	-0.0035
970	80	1	0.0125	0.000156	0.004349	-0.00404
2568	125	9	0.072	0.000576	0.007014	-0.00586
480	125	3	0.024	0.000192	0.00391	-0.00353
2850	125	10	0.08	0.00064	0.007426	-0.00615
1860	125	5	0.04	0.00032	0.005119	-0.00448
4385	200	10	0.05	0.00025	0.003604	-0.0031
970	80	3	0.0375	0.000469	0.007729	-0.00679
2568	125	7	0.056	0.000448	0.006126	-0.00523
480	125	2	0.016	0.000128	0.003164	-0.00291
2850	125	11	0.088	0.000704	0.007821	-0.00641
55302	3245	158				

Fig 4.7



V. CONCLUSION

From the above information and reviewed research paper I have concluded that Statistical Process Control is an effective and efficient tool for process and quality control in all types of industry not only in manufacturing industry where customer satisfaction and quality are the major concern. In the current scenario a company need to produce quality products in cost-efficient manner in order to survive in the competitive market, SPC can be very useful to achieve desired objectives and quality with its tools and techniques. In this paper it has found that the Statistical Process Control tools and Six Sigma methods can be applied to different

product for reducing defects and minimize variations in process.

Control Charts represent an image of a process overtime. One can identify that a process is under control by interpreting the image if most of the points should be near the average or central line, no points should be beyond the control limits. DMAIC and DMADV the Six Sigma process improvement models helps to improve an existing process and even establishing a new process too. Six Sigma as a statistical tool focuses on maintaining three point four defects per million opportunities. Thus Statistical Process Control and Six Sigma techniques are used globally to improve quality. Statistical Process Control is most effective when it is integrated into an overall company's quality improvement system.

LIMITATIONS AND FUTURE SCOPE

- Implementation of Statistical process Control is a costly endeavor. Companies need to spend money acquiring the necessary resources, material and recruiting personnel who are skilled in the quality function.
- For quality measurements it does not provide an integer number or by how much the rejected products are defective, which would require precise measurements.
- Statistical Process Control emphasizes early detection and prevention of problems, but however it takes a lot of time to apply successfully in a manufacturing setting, as it requires more observations.
- Six Sigma models and methods can be very expensive for small businesses the main cause of this cost is training.
- Six Sigma focuses on a strict and a rigid process to follow and that goes against the new trends that favor creativity and innovation.

FUTURE SCOPE

Today, Statistical process control has widen its scope to enclose many elements driving industry 4.0, such as real-time data collection, analysis and reporting. For many decades, quality professionals have used statistical process control to monitor, control and improve their manufacturing processes.

Six sigma is one of the key initiatives of quality improvement techniques, many large companies have improved the quality of manufactured goods or services delivered. Six Sigma scope is much more broader than other quality management programs as it can be applied to every business process of an organization. Six sigma is likely to remain as one of the key initiatives for improvement of management process. Six sigma professionals are trying to integrate six sigma with other existing innovative management practices to make it more attractive.

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