Application of 7 Quality Control (7 QC) Tools for Continuous Improvement of Manufacturing Processes

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Abstract— In this paper a review of systematic use of 7 QC tools is presented. The main aim of this paper is to provide an easy introduction of 7 QC tools and to improve the quality level of manufacturing processes by applying it.QC tools are the means for Collecting data , analyzing data , identifying root causes and measuring the results. these tools are related to numerical data processing .All of these tools together can provide great process tracking and analysis that can be very helpful for quality improvements. These tools make quality improvements easier to see, implement and track.

The work shows continuous use of these tools upgrades the personnel characteristics of the people involved. It enhances their ability to think generate ideas, solve problem and do proper planning. The development of people improves the internal environment of the organization, Which plays a major role in the total Quality Culture.

Keywords— QC Tools , continuous improvement , manufacturing processes ,Quality control , Root Cause analysis ,PDCA,Efficiency

INTRODUCTION

The 7 QC Tools are simple statistical tools used for problem solving. These tools were either developed in Japan or introduced to Japan by the Quality Gurus such as Deming and Juran. In terms of importance, these are the most useful. Kaoru Ishikawa has stated that these 7 tools can be used to solve 95 percent of all problems. These tools have been the foundation of Japan's astomishing industrial resurgence after the second world war.

For solving quality problems seven QC tools used are Pareto Diagram, Cause & Effect Diagram ,Histogram, Control Charts , Scatter Diagrams, Graphs and Check Sheets . all this tools are important tools used widely at manufacturing field to monitor the overall operation and continuous process improvement. This tools are used to find out root causes and eliminates them , thus the manufacturing process can be improved. The modes of defects on production line are investigated through direct observation on the production line and statistical tools.

Methodology

For solving quality problems following seven QC tools are required

1. Pareto Diagram

2. Cause & Effect Diagram

3. Histogram

4. Control Charts

5. Scatter Diagrams

6. Graphs

7. Check Sheets

1) Pareto Diagram

Pareto Diagram is a tool that arranges items in the order of the magnitude of their contribution, thereby identifying a few items exerting maximum influence. This tool is used in SPC and quality improvement for prioritizing projects for improvement, prioritising setting up of corrective action teams to solve problems, identifying products on which most complaints are received, identifying the nature of complaints occurring most often, identifying most frequent causes for rejections or for other similar purposes. The origin of the tool lies in the observation by an Italian economist Vilfredo Pareto that a large portion of wealth was in the hands of a few people. He observed that such distribution pattern was common in most fields. Pareto principle also known as the 80/20 rule is used in the field of materials management for ABC analysis. 20% of the items purchased by a company account for 80% of the value. These constitute the A items on which maximum attention is paid. Dr.Juran suggested the use of this principle to quality control for separating the "vital few" problems from the "trivial many" now called the "useful many".

Procedure :

The steps in the preparation of a Pareto Diagram are :

1. From the available data calculate the contribution of each individual item.

2. Arrange the items in descending order of their individual contributions. If there are too many items contributing a small percentage of the contribution, group them together as "others". It is obvious that "others" will contribute more than a few single individual items. Still it is kept last in the new order of items.
3. Tabulate the items, their contributions in absolute number as well as in percent of total and cumulative contribution of the items.
4. Draw X and Y axes. Various items are represented on the X-axis. Unlike other graphs Pareto Diagrams have two Y-axes - one on the left representing numbers and the one on right representing the percent contributions. The scale for X-axis is selected in such a manner that all the items including others are accommodated between the two Y-axes. The scales for the Y-axes are so selected that the total number of items on the left side and 100% on the right side occupy the same height.
5. Draw bars representing the contributions of each item.
6. Plot points for cumulative contributions at the end of each item. A simple way to do this is to draw the bars for the second and each subsequent item at their normal place on the X-axis as well as at a level where the previous bar ends. This bar at the higher level is drawn in dotted lines. Drawing the second bar is not normally recommended in the texts.
7. Connect the points. If additional bars as suggested in step 6 are drawn this becomes simple. All one needs to do is - connect the diagonals of the bars to the origin.
8. The chart is now ready for interpretation. The slope of the chart suddenly changes at some point. This point separates the 'vital few' from the 'useful many' like the A,B and C class items in materials management.

2) Cause & Effect Diagram

A Cause-and Effect Diagram is a tool that shows systematic relationship between a result or a symptom or an effect and its possible causes. It is an effective tool to systematically generate ideas about causes for problems and to present these in a structured form. This tool was devised by Dr. Kouro Ishikawa and as mentioned earlier is also known as Ishikawa Diagram.

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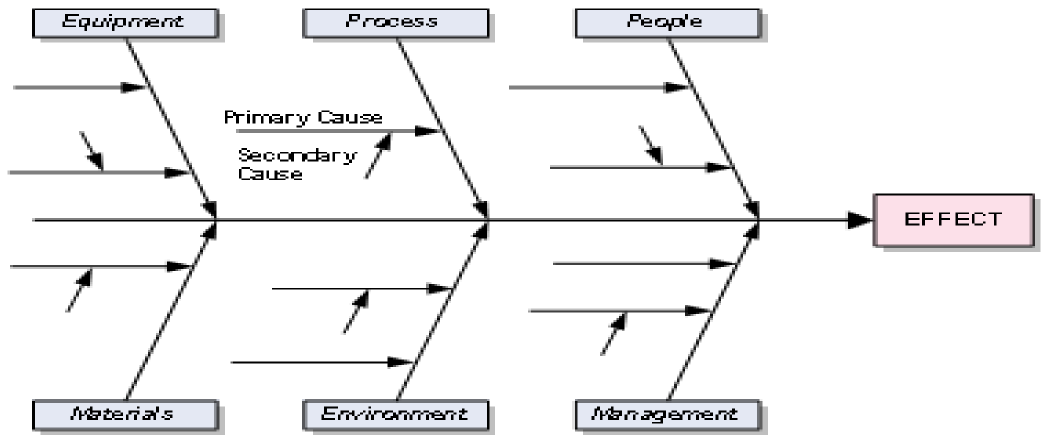

Procedure
The steps in the procedure to prepare a cause-and-effect diagram are :
1. Agree on the definition of the 'Effect' for which causes are to be found. Place the effect in the dark box at the right. Draw the spine or the backbone as a dark line leading to the box for the effect.

    1. Determine the main groups or categories of causes. Place them in boxes and connect them through large bones to the backbone.

    1. Brainstorm to find possible causes and subsidiary causes under each of the main groups. Make sure that the route from the cause to the effect is correctly depicted. The path must start from a root cause and end in the effect.

    1. After completing all the main groups, brainstorm for more causes that may have escaped earlier.

1. Once the diagram is complete, discuss relative importance of the causes. Short list the important root causes.

3) Histogram

Histograms or Frequency Distribution Diagrams are bar charts showing the distribution pattern of observations grouped in convenient class intervals and arranged in order of magnitude. Histograms are useful in studying patterns of distribution and in drawing conclusions about the process based on the pattern.
The Procedure to prepare a Histogram consists of the following steps :
1. Collect data (preferably 50 or more observations of an item).

1. Arrange all values in an ascending order.

1. Divide the entire range of values into a convenient number of groups each representing an equal class interval. It is customary to have number of groups equal to or less than the square root of the number of observations. However one should not be too rigid about this. The reason for this cautionary note will be obvious when we see some examples.

1. Note the number of observations or frequency in each group.

1. Draw X-axis and Y-axis and decide appropriate scales for the groups on X-axis and the number of observations or the frequency on Y-axis.

1. Draw bars representing the frequency for each of the groups.

1. Provide a suitable title to the Histogram.

1. Study the pattern of distribution and draw conclusion.

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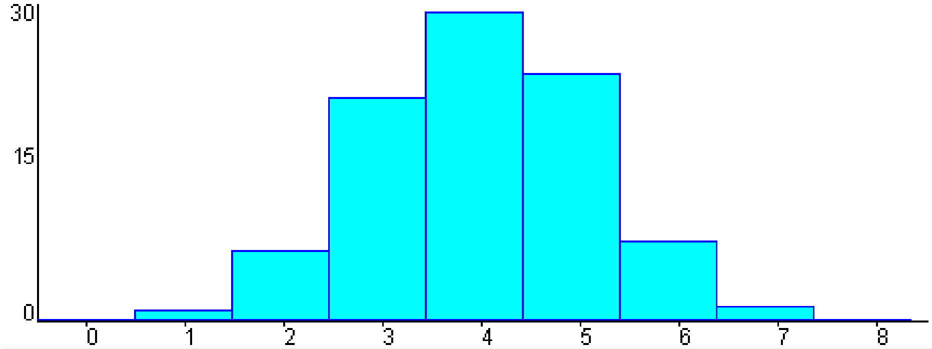
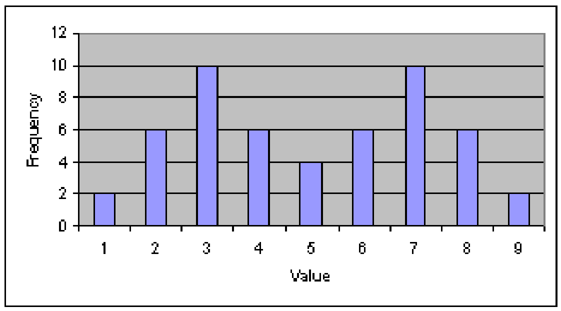
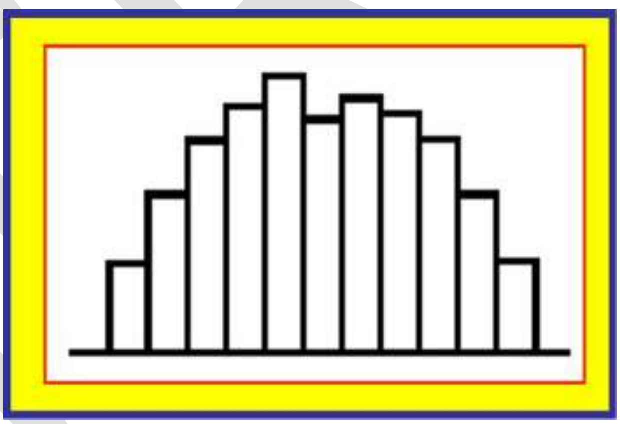


normal histogram



Bi modal



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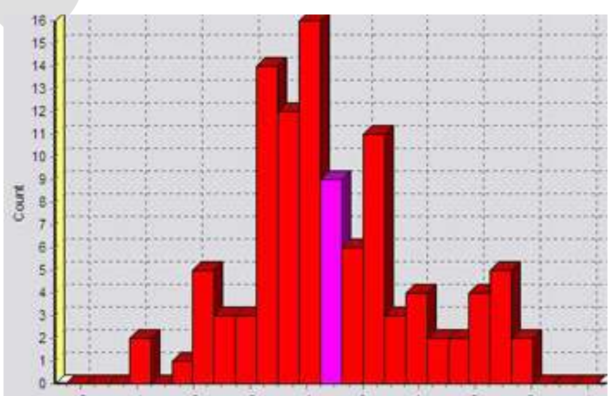

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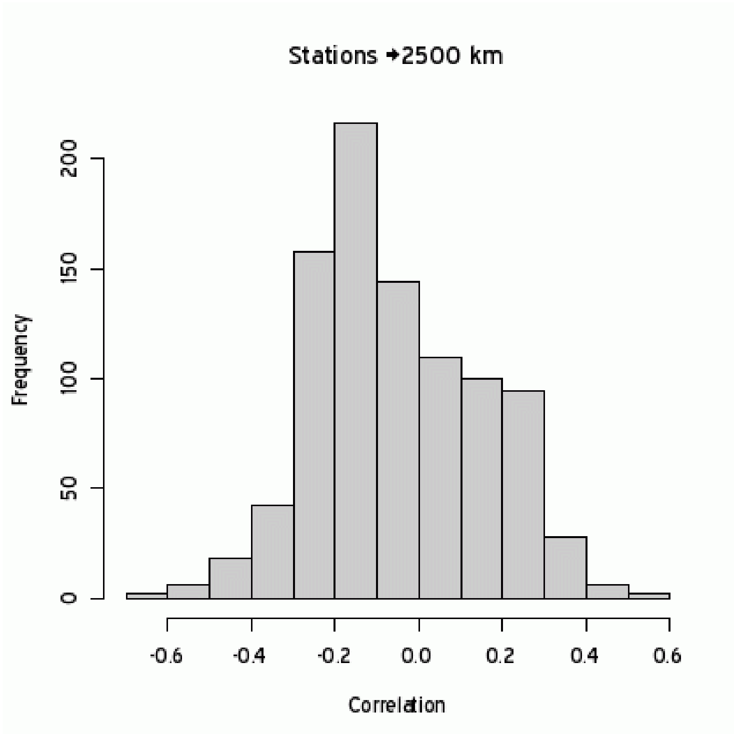
alternate peaks and vales



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4) **Control Charts**

Variability is inherent in all manufacturing processes. These variations may be due to two causes ;
i. Random / Chance causes (un-preventable).
ii. Assignable causes (preventable).

Control charts was developed by Dr. Walter A. Shewhart during 1920's while he was with Bell Telephone Laboratories.
These charts separate out assignable causes.
Control chart makes possible the diagnosis and correction of many production troubles and brings substantial improvements in the quality of the products and reduction of spoilage and rework.
It tells us when to leave a process alone as well as when to take action to correc trouble
.

BASIC CONCEPTS :

a. ***Data is of two types :***
Variable - measured and expressed quantitatively
Attribute - quanlitative
b.mean and Range :

–X - Mean is the average of a sub-group
R - Range is the difference between the minimum and maximum in a sub-group ***c.control Charts for Variables***

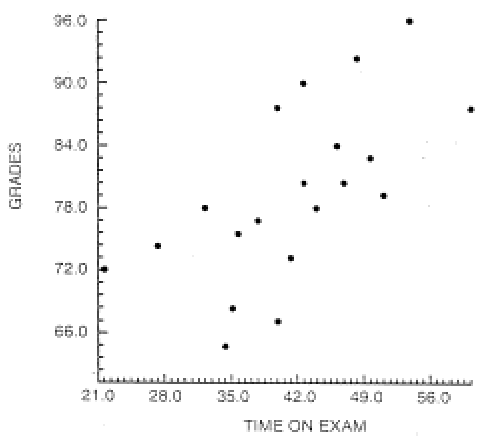
Charts depleting the variations in –X and R with time are known as –X and R charts. –X and R charts are used for variable data when the sample size of the subgroup is 2-5. When the subgroup size is larger, s Charts are used instead of R charts where s is the standard deviation of the subgroup.

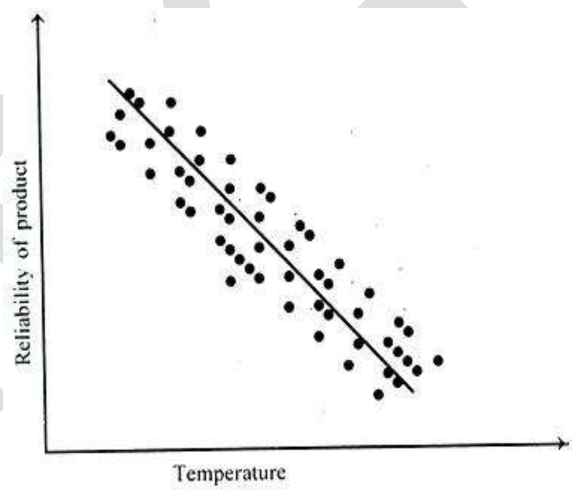
d.control Charts for Attributes

The control charts for attributes are p-chart, np-chart, c-chart and u-chart. Control charts for defectives are p and np charts. P charts are used when the sample size is constant and np charts are used when the sample size is variable. In the case where the number of defects is the data available for plotting, c and u charts are used. If the sample size is constant, c charts are used and u charts are used for variable sample sizes.

5) Scatter Diagram

When solving a problem or analysing a situation one needs to know the relationship between two variables. A relationship may or may not exist between two variables. If a relationship exists, it may be positive or negative, it may be strong or weak and may be simple or complex. A tool to study the relationship between two variables is known as Scatter Diagram. It consists of plotting a series of points representing several observations on a graph in which one variable is on X-axis and the other variable in on Y-axis. If more than one set of values are identical, requiring more points at the same spot, a small circle is drawn around the original dot to indicate second point with the same values. The way the points lie scattered in the quadrant gives a good indication of the relationship between the two variables.





6) Graphs

Graphs of various types are used for pictoral representation of data. Pictoral representation enables the user or viewer to quickly grasp the meaning of the data. Different graphical representation of data are chosen depending on the purpose of the analysis and preference of the audience. The different types of graphs used are as given below :

Sr.No	**Type of graph**	**purpose**
1	Bar Graph	To compare sizes of data
2	Line Graph	To represent changes of data
3	Gantt chart	To plan and schedule
4	Radar chart	To represent changes in data (before and after)
5	Band Graph	Same as above

7) Check Sheets

8.1 As measurement and collection of data forms the basis for any analysis, this activity needs to be planned in such a way that the information collected is both relevant and comprehensive.

8.2 Check sheets are tools for collecting data. They are designed specific to the type of data to be collected. Check sheets aid in systematic collection of data. Some examples of check sheets are daily maintenance check sheets, attendance records, production log books, etc.

Data collected using check sheets needs to be meaningfully classified. Such classification helps gaining a preliminary understanding of relevance and dispersion of the data so that further analysis can be planned to obtain a meaningful output. Meaningful classification of data is called stratification. Stratification may be by group, location, type, origin, symptom, etc.

7QC TOOLS THROUGH PDCA-CYCLE

In successful application of quality tools an implemented quality management system is an advantage. The quality management principles are a starting point for the company's management striving for continuous efficiency improvement over a long period of time and customer satisfaction. A quality management system is based on the integrity of all production and support resources of a certain company. It enables a faultless process flow in meeting related contracts, standards and market quality requirements. Implementation of a quality management system is always a part of a company's development processentification and/or process analysis. Continuous improvement as a fifth principle of QMS (ISO 9001:2000) could not be realized without quality tools which are presented through four groups of activities of Deming's quality cycle or PDCA-cycle, The PDCA-cycle is an integral part of process management and is designed to be used as a dynamic model because one cycle represents one complete step of improvement. The PDCA-cycle is used to coordinate continuous improvement efforts. It emphasizes and demonstrates that improvement programs must start with careful planning, must result in effective action, and must move on again to careful planning in a continuous cycle – the Deming's quality cycle is never-ending. It is a strategy used to achieve breakthrough improvements in safety, quality, morale, delivery cost, and other critical business objectives.

The completion of one cycle continues with the beginning of the next. A PDCA-cycle consists of four consecutive steps or phases, as

follows:

• Plan - analysis of what needs to be improved by taking into consideration areas that hold opportunities for change. Decision on what should be changed.

• Do - implementation of the changes that are decided on in the Plan step.

• Check - Control and measurement of processes and products in accordance to changes made in previous steps and in accordance with policy, goals and requirements on products. Report on results.

• Act - Adoption or reaction to the changes or running the PDCA-cycle through again. Keeping improvement on-going.

Seven basic quality tools (7QC tools) in correlation with PDCA-cycle steps

Seven basic quality tools (7QC tools)					
	Plan	Do	Plan , Check	Plan ,Act	Check
	Problem Identification	Implement solutions	Process analysis	Solution Development	Result Evaluation
Flow chart	√			√	
Cause and Effect diagram	√		√		
Check Sheet	√		√		√
Pareto diagram	√		√		√
Histogram	√				√
Scatter plot	√		√	√	√
Control chart	√		√		√

CONCLUSION

- Statististical QC is chiefly concerned in making sure that several procedures and working arrangements are in place to provide for effective and efficient statistical processes , to minimize the risk of errors or weaknesses in procedures or systems or in source material
- Seven QC tools are most helpful in troubleshooting issues related to quality
- All processes are affected by multiple factors and therefore statistical QC tools can be applied to any process.
- The continuous use of these tools upgrades the personnel characteristics of the people involved. It enhances their ability to think generate ideas, solve problem and do proper planning.

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