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Quality Improvement Of Fan Manufacturing Industry By Using Basic Seven Tools Of Quality: A Case Study

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ABSTRACT
Research was carried out in a Fan manufacturing industry to address the quality related problems and improve their quality level by implementing basic seven tools of quality. These are important tools used worldwide in manufacturing industries for continual improvement. Flow chart, Check sheet, Histogram, Cause & Effect diagram, Pareto chart, Scatter diagram & Control charts were implemented in different steps of manufacturing process to define the problem, measure its impact, finding out its root cause and its removal to ensure the production of non defective items. The case study was carried out in "FECTO FAN" Gujranwala, Pakistan.
Keywords – Quality Tools, Quality Improvement, Flow chart, Check sheet, Histogram, Cause & Effect diagram, Pareto chart, Scatter diagram, Control charts

I. INTRODUCTION

No one can deny the importance of quality in modern world competitive market where only those survive, who can provide better quality products.

Edward Deming explains "The Deming Chain Reaction" in his book *"out of the crisis"* in 1986 [1]. According to him "when the quality is improved, the cost decrease (because of less rework, fewer mistakes, fewer delays and better use of machine, time and material), when cost decrease productivity improves, when productivity improves they capture the market with better quality & low price and in this way they stay in the business, enhance their business and provide more jobs".

No one can deny the importance of quality especially in such a competitive market where only those survive, who can provide better quality products.

The seven quality tools were developed independently of each other's however it was first popularized by *Dr. Kaoru Ishikawa* of Tokyo University during the Quality revolution in Japan. Dr. *Kaoru Ishikawa* did not invent all of these tools, some of these were already in use since 1900s, but he took all these seven tools and made a set of these seven tools and named it "the basic seven tools of quality". That's why these tools are also called Ishikawa tools of quality. These tools are also known as basic quality tools because these tools are suitable for people and required less formal training statistics and because they can be used to solve the vast majority of quality-related issues [2].

Tools of quality can be implemented through many ways in the process industry but PDCA cycle and DMAIC methodology are the most famous and widely used technique through quality tools can be implemented in industrial process.

PDCA is a continual improvement Deming's cycle. PDCA is abbreviation of plan, do, study, act, this as a four step iterative cycle used for process improvement. Planning step is about establishing quality targets and observing the process, in second step data is collected and problem is identified, in third step problem is analyzed and at the end steps are taken to remove the problems and to achieve quality targets.

DMAIC methodology is also same as PDCA cycle but the steps of DMAIC are a bit more explanatory than the PDCA cycle. DMAIC is the abbreviation of Define, Measure, Analyze, Improve and Control. DMAIC methodology is used for process improvement. DMAIC is a systematic way of improving process by defining the problem then measuring its impact, examining why the problem is occurring, then improving the process by removing the problem and at the end control the process so that no more problems occurs.

Professor *"Nankana"* named these tools as the "Magnificent Seven" due to their efficiency in solving and improving process in industry. One of the simplest and most effective tools used by engineers in manufacturing and service processes for problem solving and quality improvement, are the basic tools known as magnificent seven [3]. A single quality tool on its own is enough to produce positive results in a limited area [4]. Quality tools can be used at all stages of the product development and production, with the primary goals of cost reduction and customer satisfaction [5]. Quality tools are considered to be the simplest and easiest tools that one can use to improve the quality of their industrial process and no special skills or huge capital is required to use these tools [3].

II. LITERATURE REVIEW

This research was carried out in “Fecto Fan Company”. Who are specialized in manufacturing all type of ceiling fans. There were two sections in plant, manufacturing and assembling.

The study found that there were total five types of defect occurring in fan manufacturing process. Defects are as below:

- Difference between size of Upper and Lower Ribbon (ULR)
- Shorter length of Down Rod (DR)
- Variation in size of Canopy (VC)
- Blade Flange under size (BF)
- Steel Ribbon over size (SR)

Now the goal was to eliminate all these problems and to ensure flawless manufacturing process. For this purpose basic seven tools of quality were implemented. Following are the basic 7QC tools:

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

There tools were implemented through DMAIC methodology. Every tool was used in different steps of DMAIC methodology for better results. Use quality tools in different steps of DMAIC methodology are shown in table 1.

S.N	Tool	Application
1	Flow chart	Define, Control
2	Check Sheet	Measure, Analyze
3	Histogram	Measure, Analyze
4	Cause & effect diagram	Analyze
5	Pareto diagram	Analyze
6	Scatter diagram	Analyze, Improve
7	Control charts	Control

Table 1: Use of 7QC in different Steps of DMAIC Methodology.

2.1 FLOW CHART

Flow chart is one the basic tool. It is used to study the whole process. Flow charts are used to identify the problem and control the process after defect removal. Flow chart shows the whole process step wise.

Flow chart of the whole process (from raw material to end product) was designed and after studying the process it was found that manufacturing section is the most problematic section as all of the five defects occur in manufacturing section and assembling section was declared as non defective section. So, at this stage it was decided all other tools will be implemented only on manufacturing section.

2.2 CHECK SHEET

Check sheet is an important tool used to collect data and record that which process occurs how many times. It helps to categorize data. The data collected through check sheet can be used in other tools like Pareto chart and Histogram.

Data was collected through check sheet for 30 days and the results are as below shown in table 2.

Table 2: Check Sheet for various modes of defects with frequency and percentage.

Type of Defects	Total Qty Produced	Rej. Qty	% Rej Qty	Cum. Qty	% Cum Qty
Difference between upper and lower Ribbon (ULR)	7578	363	54.50 %	363	54.50
Shorter length of Down Rod (DR)		112	16.81 %	475	71.33
Variation in size of Canopy (VC)		92	13.81 %	567	85.15
Blade Flange under size (BF)		78	11.71 %	645	96.85
Steel Ribbon over size (SR)		21	3.15 %	666	100
Total	4578	666	100%	666	100

2.3 PARETO CHART

Pareto is one of the most important and useful tool. It was initially developed by Italian economist named Vilfredo Pareto. It consists of simple series of bar whose height indicated the impact of defect/problem. It is based on 20-80 rule. This shows that which of the 20% errors cause 80% defects. Data in Pareto chart is arranged in descending order and shows variables in graphical form.

Pareto chart in Figure 1 shows the data in graphical form. The frequency of every defect is visible and its height shows the impact of every problem. After implementing 20-80 rule on the Pareto chart it shows that two problems URL (difference between upper and lower ribbon) and DR (shorter length of down rod) are the most problematic areas and these two problems whose contribution in all the problems are just 20%, cause 80% of disturbance. So from this Pareto chart it figured out the first we have to focus on these two problems (URL and DR), to eliminate them from the process. If the two problems are eliminated then 80% of defects will be reduced.

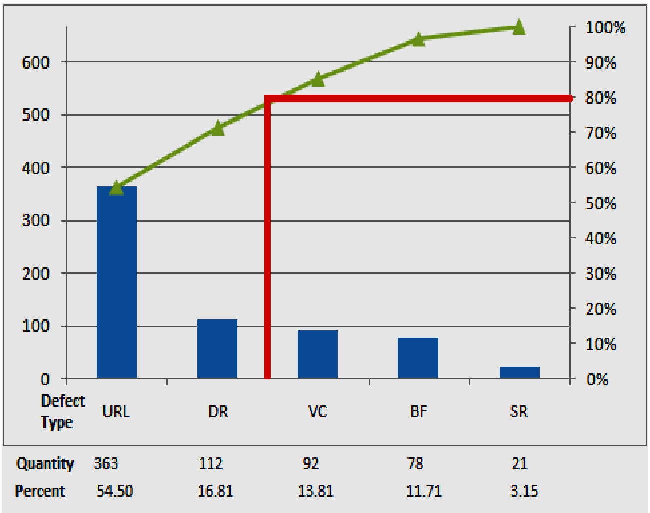

Figure 1: Pareto Chart shows types of defects in graphical form.

2.4 HISTOGRAM

Histogram is most commonly used graph among all quality tools. Histogram is graphical representation of numeric data used to shows how often each different value in a set of data occurs. Histogram is used to determine shape of data set. Histogram works best when the amount of data is less but when there is huge data we go for Pareto chart as Pareto chart also arrange data in descending order.

Histogram is shown in figure 2 below shows the data of upper and lower ribbon. It shows cell boundaries and its frequencies.

S.N	Cell Boundaries (cm)		Frequency
1	15.50	16.00	2
2	16.00	16.50	2
3	16.50	17.00	4
4	17.00	17.50	0
5	17.50	18.00	8
6	18.00	18.50	13
7	18.50	19.00	16
8	19.00	19.50	11
9	19.50	20.00	0
10	20.00	20.50	9
11	20.50	21.00	6
12	21.00	21.50	5
13	21.50	22.00	3
14	22.00	22.50	3
15	22.50	23.00	3

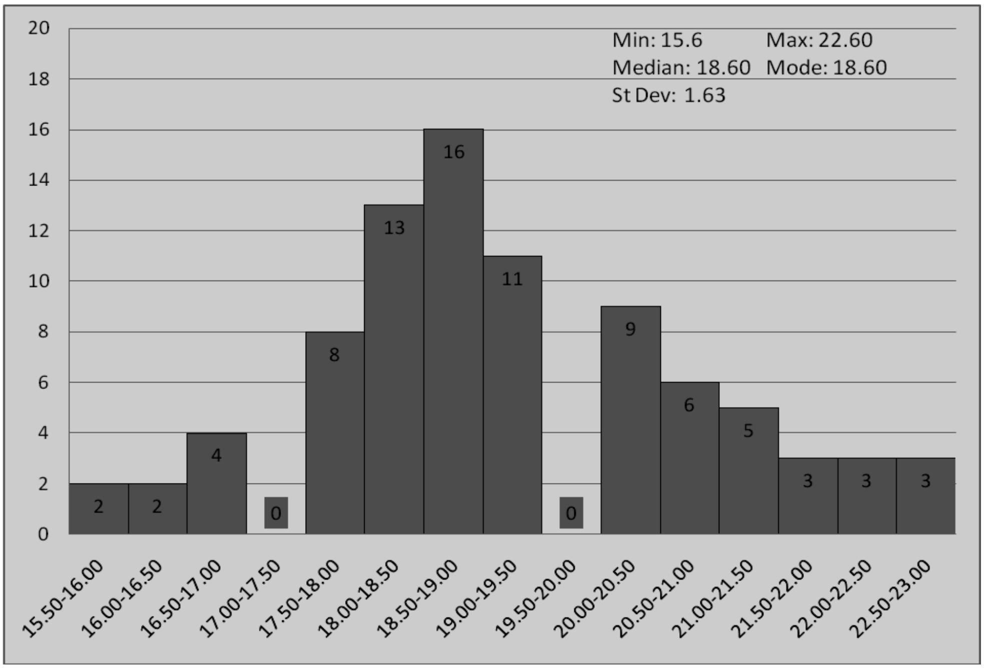

Figure 2: Histogram Chart

2.5 CAUSE & EFFECT DIAGRAM

Cause and effect diagram was invented by a Japanese professor name Dr. Ishikawa. This tool is also known as Ishikawa or Fish bone diagram because of its graphical structure. It is an important tool used to figure out the root causes of a problem. In this technique all the possible causes of a problem are taken into account and try to find out the reason of every cause which makes the problem happen. This technique can be applied by two methods i.e. 4M's Method or 6M's Method. If problem is small than 4M's Method is enough to find its root cause. The 4M's includes Men, Material, Machine and Method. But we will go for 6M's method if problem is very complex and its scale is very high. In 6M's technique there will be addition of Measurement and Mother Nature. M's of fish bone diagram be increase as per requirement which includes Money, Management etc.

Cause and effect diagrams were constructed for two major defects (URL & DR) which cause 80% of the problem. Cause and effect diagram shown in figure 3 and 4, were built to find out the root causes of the problem URL and DR Respectively.

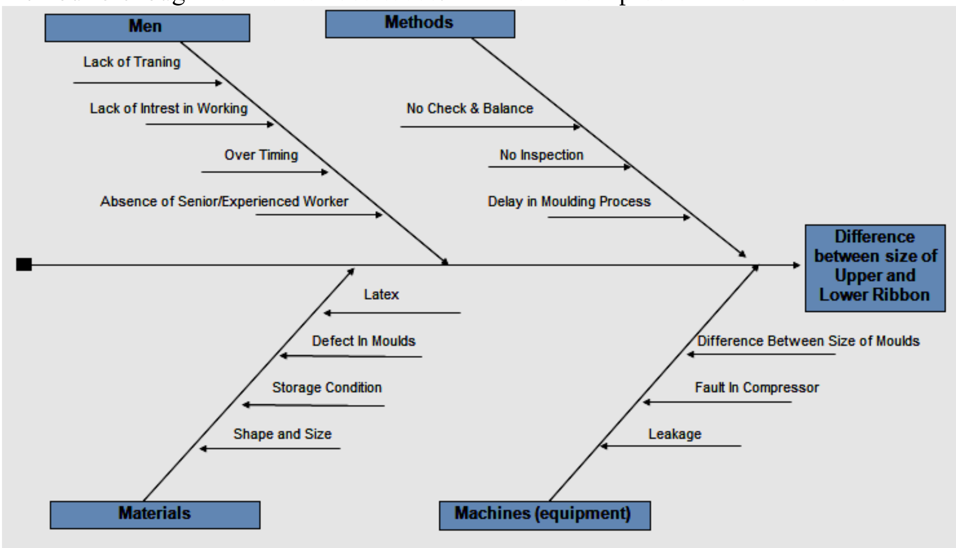

Figure 3: Fish Bone Diagram for URL

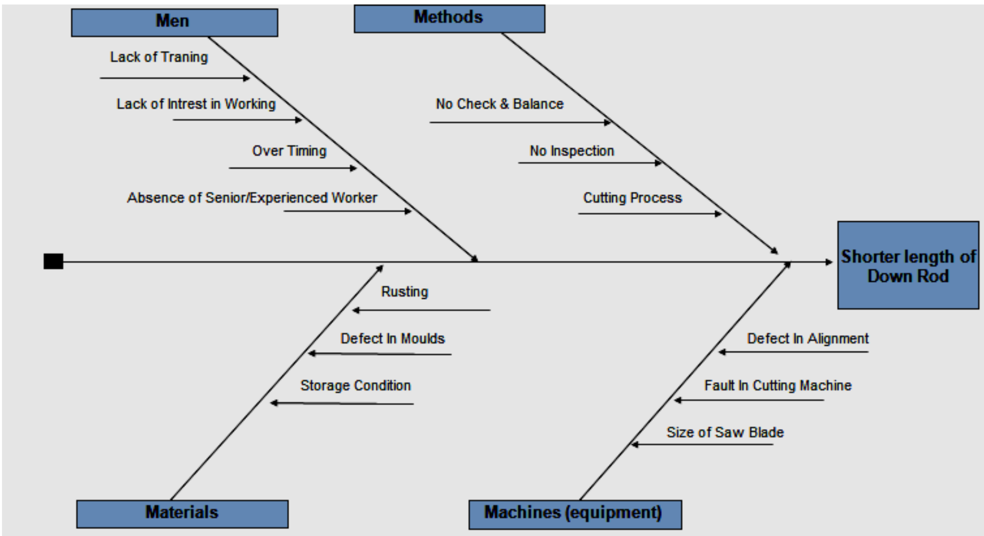

Figure 3: Fishbone Diagram for DR

2.6 SCATTER DIAGRAM

Scatter diagram is used for paired numeric data, it is also known as X-Y plot. Relation between two variables can find out through scatter diagram. In scatter diagram independent variable is plotted on X-axis and dependent variable is plotted on Y-axis. Scatter plot strengthen the results of cause & effect diagram.

In cause and effect diagram it was noticed that difference between upper and lower ribbon is mainly due to huge delay between molding process and storage condition (high temperature in store room). Now to prove this statement true scatter diagram was implemented to find out whether delay in molding process and high temperature of store room effect the size of ribbon or not?

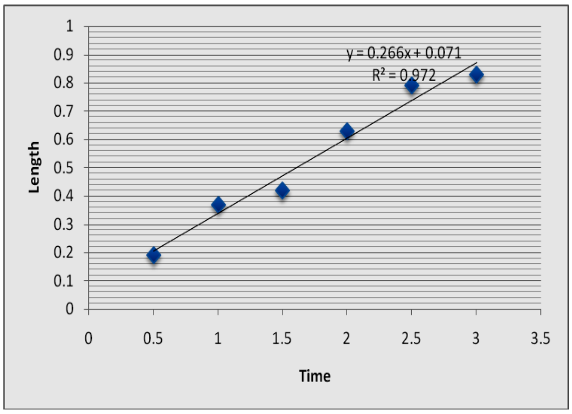

Figure 4: Scatter Diagram showing relation between time delay and deviation in length of ribbon.

Figure above shows strong relation between time delay and deviation in length of ribbon. It is clear from the scatter plot that when time delay increase the length of ribbon deviate. Scatter diagram shows high positive corelation between time and length of ribbon.

Another scatter diagram was constructed to findout the relation between storage condition size of ribbon.

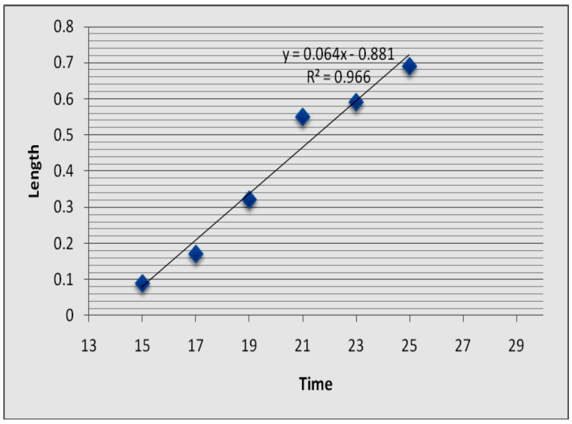

Figure 5: Scatter Diagram showin relation bween temperature and deviation in length.

The figure above shows high positive corelation between temperature and length of ribbon. These two scatter diagram confirms that's the difference between upper and lower ribbon is due to delay between moulding process and high temperature of store room.

Another scatter diagram was also constructed for second defect DR (shorter length of Down Rod), which confirm that this defect is due to defect in the allignment of saw machine.

III. Results and removal of defects

After implementing basic tools of quality the entire root causes of major defects were find out. Result of every single tool of quality is shown in table 3 below.

Table 5: Results of basic tools of quality

Tools of Quality	Result
Flow Chart	Defects are only in manufacturing section
Check Sheet	Categorize defects according to their magnitude
Pareto Chart	80% of the problems are due to URL and DR
Histogram	Maximum variation between 18.50-19.00
Cause & Effect	Find out the root causes of major problems
Scatter Diagram	Strong correlation between variables

After the identification of major defects and its root causes the technical and managerial staff of the company remove these defects from the manufacturing process.

IV. Quality Assurance

After removal of defects from manufacturing process control chart was implemented to make it sure that process is now under control.

4.1 Control Chart

Control charts are also known as statistical process control charts (SPC). These are most important and powerful quality tool to study variation of process with time. Control charts are used to check stability of process. Control charts have two control limits. These limits define boundaries for minimum and maximum values.

Data for control is shown below in table 6.

Xbar-R Chart of data 1-6								
Tolerance: ± 8%								
S.N	1	2	3	4	5	6	X-Bar	R-Bar
1	0.13	0.36	0.32	0.45	0.67	0.54	0.41	0.54
2	0.25	0.83	0.46	0.34	0.45	0.65	0.49	0.58
3	0.91	0.81	0.10	0.76	0.33	0.74	0.60	0.81
4	0.45	0.18	0.54	0.39	0.98	0.24	0.46	0.80
5	0.19	0.44	0.77	0.29	0.54	0.46	0.44	0.58
6	0.67	0.58	0.21	0.58	0.46	0.57	0.51	0.46

The figure 5 shows control process chart which was constructed after removal of defects from the manufacturing process. The chart shows that the process is completely under control and there is no variation beyond the given tolerance.

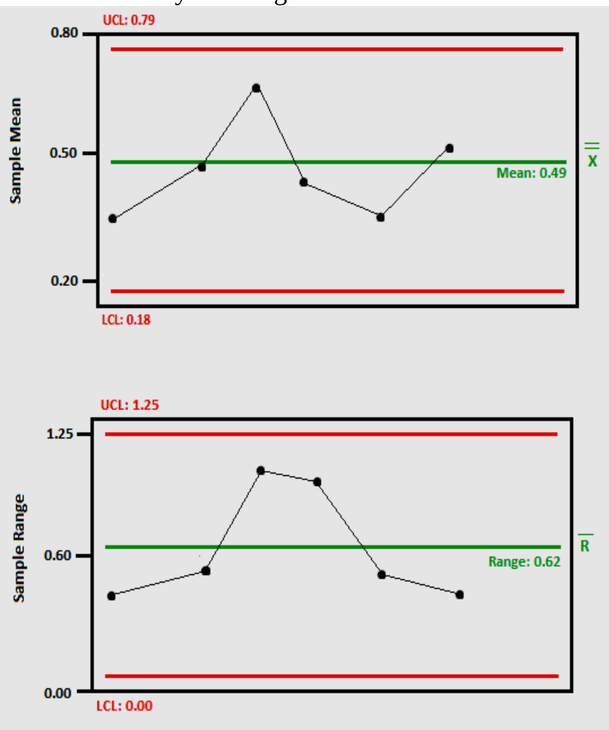

Figure 6: X-R Bar Control Chart

V. Conclusion

From the case study it has been concluded that basic seven tools of quality are very useful and effective in identifying and removal of defects from the manufacturing process. These tools are helpful in every stage of defect removal process. This case study strengthen the famous statement of quality guru Dr. Ishikawa that "95% of quality related industrial problems can be solved simply by applying seven basic tools of quality" [6].

References

[1] William Edwards Deming, *Out of the crisis*, 1st Ed (Massachusetts, MIT Press, 1982)

[2] Ishikawa. K, *Use of Quality Tools, what is Total Quality Control?* 1st ed, (Englewood Cliff, N.J: Prentice Hall, 1985)

[3] Nankana, A. N, *The Seven Magnificent: Simple, Quick and Cost Effective Tools for Continuous Improvement*, (India: New Age International Publishers, 2005.)

[4] Rhys. R, Paul T. Thomas & Kelly P. Thomas, Quality Management Tools & techniques: Profiling SME Use & Customer Expectations, *The International Journal for Quality and Standard, Vol: 1*, pp: 1-17, 2007.

[5] G. Paliska, D. Pavletic and M. Sokovic, Quality Tools - Systematic use in process industry, *Journal of Achievements in Materials and Manufacturing Engineering, Vol: 25*, pp: 79-82, 2007.

[6] K. Ishikawa, *Introduction to basic tools of quality, in Guide to Quality Control, 2nd ed,* (New York: Quality Resources, 1986)