A Review on Evaluating the Effects of Total Quality Management Tools in Various Business Practises

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***Abstract*— In today's competitive economy, major emphasis is on the availability of product and process, at low cost and high quality. Though the approach for managing quality are different from one company to another, there are few common factors among them which is summarised to form quality principle known as Total Quality Management (TQM).**

Tools of TQM are used in optimisation of the business process through waste reduction and quality improvement. With the proper usage of these tools several issues within the organisation like poor quality and higher percentage of scraps can be addressed which would be beneficial in attaining higher profitability.

Here few tools of TQM such as Poke-A-Yoke being used in a auto duct manufacturing industry to eliminate human errors in finishing, fishbone diagram being used in a manufacturing firm to show effect of providing excess tolerance limit, the application of Root cause analysis in a manufacturing firm to analyse root cause of problems such as cracks in cradles, vibrations and noise during machining, PDCA cycle used for continuous improvement in quality of the product in a manufacturing firm are discussed.

No single tool can provide solutions to all the applications; usage of TQM tools requires proper knowhow about each tool and its areas of application. But results obtained by TQM tools take time to have a noteworthy effect when implemented in the industry

***Index Terms*— Fishbone diagram, Poke-A-Yoke, PDCA cycle and Root cause analysis.**

I. INTRODUCTION

In present competitive market conditions, providing product or process at high quality and at low cost helps in staying ahead of the competition and in turn achieving strong hold of the overall area of the market. In the present trend of targeting customer by companies as the final decision maker, maintaining quality of the product to realise customer satisfaction is a challenging activity. This aim can be accomplished by using the concepts of TQM along with its tools and techniques.

TQM is a managerial approach developed by the Japanese which aims at achieving customer expectation by improving the quality of the product, process and services involved. TQM concepts can be used to maintain quality standards through continuous management of activities involved.

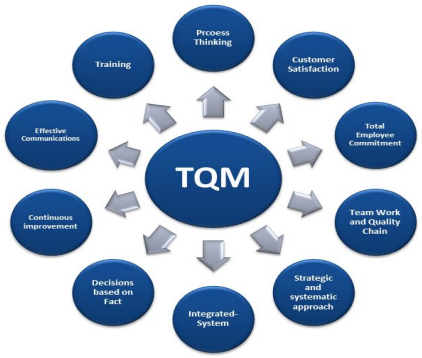

Figure 1: Total Quality Management

As seen from the figure, the main goal of TQM is achieving satisfaction of the customer by taking various measures such as training, team works, effective communication, employee cooperation, etc. Apart from all such measures usage of specific TQM tools for particular areas of problem may lead to higher quality function and lower rates of rejection. Some of the TQM tools discussed here are:

A. Poka-Yoke (fault proofing)

"Poka Yoke is a quality management concept developed by a matsushita manufacturing engineer named shigeo shingo to prevent human errors in production line. Poka-Yoke (Pronounced as 'poh-kah yoh-kay') derived from Japanese word – "yokeru" which means "to avoid" and "poka" which means "inadvertent errors" [1]. Its main aim is to eliminate errors of any form. A defects exists in either of the two states, defect already occurred, calling for defect detection or is about to occur calling for defect prediction [2]. "There are three types of Poka-Yoke, first one being the Contact method identifies the products defects by testing the physical characteristics, second type is the fixed value method which indicates the operator if fixed number of movements are not made and the third one is the motion step method which determines whether the prescribed steps are followed or not " [3]. Poka-Yoke can be used in various product, process and service oriented industries but the major application of Poka-Yoke is seen in manufacturing industries where reduction in minor errors can have a noteworthy effect on the overall output.

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B. Cause and Effect Diagram

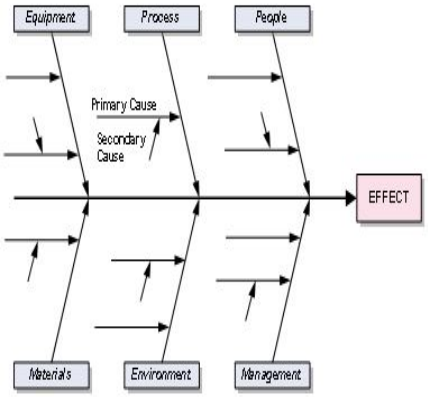

Figure 2: outline of Cause and Effect diagram

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 [4]. It was invented by Dr.Ishikawa a Japanese professor. Cause and effect diagram uses six parameters like Method, Measurement, Man, Mother Nature, Machine and Material. This technique involves a rigorous brainstorming involving a number of experts which helps in determining maximum number of causes [5]. "Procedure to be followed to prepare cause and effect diagram is as follows:

- Determine the main group or categories of causes. Place them in boxes and connect them through large bones to the backbone
- Brainstorm to find possible causes and subsidiary causes under each of the main groups. Make sure that the root from the cause to the effect is correctly depicted. The path must start from a root cause and end in the effect
- After completing all the main groups, brainstorm for more causes that may have escaped earlier" [4].

C. Root Cause Analysis

"It is the process of identifying casual factors using a structured approach with techniques designed to provide a focus for identifying and resolving problems. Tools that assist groups or individuals in identifying the root causes of problems are known as root cause analysis tools. Some of the tools and techniques include the Cause and Effect Diagram, Interrelationship Diagram, Current Reality Tree, Why Why Analysis and Multi Vari Analysis" [6]. Here we will be discussing about the usage of Why Why technique in detail. "Procedural approach of Root Cause Analysis.

Step 1: Select tool

Step 2: collect data

Step 3: Analyse the data using root cause analysis tools and techniques

Step 4: Consider results and derive conclusions

Step 5: Act

Some of the benefits of root causes analysis are: Removal of recurring failure, Empowerment of maintenance staff, Recording of failure data, improved understanding on failure mechanism reliability and cost improvement" [7].

D. PDCA cycle

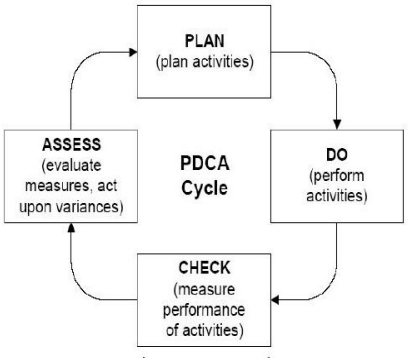

Figure 3: Plan-Do-Check-Act cycle

"The most common process of continuous improvement is the PDCA cycle which was first developed by Walter Shewhart in 1920s and promoted by quality preceptors Dr. Edwards Deming" [5]. "Deming's purpose was to use PDCA with a continuous improvement process to help rebuild Japanese industries so that they could compete in the world market in future" [8]. "PDCA-cycle consists of four consecutive steps, as follows

- Plan: Identifying and analysing the problem for improvement.
- Do: Establish experiments to test the hypothesis
- Check: Analyze data on the solution, validate hypothesis.
- Act: Take corrective action for continuous improvement" [5].
- PDCA cycle is required in process improvement which starts with careful planning results in corrective and preventive action supported by appropriate quality control tools [5].

II. METHODOLOGY

Reducing cycle time and improving quality helps firms to attain the desired corporate performance and also establishes increased productivity, improved employee relationship and thereby helps to achieve higher market shares and higher profit margin. By giving sufficient time after initiating Quality Management practises, results have led to accomplish the above stated objective. Improved quality does not really mean increasing the number of inspections made but it refers to the detection and correction of quality related errors on spot of occurrence. Common belief is considerable amount of time and money will be wasted for improving quality. But a properly organised way to improve quality does not require extra time or money. Various Quality management tools such as Poka Yoke, cause and effect diagram, Root cause analysis and PDCA cycles can to utilized in quality improvement in any forms of industry which can be seen from the following case studies.

Pratik D Tak et al [2015] [9] defines the problem encountered in an automobile manufacturing firm as; holes are being drilled into the rare end cap of an automobile even when the metal clips are not fitted. The components again have to be sent for fitting the metal clips which was time consuming and hence overall time of those products increased. In a lot of 50 components, metal clips of two to three components were

missing. When this is considered in parts per million the wastage of time for reassembling is too high. Hence Poka-Yoke concept was used here."Poka-Yoke technique can be applied both to prevent causes, which will result in subsequent occurrence of errors and to carry out inexpensive control determining whether to adopt or reject the product" [3]. Use of Poka Yoke Requires strong basis in the overall quality management. Clear indications to distinguish between a defective and corrective product is necessary. It should not be forgotten that the method of poka yoke requires an immediate reaction and the correction as well as a result in the operation [10].

"A methodical approach to build up Poka-Yoke counter measures has been proposed by the ADS methodology which consists of a three step analysis of the risks to be managed.

1. Identification of need.
2. Identification of Possible.
3. 3.Management of mistake before satisfying the need" [11].

Sensors were used to detect whether all the 4 clips where in place. If any clip was missing, the sensor would send electrical signals which would stop the passage of air from the compressor to the pneumatic cylinder and the punching action would not be completed. This way fool proof technique was developed.

Patel Parikshit K et al [2013] [3] states poka-yoke technique can be applied both to prevent causes, which will result in subsequent occurrence of errors and to carry out inexpensive control determining whether to adopt or reject the product [3].In his paper he identifies the major problem in an Air duct manufacturing firm as the rejections of the manufactured goods due to human errors. This was because of lack of training and the firm was dependent on human skills for smooth finishing of the product. Poka-Yoke is a Japanese term that means 'mistake proofing'. Its purpose is to eliminate product defects by preventing, correcting or drawing attention to human errors as they occur. He also say either the operator is alerted when a mistake is about to be made or the poka-yoke device actually prevents the mistake from being made [3].

Technically poka-yoke can be used to prevent occurrence of problem and to make decision relating whether to accept or reject the product. Errors arise from various reasons but not of them can be prevented if only people are able to identify the problems at the time of formation, define the causes and make appropriate corrective steps. Prevention of defects in the process before their appearance is the best way defect reduction and thus reduces the cost [10]. Here solution to the problem of rejections of Air duct due to no proper finishing is acknowledged through an attention type of Poka-yoke where errors made by the workers were highlighted. Here solution to the problem is suggested as to use either a shut out type (preventing an error being made) or an attention type (highlighting that an error has been made) poka-yoke. [3].

R. Kalantri et al [2013] [12] states root cause analysis is the process of identifying the casual factors using a structured approach with techniques designed to provide a focus for identifying and resolving the problems [6]. Root cause assessment is a very structured process of discovery that requires users to go through a series of step by step activities, all designed to find out why something happened and what can be done to prevent it from happening again [12]. Review of the case study in a cable manufacturing industry for the problems on tubular Strander is discussed here. Initially the problems and its related root causes were to be identified by using the 5 whys technique. It is found that tubular Strander developed cracks and vibrations of the pipe due to eccentric running. Solutions to the above stated problem were provided as to relieve the stress by heat treatment. To eliminate vibrations, dynamic pipe balancing needs to be done using balancing machines which also helps in eliminating the cracks formed. Changing the rollers from hylem to metallic reduced the noise that was produced. Limitations encountered were; it should be seen that mechanical property of the material will not change during heat treatment. "Stress relieving between machining operations can be performed on pre-treated material. The stress relieving effectiveness may have to be reduced to prevent loss of mechanical properties" [12]. Many forms of steel require quick cooling where some amount of stress is unavoidably induced. This way Root Cause analysis was used to collect empirical data and provide a structured approach to solve the problems that were encountered in a cable manufacturing industry.

Cause and Effect Diagram is a tool of Root Cause Analysis which is used to determine and accumulate the key causes which contribute to an undesired effect.

A case study was conducted by "Masoud Hekmatpanah [2011] in an oil industry, made use of cause and effect diagram along with the six sigma technique in a four litre canning process to tackle the problem of oil wastage and scrap of the four litre filling cans" [13]. Data collected suggests that around 50000ppm cans were rejected as scraps which was contributing excessively to the company's capital investment. The approach to sketch the causes contributing to an effect i.e. production line problems combined brainstorming practice and concept mapping. Process has four steps: determine problem, identify factors involved, acknowledging the possible causes and analysing the cause and effect diagram used to resolve various problems. Significant or key causes where identified and were grouped as environment, method, machine, measurement, material and people. Various sub causes for each of the above stated key causes is identified. A logical scheme is developed for the effect implementation of fish bone diagram. This way the problem of wastage of oil during production was reduced.

For the problem of Tin scraps which was caused by the improper cutting of plate, another cause and effect diagram was plotted which included the same set of key factors for which the sub cause had to be determined through brain storming method. Some of the sub causes contributing significantly to the problem were improper equipment maintenance, non aligned system, inability to employ precision tools and un-calibrated measuring device.

These diagrams were careful examined and solutions to the problem encountered were derived through a continuous brainstorming, creative and innovative methodology using a team highly qualified and experienced professionals. "Once these solutions were completely revaluated for risk factors in execution, for likely effectiveness in process improvement and scrap reduction, the improvement plan was implemented" [13]. In another example we see how cause and effect diagram along with other quality control tools were used to tackle the problems of variation in size of upper and lower ribbon and variation in the length of down rod. Sulaman Muhammad states "No one can deny the importance of quality especially in a competitive market where only those survive, who can provide better quality products" [14]. This can be

accomplished only when the factors which are considered to be a hindrance in quality improvement are identified and appropriate solution is provided. The data related to the problems encountered were collected using a check sheet from which the total quantities of products were noted, number of rejected quantities and percentage of rejected quantities are found out. Now deeper analysis was carried out to find why rejects occurred through a series of brainstorming technique which involved higher officials experienced in the production line. For both the problems encountered that is variation in size of the ribbon and in length of the down rod common key causes were identified. Key causes for the problem of ribbon included various sub causes such as lack of training, lack of interest in work, no check and balance, no inspection, difference between size of mould, defects in moulds and many more sub causes were identified. For the problem length of down rod sub causes include cutting process, fault in cutting machine, size of saw blade, storage condition, negligence, rusting were found out. Here solution had to be provided to sub causes in the first step and later on for the key causes. Errors occurring due to negligence and lack of interest were solved by strict supervision and motivating the employee through financial and non financial rewards. Solutions to other causes were provided using a combination of different quality control tools such as pareto chart, scatter diagram, control charts, etc along with brainstorming technique. Hence the problem of variation in ribbon and length of down rod were solved.

"Deming, Father of total quality management has put forth the concept of Plan, Do, Check and Act cycle. The PDCA cycle was broadened to include strategies and methods to develop, tests and implement changes that would result in improvement" [8]. According to Pratik J Patel et al [2014] [5] "PDCA cycle is required in process improvement. The process improvement starts with careful planning, results in corrective and preventive actions supported by appropriate quality control tools. In his case study he used PDCA cycle to plan, perform, evaluate and measure the activities related to Taper shank drill bit tool" [5].Basic quality tools were grouped under the four categories of Plan, Do, Check and Act according to their relevance. Planning included the sub topic as problem identifying under which related quality control tools were listed. Sub topic under Do was establish hypothesis under which respective control tools were listed. This process of listing the quality control tools was carried out for check and act which included Validate hypothesis and continuous improvement. Now the individual tools were used for analysis such as the check sheet was used to collect data related to types of defects, rejected products and percentage of rejected products. Pareto chart was used which showed most effective defects as marginal over size, body dia test and flute grinding error. Histogram was used to analyse the variations of the data set. Cause and effect diagram was used to identify the key causes and sub causes contributing to the problem of marginal oversize. Control chart which includes variable chart and attribute chart was used to determine the process variability. Here the parameter considered was the height of the tool lip which was analysed to check whether it was within the limit or not. Run chart and scatter diagrams were also used and all the quality tools were carefully analysed to arrive at the suitable solution. In this way the process of Plan, do, check and act was made used in a manufacturing firm to solve the problem.

CONCLUSION

No single tool can provide solutions to all the applications; usage of TQM tools requires proper knowhow about each tool and its areas of application. But results obtained by TQM tools take time to have a noteworthy effect when implemented in the industry.

Poka Yoke is one of the tools of TQM which can be used effectively in solving problems through the technique of mistake proofing. Here Poka Yoke was used in an automobile manufacturing firm and a blow moulding industry to provide solutions to the problem of rejects through error proofing.

Through the usage of Five why technique, root causes leading to problems were analysed in a manufacturing firm and through a series of brainstorming technique involving experts from different departments within the firm suitable solution was arrived at.

In an Oil industry, to encounter the problem of oil wastage and inefficient usage of cans a cause and effect diagram was plotted. It clearly depicted the key variants contributing to the problem which were solved in the later stages through brainstorming method.

The seven quality tools were categorized under the PDCA cycle according to their relevance and an analysis was carried out in a tool manufacturing industry to solve problem related to tool tip height. Proper usage of PDCA cycle helped to overcome the problem related to taper tool.

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