Quality Failure Analysis And Quality Improvement Methods In Small And Medium Manufacturing Companies (A Case Study Of Shamco Industries Limited)

Joseph Chege Ngugi, Peter Muchiri, Joseph Muguthu, Celestin Nkundineza

Abstract: This paper elucidates the analysis of quality failure in small and medium manufacturing companies and established methodological approaches that mitigate these problems in order to improve on the quality of products manufactured. The study was carried out at shamco industries limited a steel furniture manufacturing company in Nairobi County in Kenya. The company's records for the year 2014-2016 provided the secondary data regarding the customer complaints that led to the poor quality of steel furniture. The study adopted a case study methodology and brainstorming was the main method that was used to collect primary data. The defects were ranked in the order of severity, occurrence and detect-ability using Failure Mode and Effect Analysis (FMEA). The most common defect was dripping paint which appeared in almost all products. The most critical defect on the other hand was breaking of welded joints. After brainstorming with the experts in the company, root causes of these defects were determined. It was found that causes due to the Workers were 35%, due to the processes were 30%, due to materials were 24% and due to the machines were 11% respectively. The research provided the knowledge of quality failure analysis and established practical solutions to the detected defects. The paper concludes that similar analysis on quality is required to be done in other manufacturing companies so that quality of the products manufactured can be improved and become competitive in the global market.

Key words: Quality, Failure, Quality Improvement, SMMI.

1.0 INTRODUCTION

Quality has been identified as one of the strategic goals in any manufacturing company that brings about customer satisfaction. Other goals include flexibility, speed and dependability. Nevertheless, managing quality supports the three goals as well as low cost as in [1].The bottom line is that well managed quality reduces costs and makes the individual company's products compete in the market. Small and medium manufacturing industries (SMMI) lose between 5%-15% sales revenue due to lack of attention to quality [2]. Quality is considered as the consistence to customers' requirements as well as their expectations and therefore a major drive to customer satisfaction or dissatisfaction.

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Shamco industries limited, a furniture manufacturing company in Kenya is faced with quality challenges besides the competition from other *similar companies in Kenya. Nevertheless, Furniture products are made by informal sector commonly referred to as 'jua kali' and other furniture are imported from foreign countries like china, turkey and Indonesia just to mention a few. Global market demands that products should be of high quality and have fair price as in [3]. In recent years customers at this furniture manufacturing company have complained of poor quality in product manufactured. The company has seen some of the products returned for reworking. This increases the cost of production that makes the price charged to customers to go high. Consequently this is affecting the reputation of this company negatively. Quality improvement is necessary to mitigate the effect of these quality problems. Quality improvement is a considerable force throughout the world according to [4].

1.1 statement of the problem

Manufacturing companies produce goods to satisfy customer needs. In the process of production, defective products are produced and find their way to the customers. This makes these products unpopular to the customers. Costs associated with poor quality increase making the products uncompetitive in the market. Quality failure analysis is ignored or it is not done to unearth the root causes of these defects and methods to solve them established. It is on this premise that this study was carried out.

1.2 Objectives of the study

1.2.1 Main objective

- Quality failure analysis and quality improvement methods in small and medium manufacturing companies.

1.2.2 Specific objectives

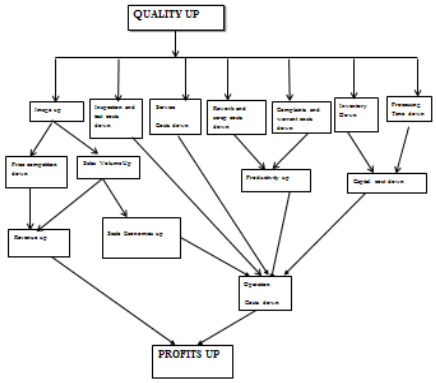
1. To establish the problems in steel furniture that lead to poor quality.
2. To rank the identified quality problems using Failure Mode and Effect Analysis (FMEA).
3. To determine the root causes of the investigated quality problems and
4. To establish methods of mitigating the effect of investigated quality problem

2.0 LITERATURE REVIEW

2.1 Importance of quality

Quality is important in the products manufactured or services rendered to satisfy the ever increasing customer needs. According to [5] quality is important for the following reasons

- Company reputation: the reputation of any company is dependent largely on the quality of goods produced or services rendered.
- Product liability: companies have been accused of producing sub-standard goods and rendering sub-standard services which has led to endless court cases. Costs associated with penalties and compensations can be reduced if quality is improved. Likewise poor quality of processes leads to deaths. So to avoid this, quality improvement is necessary as shown in the figure below



Source : [9]

2.2 Cost of quality

The cost of quality is classified into internal failure and external failure costs. Internal failures include scrap, rework and process failure, down time and price reduction. External failure costs include cost due to complaints, returns, warranty claims, liability and lost sales as can be found in [1]. Also costs of quality are categorized into prevention cost, appraisal costs, internal failure costs and external failure costs. Preventive costs are those incurred in trying to prevent problems, failures and errors from occurring in the first place. Appraisal costs on the other hand are those associated with controlling quality to check whether an error occurred during or after the formation of a product or service. Therefore the cost of quality can be computed as follows

$$COQ = \frac{\Sigma(E+I+P)}{S} * 100\% \quad (1)$$

Where E= external cost, I= internal cost, A= appraisal, P= preventive, S= sales

2.3 Quality improvement

Quality improvement can be considered as a wheel on which companies are driven forward. It is done so that companies can catch up with the ever changing customer demands according to [6]. Improvement of quality does not happen simply by getting everyone in the company to think about quality. Many systems in manufacturing companies prevent people from making improvement according to [1]. The writers further asserts that operators can only correct 15% of quality problems while 85% is the responsibility of management especially when the systems are formulated.

3.0 RESEARCH METHODOLOGY

The objective of this research was quality failure analysis and quality improvement methods in small and medium manufacturing companies. However this is a very wide area of research and therefore this study narrowed down to quality failure analysis and quality improvement in steel furniture manufacturing company (Shamco industries limited). The study adopted a case study methodology. A case study research is a comprehensive in-depth investigation of a phenomenon in one or more real life setting over a period of time [8]. In this research quality problems affecting the quality of steel furniture were investigated. Case study methodology has an advantage of allowing the researcher to modify the research question during the research process when the original questions seem to be less relevant. In this research investigated quality problems were ranked and the root causes of the investigated quality problems were established. Secondary data collected involved the complaints of the customers as recorded in the year 2014 -2016. Secondary data analysis was done to show the severe and critical defects in the products manufactured in this company. Primary data collection involved investigating the severity, rate of occurrence and detect-ability of the defects. The method used was brainstorming with experts from across all the departments in the company. This necessitated getting diverse and unbiased information. According to [7], brainstorming is used to generate many ideas without assessing their values. It involves collecting people's ideas and opinion to allow any decision to be taken on the basis of facts. Direct observation was another method used in this study. Using Failure Mode and Effect Analysis, Risk Priority Number (RPN) was obtained from the results of brainstorming. FMEA is used when investigating a process to identify possible cause of failure. After establishing the quality problems, ranking followed. Pareto diagram was used to show graphically risk of the investigated defects. Root causes of the investigated defects were established categorizing them in terms of workers based, material based, machine based or process based. The purpose of Cause Effect Analysis is to find out the possible causes and point out possible areas where data can be collected [7].Cause and effect analysis was used to establish the root causes of the defects after thorough brainstorming.

3.1 Failure mode and effect analysis

Failure mode and effect analysis (FMEA) is used to assist in the fool proofing of design or a process [7]. It is used to investigate a process to identify possible causes of failure. FMEA offers a structure of thinking through the likelihood, seriousness and probability of potential problems. Three questions are asked when dealing with FMEA and they are:

- What is the likelihood that a failure will occur (occurrence)?
- What would be the consequence of the failure (severity)? And
- How likely would such a failure be detected before it causes affects the customer?(detect-ability)

The process follows the following steps

1. Brainstorming looks at what can go wrong
2. For each problem estimate how likely it is found if it is wrong. This is graded on a scale of 1-10 as follows (**D**)

Table 2:1 *Interpretation of scale on detection of defects*

Scale	Interpretation	Probability of Detection (%)
1	Very high	86-100
2	Very high	76-85
3	High	66-75
4	High	56-65
5	Moderate	46-55
6	Moderate	36-45
7	Low	26-35
8	Low	16-25
9	Very low	6-15
10	Remote	0-5

Source: [7]

3. For each potential problem estimate how costly it is likely to be. This is graded on a scale of 1-10 (**S**)

Table 2:2 *interpretation of the scale on defect severity*

Scale	Interpretation
1	Minor
2	Low
3	low
4	Moderate
5	Moderate
6	Moderate
7	High
8	High
9	Very high
10	Catastrophe

Source: [7]

4. Next estimate how likely that each potential failure will happen. A scale of 1-10 is used(**O**)

Table 2:3 *Interpretation of the scale on defect occurrence*

Scale	Interpretation	Likelihood
1	Remote	Effectively 0
2	Very low	1 in 20000
3	Low	1 in 10000
4	Moderate	1 in 2000
5	Moderate	1 in 1000
6	Moderate	1 in 200
7	High	1 in100
8	High	1 in 20
9	Very high	1 in 10
10	Very high	1 in 2

Source: [7]

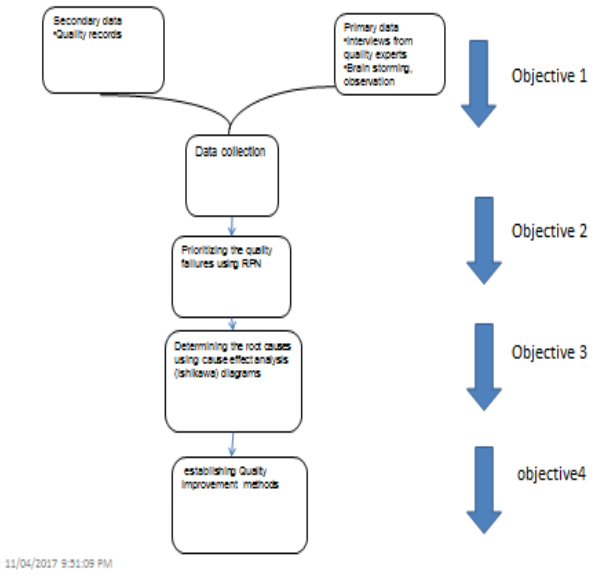
Multiplying the output of 2, 3 and4 generate Risk Priority Number (RPN). RPN lie between 1 and 10000. To rank the potential by RPN, two rules are used

a) No potential failure can have RPN greater than 700
b) No individual output from stage 2, 3 or 4 can exceed 7. These rules show which potential failure must be investigated.

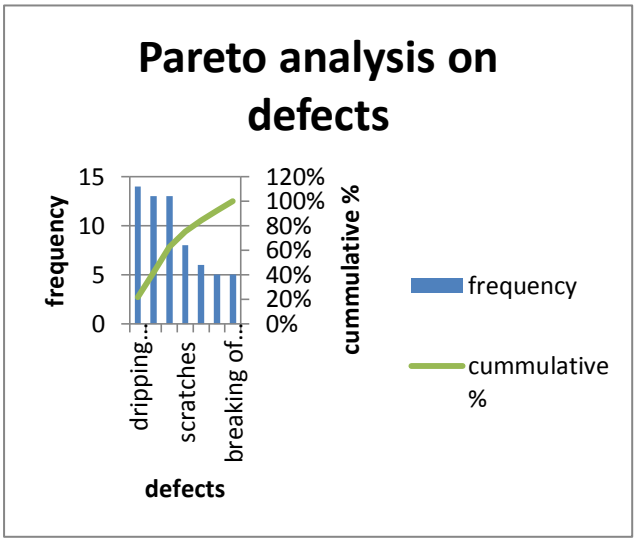
Therefore RPN is given by the following relation

$$RPN = S * O * D \qquad (2)$$

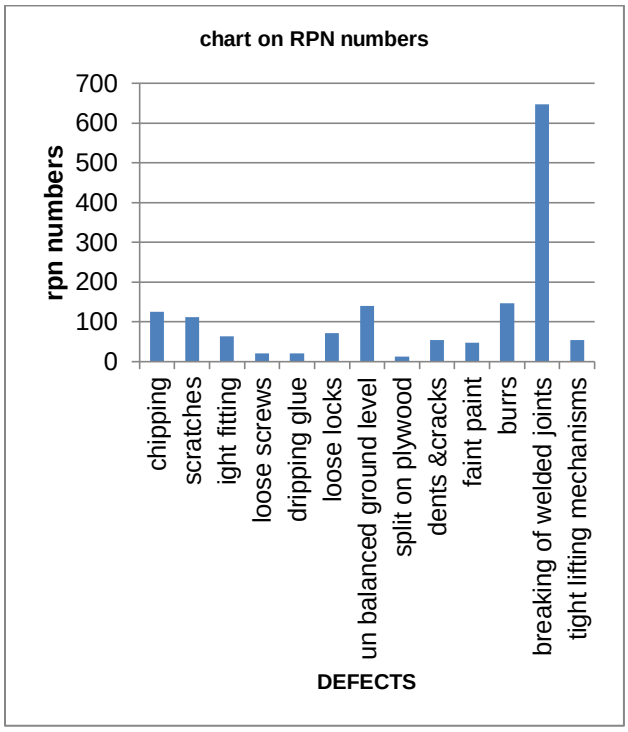
Where RPN= risk priority number, S=severity, O= occurrence And D= detect ability The summary of the methodology used in this study was as shown below



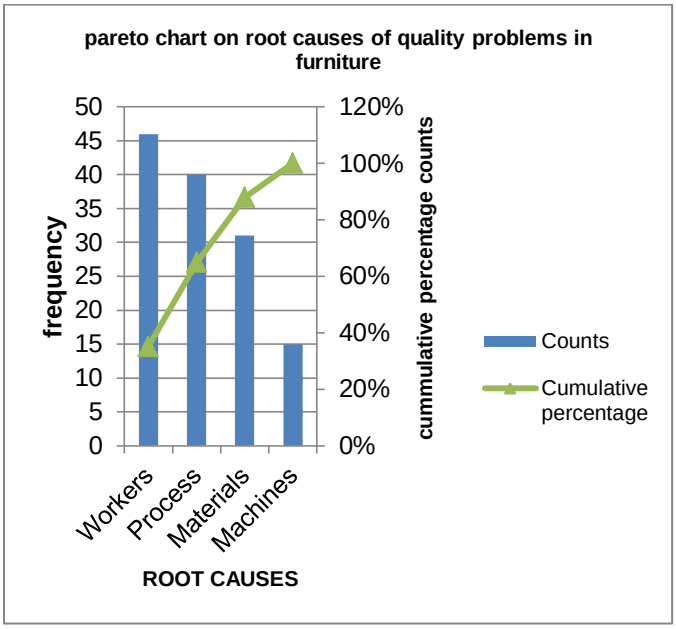
4.0 FINDINGS AND DISCUSSION



The main objective of the study was to analyze the quality failure and establish quality improvement methods. The study established that the critical defects in steel furniture manufacturing company were dripping paint at 22%, faint paint at 20%, unbalanced ground level at 20%, scratches at 13%, cracks and dents at 9%, burrs at 8% and breaking of welded joints at 8%. These defects occur in different products in different proportions as indicated by the respective percentages. From these results it is clear that more emphasis should be put on the dripping of paint and get the solution to it. The mixing of the paint should be thoroughly checked and the solvents chosen correctly. Also the method of applying the paint needs to be reviewed. Using Failure Mode and Effect Analysis the Risk Priority Numbers (RPN) was calculated and the results showed that breaking of welded joints had the highest figure of 648 while splits on ply wood had the lowest RPN of 12. Other defects had the RPN as follows chipping 126, scratches 112, unbalanced ground level 140, and tight lifting mechanisms 54. Breaking of welded joints seems to be very risky going by the RPN number.



Since customers will not accept products which have this kind of failure, it means thorough inspection should be done before the product go to the customer. The operator should be the first person to inspect the work before allowing it to the next stage of production. This can easily be done using peening hammer. It was found that the root causes of the investigated defects were due to multiple causes with workers contributing to 35%, process at 30%, materials at 23%, and machines at 11%.



To improve the condition of workers, training is required to make sure that right skills are imparted on the workers. Process under which products go through needs to be redesigned to ensure that right process is followed in the production line. To get the right product, right materials are supposed to be used and this can only be achieved through thorough inspection of the raw materials. Machine maintenance is paramount to make sure that they are available when they are needed. Calibration of the tools is also required to make sure that right measurements are obtained.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This paper presented the quality failure analysis in steel manufacturing company. The quality problems were ranked according to severity, rate of occurrence and detect-ability. Using Failure Mode and Effect Analysis (FMEA), Risk Priority Numbers were calculated and the investigated defects were ranked. Root causes of the investigated were established and this led to the establishment of methodological approach that can mitigate the investigated defects. This paper recommends application of quality improvement cycles like Plan, Do, Check and Act (PDCA) and Define, Measure, Analyze, Implement, and Control (DMAIC) when applying methods outlined and this can only be achieved if all stake holders in the production process are fully involved. Further research is encouraged in other manufacturing companies in a bid to improve the quality of manufactured products.

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IMPORTANT INFORMATION
Formulating risk priority number (RPN)

Detect-ability		Severity		Occurrence		
Interpretation	Probability of Detection	Scale 1-10	Interpretation	Scale 1-10	Interpretation	Likelihood
Very high	86-100	1	Minor	1	Remote	Effectively 0
Very high	76-85	2	Low	2	Very low	1 in 20000
High	66-75	3	Low	3	Low	1 in 10000
High	56-65	4	Moderate	4	Moderate	1 in 2000
Moderate	46-55	5	Moderate	5	Moderate	1 in 1000
Moderate	36-45	6	Moderate	6	Moderate	1 in 200
Low	26-35	7	High	7	High	1 in100
Low	16-25	8	High	8	High	1 in 20
Very low	6 -5	9	Very high	9	Very high	1 in 10
Remote	0-5	10	Catastrophe	10	Very high	1 in 2

Results from the brainstorming session and the calculated risk priority numbers

DEFECTS	DETECTABILITY	SEVERITY	RATE OF OCCURRENCE	RPN NUMBER
Chipping	2	7	9	126
Scratches	2	7	8	112
tight fittings	1	8	8	64
loose screws	1	3	7	21
dripping glue	1	3	7	21
loose locks	1	9	8	72
unbalanced ground level	5	4	7	140
splits on plywood	1	2	6	12
dents and cracks	1	9	6	54
faint paint	6	1	8	48
Burrs	3	7	7	147
breaking of welded joints	9	9	8	648
tight lifting mechanisms	1	9	6	54