DEPARTMENT OF PRODUCTION ENGINEERING

FACULTY OF ENGINEERING

UNIVERSITY OF BENIN

BENIN CITY

PROJECT TOPIC:

APPLICATION OF LEAN SIX-SIGMA IN A MANUFACTURING COMPANY (CASE STUDY: MOUKA FOAM)

BY

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DECEMBER 2022

CERTIFICATION

This is Certify that the Project Report here was carried out by OMORAGBON FREEDOM, ENG1504077, in the Department of Production Engineering, Faculty of Engineering, University of Benin, Benin City. In accordance with rules and regulations of the University of Benin.

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DEDICATION

This project is dedicated to God for his mercy and protection and for the Knowledge, he has enabled me to acquire.

ACKNOWLEDGEMENT

My sincere gratitude goes to God Almighty for giving me the moral, courage and enthusiasm to embark on this project. Project which has opened my eyes to the different technology advancements under the scope of the study of work.

I appreciate the efforts of my parents Mr. and Mrs. OMORAGBON for bringing me up morally and academically. I must register my profound gratitude to my parents for their guide, moral and financial supports.

I wish to appreciate the University of Benin for giving me this great opportunity. I wish to appreciate the Head of Department, Production Engineering, Engr. Dr. I D. Erhunmwun and my course adviser Engr.Dr. Emmanuel Ikpoza.

It is pertinent at this point to appreciate the effort of my project supervisor Engr. Dr.

Chris for his support and encouragement.

I also wish to appreciate all my lecturers whose efforts have contributed to my know Ledge base in Engineering. I wish to say a big Thank You.

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CHAPTER 1

BACKGROUND TO THE STUDY

Every organisation aims at profit maximization and growth. Growth and profits are directly related to the level of satisfaction that is imparted by the product or the services to the customers. Customer wants value for money. He wants the best quality in the given cost. So how does an organisations achieve this quality? Quality is a subjective constraint. Every customer has a different taste of quality. So, it is the job of the organisation to provide everything in terms of quality that every customer demands. So, from where does this quality start? It starts from the moment the manufacturer purchases the raw material from the supplier. This quality is percolated in the product through right set of processes, activities with the use of right resources in terms of human and technology and ultimately right quality is achieved by reduction in defect in the product. Lesser is the tolerance limit for defect, better is the quality. This concept drives the organization towards the concept of least deviation in the products that are manufactured. This drives the organisation towards Six-Sigma. Two of the most popular continuous improvement programs are Six Sigma and lean management. Six Sigma was founded by Motorola Corporation and subsequently adopted by many US companies, including General Electrical GE and Allied Signal. Lean management originated at Toyota in Japan and has been implemented by many major US firms, including Danaher Corporation and Harley-Davidson. Six Sigma and lean management have diverse roots, (Arn Heiter and Maley Eff, 2005). management (TQM) and just-in-time (JIT), (Naslund, 2008). Both Six Sigma and lean management have evolved into comprehensive management systems which clarify in lean six sigma methodology. In each case, their effective implementation involves cultural changes in organizations, new approaches to production and to servicing customers, and a high degree of training and education of employees, from upper management to the shop floor. As such, both systems have come to encompass common features, such as an emphasis on customer satisfaction, high quality, and comprehensive employee training and empowerment, (Arn Heiter and Maley Eff, 2005). Some elements to eliminate many misconceptions regarding Six Sigma and lean management by describing each system and the key concepts and techniques that underlie their implementation, (Arn Heiter and Maley Eff, 2005). Lean defined as systematic approach to identifying and implementation, (Arn Heiter and Maley Eff, 2005). “Lean production” term is a result of the benchmarking results from the IMVP. The word “lean” was suggested because the best assembly plants (the Japanese plants) (Womack et al., 1990, p. 13). (Dahlgaard, Park 2006), The concept of lean management can be traced to the Toyota production system (TPS), a manufacturing philosophy pioneered by the Japanese engineers Taiichi Ohno and Shigeo Shingo, (Arn Heiter and Maleyeff,2005). Toyota Production System (TPS) is recognized with being the birthplace of just-intime (JIT)production methods, a key element of lean production, and for this reason the TPS remains a model of excellence for supportive of lean management,(Arn Heiter and Maleyeff,2005).TPS was the developed of manufacturing began shortly after the Second World War, pioneered by Taiichi Ohno and associates, while employed by the Toyota motor company. Forced by shortages in both capital and resources, Eiji Toyoda trained his workers to eliminate all types of waste (seven

wastes). Eiji defined the waste as “anything other than the minimum amount of equipment, materials, parts, space and time which are absolutely essential to add value to the product” (Russell and Taylor, 2000,),(Pepper, Spedding ,2010).The Toyota Production System (TPS) became the dominant production model to emerge from a number of concepts around at the time (Katayama and Bennett, 1996; Barte Zaghi, 1999). As a result of the International Motor Vehicle Program (IMVP) benchmarking study, and the work of Womack et al. (1990), US and European companies began adapting the TPS under the title of just-in-time (JIT) to remain competitive with Japanese industry.(Pepper, Spedding ,2010).Lean manufacturing is about controlling the resources in accordance with the customers’ needs and to reduce unnecessary waste or non-value add (including the waste of time). The concept was introduced at a larger scale by Toyota in the 1950s, but not labelled lean manufacturing until the now famous book about the automobile appeared in 1990. (Andersson, Eriksson and Torstensson, 2006). Lean manufacturing started in the form of the Toyota Production System has been around for decades, it did not get integrated with Six Sigma until the late 1990s and early 2000s (George, 2002, 2003). the approach in the areas where improvements could be identified and implemented quickly (one to four weeks), many of which involved the flow of information and materials through a process. Today Lean Six Sigma is the improvement approach of choice. (Snee,2010). Lean Six Sigma is the latest generation of improvement approaches. I argue that improvement approaches are not fads but steps along the way in evolution of business improvement methodology. Each approach builds on previous approaches adopting the effective aspects of previous approaches and that have been identified. (Snee, 2010) Some articles and journal to clarifying a brief overview of some of the central components of Lean Six Sigma’s two underlying concepts is provided as a background to discussions. The components have been derived theoretically, which is one of the several possible ways to deconstruct Six Sigma and Lean. Six Sigma can be broken down into seven parts: DMAIC

(Hoerl, 2004), Six Sigma toolbox (Magnusson et al., 2003), Six-Sigma organisation (Hoerl, 2004; Bergman andKlefsjo¨, 2003; Magnusson et al., 2003), reduction of variation (Nave, 2002; Naslund, 2008; Bertels, 2008), customer focus (Bergman and Klefsjo¨, 2003), decisions based on facts(Goh and Xie, 2004). Similarly, Lean can be said to be based on the four following concepts: Lean tools and techniques – notably value stream mapping (Womack, 2006; Alukal, 2003), the involvement of people (Holbeche, 1997), continuous improvement (Ricondo and Viles, 2005) and removal of waste (Spector, 2006; Alukal, 2003; Naslund, 2008). Six-Sigma is the latest generation improvement of improvement approaches.

1.1 Statement of the Problem

With the current level of high rivalrous among companies, industries which are production or service-oriented business. There is a need to meet customer's needs(wants) for every business enterprise that wants to remain in the transitional marketplace. Most business organizations have rather leaned on quality policies inclined towards the end of production to detect product defects (Asset et al., 2012arlind). This is product quality control with grave consequences in the form of internal and external failure costs such as scrap, rework or salvage, retest and penalty for not meeting schedule and complaint adjustment, product return and warranty charges respectively (Asset et al., 2012arlind). Preferably, quality policies should be built around the process quality control, which will enable prevention of product defects. Lean Six-Sigma has swiftly established itself as the key business process improvement strategy of choice for many companies (Hill 2018). As declare by (Uzorh et al, 2019), currently in many companies, Lean Six-Sigma is improving their results from the last years. Therefore, an attempt can be made to duplicate it in the foam production industry too. in view above, the research project is to deploy the Lean Six Sigma approach to ensure continuous quality improvement of production process aimed at reduction in the process variability and the continuous improvement in process capabilities in which will reduce waste in cost, improve product quality and enhance customer satisfaction.

1.2 Aim of the Project Work

The aim of this project research is to estimate foam production process which in turn bring about quantity improvement in a production line using a specific set of tools from the Lean Six-Sigma methodology.

1.3 Objectives of the Project Work

To achieve this aim, the following objectives would be pursued:

i. To collect data and measure the current performance ii. Evaluate the production process

iii. Check for variance between laboratory and process results

iv. To bring about quality improvement in production process

1.4 Scope of the Project Work

Lean Six-Sigma has been used over a wide range of industries to improve product delivery both from an effective and efficient standpoint. This research work reviewed the deployment of Lean Six-Sigma to Mouka foam industry, in particular the production process lines. The tools to be used in this study is drawn from the lean six-sigma methodology

DMAIC, specifically D-define, M-measure, would be the process methodology to be used.

1.5 Significance of the Study

Current economic crisis raises the constant demand for profitable solutions that allow organizations to gain competitive advantage. For this reason, more and more companies search for management methodologist that allow them to improve their products and/or service characteristics, perfect their processes, decrease costs, improve the capital's profitability and costumers' satisfaction. This have been attempted through Lean Management and Six-Sigma integrated approaches in their managerial and production processes in which, Lean focus mainly on the waste elimination, using simple and visual techniques whenever possible and Six-Sigma on the control and the processes variability reduction, using statistical tools for this purpose.

CHAPTER 2

LITERATURE REVIEW

In the world today, quality is a competitive weapon which organization use to attract customers in the global market. This is done to ensure customer's satisfaction and for the sustainability which could be achieved by the ccontinuousimprovement in the business processes to be more effective and efficient, as is the case of Toyota. Improvement as a means of reduction in variability in process and product, is the key goal of quality and the key parameter for organizational success. Different conceptions, methods, and tools may be employed to uphold the good quality level and help in continuous improvement in an organisation. Lean emphases on producing products and service at minimum time and cost. Motorola is the originator of Six-Sigma which brought this new concept of quality in 1980s after being consistently, beat in the competitive marketplace by foreign firms. When the process operates at the Six-Sigma level, the amount of variation is so small or minimum that the resultant products and service are 99.999% defect free (Leathers, 2006). The approach of Six-Sigma differs from the conventional quality improvement programs as it focuses on input variables. While conventional process improvement methods and techniques depend upon the measuring the outputs and establishing the control plans to protect customers' requirements from organizational defects (Kwak and Anbari, 2006). Six-sigma based on the concept of customers cantered, systematic and the data driven technique for doing the things better. It is a disciplined and the data driven approach to eliminate or remove the defects in any process from manufacturing to transactional and from product to service who is end user of product. Six-Sigma is a detailed and the lithe system to achieve, sustain and maximize the business success. Six-Sigma is not a theory of management or even a single business methodology. Six-Sigma is not a theory of management or even a single business methodology. Six-Sigma is a method of providing defects free product of service to the customers. Six-Sigma gives us different tools to improve systematically the entire business. The Lean

Six-Sigma's DMAIC to improve production process is very rarely seen in the potable water

production industry. Most of the studies are focused on the physical, chemical and bacteriological water quality parameters of different water products from various companies, without further investigation on the production process for the necessary improvement as applicable.

2.1 The Concept of Quality

Quality is a relative term, generally used with references to the end use of the product (Jayakumar and Raju 2016). However, in technical terms, several authorities have given up their definitions of quality. As citied by (Summer, 2018), the American Society for Quality have two meanings: (1) the characteristics of a product or service that bear on its ability to satisfy stated or implied needs and (2) a product or service free of deficiencies. The following professionals as citied 7 in (Summer, 2018) gave their definitions too. (Juran, 1995) describes quality as fitness for use, while (Crosby, 1979) discuss quality as conformance to requirement and non-quality as nonconformance. According to the the ISO 9000 standards as citied by (Krishnamoorthi et al 2018), quality is defined as the "degree to which a set of inherent characteristics fulfils requirements". (Montgomery, 2009) argued that, a modern definition of quality is preferable, which is, quality is inversely proportional to variability. Hence, he noted that, this definition implies that if variably in the important characteristics of a product decreases, the quality of the product increases.

2.1.1 Dimensions of Quality

Quality as many dimensions (Jayakumar and Raju, 2106), which could be objective and subjective as well. Dimensions of Quality are the various features/aspects of a product or service, which the customer uses to evaluate the product or service (Jayakumar and Raju, 2016). They are the things that make it stand out from competitors and give it value. These are the things differentiate your business from others in the marketplace.

Performance

A performance characteristic describes a product's essential function. for a car, performance would include characteristics like millage per gallon, acceleration, handling, cruising speed etc. for a smart phone, performance would include characteristics like clear phone reception, data speed etc. ii. Features

Features are a secondary aspect of performance. They're "the bells and whistles" of product and services. They're the ones who add extra functionality to their essential functions. for a car, features would include the built-in GPS, seat warmer, smartphone integration etc. for a smartphone, features could include a high-resolution camera, retina or fingerprint sensor. sometimes it might be challenging to say which is a performance dimension and which is a feature dimension.

Reliability

Reliability id the ability of a product or service to perform as expected over time. for example, if you buy a new car, you do not expect the vehicle to break down frequently. The most used reliability measurements are the Mean Time to Failure (MTTF) and the Mean Time Between Failures (MTBF).

Conformance

Conformance is the degree to which a product confronts to its specifications. for example, when we talk about conformance in software development, we mean that the code complies with the requirement defined by the customer. Quality Guru Philip Crosby defines quality as conformance to requirements.

Durability

Durability is the measurement of product life. This defines the amount of use the customer could get from the product before it deteriorates. for example, for how long will your car last? Durability is measured by the number of cycles or the time a component will function properly as a part of the product life.

Serviceability

Serviceability is the ease at which a user can repair a faulty product or get it fixed. it could be measured in terms of how much time and effort it takes to get a faulty product and returned to regular use.

Aesthetics

Aesthetics refers to the appearance of a product or service. it includes all aspects related to the physical appearance of a product, for example, the weight, color, size, texture, packaging design etc.

Perceived Quality

Perceived quality is the overall opinion of the customers towards the product. It's the combined effects of factor such as brand name, price, salesperson, marketing strategy etc.

Responsiveness

Is the measure of how well the manufacturer of the product is able to adapt. The above was also corrobated by (Jayakumar and Raju, 2016), however, added the ninth dimension, which is responsiveness.

2.1.2 Quality improvement

(Montgomery, 2009) defined quality improvement as the reduction of variability in processes and products. He stated that, excessive variability in process performance often results in waste. This means, reduction of variability (elimination of the waste) leads to 12 improvements of the quality of the process and quality of the product (Krishnamoorthi et al 2018). (Krishnamoorthi et al 2018), further stated that, discovering problems or improvement opportunities in processes and making process improvement to achieved improve product quality and customer satisfaction is a nonending, continuous process. This is where continuous satisfaction quality improvement becomes so needful.

2.2 LEAN CONCEPT

2.2.1 MEANING AND CONCEPT OF LEAN

Lean defined as systematic approach to identifying and eliminating nonvalue add (wastes) through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection. (Andersson, et al 2006) "Lean production" term is a result of the benchmarking results from the

IMVP. The word "lean" was suggested because the best assembly plants (the Japanese plants) (Womack et al.,1990, p. 13). (Dahlgaard, Park 2006). The concept of lean management can be traced to the Toyota production system (TPS), a manufacturing philosophy pioneered by the Japanese engineers Taiichi Ohno and Shigeo Shingo,(Arn Heiter and Maleyeff,2005). Toyota Production System (TPS) is recognized with being the birthplace of just-in-time (JIT)production methods, a key element of lean production, and for this reason the TPS remains a model of excellence for supportive of lean management,(Arn Heiter and Maleyeff,2005).TPS was the developed of manufacturing began shortly after the Second World War, pioneered by Taiichi Ohno and associates, while employed by the Toyota motor company. Forced by shortages in both capital and resources, Eiji Toyoda trained his workers to eliminate minimum amount of equipment, materials, parts, space and all types of waste (seven wastes). Eiji defined the waste as "anything other than the minimum amount of equipment, materials, parts, space and time which are absolutely essential to add value to the product" (Russell and Taylor, 2000, p. 737), (Pepper, Spedding ,2010). The Toyota Production System (TPS) became the dominant production model to emerge from several concepts around at the time (Katayama and Bennett, 1996; Bartezzaghi, 1999). As a result of the International Motor Vehicle Program (IMVP) benchmarking study, and the work of Womack et al. (1990), US and European companies began adapting the TPS under the title of just-intime (JIT) to remain competitive with Japanese industry.(Pepper, Spedding ,2010).

2.3 SIX SIGMA METHODOLOGY

2.3.1 OVERVIEW OF SIX SIGMA

The six-sigma methodology was developed at Motorola in 1987 in response to sub-standard product quality traced in many cases to decisions made by engineers when designing component parts. Traditionally, design engineers used the "three-sigma" rule when evaluating whether or not an acceptable proportion of manufactured components would be supposed to meet tolerances. When a component's tolerances were consistent with a spread of six standard deviation units of process variation, about 99.7 percent of the components for a cantered process would be expected to conform to tolerances. That is, only 0.3 percent of parts would be nonconforming to tolerances, which means that to3,000 defected parts per million (DPPM), (Arnheiter and Maleyeff,2005). The six-sigma started by Motorola was the first company to launch a six-sigma approach in the mid1980sIn 1988, where the Motorola specialized in electronic products, Bill Smith1986 is engineer and statistician at Motorola, introduce the six-sigma concept aiming to attack the existing quality problems in the company. Motorola received the Malcolm Baldrige National Quality Award, which led to an increased interest of six sigma in other organizations, see Pyzdek (2001). Today, a number of global organizations have developed six sigma approach of their own and six sigma is now established in almost every industry. (Andersson, et al 2006). At Motorola, when studying the relationship between the quality of component and the quality of final product it was discovered that, from lot-to-lot, a process tended to shift a maximum of 1.5 sigma units (McFadden, 1993). This concept is shown graphically in next Figure, which shows a cantered process and processes, shifted 1.5 sigma units in both directions. Table provides the relationship between component quality and final product quality, assuming that the full 1.5 sigma shift takes place. In next Table,SSigma levell is the standardized process variation (see Figure), OFD quality is the NCPPMif thee process shifts a full

1.5 sigma units, and the probabilities in the table provide the proportion of final products that will be free of defects. For example, if the company sets a goal for final product quality of 99.7 percent and products include about 1,000 OFDs, then the 3.4 DPPM corresponding to the Six-Sigma methodology would become the standard against which all decisions were made, (Arnheiter and Maleyeff,2005). A company whose performance is measured to six sigma (the reference of the market) generates only 3.4 DPMO (almost perfection), Tandis Qu, a company with Three Sigma i.e., the current standard, must support the cost of 66,800DPMO

i. decision-making based on data

ii. the object is to receive is to repeat the defects and the variation

iii. implication and engagement of the person in charge

iv. rigorous respect of the methos stages

2.3.2 METHODOLOGY OF SIX SIGMA

Six sigma is a process improvement methodology which includes different phases i. Define

In the define phase, the goals of the improvement activity are clearly defined. The parameters which greatly influence the goals of the enterprise in respect to quality are called critical to quality (CTQ) parameters. In the process of defining, the goals CTQ are identified through Voice of Customer (VOC). VOC is collected by conducting brain storming sessions among the customers. Project Charter, CTQ flow down,,, and Process mapping are the important tools used in this phase. Project charter is a document stating the purposes of the project. It contains the elements such as business case, problem statement and goal statement. Business case indicates the purpose of the project in which the goals andobjectives are established. The next element is the problem statement which clearly expresses the problem to execute. After establishing the problem statement,, the six-sigma team has to decide the target values by thoroughly observing the past data. These values are mentioned in a statement called Goal statement. Process mapping is the key step in understanding the processes involved in an enterprise. The process map (SIPOC chart) starts with supplying raw materials and ends with the benefits received by the customer.

Measure

In this phase past data pertaining to CTQ s is collected. The baseline statistics such as sample mean (μ), standard deviation (σ) and process capability indices Cp and CPk. for each CTQ are calculated. The mean is the simple average of the observations in a data set. The Sample mean is determined by adding all observations in a sample and dividing the number of observations in that sample. Standard deviation measures the variability of the observations around the mean. It is equal to the positive square root of variance. The variance also measures the fluctuations of the observation around the mean. The larger is the value, the greater is the fluctuation. The process capability index is an easily understood aggregate measure of the goodness of process performance. iii. Analyze

In this phase critical analysis is carried out with the help of certain tools such as Fishbone disgram

(Cause and Effect diagram) and pareto diagram. Fishbone digrams are usedto identify and systematically list the different root causes that can be used attributed to a problem. Thus, these diagram help to determine which of several causes has the greatest effect. The main application of these diagram is the dispersion analysis.

Improve

Failure Mode and Effect Analysis (FMEA) is carried out in this phase to identify the possible types of failures. The objective of conducting FMEA is to anticipate all possible types of failures that could occur. The FMEA tabular form includes parameters such as mode of failure, effects of failure and its severity rating (S), possible causes of failure and their intensity of occurrence (O), current prevention methods, detection column (D), Risk Priority Number (R), recommended actions and Responsible persons. The severity column has an entry designating the severity of the effect for the failure mode, that is, the seriousness of the impact of the particular failure. The occurrence column has an entry designating the likelihood that is the failure will occur. The detection column has an entry designating the likelihood that the detection method is accurately detect the failure.

Control

The control phase aims to institutionalize the improvement results from six sigma through documentation and standardization of the new procedures. It includes the setting up of monitoring and process control systems. Control charts are used to monitor the system performance. In the control phase control charts are prepared in respect of CTQs to sustain the quality improvement.

2.3.3 Benefit and advantage of Six Sigma

Six-Sigma is a methodology which helps to:

Developed the statistical analysis of the data ii. allowing undervaluing of financial risks

helps to motivate the employees of the organization by ensuring that the employees are able to use the available technology for their ease of work and their time is saved. Productivity is automatically increased when the employees are motivated and inspired to keep working and challenging their limits.

Helps to identify the potential problems or pullbacks of the process in advance, thus it helps the project management team to strategize and plan to reduce and eliminate the problems and waste so that the productivity is not affected and the quality of the product and services offered to the customers is not compromised at any point. It helps the project management team to recognize the strengths and weaknesses of the business process resulting in the elimination of the unwanted process.

2.4 LEAN SIX SIGMA (LSS)

Lean Six Sigma (LSS) has been marketed as a new organizational change and improvement method, particularly as a cost reduction mechanism (Hoerl et al.,2004; Edward and John, 2005). In the recent past, efforts have been made to promote LSS George et al., 2003; Edward and John, 2005; Brett and Queen, 2005; Caldwell et al.,2005). Lean and Six Sigma are two of the most effective businessimprovement techniques available (Spector, 2006). The use of LSS techniques helps companies to improve operational efficiency and effectiveness especially when companies must operate in a highly competitive globalized market (George et al., 2003; Hoerl et al., 2004). The implementation of LSS initiative is believed to have encountered enormous difficulties (Denton and Hodgson, 1997). Therefore, several electronic manufacturing service (EMS) industries have implemented LSS program to improve performance. However, not all industries have benefitted from this program as the implementation was somehow not effective. Some of these companies have their own queries on LSS implementation in terms of cost and time. LSS is becoming a popular technique for improving productivity and quality. The aim of this study is to determine the critical success factors (CSFs) for the successful implementation of LSS in EMS industries and to evaluate its impact on the company performance using empirical study. According to (Rathilall and Singh 2018), within the context of Lean, the objective is to eliminate waste throughout a manufacturing system whereas Six Sigma, concentrate on reducing defects in a process. Therefore, they can be seen as complementary as both bodies of knowledge are needed to effectively solve problems encountered by an organization. (Shirey, 2017) inferred that, because Lean Six Sigma is a structured method of implementing process improvement using its DMAIC- Define, Measure, Analyse, Improve, and Control strategy wit a variety of tools. Lean Six Sigma has the same DMAIC improvement process as the original Six Sigma, but in addiction to Six Sigma tools, Lean tools are also incorporated into different steps. Whereas Six Sigma mainly focuses on defect and variation reductions, Lean adds more focus on process standardization and simplication as well as waste reduction (Tikkala, 2014).

2.5 Review of Applications of Lean Six Sigma:

DMAIC methodology

This is to further proof or show the significance and reliability of Lean Six Sigma, a review of other related literature was done. The Lean Six Sigma / LSS approach has received a lot of attention in various industrial sectors, from the manufacturing industry to the service industry. More specific knowledge about Lean Six Sigma has increased. Much of the training and research on Lean Six Sigma is carried out in various sectors. This literature review is related to LSS's purpose to provide an overview of Lean Six Sigma implementation in the manufacturing industry. The Lean Six Sigma approach introduced and implemented for a long time is DMAIC (Define, Measure, Analyse, Improve, and control). These phases of Lean Six Sigma to make recommendations to ensure quality improvement in the production of mouka foam industry.

2.5.1 The Application of Lean Six-Sigma Methodology in the Manufacturing Sector (Case Study Brewing Firms)

Enoch (2013) carried out an empirical study to examine the effect of Six Sigma Methodologies on Organizational Profitability among the Manufacturing SMEs in Nigeria. The population of the study contained 450 manufacturing SMEs with 2250 employees. The study sample is 225 MSMEs with total 1026 employees selected randomly. The study used structured questions to collect data and a total 1002 copies of questionnaire duly filled were returned. The study used Pearson Product Moment Correction (PPMC) Coefficient to analyze the collected data. Findings revealed a relationship between Six Sigma Methodology (quality input) and profitability of the studied manufacturing SMEs. Ariguzo, Amos, Egwakhe and Adefulu (2019) assessed the effect of Lean Manufacturing System on profitability of the Nigerian food and beverage sub-sector. Expost-facto research design was used for the study. The study carried out a post-effect review of three determining agents of LMS (Material Leanness, Employees Leanness, and Money Leanness) on the Profit (PAT) of multinational Food and beverage corporations in Nigeria. A comparison was done amongst the three multinational firms sampled along pre-and-post acceptance of the application of lean manufacturing system. Time series data was collected for a period of 25years (1994-2018) which makes up the total number of observations. The trustworthiness or reliability of the data was anchored on the legal measure regulating the financial explanations of these firms to the Nigeria Stock Exchange Commission and the morality of the Audit Firms that certified the financial reports before public disclosure.

Multiple regression analysis was used to analyze the collected data. The study found lean manufacturing (emphasis on quality) to have significantly affected profitability in Nestle and Cadbury Plc, but observed no changes in Unilever.Adan and Mohammed (2014) examined Six Sigma Manufacturing and performance of a semiconductor company in Palestine. Survey and Expost-Facto design was used, questionnaireand observation method was used to collect data. Questionnaire was used to elicit information from 55 respondents while 3 weeks production data was also observed by the researcher. DMAIC, Box diagram, Cause and effect matrix, ANOVA, Control chart, Histogram, Normal probability plot were used to analyze the collected data. Findings revealed reduction in the electrical failures of about 50% with better quality could impact the profitability of the organization. Abidakun, Leramo, Ohunakin, Babarinde, and Ekundayo-Osunkoya (2014) conducted an empirical study to determine the suitability of Six Sigma method on Nigerian fabricating industry. Selected fabricating firms in Lagos, Nigeria were used for the study. Survey design was used as 75

respondents were interviewed. The study used DMAIC and control chart to identify sources and causes of waste with the goal of supplying veritable solutions. The study found a sigma level of 1.87 in the aluminium milling firm which indicated that there is room for improvement, to reduce the rework or flaw in this firm 37.05% of total production, to 4.1% if Six Sigma method is applied. In other words, an application of Six Sigma Methodologies through ensuring quality input could impact the profitability of the organization.

Agina-Obu (2015) investigated the rate of applicability of Six Sigma in Nigerian fabrication firms using Aveon Offshore in Port Harcourt as a study case. It was a survey study. The study used a semistructured set of questions which were drawn for in-depth interviews of twenty respondents and data obtained were analyzed using Thematic Network Analysis. The study found that a relationship exists between Six Sigma methodology and profitability.

2.5.2 Application of Statistical Quality Control in Manufacturing Company A Case Study of Mouka Foam

Quality control is a process or a set of processes which are aimed at ensuring that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirement of the client or customer (Salimu, 2012). According to ISO 9000 quality control is a part of quality management that is aimed at satisfying quality requirements. Quality control tools such as p-chart, u-chart, X-bar and R chart as well as process capability chart were used to observe field data obtained from the foam production company on important process of foam production and marketing for 30 working days. This was done to check if the processes were in control or out of control and to verify the capability of the marketing process of the product meeting present specification. This results from the p-chart and u-chart showed that the production and packaging process of the product is not in control and hence the need for further investigation and corrective measures to prevent variability in the process and thus allowing improvement in the quality of the product. Also, the result from X-chart and R charts showed that marketing process was in statistical process control in respect of the product sales recorded by the independent marketers with no assignable cause of variation. It also revealed that, the product marketing product marketing process has low capability of successfully attending the present specification limits in respect of the product sales and hence generating low profit for the company.

2.5.3 Management of the Production of Foam to Improve Quality A Case Study Mouka Foam

Particular significance is paid to a development of a concept of continuous improvement in a context of implementation of submitted and unique enterprises, such as projects. H. Kerzner explains the perfection in project management in a context of success measured in a scope of a single project, as well as an organization (Kerzner, 1998), whereas, the main scopes of improvement in project management IPMA includes: people and goals, processes and resources and results of a project (Project Excellence Baseline, 2016). Project, as an action of a unique and temporary character (A Guide to PMBOK, 2013; Crosby, 1986) is described by basic parameters, i.e., meeting the requirements, time and cost (Deming, 1982). Meeting the requirements refers to quality requirements concerning the project.

Quality in professional literature has various interpretations. Most generally, quality is perceived as a degree of adjustment of a given object to expectations of an object. P.B.

Crosby [Crosby, 1986; PN-EN ISO, 2001; Radin and Coffee, 1993), E.W. Deming (Deming, 1982; Yoon and Lasarus, 1993), defining quality, draw the attention to such elements as: compliance with requirements, reliability, cost. More, precisely, quality is interpreted in a product, usability, usability, value and normative approach. One should perceive that normative quality is of universalaracter, this type of quality unites other types of approach, explaining quality as a collection of inherent propertiesofmeting requirements (Juchniewicz, 2019). Therefore, what is the project quality? – project quality can be defined simply, as capability to meet requirements specified at every stage of its implementation. Project quality is affected by many interlinked elements, such as: surroundings – political, In production projects, despite criticism, the Total Quality Management (TQM) can be applied (Kozień, 2017; Kozień, 2018a). TQM is a philosophy of continuous improvement engaging the resources of project organization with a purpose of creation and delivery of value to a client. TQM assumed culture of improvement based on principles and tools supporting its application (Kozień, 2002). The significant principles which should be observed in a production process include: client-orientation, involvement of people (formation of interdisciplinary teams oriented on cooperation), procedural approach, continuous improvement. The advantage of TQM is a vast scope of instruments, which is used in quality management. For example, the tools which can be used to secure quality requirements in a production process may include: 5 WHY, FMEA, 5S, Kanban, Pareto Diagrams, Histograms. Institutional, technical, social and cultural, preparation and implementation of a project, therefore the application of methods and methodologies of project management.

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2.6 Process Flow Chart (PFC)

The process flow chart (PFC) is a schematic representation of the operations, or activities, starting from raw material and leading to the production of the final product (Krishnamoorthi et al 2108). It is used in the measure stage to document the current process, while in the analyze phase , is reversed to reveal difficulties in the process that may contribute to delays or even defects. In the flowchart, each task is represented by a symbol, which represent processes, decisions, storage, transportation etc, (Montgomery, 2009, Pyzdek and Keller, 2010). This qualitative analysis is carried out to evaluate the variability of the routinely monitored quality parameters of a process or product but the use of control charts. The process is to analyze for issues and root causes (Shirey, 2017)

2.6.1 Control Chart

Control charts are used to routinely monitor quality. Depending on the number of process characteristics to be monitored, there are two basic types of control charts. The first, referred to as a univariate control chart, is a graphical display (chart) of one quality characteristic. The second, referred to as a multivariate control chart, is a graphical display of a statistic that summarizes or represents more than one quality characteristic. If a single quality characteristic has been measured or computed from a sample, the control chart shows the value of the quality characteristic versus the sample number or versus time. In general, the chart contains a center line that represents the mean value for the in-control process. Two other horizontal lines, called the upper control limit (UCL) and the lower control limit (LCL), are also shown on the chart. These control limits are chosen so that almost all of the data points will fall within these limits as long as the process remains incontrol. The control limits as pictured in the graph might be 0.001 probability limits. If so, and if chance causes alone were present, the probability of a point falling above the upper limit would be one out of a thousand, and similarly, a point falling below the lower limit would be one out of a thousand. We would be searching for an assignable cause if a point would fall outside these limits. Where we put these limits will determine the risk of undertaking such a search when in reality there is no assignable cause for variation. Since two out of a thousand is a very small risk, the 0.001 limits may be said to give practical assurances that, if a point falls outside these limits, the variation was caused be an assignable cause. It must be noted that two out of one thousand is a purely arbitrary number. There is no reason why it could not have been set to one out a hundred or even larger. The decision would depend on the amount of risk the management of the quality control program is willing to take. In general (in the world of quality control) it is customary to use limits that approximate the 0.002 standard. Letting X denote the value of a process characteristic, if the system of chance causes generates a variation in X that follows the normal distribution, the 0.001 probability limits will be very close to the 3σ limits. From normal tables we glean that the 3σ in one direction is 0.00135, or in both directions 0.0027. For normal distributions, therefore, the 3σ limits are the practical equivalent of 0.001 probability limits. In the U.S., whether X is normally distributed or not, it is an acceptable practice to base the control limits upon a multiple of the standard deviation. Usually this multiple is 3 and thus the limits are called 3-sigma limits. This term is used whether the standard deviation is the universe or population parameter, or some estimate thereof, or simply a "standard value" for control chart purposes. It should be inferred from the context what standard deviation is involved. If the underlying distribution is skewed, say in the positive direction, the 3-sigma limit will fall short of the upper 0.001 limit, while the lower 3-sigma limit will fall below the 0.001 limit. This situation means that the risk of looking for assignable causes of positive variation when none exists will be greater than one out of a thousand. But the risk of searching for an assignable cause of negative variation, when none exists, will be reduced. The net result, however, will be an increase in the risk of a chance variation beyond the control limits. How much this risk will be increased will depend on the degree of skewness. If variation in quality follows a Poisson distribution, for example, for which np = 0.8, the risk of exceeding the upper limit by chance would be raised by the use of 3-sigma limits from 0.001 to 0.009 and the lower limit reduces from 0.001 to 0. For a Poisson distribution the mean and variance both equal np. Hence the upper 3-sigma limit is 0.8 + 3 sqrt(0.8) = 3.48 and the lower limit is 0 (here sqrt denotes "square root"). For np = 0.8 the probability of getting more than 3 successes is 0.009. If a data point falls outside the control limits, we assume that the process is probably out of control and that an investigation is warranted to find and eliminate the cause or causes. Does this mean that when all points fall within the limits, the process is in control? Not necessarily. If the plot looks non-random, that is, if the points exhibit some form of systematic behaviour, there is still something wrong. For example, if the first 25 of 30 points fall above the centre line and the last 5 fall below the centre line, we would wish to know why this is so. Statistical methods to detect sequences or non-random patterns can be applied to the interpretation of control charts. To be sure, "in control" implies that all points are between the control limits, and they form a random pattern. The control chart assumes that the data come from a normal (bell-shaped on Gaussian) distribution (Young, et al 2019). Control charts plotted on a rectangular coordinate axis-vertical scale (ordinate) representing the statistical measures of X and R and horizontal scale (abscissa) representing the sample number. Hours, dates, or lot of numbers may also be represented on the horizontal scale. Sample points, mean or range are indicated on chart by points which may or may not be joined (Bhasin et al, 2016). Control charts are used in two distinct phases. In the first phase, control charts are used retrospectively on a set of historical data to determine whether or not a process has been in statistical control, while in the second phase, it is used prospectively with samples taken sequentially over time to detect changes from an in-control process. (Smeti et al, 2007, Montgomery, 2009).

2.6.2 Purpose of Control Charts

As indicated by (Benneyan, 1998 and Krishnamoorthi, et al 2018). control charts are valuable for several purposes throughout the process improvement cycle. These are:

i. To maintain a process at its current level ii. to control a process at a given target or nominal value.

iii. Identifying, testing, and verifying process improvement opportunities.

iv. Testing for and establishing a state of statistical control.

v. Monitoring an in-control process for changes in process and outcome quality.

(Jayakumar and Raju 2016, Chero, 2019 and Tiberiu, 2013) expressed that, the source of variation are either as a result of natural variation which exists within any process therefore they are causes that are always present during the process or special cause which is attributed to specific circumstances, there presence indicate that the process is out of control and it is not stable.

2.6.3 Types of Control Charts

There are two types of control charts; those that analyze attributes and those that look at variables in a process or project. Examples of a control chart include:

i. X-Bar & R Control Charts

ii. X-Bar & S Control Charts

iii. U Charts iv. P Control Charts

v. C Control Charts

2.7 Foam Quality Parameters

The first stage investigated the feasibility of using foamed bitumen as a potential stabilising technique (Saleh and Herrington 2003). Some preliminary tests were carried out to evaluate the properties of these mixes (Saleh and Herrington 2003, Saleh 2004a, Saleh2004b).

2.7.1 Foam Parameters

i. Effect of Ph

The solution pH can influence the foaming properties of particle-stabilized foams through a variety of mechanisms including changing the surface charge (zeta potential) and thereby, altering the hydrophobicity of the particles (depending on the pH).

In general, uncharged surfaces are more hydrophobic than charged ones. Typically, zeta potential which is a measure of the magnitude of electrostatic interactions between suspended particles decreases (becomes more negative) as the pH increases. Therefore, in addition to tuning particles hydrophobicity through surface modification or chemical synthesis, one can obtain the optimum particle hydrophobicity in an aqueous solution by adjusting the pH.

ii. Effect of injected gas type

Depending on the application and local availability, various types of gases such as N2, CH4, CO2, steam, or gas mixtures like air, light hydrocarbons, and flue gas are used to generate foams. The type of injected gas can affect the stability of foams in various ways:

(i)

The nature of injected gas affects the coarsening rate of foams, driven by gas diffusion. Gases with less solubility in water form much more stable foams than water-soluble gases as water solubility eases the transport of gas molecules across water films changing the foam quality. At the same gas flow rate, injection of a low soluble gas generates foams with higher quality than gases with high solubility.

(ii)

The disjoining pressure is highly dependent on the gas type. Different gas types have different intermolecular interactions, affecting the stability of the foam lamellae.

iii. Effect of temperature

Temperature is an important operational condition that needs to be taken into consideration when dealing with foams. Any variation in the temperature during and after foam generation can affect the surfactant adsorption properties, precipitation behaviour, dissolution and CMC of surfactant, the viscosity of the solution, interface tension, Brownian motion, etc., thereby influencing the foam formation and stability. Elevated temperatures on one hand promote the molecular thermal motion, facilitating the bubble coalescence, and on the other hand, increases the liquid evaporation, resulting in thinner liquid films.

iv. Foam formation and characteristics

Surfactants reduce the required amount of energy for creating bubbles by reducing the surface tension. This leads to the formation of a light mass of bubbles called "foam", characterized by bubbles, thin liquid films separating the bubbles, also referred to as lamellae, and Plateau borders, connections of three films, and nodes connecting four Plateau borders. Similar to bubbly gas-liquid two-phase flows, liquid foams are composed of dispersed gas bubbles in a liquid medium. Gas or liquid fraction in the system plays a key role in determining the foam structure or distinguishing foam from bubbly liquids. Fig. 1 illustrates the role of the gas volume fraction in foam formation and its structure. At low gas volume fractions, φG ($\varphi G = 1 - \varphi L$), the gas-liquid system represents a bubbly liquid, while, above a critical gas fraction (i.e., maximum packing fraction), $\varphi Gc \approx 0.64$, the system exhibits a viscoelastic behaviour with an apparent yield stress, defining foams. This yield stress is attributed to the internal structure of the foam. Foams with gas volume fractions between φGc and ~ 0.85 are known as wet foams. Beyond this gas volume fraction, bubbles deform from nearly spherical to nearly polyhedral shapes forming a dry foam. It is reported that there is a powerlaw relationship between the change in the number of neighbouring bubbles ΔN and $\Delta\varphi G$, the change in gas volume fraction from the jamming point.

2.7.2 Tools used in Lean Six-Sigma

There are variety of tools that can be used for lean six-sigma approach. It is not required to use all tools times. Based on the nature of the process the selection of tools vary. Different tools can be used in different phases of the implementation process. The usage of some of the common tools is discussed in the following section.

Flow diagram: This is a graphic representation of the series of steps followed in the course of a process. These diagrams help examine the logic; or lack of logic, in the sequence of steps that are used to produce output. It oftens helps in identifying bottlenecks so that improvement teams working on projects can actually target these areas first. In general, it gives a good perspective of the process as whole. Flow diagrams can also be used to define the scope of a quality improvement project and the boundaries of the team's effort.

Histogram: A histogram is used to graphically summarize and the display the distribution of data set. In a typical frequency histogram, the height of the bars are determined by the class frequency. Given that the bars in a histogram are of equal width, the area of a particular bar is relative to the equivalent class relative frequency.

Brainstorming: Alex Osborn developed brainstorming technique in 1950s. The on success of this technique is based on the quantity of ideas. It is group for generating new ideas and promoting creative thinking. According to Dr. Juan, there are four rules of brainstorming such as no idea can be criticized, self-critism and self-judgement ideas in the shortest possible time, and team member should expand ideas. This technique may be used to define a project, to develop the theories for identifying symptoms of the problem, and for designing solutions after identification of the root causes

DMAIC: DMAIC stands for Define, Measure, Analyze, improve and control. It is a systematic six-sigma approach can be used for process improvement or redesign.

Pareto Chart: A Pareto chart is one form of histogram or bar chart that is developed in the decreasing order of occurrences of category that has a higher impact on the problem. A scatter plot helps in identifying the relationship between various factors of significance. The main objective of the scatter plot would be to develop an equation that helps in projecting the value of one variable with respect to the other variable. There are different correlations that can be depicted from a scatter plot.

CHAPTER 3

RESEARCH METHODOLOGY

The LSS framework has five phases with each phase providing an easy and structural guide towards root-cause identification of a problem, hence proposing and implementing feasible solution to eliminate the root cause through continuous improvement. It should be noted that there is by no means this framework is the only technique that can be used in LSS adoption. The LSS framework as shown is actually a simplification of the Six Sigma's DMAIC methodology with guided steps on utilizing certain lean tools in each phase. The framework utilizes data driven and guided standard approach of the Six Sigma DMAIC methodology while utilizing lean tools in each phase to determine improvement opportunities and further analyze the problem(s).

3.1 Define stage

In the Define phase of the project, the focus is on defining the current state by making the Problem statement which specifies what the team wants to improve upon which illustrates the need for the project and potential benefit. The type of things that are determined in this phase include the Scope of the project, the Project Charter.

The problem statement and goal statement are the part of Project Charter. The following deliverables should be part of the project charter:

Business Case (Financial Impact)

Problem Statement

Project Scope (Boundaries)

Goal Statement

Role of Team Members

Miles Stones/ deliverable (ends product of the project)

Resources required

Table 3.1 Project Charter

Lean six-Sigma Project Charter

Team members: Project student, Project Supervisor and Employees of the Company
Problem Definition: Due to various reasons which includes, lack of a competent workforce, lack of safety measures, inventory and supplier quality management, lack of appropriate documentation. Goal Statement: The goal of the project is to find various cause of defects and use lean six-sigma method to avoid such in a foam industry. Project Scope: The scope of the study is using DMAIC (Define, Measure, Analyze, Improve and Control) methodology on the Mouka Foam Industry. Communication Plan: Weekly meetings.

The basic metrics are cycle time, cost, value, and labor. Some of the methods used for identifying the metrics are Pareto diagram, SIPOC, voice of the customer, affinity diagram, critical to quality tree. SIPOC stands for Suppliers, Inputs, Process, Outputs, and Customers. This approach helps us to identify characteristics that are key to the process which in term facilitates identifying appropriate metrics to be used to effect improvement.

To create a SIPOC diagram:

Identify key process activities

Identify Output of the process and known customers

Identify input to the process and likely suppliers

Table 3.2 SIPOC TABLE

Suppliers	Input	Process	Output	Customer
Mouka Foam	Shiping instruction Truck/Trailer	Shipping	Delivered product	Retail Store

3.2 Measure stage

The Measure is the second step of the Six Sigma methodology. A base line measure is taken using actual data. This measure becomes the origin from which the team can guage improvement. It is within the Measure phase that a project begin to take shape and much of the hands-on activity is performed. The goal of Measure phase is to establish a clear understanding of the current state of the process you want to improve. For example, a medical practioner prescribes various tests like blood test, ECG test etc for a patient admitted in a hospital. The test reports of various laboratorical tests reflect the current state of health of the patient. Similarly, a Six Sigma practioner, determines current state of health of the system under consideration in this phase.

The deliverables in this phase are refined process map, and refined Project Charter. Some of the tools used in Measure phase are:

Flow Charts

Fish bone diagrams

Scatter diagrams

Histograms

These metrics will establish the base line of the current state. The outcome of applying these tools in the form of charts, graphs or plots helps the Six Sigma Practitioner to understand how the data is distributed. He or she is able to know what the data are doing. The distribution that is associated with data related to a process speaks volumes. The data distribution can be categorized into:

Normal Distribution

Poison

Chi Square

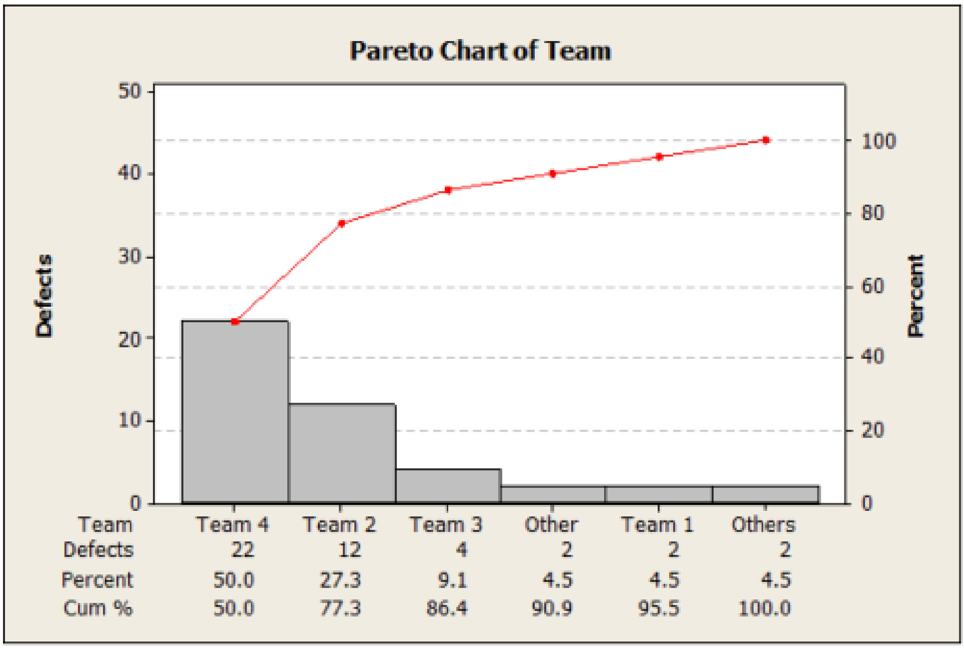

Figure 3.2 Pareto Chart

Table 3.2 Quantity of the product produced per month.

Month	Quantity (Foam)
Jan	5200
Feb	4900
Mar	4900
April	4900
May	4900
June	4900
July	4900
Aug	4900
Sep	4900
Oct	4900
Nov	4900
Dec	5200

Table 3.7: Quantity of the product supplied per month.

Month	Quantity (Foam)
Jan	1000
Feb	970
Mar	970
April	990
May	950
June	950
July	950
August	950
Sep	950
Oct	950
Nov	950
Dec	1000

3.3 Analyze Stage

In this step, the team identify several possible causes (X's) of variation or defects that are affecting the outputs (Y's) of the process. One of the most frequently used tools in the analyze phase is the Cause-and-Effect Diagram'. The Cause & Effect Diagram is a technique to graphically identify and organize many possible causes of a problem (effect). They help identify the most likely ROOT CAUSES of a problem. This tool can help focus problem solving and reduce subjective decision making.

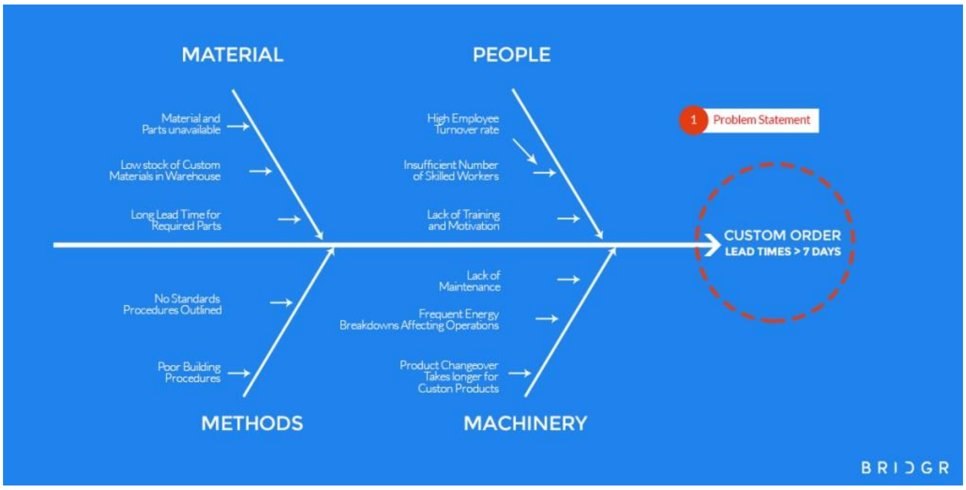

Figure 3.3 Cause and Effect Diagram

3.4 Improve Stage

In this step, the team would brainstorm to come up with counter measures and lasting process improvements that address the validated root causes. The most preferred tool used in this phase is affinity diagram. We have measured our data and performed some analysis on the data to know where our process is, it is time to improve it.

3.5 Control Stage

In this step, our process has been measured, our data analyzed, and our process improved. The improvement we have made will be sustained. We need to build an appropriate level of control so that it does not enter into an undesirable state. One of the important tools that can be used to achieve this objective is Statistical Process Control (SPC). The purpose of SPC is to provide the practitioner with real-time feedback which indicates whether a process is under control or not. There are also some lean tools like the 5S's, the Kaizen blitz, kanban, poka-yoke etc. It is essential to ensure that the improved process is not only followed but the final product attains the improved levels of quality. This can be achieved by controlling the process and more importantly continuously optimizing it in order to constantly reduce the process variations.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 DEFINE PHASE

There are two deliverables in the definite phase. They are,

Project Charter

The voice of customer

4.1.1 Project Charter

The project charter provides the preliminary delineation of roles and responsibilities, project objectives, main stake holders etc. The utilities are distributing mouka mattress to the various categories of consumers at different stations.

4.1.1.1 Problem Definition

Due to various reasons which includes, Due to various reasons which includes, lack of a competent workforce, lack of safety measures, inventory and supplier quality management, lack of appropriate documentation, terms of quality, transportation and getting the distribution network right.

4.1.1.2 Goal Statement

The goal of project is to find out the various causes for defects and the method to avoid such in mouka foam industry in regard terms of quality.

4.1.2 The Voice of Customer

The process of getting, analyzing and integrating operation is called the “Voice of Customer” and is one of most critical components of Lean Six-Sigma. Before defining the process defects, units and opportunities, we need to understand the needs of the customers. The Voice of Customer will be obtained by the following ways,

Surveys

Direct customer observation

Customer complaint process

Table 4.1 The Voice of Customer

Voice of Customer	Theme Statement	CTQ Attribute
Frequent supply of foam with defects.	The customer wants good quality of foam(mattress) delivered.	Avoid defects using Lean SixSigma methodology.

Opportunities are the total number number of chances per unit to have a defect. Each opportunity must be independent of other opportunities and, like a unit, must be measurable and observable. The final requirement of an opportunity is that it directly relates to the customer CTQ. The total count of opportunities indicates the complexity of a product or services.

4.2 Measure Phase

Research on improving Mouka foam distribution by using lean six-sigma was carried out on Mouka Foam company.

Table 4.1 Percentage of foams rejected in Line A (day 1)

Line A (500 foams)	Filling	Labelling	Others	Total
Defects	6	2	2	10
Foam (%)	0.17	0.06	0.06	0.29
Defects (%)	46.15	15.38	15.38	76.91

Table 4.2 showed the percentage of foams rejected in line B at day 1 + day 2

Table 4.2 Percentage of bottles rejected in Line B (day 1 + day 2)

Line B (350 foams)	Filling	Labelling	Others	Total
Defects	7	13	7	27
Foam (%)	0.05	0.09	0.05	0.19
Defects (%)	20	37.14	20	77.14

DPU = = = 3.8856

DPO = = = 0.06789

DPMO = = = 0.06789 X 1,000000 = 67,890

The sigma level is obtained by converting the DPMO value. The sigma level obtained is 2.54 To improve service quality, service levels need to be measured. Measuring the level is done through lean six sigma. According to the calculation service quality of mouka foam reaches level 2.54 sigma which is far from the expectation of 6 sigma. The results of the measure phase include; the result have the sigma level at 2.94 with DPMO 67890 and a satisfaction level of 89.6%

4.3 Analyze Phase

The Analyze Phase consists of the following,

Identifying Functional Requirements

Developing alternative concept

Evaluating alternative

Selecting a best fit concept

In this phase cause and effect diagram is used to analyze the various causes of the problem

4.4 Improve Phase

There are many tools available in Improve phase

Process re-design principles

Development of alternative solutions

Design of Experiments (DOE)

Pilot Experiments

Cost/Benefit Analysis

Implementation plan

In this study Pilot experiment was used. Preventive maintenance is a schedule of planned maintenance actions aimed at the prevention of breakdowns and failures. The primary goal of preventive maintenance is to prevent the failure of equipment before it actually occurs. It is designed to preserve and enhance equipment reliability by replacing worn components before they actually fail.

4.5 Control Phase

The main purpose of control is to make sure that any gains the team makes will last. The team must transfer what they learned, the process and document, the new improved procedures to train everyone, setup procedures for tracking key/vital signs, hand-off ongoing management to the process owner, complete the project documentation. This action will help the following,

Prevent backsliding

React quickly to future problem

Share the learning with others in the organization.

After implementation of new proposal, the senior officials shall conduct a periodical review meeting in every month to monitor the progress on reduction of interruptions and conduct the brainstorming meeting for further improvement. The existing records and documents are updated regularly, and the root cause of the problem can also be documented and communicated to other line section should be aware.

4.6 Discussion

Based on the results of the analysis that Mouka Foam has not been able to provide service quality that satisfies customers. This can be seen from the results of measuring the sigma level still at 2.54 sigma and it is still far from the level 6 sigma. This shows that Mouka foam has not been able to provide services that satisfy customers. On analysis of the data using the Pareto chart, it was found that the most defects were detected. The first stage was Define Phase whereby the problem was identified, and the Project Charter was established to determine the scope as well as other parameters relevant to the project. Pareto Chart and Pie Chart were prepared from the data collected. Service improvement can be done by analyzing identification of the causes of critical to quality and making improvements. The methodology used in improving service quality is lean six sigma with the DMAIC principle (Define, Measure, Analyze, Improve and Control). Define is used to determine critical to quality, measure to calculate service quality gap, baseline variable and attribute level sigma and DPMO, analyze looks for root cause which becomes waste, namely defect of power outages. Expectations of measurement, analysis and efforts to improve service quality are carried out so that the level of customer satisfaction sigma can be improved. Lowering the gap between perceptions and interests, improving service quality, reducing the value of DPMO, increasing the value of six sigma, reducing waste on the distribution of electricity. Managerial Implications Continuous improvement is important for management to improve service quality. Mouka foam must be able to provide service quality that meets customer wants and needs. If service quality improvement is not carried out, customer complaints will occur. The process that becomes critical to quality is that Mouka has not been able to fulfill the services expected by customers. Service improvement can be done by analyzing identification of the causes of critical to quality and making improvements.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSION

The calculation of sigma level and analysis shows that the service quality of BEDC is still not able to provide maximum satisfaction to customers. It is seen that the calculation of the level of service quality sigma is still far from the target of achieving 6 sigma. Sigma level measurement using the lean six sigma method shows that the sigma level is at 2.54 with a DPMO value of 67890. This study mainly focuses on reduction of detect in a foam manufacturing company (Mouka Foam). Lean Six sigma approaches were followed to identify the causes and reduce them because reduction in failure time increases the customer satisfaction. Using cause and effect diagram analysis to identify the causes for over processing time. Even after the implementation of Six Sigma control method, tracking each department or section's working schedules is necessary. Monitoring and controlling in the set range should be acknowledged. A Workflow chart with its standard executing plan should be developed and established. Monitoring the overall operation should be implemented. Regular education training is needed to upgrade staffs' quality, strengthen the process cycle, solve problem, improve performance efficiency, and enhance overall service quality of Mouka Foam. The need for continuous training, development of staff and, effective communication throughout the full duration of the project was essential to project success. The LSS team noticed early in the programme that without constant updating of staff and ensuring that the team were fully informed of progress on the project that project momentum quickly dropped off. The introduction of daily meetings and frequent training and development sessions introduced early into the project helped maintain project momentum. A significant proportion of time was spent in training and preparing the workforce, it was felt that this stage could have been extended even further before the company progressed. Implementing the study recommendations and action plan is expected to lead to a gradual improvement and, consequently, to an increased process Sigma level. Such improvement in the critical service of power distribution is also expected to reduce the operating and maintenance costs of the utility company along with higher service level and customer satisfaction.

5.2 RECOMMENDATION

Some valuable recommendations to restore the issues and challenges in the manufacturing industry

(Mouka Foam) in particular and other distribution companies in general may be; increase customer satisfaction by improving service quality, and with this research the unit can see the results of the study as a reference for decision making and which attributes are the top priorities.

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