

CHAPTER 2 - LITERATURE REVIEW

2.1 Quality Management

The primary goal of quality management is to guarantee that the final product is produced in strict agreement with the specific product's criteria and established requirements (James, 2012). Regarding quality, it is important to note that there is no universally agreed upon definition, and it encompasses a wide range of aspects that are subject to interpretation (Suwendra, 2014). Producer quality refers to the adherence to established quality criteria by the producers (Purba, 2017). Quality control has several objectives, including: (1) Enhancing uncontrolled processes, (2) Regulating the final product by sampling the receipt, (3) Ensuring the production of high-quality products, (4) Minimizing the expenses associated with inspection, (5) Striving to reduce product design and process costs through the use of specific production quality, and (6) Minimizing production costs as much as possible (Cullison et al., 2013). Commonly acknowledged quality attributes encompass: (1) Quality denotes the fulfillment of defined prerequisites or assertions, (2) Quality is congruent with the intended purpose. (3) Quality encompasses continuous development and augmentation, (4) Quality requires making persistent efforts to fulfill customer requirements, (5) Quality is defined by user contentment (Chunxioa et al., 2013). Quality is typically defined as a quantitative measure that reflects the level of excellence of a product. It can also refer to the optimal state of a product within specific boundaries, as determined by the consumer's preferences. Typically, buyers prioritize product pricing and product advantages as the most crucial conditions. The correlation between these two factors can be ascribed to various important components: 1. The exact definition of operating characteristics is as follows: (2). The product's age and reliability are (3). The production process of the product, (4). The production conditions of the product are unspecified. The implementation and upkeep of both the merchandise and the infrastructure in the specified area (Milln et al., 2013). Quality can be defined as the degree of satisfaction obtained from the utilization of objects, encompassing multiple elements. Product quality refers to the

overall standard and excellence of a product or service. Cost quality refers to the level of quality in relation to the cost of a product or service. Delivery quality, on the other hand, pertains to the quality of the products being delivered. Safety quality refers to the level of protection and security provided. It encompasses the effectiveness and usefulness of measures taken to ensure safety. The concept of customer service excellence (Pylväs et al., 2015). The enhancement of product quality to augment client pleasure is a significant characteristic in a company organization, as defined by Nugroho (2015).

2.2 Remanufacturing Business

The remanufacturing sector was established in 2005 when the US Environmental Protection Agency or EPA introduced the Comprehensive Procurement Guidance program or CPG. The objective of this program was to encourage decreased waste and resource preservation through the promotion of waste material reuse and the implementation of targeted recycling initiatives. These efforts would enable the transformation of these resources into new goods. In 2004, the EPA launched a selection of reconditioned automotive components. Remanufacturing entails the utilization of a part of the original structure while replacing or reconstructing any defective components. The testing approach follows the same specifications process as the manufacturing process for new items (<https://www.epa.gov/>).

The remanufacturing business is a sector that takes a part of its original equipment and uses it to rebuild damaged components, replacing them with new equipment. This procedure follows the same specifications as the production procedure for new items. The re-made items possess the same level of quality as the new manufactured one (Ijomah, 2008; Ijomah and Childe, 2010). The unpredictable and irregular occurrence of the condition and quantity of returning cores in remanufacturing is a complex factor that impacts several parts of planning and management (Junior et al., 2012). The quality of returned merchandise may vary, ranging from minor scratches to substantial damage. Hence, it is imperative to carry out inspection and sorting protocols to segregate the important cores. The preference lies in obtaining returns of superior quality, as the quality of the returns directly influences various factors such as the level of effort needed for remanufacturing, the time required for processing, the

rate of success of remanufacturing, the order of processes employed, the degree of cost savings, and the quantity of cores that are discarded (Ortegon et al., 2013). The extent in remanufacturing and the standards for assessing satisfactory quality differ based on the remanufacturer's kind and their operational framework. Independent remanufacturers strive to repair a maximum number of parts, while OEM remanufacturers possess the freedom to be more selective in accepting cores. The cornerstone of a prosperous remanufacturing facility lies in its reliable engineering expertise and capacities. The effectiveness of remanufacturing is highly dependent on the proficiency of specialist and their thorough comprehension of cores and the restoration procedure (Ijomah, 2009).

The remanufacturing process carried out by UTE can be described simply in figure 2.1 below.

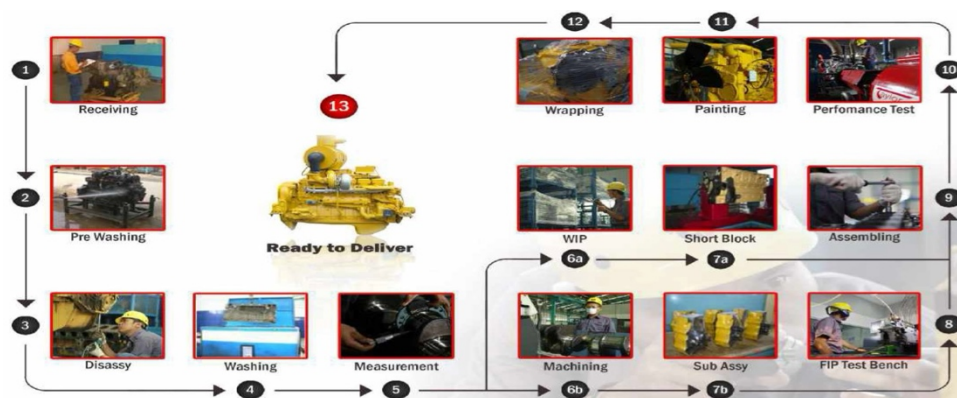


Figure 2.1 Remanufacturing Process

Remanufactured products produced by UTE are divided into 4 main classifications called product hierarchies as follows:

- a. Hydraulic Cylinder
- b. engine
- c. Power Train, as well
- d. Hydraulic System.

One of the parameters that influences customer satisfaction comes from the quality of the products received by customers. Remanufactured product failure during the production process is called Product Failure in Process (FIP), and the costs incurred by the Company due to product failure are called Product Failure Costs.

The Company's failure to manage product failures in the process will have an impact on high levels of product failures in the field which will ultimately result in high product failure costs.

The product failure in process ratio is calculated by comparing the quantity of product failures during the production process to the quantity of production during a certain period. Based on the Company's best practice, the maximum allowable tolerance for product failure in process is 2.5%.

2.3 Six Sigma

Six Sigma is a management strategy concept that was first introduced by Motorola in 1986. Its purpose is to improve product quality by reducing variances in production operations, particularly in the competitive semiconductor industry. Motorola was awarded the coveted Malcolm Baldrige Quality Award in 1988 for being the first American corporation to successfully implement the Six Sigma methodology (Parsana et al., 2014). Producer quality refers to the adherence to established quality criteria by producers (Purba, 2017). Based on these data, if we just consider a quality level of 99 percent or a defect level of 1 percent in manufacturing sectors or services, there is a potential risk of fatalities. Hence, to attain a level of quality of 99.9996 % or complete absence of faults, an organization must apply a combination of adaptability and rigor in problem-solving, depending on statistical methodologies rather than intuitive or trial and error. The Six Sigma methodology has the benefit of extensive utilization of statistical techniques (Pacheco, 2014). The utilization of Six Sigma's methods is crucial due to its substantial impact on the realm of science and application, namely in the reduction of waste and the generation of added value. Six Sigma empowers users to identify inefficiencies and hidden costs, eliminate defects, improve profit margins, satisfy customer expectations, promote employee commitment and satisfaction, and assist corporate expansion (Patil et al., 2015). A Six Sigma management method is employed to guarantee that enhancement initiatives and critical opportunities are efficiently developed utilizing a metric-based methodology and aligned with the company's objective. Six Sigma enables quality enhancement within an organization by identifying and eliminating the underlying causes of defects and mistakes. This is accomplished by minimizing fluctuations in production and commercial procedures (Mittal, 2014). The process of improving the ability of processes utilizing the Six

Sigma technique consists of a series of standardized steps, namely defining, measuring, analyzing, enhancing, and controlling, which are interrelated using statistical testing. Within a specific initiative within an actual Six Sigma enterprise, there is often a stage that follows a methodical approach with the goal of attaining quantifiable objective values. The values may encompass objectives such as minimizing the duration of cycles, mitigating air pollution, cutting expenses, improving customer satisfaction, and maximizing financial gains (Mittal, 2014). Implementing Six Sigma in a business or organization requires a substantial upfront investment, but it is certain to result in long-term advantages such as cost reduction, higher profits, improved uniformity in quality procedures, enhanced employee productivity, and higher quality of service and products. These particular characteristics would enhance consumer satisfaction and facilitate the firm in attaining its objectives (Mittal, 2014). By employing DMAIC alongside a statistical technique, it is possible to ascertain the root causes of the problem and improve the production process. The implementation of the six-sigma methodology resulted in a notable enhancement in the process capabilities, as evidenced by the increase in the sigma value from 2.2 to 3.1. The implementation of this enhancement led to a monthly reduction in expenses amounting to \$18,394.2 (Syafwiratama et al., 2017). Six sigma is a systematic, flexible, measurable, and effective methodology for addressing various problems in the industrial sector (Trimarjoko et al., 2019). The Six Sigma methodology is utilized in UTE to improve the standard of Remanufacturing products, based on what comes out of the investigations. It is done to enhance customer happiness and achieve more benefits for the firm.

A thorough understanding the five-step approach is crucial for successfully applying the Six Sigma methodology. The main goal of Six Sigma is to attain customer satisfaction through the implementation of process enhancements and the reduction of waste. The DMAIC, which (defining, measurement, analyze, improve, and control) five-step process is used to achieve this:

a. Define the causes of process problems.

In order to begin implementing the Six Sigma procedure, the first step is to accurately identify the particular area that needs improvement, as seen by the customer. Contemplate your intended goals and determine if you have the requisite resources to achieve them. Implement a customer-focused approach and establish

synchronization with stakeholders to verify that you are satisfying their expectations. During this stage, a team analyzes the particular issues that need to be given priority, creates and builds an illustration of the process to set and improve goals and results, and clarifies the client's requirements. This stage also ensures that the team aligns its goals with the ones of the the company's leaders.

b. Measure the b. Assess the significant components of existing procedures.

The team is committed to gathering data to evaluate the current performance of the process you are involved in and find potential areas for enhancement or progress. Utilize clear and specific procedures for gathering data, including defining data criteria, documenting expected outcomes, using standardized approaches to ensure accurate measurements, and identifying potential areas of inefficiency. During this stage, the team can assess the amount of time it takes for a task to be completed and develop a benchmark for the process's performance. This benchmark can then be used to compare and test the effectiveness of any new process changes.

c. Analyze the data.

Once you have collected the measurements, you can utilize analysis tools to pinpoint the precise areas of concern in the process. This allows you to separate and evaluate each potential factor contributing to process failure. When analyzing data, it is recommended to articulate your goals using numerical metrics. For instance, you can endeavor to reduce the quantity of defective products by 25%. Using past information is beneficial for identifying fluctuations.

d. Improve the processes.

After identifying the cause of the process problem, the team proceeds to ascertain the correlation between variables. The purpose of this step is to determine the acceptable range of process tolerance and operating conditions, and then develop plans for improvement. Improvement plans may have a systematic procedure that enables team members to offer their ideas according to their respective areas of expertise. Implementing systematic enhancements leads to sustainable progress that enhances the project's foundation and client satisfaction. Structured improvements can be developed by a process of testing multiple options and ultimately selecting the most optimal solution.

e. Control and check for errors.

Verify that your team has successfully adopted the new procedure and ensure that the enhancements are enduring. In order to accomplish this, it is essential to verify the accuracy and reliability of your measurement system, ensuring that it aligns with your objectives, and subsequently implementing appropriate control measures. Exercising control over the new procedure guarantees its continued efficiency, aids in preserving the enhancements, and retains client contentment. Control methods may encompass the implementation of straightforward upgrading procedures and the establishment of a monitoring strategy to assess the effectiveness of the new process. Your team may develop a reaction strategy that considers your data to effectively tackle future difficulties.

2.4 Previous Study

The various information from the previous research has been collected to aligning this research intention, sharpening the direction of the research and find other ways that others have not yet gone through as seen in table 2.1.

Table 2.1 Previous Study

No.	Title	Authors	Variable	Result
1.	Implementation of Six Sigma in Product Quality Control	(Elfanda, 2021)	▪ Six Sigma, ▪ Product Quality Control, ▪ DMAIC (Define, Measure, Analyze, Improve, Control).	▪ The results of the calculation of Six Sigma value from CV. Gemilang Kencana has a sigma level 3.8 with the possibility of damage/ defects to the product up to 11,760 pcs in a million chance of production (DPMO). To reduce the number of damaged/ defective products that occur in

				the production process by sorting the highest percentage of causes damage, namely packaging leakage by 37%, untidy products by 50%, and less full products by 13%.
2.	Adoption of Six Sigma DMAIC to reduce cost of poor quality	(Prashar, 2014)	▪ Six sigma, ▪ DMAIC, ▪ Cost of poor quality (COPQ), ▪ Process failure mode effect analysis (PFMEA), ▪ Cause and effect diagram,	▪ After completing the Define, Measure and Analyze phase, it was found that use of extreme tolerances and cross-fitment of bearings are the root cause of cooling fan assembly failure. The major recommendations made during the Improve phase were to design a bearing matching software for improving the cross-fitment of bearings and to procure a hydraulic jig with electronic jig instead of manual jig. The value of implementing these recommended solutions equate to a saving of INR 34 lacs per annum.

				Since it was a chronic problem, the company expects this to be a recurring saving.
3.	Improving The Quality of Manufacturing Products with The Application Of Lean Six-Sigma	(Harisupriyanto, Prasetiawan and Rahma Supri, 2019)	▪ Lean, ▪ Waste, ▪ Six Sigma, ▪ Defect, ▪ DPMO.	▪ The process of welding, cutting, and bending process is considered a major problem, so the main concern for quality improvement is for the main problem. The target to be achieved is to increase the sigma value of both processes. The alternative is chosen, namely creating and supervising SOPs, and training to improve the skills, knowledge, and abilities of each employee. These alternatives can increase the sigma value from the initial conditions from 2.93 to 3.20. The increase in sigma value indicates a decrease in the level of DPMO.
4.	Improving Products	(Mareček -	▪ Six Sigma, ▪ DMAIC,	▪ The aim of the project was to eliminate the

	Quality Applying Six Sigma	Kolibiský and Kučerová , 2020)	▪ Quality, ▪ Nonconformi ng products, ▪ Calibration process, ▪ Improving	process of calibrating parts after hardening, which were marked as nonconforming products. By applying the DMAIC logic cycle, improvements were made that shortened the production process and time to deliver production orders to the customer, reduce production costs, and retain a significant customer.
5.	Applying lean Six Sigma for waste reduction in a bias tyre manufacturing environment	(Sasikum ar <i>et al.</i> , 2023)	▪ Lean Six Sigma (LSS), ▪ Analytic Hierarchy Process (AHP), ▪ Quality improvement, ▪ Waste management, ▪ Welding wire	▪ The study compares the performance of the plant before and after implementation of the proposed solutions for waste reduction. Improvements in yield, waste, Defects Per Million Opportunities (DPMO), and sigma levels were achieved. The Lean Six Sigma methodology was linked to the Analytic Hierarchy Process (AHP) to prioritize the

				causes of waste. The objective was to use an analytical method in judging the influence of the waste causes on the amount of waste to enrich the methodology effectiveness and facilitate some ease of use in the practical field.
6.	A Review of Lean Implementation Practices in Indian SMEs Particularly in Gujarat'	(Singh and Thakar, 2014)	▪ India, ▪ SMEs, ▪ Sigma, Review	▪ The objective of this paper is to review and examine the expansion and encounters of Six - Sigma practices in Indian SMEs particularly in state of Gujarat. This paper is mainly concerned about the application/gaps of Six - Sigma in Indian SMEs especially in Gujarat region.

2.5 Study Differences

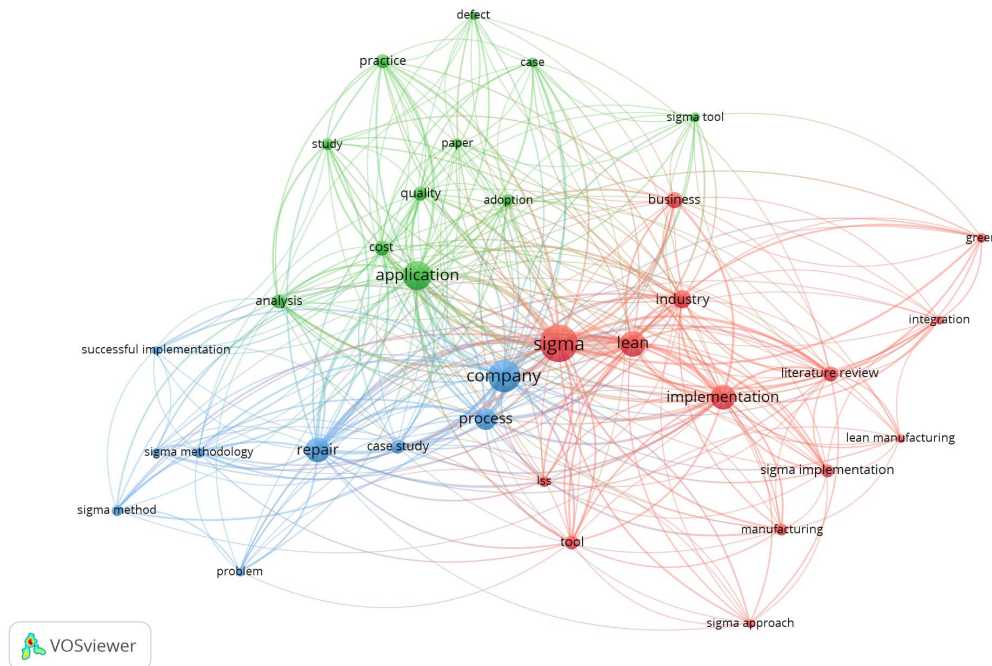


Figure 2.2 Mapping Research Topic Based on VOS viewer

From several previous research sources as references, Six Sigma is implemented to improve product quality in companies engaged in Manufacturing as described in figure 2.2 above.

In this study, researchers will implement Six Sigma to improve products quality and reduce product failure in process in Remanufacturing Company. This is what differentiates the research conducted with several previous studies.