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Application of Six Sigma to Improve Productivity and Product Quality

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ABSTRACT

The Six-Sigma approach was developed as a reaction to the swift progressions in technology and the demand for enhanced accuracy and automation in processes. Error tolerance has been drastically reduced in the current era of extremely sophisticated systems, which has led to the need for more stringent conformity standards. The effectiveness of Six Sigma as an approach for reducing faults and increasing efficiency has been demonstrated in numerous industries, including healthcare, engineering, and manufacturing. This methodology is based on the concepts of statistical process control and utilizes sigma measurements to verify compliance with predetermined parameters. When a business decides to adopt Six Sigma, it generally evaluates and selects one of three methodologies. One approach is a thorough corporate transformation that seeks to liberate the organization from ingrained practices, reclaim clientele that have been lost, and recuperate from substantial financial setbacks. This methodology entails a comprehensive analysis of all critical procedures in search of possible enhancements. The second strategy prioritizes strategic enhancement by allocating dedicated teams and conducting training programmers to concentrate on significant opportunities and shortcomings in a limited number of essential business domains. Problem-solving, the third method focuses on resolving particular, enduring challenges, providing firms with a means to harness the advantages of Six Sigma without undergoing substantial organizational transformation

Keywords: Six Sigma, Productivity, Product Quality etc**.**

I. 1. Introduction

Six Sigma, abbreviated as 6∫, is a systematic methodology that optimizes manufacturing and business processes through the implementation of particular tools and processes. The concept was first introduced by Bill Smith and Mikael J Harry in conjunction with Motorola in 1986. It garnered considerable attention and support when Jack Welch integrated it into the operational strategy of General Electric in 1995. This approach is widely recognized for its ability to enhance quality and reduce process variation. By identifying and correcting faults, as well as suggesting alternate techniques for manufacturing and business operations, it endeavors to increase the output of processes. The Six Sigma framework comprises a sequence of activities comprising statistical approaches, quality control processes, and empirical methodologies. These components are organized according to five phases of guidance that pertain to the management of system resources. Each Six Sigma project inside an organization is structured to adhere to these procedural phases, with each step having its own unique value objectives. The principal objectives of Six Sigma implementation are the reduction of costs and variability, the enhancement of customer happiness and profitability, and the decrease in operation cycle times. Six Sigma, a term that was formally registered as a trademark by Motorola on December 28, 1993, originated from the field of statistical analysis. As indicated by the sigma level, it gives a metric for assessing the quality and efficiency of manufacturing. The objective of Six Sigma's manufacturing process adoption is to achieve an almost flawless accuracy rate of 99.99966 percent, permitting a maximum of 3.4 errors per million items. The initial benchmark of 3.4 faults per million, established by Motorola for its subsidiaries, swiftly evolved into a criterion for excellence in quality management.

Scholars and professionals throughout the world have acknowledged Six Sigma as a unique and very successful approach to quality improvement. Its focused approach to process quality control, thorough analysis, and empirical decision-making distinguish it from other quality programmers. Its increasing adoption by organizations across the globe, representing diverse industries and backgrounds, serves as evidence of its efficacy. In business organizations, Six Sigma is seen as a crucial approach for obtaining high levels of efficiency and productivity. As time has progressed, academics hailing from many nations have reevaluated Six Sigma, contributing varied viewpoints regarding its execution and consequences, thereby expanding the methodology's range and practicality.

II. 2. Six Sigma general Definitions

The Six-Sigma approach was developed as a reaction to the swift progressions in technology and the demand for enhanced accuracy and automation in processes. Error tolerance has been drastically reduced in the current era of extremely sophisticated systems, which has led to the need for more stringent

conformity standards. The effectiveness of Six Sigma as an approach for reducing faults and increasing efficiency has been demonstrated in numerous industries, including healthcare, engineering, and manufacturing. This methodology is based on the concepts of statistical process control and utilizes sigma measurements to verify compliance with predetermined parameters. When a business decides to adopt Six Sigma, it generally evaluates and selects one of three methodologies. One approach is a thorough corporate transformation that seeks to liberate the organization from ingrained practices, reclaim clientele that have been lost, and recuperate from substantial financial setbacks. This methodology entails a comprehensive analysis of all critical procedures in search of possible enhancements. The second strategy prioritizes strategic enhancement by allocating dedicated teams and conducting training programmers to concentrate on significant opportunities and shortcomings in a limited number of essential business domains. Problem-solving, the third method, focuses on resolving particular, enduring challenges, providing firms with a means to harness the advantages of Six Sigma without undergoing substantial organizational transformation.

After a strategy has been selected, a multidisciplinary team consisting of facilitators, business leaders, team members, and team leaders is assembled. Positions within this group are frequently denoted by distinct designations such as Master Black Belts (MBs), Black Belts (BBs), and Green Belts (GBs) (MBBs). BBs direct and conclude projects, mentor GBs, and impart training. After receiving training on some areas of the approach, GBs assist BBs or oversee smaller initiatives. MBBs provide Six-Sigma tool expertise and mentoring to GBs and BBs. The responsibilities of champions include the identification of noteworthy projects, the provision of logistical assistance, and the sustenance of progress. When projects are concluded, process owners take ownership of them, so guaranteeing the long-term viability of the advantages and eliminating barriers for BBs. Financial advocates develop benchmarks for assessing the cost-effectiveness of a project and guarantee the achievement of concrete and immaterial advantages.

DMAIC, representing the five-step method that underpins Six-Sigma, is as follows: Define Measure, Analyze, Improve, and Control. After defining the factors that influence performance, the procedure proceeds to assess pertinent quality data. By doing a thorough statistical analysis of this data, correlations between faults and potential root causes can be identified. Following this, measures are taken to develop and maintain improvements for these underlying reasons while subjecting them to rigorous statistical oversight. An extra stage, termed "Transfer," which Bendell suggests be included, is dedicated to duplicating favorable results in analogous situations. An instance of this expansion was demonstrated in a task force dedicated to enhancing the door seals of various refrigeration units. In the Define phase, critical variables including the seal, panel design, and assembly were determined. It was determined through measurement that flaws were confined to a small number of places. The analysis revealed knowledge gaps between the designers of the organization and the seal suppliers. Adjustments were implemented to both the supplier system and business processes, while statistical monitoring was utilized to maintain control. Consequently, these enhancements were effectively extrapolated to further undertakings, so demonstrating the all-encompassing and flexible characteristics of the Six-Sigma approach.

expressed that Motorola was quick to set out on receiving Six Sigma as a quality drive around 1964-1965 and it was Motorola just which spearheaded the execution interaction for Six-Sigma in the eighties of the nineteenth century. It has been asserted by [1], that it was Bill Smith in 1970s at Motorola, who was instrumental in creating Six-Sigma system to fundamentally dispose of imperfections or varieties per million freedoms, as opposed to lessening in rate esteems. According to [2]; beginning of Six-Sigma should be connected in time having a place with early openings of the mechanical upset or generally in the eighteenth century in and around Europe. Six-Sigma has hints of its introduction to the world at Motorola in 1979 when Art Sunday stood up at Executive's gathering and guaranteed with full conviction that "the genuine issue at Motorola is that our quality sinks!". [3] and different analysts have expressed in their investigates that various senior architects and researchers working at Motorola organization were liable for acquainting ideas related with Six-Sigma during the 1980s. It likewise has been guaranteed by [4] that stages, Six-Sigma focused mostly on diminishing the deformities. Motorola set the vibe and was showing praiseworthy achievement rate and execution and in the period from 1994 to 20000, it was the turn for valuable first cont. age Six Sigma, which rather than imperfection decrease, focused on cost decrease. A larger part of the creators like [5] have guaranteed that Six-Sigma has been arising as an entirely unexpected element from Total Quality Management and it was additionally authenticated various different analysts like [6] and so on.

The versatile application of the Six Sigma modeling technique across various industries highlights its multifaceted pros and cons, as revealed by different authors and their respective case studies.

Salman T. Al-Mishari, with an emphasis on the service sector, notes that Six Sigma and reliability improvement methodologies such as RCM can be effectively integrated. Nonetheless, a significant limitation is the requirement for comprehensive data, which might not always be easily accessible. According to a study published in Small Scale Manufacturing by Alireza Shokri, Lean Six Sigma is useful and relevant to smaller enterprises. Notably, this research does not address any potential drawbacks associated with this methodology. Although Ayon Chakrabarty acknowledges the advantages of integrating Six Sigma inside the service industry, he also cautions that the limited availability of data may impede its successful implementation. Ike Ehie's analysis of the gear manufacturing sector reveals that the integration of Six Sigma with the theory of constraints (TOC) yields a notable improvement in the quality of outcomes. On the contrary, the report fails to acknowledge any drawbacks. RAJ The research of BARDHAN ANAND in the Deep Drawing Manufacturing Industry suggests that the combination of Six Sigma with the RSM technique can substantially reduce defects and operational concerns; nevertheless, no drawbacks are discussed.

In his General Study, Roy Andersson compares Six Sigma to TQM and Lean, stressing its benefits while also drawing attention to the shared difficulty of data collecting that plagues all three approaches.

Six Sigma can cut production costs, according to Gustavo Franco Barbosa in the context of an aircraft painting shop; nevertheless, the study makes no mention of any drawbacks. Arto Haikonen concludes, after analysing the service industry, that Six Sigma can increase the efficiency of managerial labour; the study does not address any disadvantages. Six Sigma may speed production, according to E. A. E. Osore's analysis of the sugar cane manufacturing

industry; nonetheless, he underlines that efficient data gathering is a crucial element for a successful study. Jiju Antony's research on medium-sized manufacturing businesses in the United Kingdom concludes that Six Sigma is an effective method for increasing productivity and decreasing defects in medium-sized industries. The aforementioned studies demonstrate the efficacy of Six Sigma in enhancing processes and results across a wide range of industries. Nevertheless, they continually emphasise the vital significance of thorough data collecting as an essential requirement for the effective execution of the strategy.

[7] Assert that in order to achieve the Six Sigma target of 3.4 PPM of defects, it is necessary to implement DFSS to redesign products, critical processes, and services. This claim is, nonetheless, straightforward to disprove, given that no written work unequivocally accepts or rejects this hypothesis. However, [8] argue that DMAIC and DFSS are both well-established in the logical approach and share certain similarities with the natural procedures employed in hypothesis testing and iterative trial planning. Additionally, the literature demonstrates that there are several variations of DMAIC (regardless of whether it stays the most generally embraced system). The following are distinguishable configuration streamline approvals: characterize measure dissect configuration confirms (DMADV), plan describe enhance check (DCOV), and differentiate portray advance confirm and DMADV.

III. 3. Six Sigma in manufacturing Industries

Numerous studies have provided evidence that the use of the DMAIC (Define, Measure, Analyze, Improve, and Control) methodology has yielded substantial enhancements in both quality control and process efficiency across diverse industries.

The DMAIC approach was applied by Hsiang-Chin Hung and [8] to a Taiwanese food industry with the intention of addressing process variability. The astonishing reduction of 70 percent in the defect rate of miniature custard buns as a result of their efforts demonstrates the efficacy of this technology in the food business. Additionally, they investigated critical success criteria for Six Sigma projects in this industry.

In 2010, colleagues of Prof. Dr. Vidosav MAJSTOROVI implemented the DMAIC approach in a metal processing manufacturing company located in Serbia. The implementation of their project effectively mitigated process variability and customer grievances, resulting in an upsurge in the manufacturing system's or process's Sigma Level and an overall improvement in customer satisfaction.

The study conducted by [9] centred on the application of the Six Sigma Method to enhance manufacturing industry productivity. His article presented a detailed literature analysis on the DMAIC stages of Six Sigma and its implementation in both small to medium-sized and big industrial organisations. In addition, he examined a variety of industry- standard Six Sigma quality techniques, including the two-sample t-test, fishbone diagram, and process capability analysis.

In their 2008 case study, Tushar N. Desai and Dr. R L Shrivastava explored quality and productivity enhancements in manufacturing. The authors' article emphasized the use of the Six Sigma DMAIC methodology within an industrial context, furnishing a structure for the detection, assessment, and eradication of operational process variation sources. The use of this approach resulted in enhanced utilization of resources, diminished fluctuations, and consistent quality of process output.

The Six Sigma DMAIC approach was examined by [10] within the framework of a case study pertaining to the Grinding Process. Their objective was to increase process yield and decrease process variation. By implementing this methodology, the percentage of faults in the fine grinding process was drastically decreased from 16.6% to 1.19%. This implemented improvement had a considerable financial ramification for the organization, yielding annual savings of over US$2.4 million.

In their 2011 publication, Luis Pérez Lombard, R. González Falcón, D. Velázquez Alonso, and L.M. Gallego Fernandez suggested the implementation of the Six Sigma technique as a means to enhance the energy efficiency of a naphtha transformation plant's refining unit. Their research revealed annual savings of almost 150,000 euros on average. The project characterized and optimized the refining process through the implementation of the five-phase DMAIC technique, thereby showcasing the effectiveness of Six Sigma in augmenting the energy efficiency of refining units.

The diverse range of sectors in which the DMAIC approach is implemented demonstrates its adaptability and efficacy in tackling process-related obstacles; as a result, substantial enhancements in quality, efficiency, and financial performance ensue.

Numerous studies attest to the fact that the DMAIC (Define, Measure, Analyze, Improve, Control) methodology of Six Sigma has been used with notable results across diverse industries.

The DMAIC approach was utilized by Jeroen deMast and Joran Lokkerbol (2011) and Adan Valles et al. (2009) within a semiconductor firm that specialized in the production of circuit cartridges for inkjet printers. According to their investigation, electrical failures comprised almost fifty percent of all faults. From a problem-solving standpoint, they conducted a critical analysis of the DMAIC methodology, drawing comparisons to insights derived from scientific theories pertaining to problem-solving. The objective was to ascertain constraints of the methodology, with the suggestion that these constraints might serve as impetus for enhancements to the procedure. The optimal circumstances for employing the DMAIC technique were also deliberated upon.

In their study, [11] applied the DMAIC problem-solving approach and Six Sigma concepts to analyse a scenario involving the manufacturing of elastic gloves. The findings demonstrated a decline of fifty percent in defects per million opportunities (DPMO), resulting in an enhancement of the Sigma level from 2.4 to 2.9. This investigation shed light on quality concerns within a rubber glove manufacturing company based in Thailand.[12] Implemented the Six Sigma Methodology into a manufacturing organization to control safety. The organization had a safety and security division whose primary goal was

to establish and enhance a system to prevent accidents. The research they conducted illustrated the capacity of Six Sigma to assess environmental and safety risks in the operation of an organization with the objective of detecting and mitigating accidents.[13] Assessed the operational procedures of a fan manufacturing organization with the aim of enhancing the current sigma level by increasing productivity. To achieve this, they utilized the Six Sigma DMAIC cycle. As a result, productivity increased due to the decreased fault rate. The research findings indicated that Six Sigma principles may be implemented across multiple industries, including fan manufacture, to achieve an ideal equilibrium among cost, quality, production time, and control time.[14] Examined a 350-400-person mid-sized auto ancillary unit that achieved Six Sigma quality level with the application of Six Sigma procedures. The approach was used to a product assembly in an effort to decrease the number of critical customer defects, which had a substantial effect on the enterprise's financial performance.[15] Assessed the Six Sigma deployment of medium-sized Indian automotive companies. Although the medium-scale automotive sector had a solid basis in ISO 9000 quality management systems and had adopted other quality management strategies such as Kaizen and TPM, barely a quarter had implemented Six Sigma, according to their research. An overview of Six Sigma implementation was presented by [16]. The authors emphasized the considerable research void in this field and stated that Six Sigma could be effectively implemented in small and medium-sized enterprises and service organizations operating in India.

In their study, [17] implemented the Six Sigma DMAIC methodology to reduce defects during the production of piston rings for automobiles. The percentage of rejections decreased by 13.2% from an initial 38.1 %; additional enhancements are anticipated when solutions are consistently implemented.

Numerous study studies have examined the substantial advantages that have been observed in terms of cost reduction, quality enhancement, and productivity augmentation through the implementation of Six Sigma methodology across diverse sectors. [18] In examined the application of Six Sigma methodology to the automobile industry with the aim of diminishing the cost of quality. A case study illustrating the reduction of exhaust pipe and silencer failures was incorporated into their research, demonstrating how Six Sigma guarantees regulated product quality and averts profit reductions caused by exorbitant quality expenses. They stressed that implementing Six Sigma across an organization's processes can boost employee morale and company output quality. In Small and Medium Enterprises, [19] suggested a DMAIC as part of a Lean Six Sigma (LSS) architecture (SMEs). They illustrated how the DMAIC framework enhanced productivity by 21.93 percent at a label printing company, thereby solving the difficulties faced by SMBs in competing with larger firms that offer higher-value products at lower prices.

IV. Conclusion

An exhaustive assessment of the literature was undertaken by regarding the implementation of Six Sigma in Indian SMEs. As Six Sigma is a customer-centric methodology, he stated, initiatives that maximize financial returns and customer pleasure should take precedence. Furthermore, he emphasized the difficulties that small and medium-sized enterprises (SMEs) encounter when attempting to adopt Six Sigma, namely with regard to financial and human resources, as well as the criticality of commitment from top management. Utilizing the Six Sigma DMAIC framework, increased client delivery commitments in a small-scale sector in India, which resulted in a 25 percent increase in revenue, customer satisfaction, and new business acquisition, all while enhancing delivery performance.

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