INVESTIGATION OF TOTAL QUAITY MANAGEMENT IMPLEMENTATION IN CEMENT INDUSTRY

CASE STUDY IN NATIONAL CEMENT SHARE COMPANY

ISRAEL DEBEBE

A thesis submitted to

The Department of Mechanical Design & Manufacturing Engineering Program

School of Mechanical, Chemical and Materials Engineering

presented in Partial fulfillment of the Requirement for Degree of Master of Science in Mechanical Engineering(Manufacturing Engineering)

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Declaration

I hereby declare that this Master Thesis entitled "Investigation of Total Quality Management Implementation in Cement Industry: Case Study in National Cement Share Company" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

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Recommendation

I/we, the advisor(s) of this thesis, hereby certify that I/we have read the revised version of the thesis entitled" Investigation of Total Quality Management Implementation in Cement Industry: Case Study in National Cement Share Company" prepared under my/our guidance by ISRAEL DEBEBE submitted in partial fulfillment of the requirements for the degree of Mater's of Science in in Manufacturing Engineering. Therefore, I/we recommend the submission of revised version of the thesis to the department following the applicable procedures.

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Major Advisor	Signature	Date
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Co-advisor	Signature	Date

Approval

I/we, the advisors of the thesis entitled “Investigation of Total Quality Management Implementation in Cement Industry: Case Study in National Cement Share Company” and developed by ISRAEL DEBEBE, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Major Advisor	Signature	Date
Co-advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by ISRAEL DEBEBE have read and evaluated the thesis entitled Investigation of Total Quality Management Implementation in Cement Industry: Case Study in National Cement Share Company” and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Manufacturing engineering.

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List of Acronyms and Abbreviations

CSFs	CRITICAL SUCCESS FACTOR
CM	CEMENT MILL
NCSC	NATIONAL CEMENT SHARE COMPANY
QM	QUALITY MANEGEMENT
QC	QUALITY CONTROL
QA	QUALITY ASURANCE
TQM	TOTAL QUALITY MANAGEMENT
TQC	TOTAL QUALITY CONTROL
VRM	VERTICAL RAW MILL

Abstract

Total quality management had evolved into such a widely recognized theory and methodology for achieving organizational goals. It is a company strategy that aims to achieve better performance by providing high-quality goods or services. The current study shows an investigation on the implementation of Total quality management impact on the availability of machine (total running hour and finding the root causes of National Cement Share Company machine down time. The research was done in National cement share company most critical areas that affects the production which are vertical raw mill, Kiln main machinery used to produce clinker and cement mill using qutionaries 60 random sampling as a primary data and detailed three years of recorded machine down time data was used to analyze the availability of machine and was used to identify out of control data caused due to mechanical, electrical breakdown, raw material shortage and mostly because of external issues like power problem.also the study shows that the cost analysis of both clinker and cement production had more than 40 % loss 0r 12,000,000,000 birrs has been encountered in terms of money not to mention energy loss.

Keywords: Total quality management, National cement share company, vertical raw mill

CHAPTER ONE

1 Introduction

1.1 Background of the Study

Rapid changes in the use of technology, social needs, and environmental aspects have become a major challenge for companies in maintaining and achieving competitive advantage in the last decade (Cancino et al., 2018). From an economic aspect, companies face increasing pressure to maintain their competitiveness (Gherardini et al., 2017). At the global level, companies are getting attention in terms of efficiency, quality, service, innovative customer loyalty program, and politics (Maheshwari and Vohra, 2015). As a result, traditional methods that are still used and preserved by most companies their activities are considered irrelevant regarding the conditions of the highly competitive market today (Ibidunni et al. 2017). Company's awareness is needed to change their business activities to be more innovative and higher in quality so that they are able to get out from the failure to compete for both in the national and international level (Zakuan et al. 2010).

The success achieved by the company depends on the accuracy of strategy applied. This is the result of the soaring competition level and change in the business world, that the attention on improving the quality of company's activities becomes the key to successfully achieving competitive advantage. Companies cannot continuously maintain the quality of products without adopting the in-depth strategies and practical quality management. One of the prominent business strategies that has received attention from academics and practitioners in the last decade is Total Quality Management (TQM) (Jimoh et al. 2019; Panuwatwanich and Nguyen, 2017; Salas-Arbeláez et al. 2017; Sinha and Dhall, 2018). TQM is approved as the system that improve the performance of company organization (Khawarmahmood et al. 2014; Small et al. 2017), and strengthen company's position in reaching its competitive advantage (Li et al. 2018). Besides being able to increase profits, TQM also able to increase employee and customer satisfaction (Shafiq et al. 2019). Recent studies have shown that TQM positively influences the performance of manufacturing companies (Sahoo and Yadav, 2018) and services in India (Singh et al. 2018a).

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continuously maintain the quality of products without adopting the in-depth strategies and practical quality management

Then, a strong and significant correlation between TQM and company performance (Cetindere., 2015), as well as its positive effect on the performance of company employees (Wagimin et al. 2019). Most companies claim the positive relation between the implementation of TQM concept and company performance (Konecny and Thun, 2011); (Al-Dhaafri., 2016); (Sahoo and Yadav, 2017), yet provide not optimal results on its application in some other (Yang et al. 2009). The implementation of TQM cannot be successful unless employees are directly involved in the business process by attending courses and trainings to be more competent (Khanna and Gupta, 2014).

TQM has emerged as a holistic management model because the concept of TQM is much broader than traditional quality concepts. It encompasses not only product, service and process improvement but those relating to costs and productivity and to people involvement and development (Jancikova et all., 2009). The concept of TQM is often described as a form of "Management Philosophy" based on a number of core values, such as customer focus, continuous improvement, process orientation, everybody's commitment, fast response, result orientation and learn from others. This is what we call principles or dimensions, elements or cornerstones (Hellsten et all., 2000, P239).

1.1.1 Obstacles to effective Total Quality Management

Managers encounter five common obstacles or barriers to Total Quality Management, which are (Ogbari et all., 2003, P55):

1. Inadequate human resources management,
2. Lack of planning for quality,
3. Lack of leadership for quality,
4. Inadequate resources for total quality management,
5. Lack of customer focus.

1.1.2 Quality

Quality has been defined and characterized in a variety of ways in the literature. Because of its nebulous character, several authors and researchers have concluded that the notion is related to stakeholders. It was defined as "beautiful in the eye of the beholder" based on this idea. In today's commercial environment, however, quality has been recognized to be the key to organizational success and ultimate consumer pleasure. Quality is described by Ibijola (2014), using the British Standard Institution, as the sum of a product's or service's traits and qualities that affect its capacity to meet stated demands.

As a result, it has become critical for manufacturing companies to face the present global challenges. TQM is a management philosophy based on a set of values and beliefs that underpin all of an organization's actions, processes, and resources (including staff). According to Akpeyi, these values and beliefs (2006), TQM procedures and processes, on the other hand, adapt and improve through time. Total Quality Management necessitates the extension of quality processes outside of the company, to customers and suppliers. The term "quality" connotes excellence in a variety of areas, including product design, production, marketing, and finance, to name a few. As a result, quality has evolved into a sophisticated notion that has become one of the most appealing of all management philosophies.

1.2 Statement of the problem

This research is a case study that is going to be done in a national cement share company. This is one of the largest cement industries in Ethiopia. While observing this cement industries there are a lot of problems that affects the quality of cement which decreases the production capacity of the cement from 2012 to 2014 G.C. Studies on quality management in cement industries and on projects in developing countries like Ethiopia are limited and as such relatively limited research has been dedicated to studying the factors that affect the success of quality management and successful implementation of TQM This study finds to fill this research gap by identifying the root causes for law quality performance like Due to no continues follow up, Maintenance quality (repetition), Due to not following standard operating procedure for maintenance the maintenance time will be highr which inturn increases machine down time, Quality of raw material and suggests ways to improve the quality performance for an effective

Total Quality Management implementation in cement industry in Ethiopia. Thus, if TQM has been implemented in cement industry and are resulting into huge benefits, then its implementation in the cement industry will improve quality practices and promote continuous improvement and hence, effective quality management system which will direct them in achieving quality in their things, amenities and higher organizational performance. The aim is to analyze the total quality management used in the NCSC and finding out the root causes of cement quality problems arises, causes of the low performance due to the existing operating system and how to optimize the quality of the company and so that it can be used as a benchmark and develop a TQM strategy which will help other industries to use it as a reference.

1.3 Objective of the study

1.3.1 General objectives

The general objective of this research is to investigate total quality management implementation and downtime caused due to it.

1.3.2 Specific objectives

1. Analyze the production system of national cement industry based on the existing total quality management.
2. Analyze productivity losses due to existing total quality management for the last three years in NCSC
3. Analyze the root causes that affect the total quality management in cement production.

1.4 Reserch Question

What is the main cause for production loss?

What are the main root causes that affect cement production?

How much loss is incurring in the last three years ?

1.5 Significance of study

Case study on National Cement Share Company will influence other governmental, non-governmental organizations, future researchers and academicians. So, the study that the investigation of the implementation of TQM in a national cement share company or industry would help us to know how to optimize the quality of cement, finding the people in the implementation process will help us as a model or benchmark for comparing different industries and improve and also making best decisions for the next phase of the company to be competitive in the market and efficient utilization of the machinery including cost minimization would be known.

It also helps the various organizations understand the factors that enable and hinder the implementation of TQM. Using the organizational report, it is capable to know the areas they shall address during the monitoring and evaluation of projects. To future researchers and academicians, the study has been important in the areas requiring further research to build on the topic of factors that enable and hinder the implementation of TQM.

1.6 Delimitation of scope

This research is limited to the National Cement Share Company, which is located in Dire Dawa, Ethiopia, around 550 kilometers from Addis Ababa. Even though the National Cement Factory uses TQM, the study was limited to the implementation of TQM at the National Cement Share Company. While the results were made in an attempt to generalize the findings to other businesses as well as to the National Cement Share Company, the research was limited to this specific location.

1.7 Organization of the study

first chapter states about the problem and its approach and it includes back ground of the study, problem statement, general and specific objective, significance of the study. the second chapter deals about the literature review. The third chapter includes detail back ground and work flow about the NATIONAL CEMENT SHARE COMPANY and chapter four about research Methodology discuss on the data analysis technique such as control charts, Pareto analysis to identify the major problem, cause and effect diagram so as to indicate the cause for reducing the quality cement and clinker production. Fifth chapter it consists of the data analysis and results based on the data collected. finally, six-chapter consists conclusions and recommendation obtained on doing this research.

1.8 Background Of the Company

National Cement Share Company is located in the Eastern part of Ethiopia, right at the entrance of Diredawa city at 515 km away from the capital city of Addis Ababa. The establishment of the current National Cement Share Company (NCSC), the former Diredawa Cement & Limestone Factory, dates back to 1936 G.C. Established by Italians, during occupation in 1936, and being the pioneering cement producing and selling factory in the country, the factory has played a key role in national development for 8 decades now.

NCSC, since inception up to now, has seen varying features in its mandate of establishment, ownership, structural set-up, technology, product type and volume and no of establishment, corresponding to the major socio-economic changes that took place in the country.

Ethiopia, until 1974 G.C. was a predominantly agrarian economy with feudalistic political system, wherein private ownership of means of production (especially land) and small scale as well as backward land tenure system prevailed and industry was at its infancy.

The period between 1974 -1991 G.C was a totally different socio-economic environment, where socialism was the buzz word, the role of the government in almost every economic system was owned operated and regulated by the government, private property was fully confiscated, the motto was self-sufficiency and the door of the nation was fully closed to the west or the market economy. The years between 1991 up to now, manifested a somehow mixed economic system, in the name of free market economy, where the hands of the government prevailed in the policy making as well as agriculture, manufacturing and service industry.

Correspondingly, proprietary rights/ownership, rules of law and mind sets of community of the manufacturing sector within the country have evolved in different paradigms in line with macro environmental dynamics. Being an integral part of the micro-economic system, the current NCSC has correspondingly evolved through these characteristically different economic settings. Being an integral part of the micro-economic system, the current NCSC has correspondingly evolved through these characteristically different economic settings.

Proprietary ownership wise, it has shifted hands from a private then to public, then to private-public partnership with government and finally back to a private ownership in the form of shareholding.

Considering the development of the construction Industry especially up until 2009 G.C., it has generally been stagnant. The cement factories were not only few but also the monopoly of the government. Even when the country was witnessing fast two-digit economic growth, the construction industry which was supposed to support the main economic sectors was not stimulated. This situation even obliged to spend its scanty FOREX reserve for importation of cement especially up until 2009 G.C. Though late, the measures taken to stimulate the cement industry finally led to expansion of the supply side at a very fast pace. Currently, the industry is seeing surplus, comparing the fundamentals of the cement market.

Under the prevailing context, therefore, the cement industry is not a monopolistic hold where manufacturers can produce, price and avail as they please. Survival and growth under the current situation are a matter of excellence. Recognizing the intensity of competition in the industry, government even stopped entry of new manufacturers into the industry since 2012 G.C. This made players of the industry alert and hence are taking measures to beat in the completion. National cement is no exception. Recognizing the cement industry structure, it, having holistically evaluated its standing against market and competitor realities, has transformed itself in many ways and has so far made managed to own a market share of around 15% which levels with Messobo and Derba cement.

To further pinpoint the measure transformational outcomes, National Cement has, over the last 5-6 years, managed to:

- Erect in Diredawa, alongside the old factory, a new factory, with state- of- the-art-technology, has been erected in December 2012.
- Incorporate, a couple of years ago, a new grinding plant, namely Koka Grinding Plant, having a crushing capacity of 300 TPD, and expanded it further to 800 TPD by adding one more cement processing line,
- Stretch overall existing capacity from 500 TPD to a total of more than 4500 TPD,
- NCSC, implementing ISO 9001:2008 QMS since June 2015, is governing its entire operation in an integrated quality-oriented management system. Currently it is upgrading this system to 9001:2015 and hopefully, it shall get certified in February/2018.

Currently, the factory supplies two cement products, namely: OPC (Ordinary Portland Cement) and PPC (Pozzolanic Portland Cement) both to domestic and export markets. It also supplies semi processed cement product called Clinker both for use as input for its grinding plant and for the external market as well. National Cement believes in win-win business philosophy and operates by harmonizing the interests of its stakeholders: shareholders, customers, suppliers, government, communities and the environment by operating in an eco- friendly cement processing. At the moment, the company offers job opportunity for a total of 1450 national citizens, both at managerial and operational occupations.

1.9 Vision and Mission

Vision

“Become a world class cement manufacturing company by 2025”

Mission

To produce & distribute cement products that exceedingly meet customer requirements by adopting modern technology, qualified manpower, eco-friendly and socially accountable operation and thereby create sustainable value for our stakeholders.

Core Values

- Quality
- Transparency & Accountability
- Integrity
- Team Work
- Safety, Health & Environment
- Learning
- Continuous Improvement & Innovation

1.10 Company Quality Policy Statement

- We (as NCSC) are committed, at all levels of the organization, to consistently manufacture and deliver Clinker, OPC and PPC cement products and services that satisfy stated, generally implied and obligatory requirements of our domestic as well as overseas customers and other interested parties by establishing and continually improving a quality management system based on ISO 9001-2015.We (as NCSC) are committed, at all levels of the organization, to consistently manufacture and deliver OPC and PPC cement products and services that satisfy stated, generally implied and obligatory requirements of its domestic as well as overseas customers and other interested parties by establishing and continually improving a quality management system based on ISO 9001-2015.

- We, the Management, shall show, our commitments and leadership by: making the utmost effort to encourage teamwork and empowerment of employees, providing appropriate trainings & resources, honoring planned arrangements, conducting regular reviews of the QMS and by making fact-based and decentralized decision making leading to continual improvement.
- We never compromise on work below standards.
- We shall ensure this policy statement is communicated, understood and applied within the company; and be accessible, as appropriate, to all interested parties.

To expound a little more on our participation in development ventures, national cement engages in school building, town beautification and cleaning, illumination of parts of the city with lights, provision of free potable water supply as well as sponsorship of various social causes and organizations. It constantly engages in dialogues with members of the community and government organs of the Diredawa administration and takes part in joint development ventures. In the Sports arena, also, our Football team is currently participating in the Ethiopian premier League and prominence is expected in the forthcoming not too distant a time. In view of becoming eco-friendly as well, NCSC, investing millions of birrs, transformed the old factory into now environmentally hospitable plant.

Taking last year alone, as part of its relief aid and community support, NCSC:

- Rehabilitated and handed over the public water supply points/depots and handed over to respective legitimate representatives of both the Kebele, community and administrative authorities.

- Provided exercise books and pens, enough for one-year consumption, for 250 students of the Ijanneni school, around the start-up of the school cycle and at the beginning of this Ethiopian year.
- Granted 1,000,000.00 birr in support of displaced members of the surround community and temporarily relocated in Diredawa.
- Donated 800 quintals of cement (now being dispatched in two equal lots) for the displaced community members who now are temporarily relocated in Meisso woreda.
- Newly erected 5 water points, providing potable water to the surround community for free, in a place called Gendeboye;
- Stretching as far as meisso and in areas that are believed to be accident prone; it erected road traffic signs, built houses for traffic policemen and donated reflector jacket for the eastern and Western Oromia regions,
- Donated 100 quintals of cement to community members displaced from their residences, In Kebele 05 (Addis ketema) and in Kebele 04 (gendekore) due to fire accidents.
- Encouraged entrepreneurial initiatives in regard to widening employment of the surround community, organizing unemployed youth of Gendeboye in to hollow-block producing small scale enterprises and by selling to same cement & gravel at reduced prices;
- To strengthen industry-university linkage, it supported around 500 professionals/students of the university community by providing information, research inputs, experience sharing opportunities and apprenticeship support;
- In the sport arena also, we are taking part in Football competitions and hope to qualify for premier league soon.
- Routinely carries out seedling germination, planting and distribution of same to organizations within the Dire dawa environ in an effort to be responsive to environmental health and rehabilitation;

1.11 Work flow of the company

The company’s cement production passes a series of many processes. It starts from blasting of row material up to packing of cement. The working areas of the company are crusher, row mill, pre-heater and kiln, coal mill, cements mill and packing, administration and CCR (Central Control Room) areas.

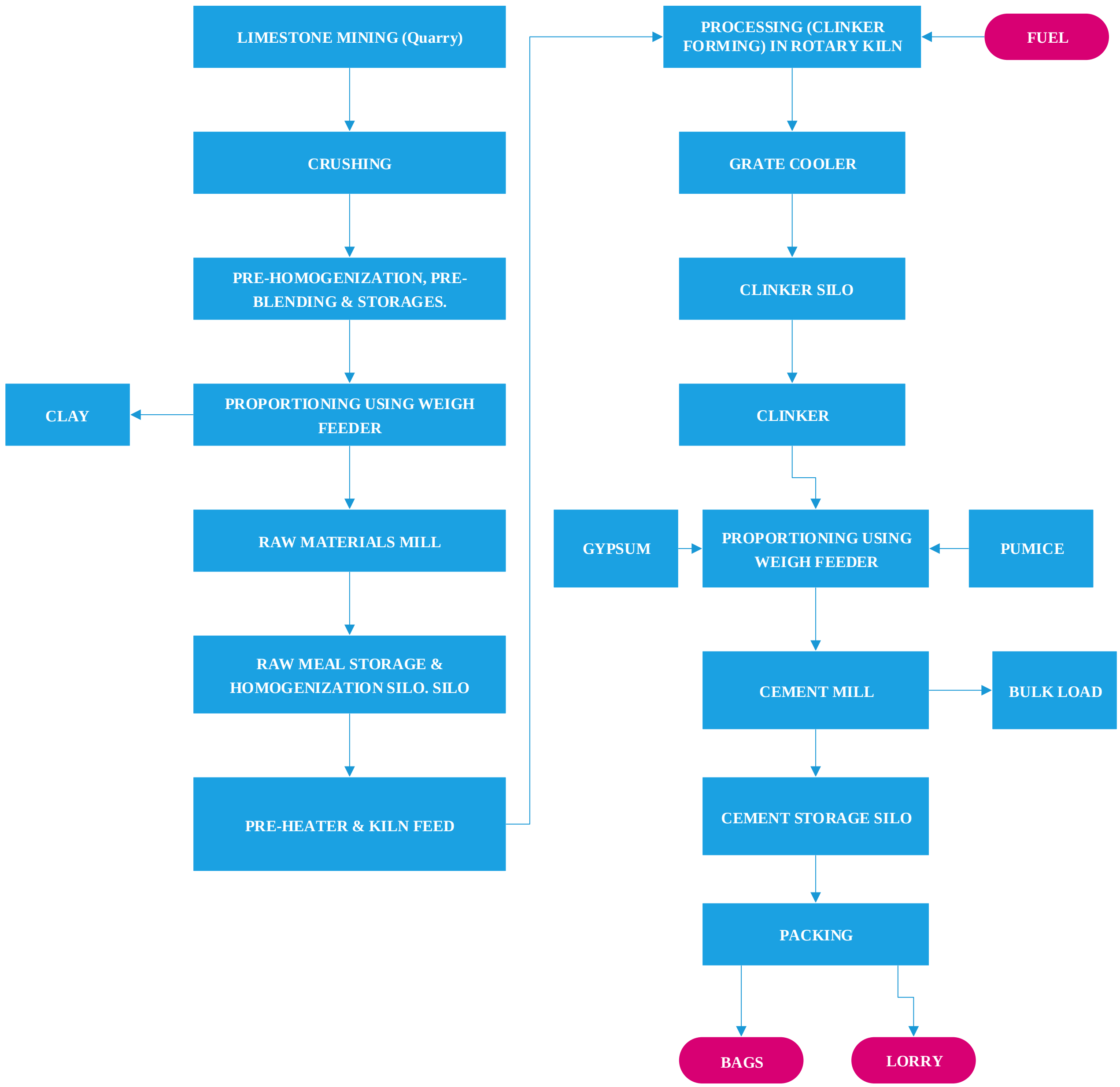


Figure 1-1:company work flow chart

CHAPTER TWO

2 Literature Review

2.1 Introduction to total quality management

Total Quality management is an approach in management based on the idea that every member of the management team must at all times maintain high standards of work in any aspect (Akgün, 2014). A customer is someone who purchases your products (Berg and Krishna, 2014). According to (Singh and Ramesh war, 2013) review on total quality management and customer focus, they briefly explained that there are two types of customers and each of them requires attention or focus. The two types of customers are internal and external customers.

Total Quality Management defines a management approach to continuous success that improves the quality of the business outputs by continuously improving organization's internal practices (Taskov and Mitreva, 2015). According to Hill and Fredendall (2016), TQM is a system of management founded on the philosophy that every employee must remain committed to sustaining high working standards in all aspects of the organization's operations. Total quality management is a technique widely used to meet or exceed customer needs and expectations. Total Quality management is a firm-wide management philosophy of continuous improvement of the products quality, services, and processes that focus on customer needs and expectations that enhances customer satisfaction and organizational performance (Fening et al., 2016).

One of the demands of the ISO 9001:2015 is using the Statistical Process Control (SPC). With SPC we can measure the current process performance and define possible improvements that can be made. The important statistical methods that are often used to detect and prevent defects are: checklists, Pareto diagram, cause and effect diagrams (Ishikawa diagram), control tickets, correlation diagrams, histograms, trend movements and so on (Kaplan & Norton, 2001; Ciampa, 2005; Deming, 1996; Mitreva et al., 2017a).

2.2 Total quality management and Industry performance

TQM is a management approach which started in Japan in the early 1980s, that seeks to enhance quality and productivity in business firms. In 1990s, TQM gained popularity among firms, who started adopting this management philosophy which focuses upon customer satisfaction and improves firm's performance (E. Al-Shdaifat et al., 2015). In TQM research literature, most firms claim positive relationship between TQM and performance (H. S. Al-Dhaafri, A. K. Al-Swidi and

R. Z. B. Yusoff et al., 2016; 2P. A. Konecny and J.-H. Thunet al., 2011; D. I. Prajogo and S. W. Hong et al., 2008; E. Sadikoglu and C. Zehir et al., 2010 ; S. Sahoo and S. Yadav et al., 2018) and yet some firms also report less than optimal results(V. R. Kannan and K. C. Tan et al., 2005; I. Sila et al., 2007; R. Sousa and C. Voss et al., 2008; J. Yang, C. W. Y. Wong, K. -H. Lai and A. N. Ntoko et al., 2009). Very few researchers have conducted empirical studies to understand TQM-performance relationship in the context of manufacturing sector. Some studies found that TQM could be adopted by manfucturing sector with considerable success (A. M. Herzallah, L. Gutiérrez-Gutiérrez and J. F. M. Rosas et al., 2014; P. O'Neill, A. Sohal and C. W. Teng et al., 2016; M. Kumar and J. Antony et al., 2008; Z. T. Temtime and G. H. Solomon et al., 2002.) However other studies have also reported adverse impact of TQM on manfucturing sector performance (D. I. Prajogo and A. Brown et al., 2006; R. Kober, T. Subraamanniam and J. Watson et al., 2012) These inconsistent findings in literature calls for further scholarly examination of the relationship between TQM and manfucturing sector performance, which leads to the hypothesis "TQM positively affects firm performance".

2.3 Total quality management dimensions

According to Nihal Erginel (2017) quality management comprises of eight aspects which include; customer focus, leadership, employee involvement, process approach, continuous improvement, systemic approach and decision-making process based on the most recent evidence (Rumane, 2016). The achievement of the quality output requires a holistic approach in the solution of minor mistakes that compromise the quality of the production. Quality management ranges from leadership to employees, from processing activities to the transportation of the output to the market (Nallusamy, 2016). Therefore, quality management calls for regular monitoring and implementation of the steps that reduces mistakes and defects at each stage of production. And the common dimensions are:

Focus on customer

Previous research has shown that customer focus as the fundamental aspect of constant quality improvement within an organization (Keinan and Karugu, 2018). The goal of customer satisfaction in TQM is achieved through attempts by the organization to design and deliver products that satisfy customer needs. According to Dubey, Gunasekaran and Ali (2015), customers dictate the products quality levels thus focusing on customers would a plus towards the organization's performance.

Eichorn (2018) observed that the organization listens to its customers, collects information and analyze this information to determine customer needs and expectations.

2.3.1 Leadership

Successful implementation of TQM required management commitment and leadership. Leadership creates and maintains an environment needed for employee engagement to achieve the organization's quality goals (Dubey, and Gunasekaran, 2015). Likewise, leadership creates a trustworthy environment that motivates workers to operate beyond normal efforts thus bringing full organizational change. The quality improvement, therefore, starts with leadership strategies towards quality improvement initiatives.

2.3.2 Employee participation

Employee participation process is designed to empower the teams in the organization to make Decisions and solve problems that arise within their area of work (Sadikoglu and Olcay, 2014). The importance of engaging employee in the organization is that it creates a well-established TQM strategy (Mosadeghrad, 2015). The process takes different forms including job sharing, teamwork, empowering employees, training, and development (Gutierrez- et al., 2018). Employee engagement is an important ingredient for achieving quality improvements and better results.

2.3.3 Strategy

Strategic planning is a constant process of assessing the market where the organization operates, evaluates its competitors and finally sets goals and formulate strategies to meet the needs of the current and potential customers (Kantardjieva, 2015). The strategy allows the organization to determine and integrate specific TQM goals and organization’s needs into a strategic plan. According to Jimenez et al., (2018), strategic planning is used in planning, developing and implementing approaches that lead to improved customer and employee satisfaction.

2.3.4 Quality improvement

TQM is founded on the idea that overall quality of the products is enhanced through improvement of the quality of the processes that relate direct or indirect to the production of the services (Malik et al., 2018). TQM is a customer-based approach thus the organization needs to be process based too (Obeidat et al., 2016). Improving production process reduce errors, rejects, reduces the production costs and reduces customer complaints (Sadikoglu and Olcay, 2014). Improvement of the processes can be achieved by simplifying the production processes and reducing wastage.

2.4 TQM in productivity of Industry

The argument that dismissing TQM on the basis of "loose" negatively-oriented evidence is unreasonable counters such beliefs. Evidence suggests that the majority of organizations that have implemented TQM believe it has helped them increase market share and improve competitiveness. Since the late 1980s, when the positive correlation between TQM implementation and increased competitiveness began to be understood, evidence has suggested that the majority of organizations that have implemented TQM believe it has helped them increase market share and improve competitiveness. Furthermore, research devoted to studying the link between TQM and performance using factual rather than perceptual data have often found that TQM procedures and healthy or better corporate performance have a cause-and-effect relationship.

Total quality management (TQM) has been viewed as a source of competitive advantage for decades, and as a result, numerous organizations across all industries have established or attempted to begin TQM programs. However, the failure of a huge percentage of those initiatives has tainted TQM's trustworthiness. The inadequacy of the quality management reference model, an emphasis on image rather than business results, a focus on existing minimum standards, non-alignment with strategic objectives, and a lack of continuity in the implementation of the total quality management program are all possible causes of failure including low performance and productivity.

2.5 TQM in maintenance

Because maintenance expenditures make up a percentage of production costs, attention is being turned to maintenance. Many companies have tried to use standard production methods to control maintenance. This is not successful. The maintenance can increase profits in two main ways: decreasing expenses and increasing capacity. Maintenance costs consist of two main divisions, labor and material. By achieving maximum availability (minimum downtime) and efficiency from plant assets, a manager ensures that a company does not need to invest in excess assets to produce its products. Benchmarking is a continuous improvement tool; it should only be started if the company wants to make changes to maintenance improvement (Yusof S.M., et al. 2000).

purpose of maintenance is not only to upkeep the plant machinery and equipment's preventing from failure and breakdowns, increasing reliability, maintainability, and availability of the operating system for maximizing production, but also to improve quality and boost higher productivity through improving capacity, faster and more dependable throughput, reducing inventory, and lowering operating cost (Ibijola, E.Y., 2015). In the investigation there has been some research on maintenance management and practice in Saudi Arabia, but it remains very limited because most of it is written from a practitioner's perspective and very few articles focus on sound scientific solutions to maintenance problems.

Quality has become one of the most important consumer decision factors in the selection among competing products and services. There is a substantial return on investment from improved quality, and successfully employing quality as an integral part of overall business strategy. In popular use, the word quality suggests a degree of excellence-a Cartier watch, a Rolls-Royce car, and a Christian Dior dress: something expensive and conforming to a high, perhaps luxurious, specification. However, this is too imprecise and limited idea of quality to be of any use in determining company policy. Different scholars give different interpretations to the term quality:

- For engineers it is conformance to specifications,
- For users it is fitness for use,
- For marketing it is the degree of excellence at an acceptable price that will influence the market share.
- For customer service a quality product is that with less customer complaint

2.6 Quality Control

Quality Control Defined. "Quality control" is a universal managerial process for conducting operations so as to provide stability to prevent adverse change and to "maintain the status quo."

Quality control may be defined as a system that is used to maintain a desired level of quality in a product or service. This task may be achieved through different measured such as:

- planning
- design
- use of proper equipment and procedures
- inspection
- taking corrective action in a case a deviation is observed between the product, service, or process output and a specified standard.

This general area may be divided into two main sub areas:

- Statistical Process Control involves the comparison of the output of a process or a service with a standard and the taking of remedial actions in case of a discrepancy between the two. It involves the determination of the ability of a process to produce a product that meets desired specifications or requirements.
- Acceptance Sampling Plans is a plan that determines the number of items to sample and the acceptance criteria stipulated conditions such as the risk of rejecting a good lot or accepting a bad lot.

2.6.1 Benefits of Quality Control

The advantages of a quality control system, however, become obvious in the long run.

- The improvement in the quality of products and services.
- The system is continually evaluated and modified to meet the changing needs of the customer.
- A quality control system improves productivity, which is one of the goals of all organizations.
- Such a system reduces costs in the long run.
- with improved productivity, the lead time on the production of parts and subassemblies is reduced, which may result in an improvement in meeting customer due dates
- Keeping the customers satisfied is a fundamental goal.

- A company that adopts this philosophy and uses a quality control system to help in meeting this objective is one that will be competitive for a long time.

2.7 Statistical Quality Control

Modern Statistical Quality Control (SQC) took the first form in 1930s in the U.S. when W. A. Shewhart of Bell Telephone Laboratory applied the Control Chart invented by him to American industries. The modern statistical theories originated in the U.K. and the application of them to SQC was attempted as early as 1935. In Japan, the study of the modern statistics was engaged before the War by a limited number of researchers. The U.S. Armed Forces stationed in Japan after the War were concerned with the low and erratic quality characteristics of Japanese communication instruments and facilities. From around 1950, SQC utilizing the Control Chart and the Sampling Inspection came to be used in many Japanese plants after the line of Dr. W.E. Deming. QC was first engaged only by engineers and factory workers.

2.8 Statistical Quality Control Definition

Statistical quality control (SQC): is the term used to describe the set of statistical tools used by quality professionals. Statistical quality control can be divided into three broad categories:

1. Descriptive statistics are used to describe quality characteristics and relationships. Included are statistics such as the mean, standard deviation, the range, and a measure of the distribution of data.

2. Statistical process control (SPC) involves inspecting a random sample of the output from a process and deciding whether the process is producing products with characteristics that fall within a predetermined range. SPC answers the question of whether the process is functioning properly or not.

3. Acceptance sampling is the process of randomly inspecting a sample of goods and deciding whether to accept the entire lot based on the results. Acceptance sampling determines whether a batch of goods should be accepted or rejected. The tools in each of these categories provide different types of information for use in analyzing quality. Descriptive statistics are used to describe certain quality characteristics, such as the central tendency and variability of observed data. Although descriptions of certain characteristics are helpful, they are not enough to help us evaluate whether there is a problem with quality. Acceptance sampling can help us do this. Acceptance sampling helps us decide whether desirable quality has been achieved for a batch of products, and whether to accept or reject the items

produced. Although this information is helpful in making the quality acceptance decision after the product has been produced, it does not help us identify and catch a quality problem during the production process. For this we need tools in the statistical process control (SPC) category.

2.9 Quality Improvement Techniques

The underlying concept of quality improvement techniques is to ensure, in a cost-efficient manner, that the product shipped to customers meets their specifications. Inspecting every product is costly and inefficient, but the consequences of shipping non-conforming product can be significant in terms of customer dissatisfaction.

2.9.1 Statistical Quality Control (SQC) Tools

Every day, throughout the world, in offices, factories, on public transport, shops, schools and so on, data are being collected and accumulated in various forms. The key process monitoring and investigating tools include:

- Histograms,
- Check sheets,
- Pareto charts,
- Cause and effect diagrams,
- Scatter diagrams, and
- Control charts.

2.9.1.1 Histogram

The histogram is a bar chart showing a distribution of variables. This tool helps identify the cause of problems in a process by shape of the distribution as well as the width of the distribution. The histogram clearly portrays information on location, spread, and shape regarding the functioning of the physical process. It can also help suggest both the nature of, and possible improvements for, the physical mechanisms at work in the process.

2.9.1.2 Check sheets

A check sheet is a paper form on which items to be checked have been printed already so that data can be collected easily and concisely. Its main purposes are:

- To make data-gathering easy
- To arrange data automatically so that they can be used easily later on.

2.9.1.3 Pareto charts

A Pareto Diagram is a bar graph used to arrange information in such a way that Priorities for process improvement can be established. Pareto diagram is used:

- To display the relative importance of data.
- To direct efforts to the biggest improvement opportunity by highlighting the vital few in contrasts to the useful many

2.9.1.4 Cause and effect diagrams

A Cause-and-Effect Diagram is a tool that helps identify, sort, and display possible causes of a specific problem or quality characteristic. The diagram graphically illustrates the relationship between a given outcome and all the factors that influence the outcome

It is used when we need to

- Identify the possible root causes, the basic reasons, for a specific effect, problem, or condition.
- Sort out and relate some of the interactions among the factors affecting a particular process or effect.
- Analyze existing problems so that corrective action can be taken.

Some of the benefits of constructing a Cause-and-Effect Diagram are that it:

1. Helps determine the root causes of a problem or quality.
2. Encourages group participation.
3. Uses an orderly, easy-to-read format
4. Indicates possible causes of variation in a process.

5. Increases knowledge of the process by helping everyone to learn more about the factors at work and how they relate.

6. Identifies areas where data should be collected for further study.

2.9.1.5 Scatter diagrams

The scatter diagram is a technique used to study the relation of two corresponding Variables. The two variables we will deal with are:

1. A quality characteristic and a factor affecting it,
2. Two related quality characteristics, or
3. Two factors relating to a single quality characteristic.

2.9.1.6 Control charts.

A Control chart is a graphical method for displaying control results and evaluating Whether a measurement procedure is in-control or out-of-control.

Uses of Control charts

The main uses of control charts are:

1. It is a proven technique for improving productivity.
2. It is effective in defect prevention.
3. It prevents unnecessary process adjustments.
4. It provides diagnostic information.
5. It provides information about process capability.

2.9.2 Types of control charts

The quality of a product can be evaluated using either an attribute of the product or a variable measure.

2.9.2.1 Variable Measure Control Chart

A variable measure is a product characteristic that is measured on a continuous scale such as length, weight, volume, or time. Two of the most commonly used variable Control charts are:

- The mean chart or X chart, and
- The range or R charts.

Mean (x-Bar) Charts

A mean control chart is often referred to as an x-bar chart. It is used to monitor changes in the mean of a process. To construct a mean chart, we first need to construct the center line of the chart. To do this we take multiple samples and compute their means. Usually these samples are small, with about four or five observations. Each sample has its own mean. The center line of the chart is then computed as the mean of all K sample means, where K is the number of samples:

$$\bar{x} = \frac{\bar{x}_{\perp}+\bar{x}_2+\cdots\overline{\bar{x}_n}}{n} \tag{2}$$

To construct the upper and lower control limits of the chart, we use the following formulas:

$$\text{Upper control limit (UCL)} = \bar{x} + Z\delta_{\bar{x}} \tag{2.1}$$

$$\text{Lower control limit (LCL)} = \bar{x} - Z\delta_{\bar{x}} \tag{2.2}$$

Where $\bar{x} =$ the average of the sample means

Z = standard normal variable () 2 for 95.44% confidence, 3 for 99.74% confidence)

$\delta_{\bar{x}} =$ standard deviation of the distribution of sample means, computed AS $\delta/\sqrt{n}$

$\delta =$ population (process) standard deviation

n = sample size (number of observations per sample)

Another way to construct the control limits is to use the sample range as an estimate of the variability of the process. Remember that the range is simply the difference between the largest and smallest values in the sample. The spread of the range can tell us about the variability of the data. In this case control limits would be constructed as follows:

$$\text{Upper control limit (UCL)} = \bar{\bar{x}} + A_2\bar{R} \tag{2.3}$$

$$\text{Lower control limit (LCL)} = \bar{\bar{x}} - A_2\bar{R} \tag{2.4}$$

Where $\bar{\bar{x}} =$ average of the sample means

$\bar{R}$ = average range of the samples

A_2= factor obtained from tables

Notes that A_2 is a factor that includes three standard deviations of ranges and is dependent on the sample size being considered.

Range (R) Charts

Range (R) charts are another type of control chart for variables. Whereas x-bar charts measure shifts in the central tendency of the process, range charts monitor the dispersion or variability of the process. The method for developing and using R-charts is the same as that for x-bar charts. The center line of the control chart is the average range, and the upper and lower control limits are computed as follows:

$$\text{CL} = \bar{R} \tag{2.5}$$

$$\text{UCL} = D_4\bar{R} \tag{2.6}$$

$$\text{LCL} = D_3\bar{R} \tag{2.7}$$

Were values for D_4 and D_3 are obtained from table

2.9.2.2 Attribute Control Chart

Attribute control charts arise when items are compared with some standard and then are classified as to whether they meet the standard or not. Attribute Control charts include:

1. P- Chart
2. nP- Chart
3. C- Chart
4. U- Chart

i**) P-Chart** With the P-chart, a sample is taken periodically from the process and the proportion of defective items in the sample is determined to see if it falls within the control limits in the chart. Since a P-chart employs a discrete, attribute measure (defective items) it is theoretically based on the binomial distribution. However, as the sample size gets larger, the normal distribution can be used to approximate the binomial distribution. It is used when the subgroups are not of equal size. The np chart is used in the more limited case of equal subgroups.

ii. np-charts: The Np-Chart can be used for the special case when the subgroups are of equal size. Then it is not necessary to convert nonconforming counts into the proportions Rather, one can directly plot the counts x (i) versus the subgroup number i.

iii. C-charts The C used to monitor the number of defects per unit. Examples are the number of returned meals in a restaurant, the number of trucks that exceed their weight limit in a month, the number of discolorations on a square foot of carpet, and the number of bacteria in a milliliter of water. Note that the types of units of measurement we are considering are a period of time, a surface area, or a volume of liquid. The average number of defects is the center line of the control chart. The upper and lower control limits are computed as follows:

$$\text{UCL} = \bar{c} - z\sqrt{\bar{c}} \tag{2.8}$$

$$\text{LCL} = \bar{c} - z\sqrt{\bar{c}} \tag{2.9}$$

iv. u-Chart: The u Chart is used when it is not possible to have an inspection unit of a fixed size defects counted in one square foot), rather the number of nonconformities is per inspection unit.

2.9.3 Analysis of Patterns on Control Charts

A control chart may indicate an out-of-control condition either when one or more points fall beyond the control limits, or when the plotted points exhibit some non-random pattern of behavior. The process is out of control if any one or more of the following criteria is met.

i) Extreme Point Conditions: One or more points outside of the control limits. This pattern may indicate:

1. A special cause of variance from a material, equipment, method, or measurement system change.

2. Wrong measurements of a part or parts.

3. Miscalculated or miss-plotted data points.

4. Miscalculated or miss-plotted control limits.

ii) Control Chart Zones: Control charts can be broken into three zones (Figure below), A, B, and C on each side of the process center line. A series of rules exist that are used to detect conditions in which the process is behaving abnormally to the extent that an out-of-control condition is declared.

iii) Two of Three Consecutive Points in Zone A or Outside Zone A

iv)Four of Five Consecutive Points in Zone B or Beyond

v) Runs Above or Below the Center Line

vi) Linear Trend

vii) Oscillatory Trend: Having 14 or more consecutive points oscillating back and worth.

viii) Avoidance of Zone C: The probability of having 8 or more consecutive points occurring on either side of the center line and do not enter Zone C.

ix) Run in Zone C: The probability of having 15 or more consecutive points occurring the Zone C.

A process is said to be "IN CONTROL" If the following are true:

1. There are no sample points outside the control limits.

2. Most points are near the process average without too many close to the control limits.

3. There is approximately equal number of sample points above and below the center line.

4. The points appear to be randomly distributed around the center line.

2.10 Process Capability

So far, we have discussed ways of monitoring the production process to ensure that it is in a state of control and that there are no assignable causes of variation. A critical aspect of statistical quality control is evaluating the ability of a production process to meet or exceed preset specifications. This is called process capability. To understand exactly what this means, let's look more closely at the term specification. Product specifications, often called tolerances, are preset ranges of acceptable quality characteristics, such as capacity of product produced in a certain time frame. For a production capacity of the factory to be considered acceptable, its characteristics must fall within this preset range. Otherwise, the factory is not in the acceptable range.

2.11 Research gap

- ✓ Literature in context to the implementation of TQM of cement sector in Ethiopia is not available. The differences in the level of acceptability of TQM tools among manufacturers, suppliers, and subcontractors in the cement sector are still unexplored.

- ✓ Present TQM tools can transform data but generally rely on intuition to conclude. TQM tools are not sufficient when strategic issues related to top management are under focus. Many strategic decisions require policy experimentations and it should also be focused in lower employee.
- ✓ Most of the works of literature broadly describe and research the implementation of TQM in the market and customer wise but not from the beginning of the TQM process which is from the quality of the manufactured product itself, manufacturing process and the causes for this poor-quality product
- ✓ Most of the authors describes TQM as a system. However, the dynamic interaction among its subsystems has not received due attention to bridge some of the existing gaps.

CHAPTER THREE

3 Methodology

3.1 Materials and Method

Research methodology involves the systemic set of laws and procedures upon which this research program is based and against which the information collected is interpreted and the results evaluated. In general, to achieve the objectives of a study, one of the significant areas to consider is the type of method that is adopted. For this reason, the research methodology adopted in this study includes research approach, population, sampling process and data collection.this study uses both primary and secondary datas to collect real time data and analyzes using statical process control which helps us to find out the existing defect by using P-charts and determine if the process is stable and predictable, as well as to monitor the effects of process improvement theories based on the machine avaliablity.

3.2 Research approach

This study adopted deductive approach which is suitably achieved by quantitative and quantitative data analysis that enabled to understand the relationship between the different variables, TQM, HRM and employees more specifically, due to the existing operating system and TQM implementation barriers existing in the company.it also includes a documented data for the last three years. The population will be selected in national cement Share Company which will be divided in strata, according to their qualification department.

3.3 Sampling process

As for the sampling method, this study was based on non-random sampling, convenience sampling was chosen. The data was collected from the population representatives who were conveniently available. Questionary population used was **80** employees as a sample from different working area in the factory for assessment of the total quality management.

3.4 Data collection

For this reason, the research methodology adopted in this study is in three different phases, but corresponding to each other. The three phases upon which these methods were applied to are;

- Primary data collection
- Secondary data collection

Primary data collection

It was mainly focused on actual gathered data from production, mechanical and electrical departments including observations and interviews and use all the data to analyze and interpreted using different methods.

Secondary data collection

Secondary data Collection was done by using questionaries distributed throughout the organization like to the top management, lower-level management and lower employees has been participated in addition the questionary were distributed throughout the different departments available within the organization. 80 questionaries were distributed but 60 questionaries were properly filled and distributed.

3.4.1 Data Analysis Process

Data collected by different methods were analyzed using Excel word, SPC software. After collecting the questionnaire copies and the primary gathered data, in order to derive the results of the research different statistical test, tables, descriptive and deductive statistics methods were analyzed and evaluated. For the root cause analysis and result fishbone diagram was used.

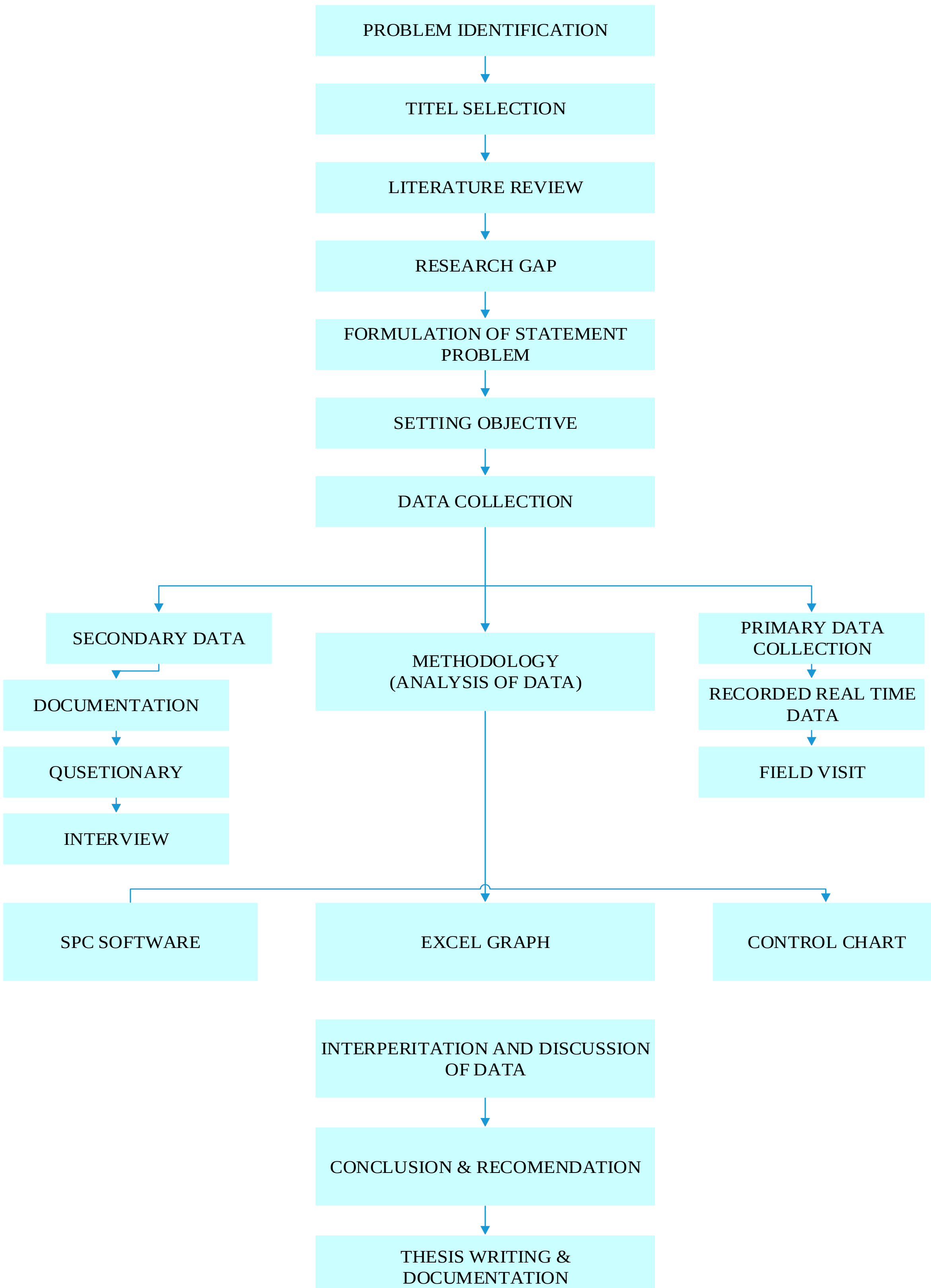


Figure 3-1:Data analysis process steps

CHAPTER FOUR

4 Data analysis & Results

During the progress of this research, data was collected through real time observation and questionnaires from participants' sample that ideally represents NATIONAL CEMENT SHARE COMPANY. Both the real-time questionnaires distributed sort to find out the views of the participants on the factors that influence the implementation of TQM system in manufacturing of cement in the Company and how the implementation of total quality management affects the availability of machine.

4.1 Interpretation of data collected using questionaries

During the progress of this research, data was collected through questionnaires from participants' sample that ideally represents National cement share company. The questionnaires distributed sort to find out the views of the participants on the factors that influence the implementation of TQM system in manufacturing of cement in the Company.

Table 5.1 Questionnaires distributed and collected A total of 80 questionnaires were distributed to the sample, of which 60 completed questionnaires were received for the final analysis representing a response rate of 75 %. Out of which, 20 (25%) of the questionnaires were excluded from the analysis and were not returned to the researcher.

Table 5.1 illustrates the number of questionnaire respondents and response rate. This high response rate could be attributed to the efforts applied by the researcher and the level of interest of the subject matter. The number of Participants and Rate of Response

Table 4-1Questionnaires distributed and collected

Description	participation	Rate of response
Questionary distributed	80	100%
Total Usable	60	75%
unusable	20	25%

Questionnaire No 1: What is your Gender?

Respondents’ reaction:

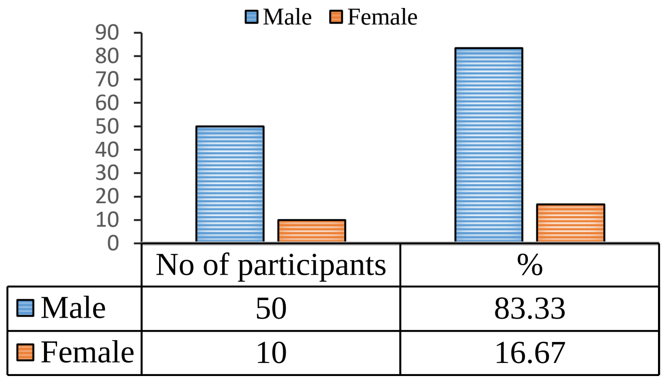


Figure 4-1 gender distribution of sample size

From the figure 4.1, it can be seen that of the 60(100%) participants that made up the sample, 50(83.33%) were males and 10(16.67%) were females. Figure 4.1 Age distribution of the sample size.

Questionnaire No2: What is your age?

Respondents’ reaction:

Table 4-2 : age distribution

	Frequency	percent
18-30	25	41.67%
31-40	16	26.67%
41-50	15	25.00%
51-60	4	6.67%
Above 61	0	0.00%
Total	60	100.00%

Table 4.2 shows Only six (0%) participants were above 61 years of age, four (6.67%) were of the age group 51 – 60 years of age, fifteen (25%) were of the age group between 41 – 50 years of age,

sixteen (26.67%) were of the age group between 31 -40 years of age. Another group of twenty-five (41.67%) participants were between 18 - 30 years of age.

Questionnaire No 3: What is your highest level of educational qualification

Respondents' reaction:

Table 4-3 Highest levels of educational qualification of participants

	Frequency	percent
High school and below	15	25.00%
Diploma	10	16.67%
Bachelor	25	41.67%
postgraduate	10	16.67%
Total	60	100.00%

Table 4.3 shows the educational qualification of the participants composed of 25%having High School or equivalent, 41.67% having Bachelors' degrees. The category of others took up 16.67%, which from the sample results composed of Masters' degree holders 16.67%. which shows that most of the employees are at least above higher educational status which is very good for the organization and for the implementation of total quality management which in turn help the research because the respondent can understand the specific questions raised on the questionary and answer in detail.

Questionnaire No 4: What is your position in the company? Your current position

Respondents' reaction:

Table 4-4: Current position of Participants' position held.

	Frequency	percent
Supervisor	12	20.00%
Management	15	25.00%
Non-Management	33	55.00%
Total	60	100.00%

From the table 4.4, only 33% participants were non-management which helps the research to evaluate and separate if the employee out sides the management know more about TQM or not and were they allowed to participate in TQM training or other activities. 15% were management position from the participants and 12% of the population was supervisors.

Questionnaire No 5: Do you have knowledge about TQM?

Respondents' reaction:

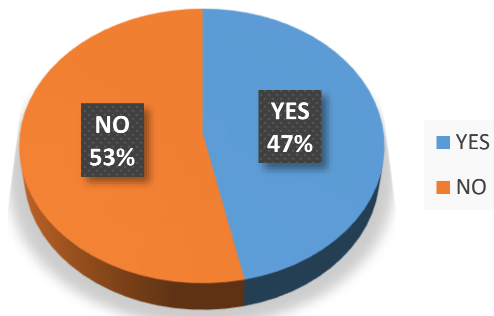


Figure 4-2 : knowledge about total quality management

In figure 4.2 shows that in the national cement share company the workers that knows more about TQM was 47% and that didn't have the knowledge about the total quality management was more than 53% which describes that more worker didn't participate on different total quality management trainings. Due to this the implementation of TQM like kaizen was not effective.

Questionnaire No 6: Describe your current TQM satisfaction? Level of TQM satisfaction

Respondents' reaction:

Table 4-5 : Current TQM satisfaction

	Frequency	percent
Less than 3 years	10	16.67%
3-6 years	38	63.33%
7-10 years	9	15.00%
More than 10 years	3	5.00%
Total	60	100%

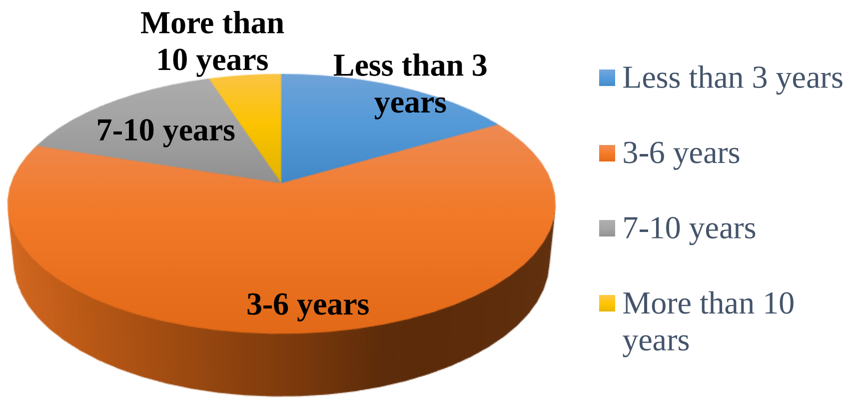


Figure 4-3 : Current TQM satisfaction

Figure 4.3 shows that 16.67% of the participants, are those that have been personally involved in quality management issues for less than three years and those with three to six years indicate 63.33% in such quality issues. nine 15% participants say they have been in it for a period of time, from seven to ten years. Lastly, those covering more than ten years had 3% of the participants in total. This chart explains that more of the employees working about less than 3 years and 3-6 years has the interest to be involved more in quality management issues. But employees who had been working for over seven years had not get any training to improve it only the had been asked to implement which was very exhausting and similar so they don't want to involve themselves in TQM.

Questionnaire No 7: What kind of total quality management philosophy is implemented in your organization?

Respondents' reaction: the reaction from the participants were the only philosophy they understand and had knowledge about was only KAIZEN, most lower employees understand kaizen as cleaning making things shine. But the middle management understand the philosophy more professionally and they know "Kaizen is an approach to creating continuous improvement based on the idea that small, ongoing positive changes can reap significant improvements" but while checking practically it was not that much fruitful.

Questionnaire No 8: Does the company have access to training facilities?

Respondents' reaction:

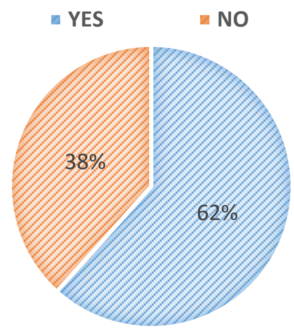


Figure 4-4 : about training facilities

Figure 4.4 shows that 62% of the participants did have access to training and 38% didn't had any training access which shows that the company didn't support training for all the employees according to their positions and work environments.

Questionnaire No 9: Which TQM key factor has been implemented in your company?

Respondents' reaction:

Table 4-6 : Which TQM key factor has been implemented in your company?

	Frequency	percent
Continuous improvement	25	14.79%
Top management commitment	6	3.55%
Quality measurement and benchmark	28	16.57%
Supplier relationships	20	11.83%
Policy and strategic plan	10	5.92%
Quality information system	13	7.69%
Organizational culture	20	11.83%
Customer focus and satisfaction	22	13.02%
Quality communication and structure	25	14.79%
Total	169	100%

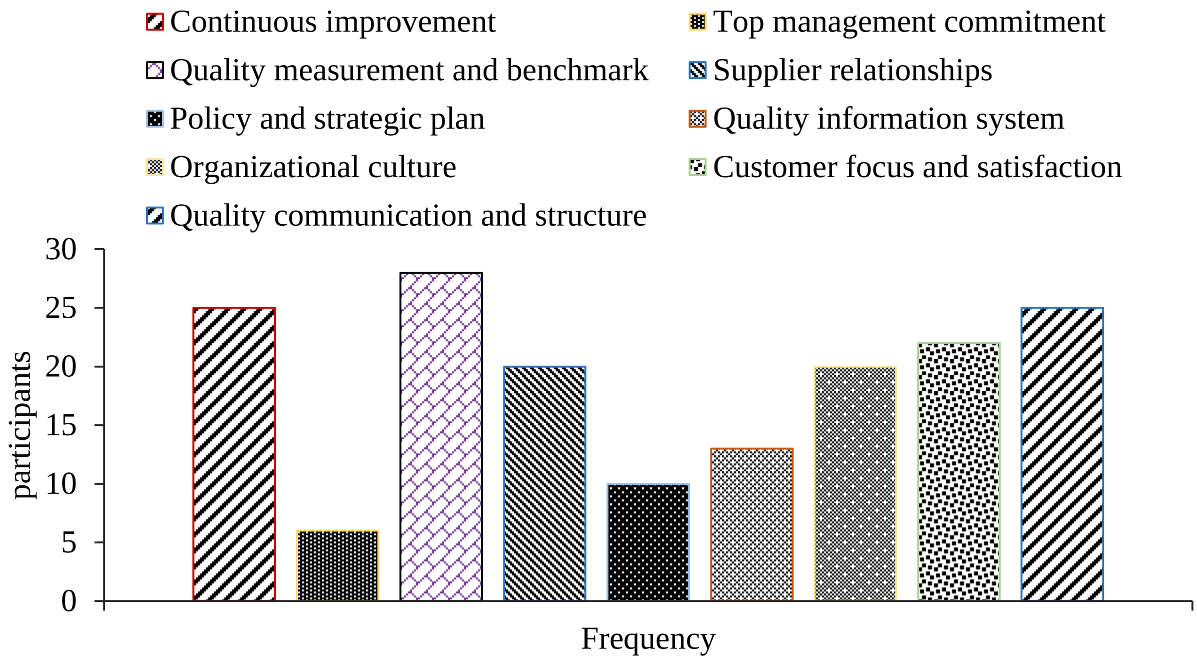


Figure 4-5 : shows Which TQM key factor has been implemented in the company

Table 4.6 and figure 4.5 shows a summation of rankings of different participants. According to this figurative illustration, the most TQM key factor was the continuous improvement as 14.79%, thereafter follows top management commitment as 3.55%, then customer focus and satisfaction of 13.02%, then policy and strategic planning of 5.92%, followed by quality information systems of 7.69%, then quality communications and structure as 14.79% follows after. Finally, the least factors found to be implemented in the company were quality measurement and benchmarking of 16.57%, suppliers' relationships of 11.83% and organizational culture of 11.83%. data shows that on this top management commitment, policy and strategic planning and organizational culture key factors are not implemented on the organization which are the main issues for the organization to effectively implement TQM and got an effective result otherwise as shown above with this low % figure for this key factor it is almost impossible to achieve the goal for effective implementation of TQM.

Questionnaire No 10: Top Management assumes active responsibility for the evaluation and improvement

Respondents' reaction:

Table 4-7 the participant thinking about if top management is actively responsible on the evaluation and improvement

	frequency	percent
Agree	25	41.67%
strongly agree	3	5.00%
Disagree	7	11.67%
Strongly Disagree	10	16.67%
Not sure	15	25.00%
Total	60	100.00%

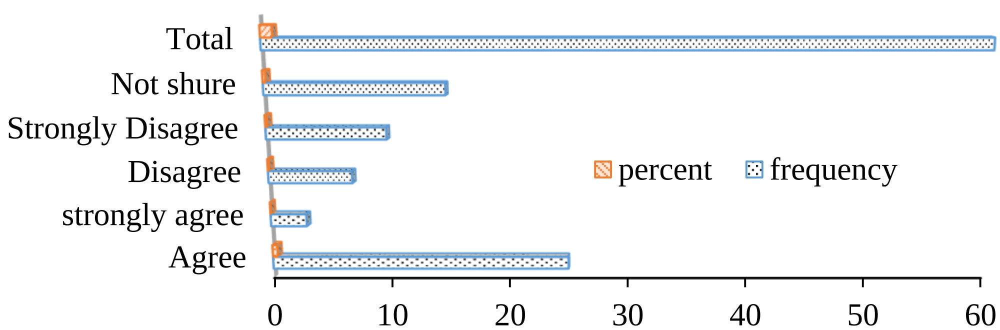


Figure 4-6 : shows the participant thinking about if top management is actively responsible on the evaluation and improvement

Figure 4.6 shows 15% of the participants were unsure which shows that they were not actively participating on total quality management, the other 41.67 % agree shows they have the knowledge about TQM and have an involvement in TQM implementation. On the other hand, 5% of the respondents strongly agree that Top Management assumes active responsibility for the evaluation and improvement that shows the management was not actively participating on the evaluation and improvement which was not satisfactory for the organization TQM improvement.

Questionnaire No 11: are the senior management committed to total quality management?

Respondents' reaction:

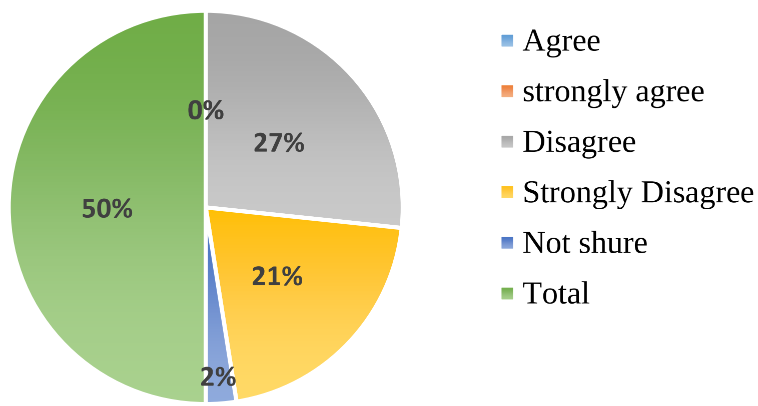
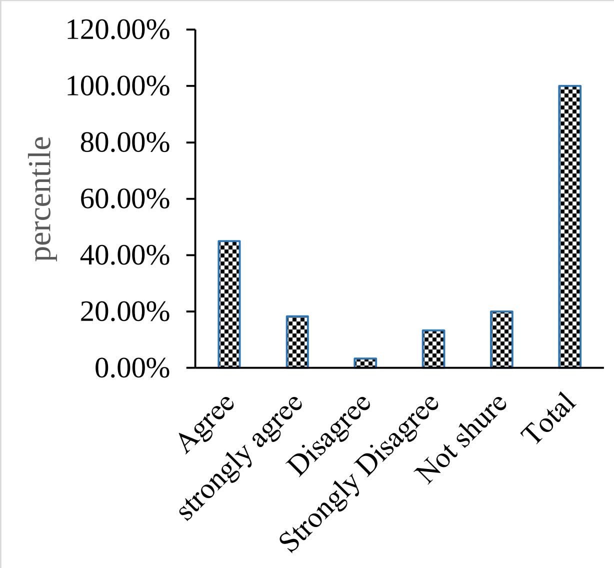


Figure 4-7 : Senior management committed to total quality management

According to the pie chart illustrated in figure 4.7, is to show that if the top and middle management employees are commited or not for the implementation of total quality management for a continuous improvement in waste reduction , increasing the quality of the product intermes of production quantity. And according to the collected data 32% of the participants Disagree that there is an inclination of top management to allocate adequate resources and time for quality management efforts, 25% strongly Disagreed to this assertion. 0% of the participants agreed. Further 3% were not sure. Major elements of quality management structure are in place to facilitate the organization's quality strategy objectives.the result shows that the higher management was not putting un effort for the implementation of total quality management which will affect the availability of machine that will determine the production.

Questionnaire No 12: Do you think Major elements of quality management structure are in place to facilitate the organization's quality strategy objectives?

Respondents' reaction:



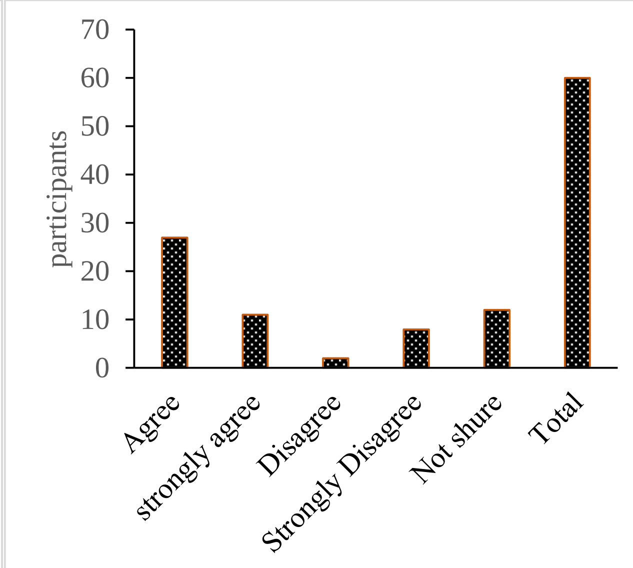


Figure 4-8 : Major elements of quality management structure are in place to facilitate the organization's quality strategy objectives.

The chart illustrated in figure 4.8, 45% of the participants agree that major elements of quality management structure are in place to facilitate the organization's quality strategy objectives which shows that the structure to facilitate the strategy for TQM is available but from the observation the structure is in place but on the implementation, it still had a long way to improve, 18.33% strongly agree to this assertion. 2% of the participants merely disagreed. Further 12% were not sure which shows that they had no knowledge of major elements of quality management.

Questionnaire No 13: is the average number of defects is decreasing in company production

Respondents' reaction:

Table 4-8 : The average number of defects is decreasing in company production

	frequency	percent
Agree	40	66.67%
strongly agree	5	8.33%
Disagree	15	25.00%
Strongly Disagree	0	0.00%

Not sure	0	0.00%
Total	60	100.00%

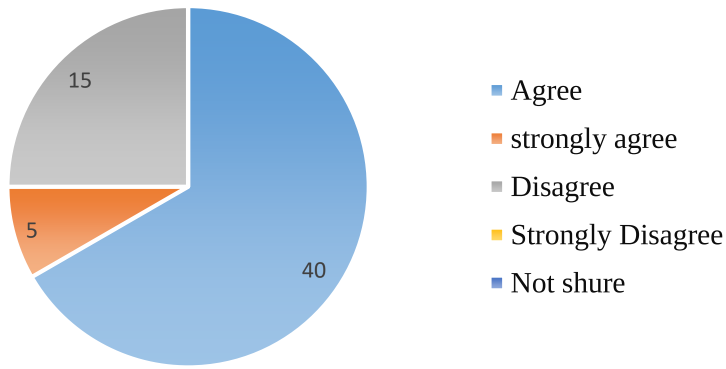


Figure 4-9 : The average number of defects is increasing in company production

According to the pie chart illustrated in Figure 4.9, the average number of defects are machine break down in which 66.67% of the participants agree the average number of defects was increased in company production which was caused due to frequent machine breakdowns, 8.33% strongly agree to this assertion. 25% of the participants also disagreed.

Questionnaire No 14: is the existing operating system increase the productivity loss?

Respondents' reaction:

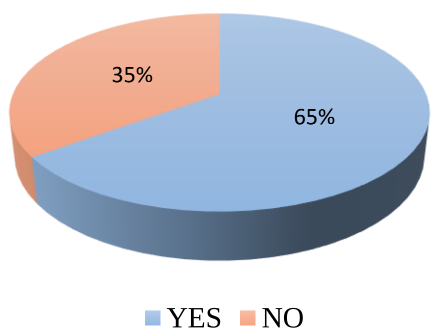


Figure 4-10 : about operating system

In Figure 4.10 shows that 65% of the participants agreed with the productivity loss due to the existing operating system which is linked with that replacement of spare part while the machine failed to operate seems efficient way to maintain it and run but before the failure of machineries happened it could be prevented by using predictive and proactive maintenances which was very efficient way of determining or for casting of root causes that may lead the machineries in to failure. According total quality management only kaizen was available but not continually applied and also there were other very recent TQM types that can increase productivity.

If you choose yes

Questionnaire No 15: What do you think should be changed to decreases the production loss?

Respondents' reaction: most participants said that kaizen was an old system for them so that it should be changed to a new system. Some says the higher management don't involve the lower employees on some decision levels because of that while the real root cause was there, they decide only by what they here and try to solve the problem. They think that to solve the main problem and increase production they believed that the higher management should include the lower employees to get some feed backs do that it would help them to decide

Questionnaire No 16: what is the main root cause for the production loss?

Respondents' reaction:

Table 4-9 : response about main root cause for the production loss

	Frequency	percent
Mechanical breakdown	40	25.00%
Electrical breakdown	33	20.63%
Raw material shortage	08	5.00%
Production problem	28	17.50%
Power fluctuation	51	31.88%
Total	160	100.00%

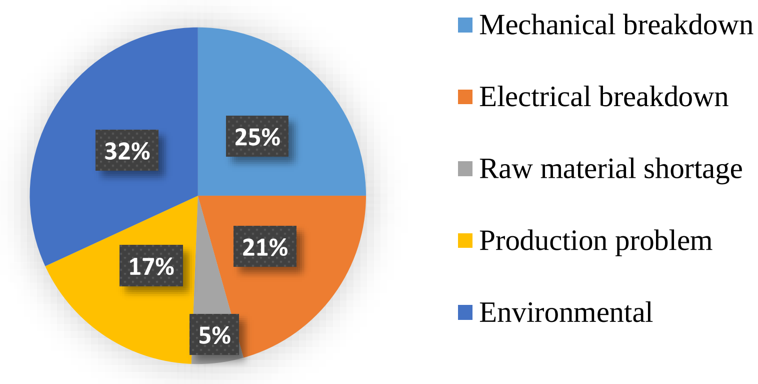


Figure 4-11: main root cause for the production loss

This table displays a summation of rankings of different participants. According to this figurative illustration in figure 4.11, the main root cause for production loss was 25% will be due to mechanical breakdown, thereafter follows Electrical breakdown (20.63%), then raw material shortage (5%), then production problems (17.5%), followed by environmental (31.88%).

Questionnaire No 17: Does the implementation of total quality management in your organization have positive change in your productivity as well as in resource management?

Respondents' reaction:

On the resource management more than 50 % of respondents answer that it doesn't have a positive impact. But in productivity of the factory, it had a good positive change. But on the overall data collected the implementation of total quality management was not satisfactory to have a positive change in productivity or in resource management.

4.2 Mechanical Down Time

machine downtime means any period of time (planned or unplanned) during which an equipment or machine was not functional or cannot work. Unplanned downtime often is a result of human error and inefficiency such as slow changeover and lack of knowledge or ability to complete tasks. Poor processes and inadequate maintenance are also common causes of unplanned downtime. On the other hand, planned machine downtime is frequently attributed to maintenance, cleaning, and upgrading equipment. Because it was a known and controlled type of downtime, planned downtime won't be part of our focus. For our research purpose we have divided the factory in three critical places which are vertical raw mill, cement mill and Kiln Because all thisthree machines are the main body of the cement factory. It was discussed that the causes of down time and how much the down time was compared to the working time from 2019 – 2022. Fish bone bellow shows that the Main root cause of breakdown of machineries listed.

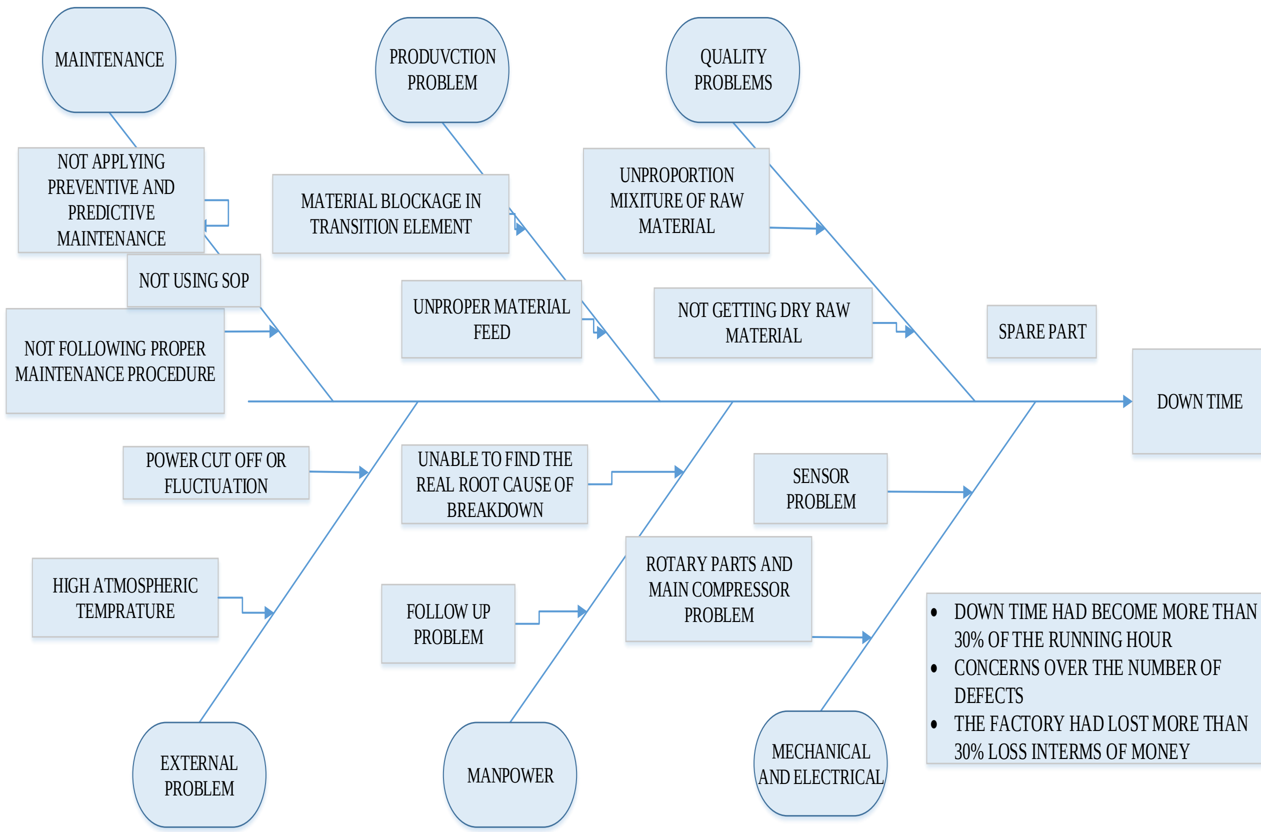


Figure 4-12 main root cause of down time

4.2.1 Vertical raw mill

The rollers of the mill are pressured by tension device. The classifier is driven by frequency control motor, which is of variable speed. Three grinding rollers are fitted under the pressure frame. The roller unit is composed by thrust parts and eye joint parts. The tension force produced by three tension rods is transmitted through the pressure frame onto three rollers, then to the material bed between grinding roller and grinding table. The closed loop of power is formed between foundation, tension rods, frame, rollers, grinding table and reducer.

Two accumulators are fitted in each hydraulic tension system as a shock absorbing system. The grinding table is rotated by main drive through the reducer, and the grinding rollers are self-rotated under the action of friction caused by grinding table. The torsion is transferred to frame through grinding rollers, moreover this torsion is transferred the machine shell by frame along its circumferential direction. The meal is fed to the grinding table through feed opening. The meal is grinded and crushed by motion between the grinding rollers and the grinding table. It is then pushed outward over the edge of the grinding table when it is grinded and crushed to specified fineness. The stream of gas flowing in all around the nozzle ring can prevent the material falling down through the nozzle and also allow the foreign bodies with high specific gravity to fall down through the nozzle and be discharged out of the mill by scrapers. The volume of discharging can be adjusted by adjusting air speed around nozzle ring. The discharged meal through discharging opening is carried by elevator and fed into mill to be grinded again.

4.2.1.1 Root causes of vertical raw mill downtime

Maintenance

- ✓ On the Inspection mostly not using the most advanced methods like predictive and proactive methods for forecasting the cause for machine downtime
- ✓ Unavailability of standard maintenance procedures or sop (standard operating procedure)

Raw material shortage

External factors

- ✓ Power fluctuation major cause for the energy loss for machinery starting

Table 4-10 : Vertical raw mill total machinery running time versus down time from 2019-2020

MONTH	Total (Rh) / MONTH	Total (Dt)/MONTH
Jul-19	645.60	98.4
Aug-19	633.40	110.43
Sep-19	551.33	168.7
Oct-19	185.52	558.47
Nov-19	629.12	91.56
Dec-19	634.14	110.88
Jan-20	606.84	136.9
Feb-20	419.30	276.69
Mar-20	576.99	166.53
Apr-20	83.41	636.93
May-20	120.78	623.22

Jun-20	583.68	136.32
Total	5670.11	3115.03

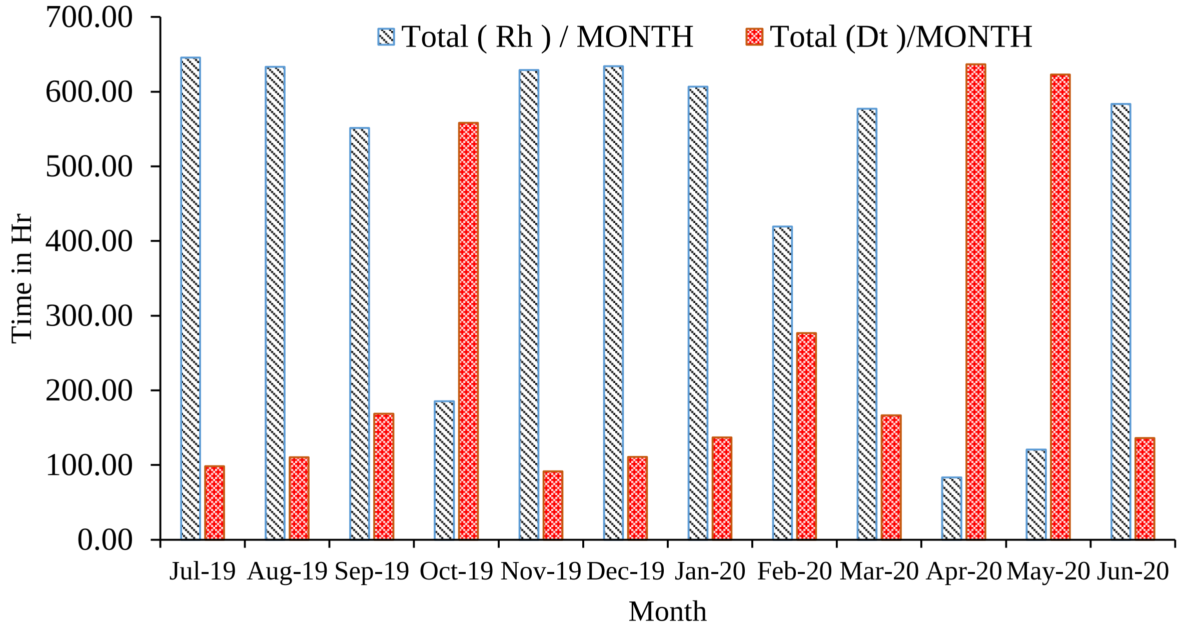


Figure 4-13:VRM total machinery running time versus down time from 2019 - 2020

Table 4-11: VRM total machinery running time versus down time from 2020-2021

MONTH	Total (Rh) / MONTH	Total (Dt)/MONTH
Jul-20	550.40	193.6
Aug-20	533.30	210.7
Sep-20	231.07	488.93
Oct-20	589.22	154.78
Nov-20	474.15	245.85
Dec-20	577.78	166.22
Jan-21	604.68	139.32
Feb-21	516.78	155.22
Mar-21	380.38	363.62
Apr-21	582.29	137.71
May-21	495.10	248.9
Jun-21	95.82	624.18

Total	5630.97	3129.03

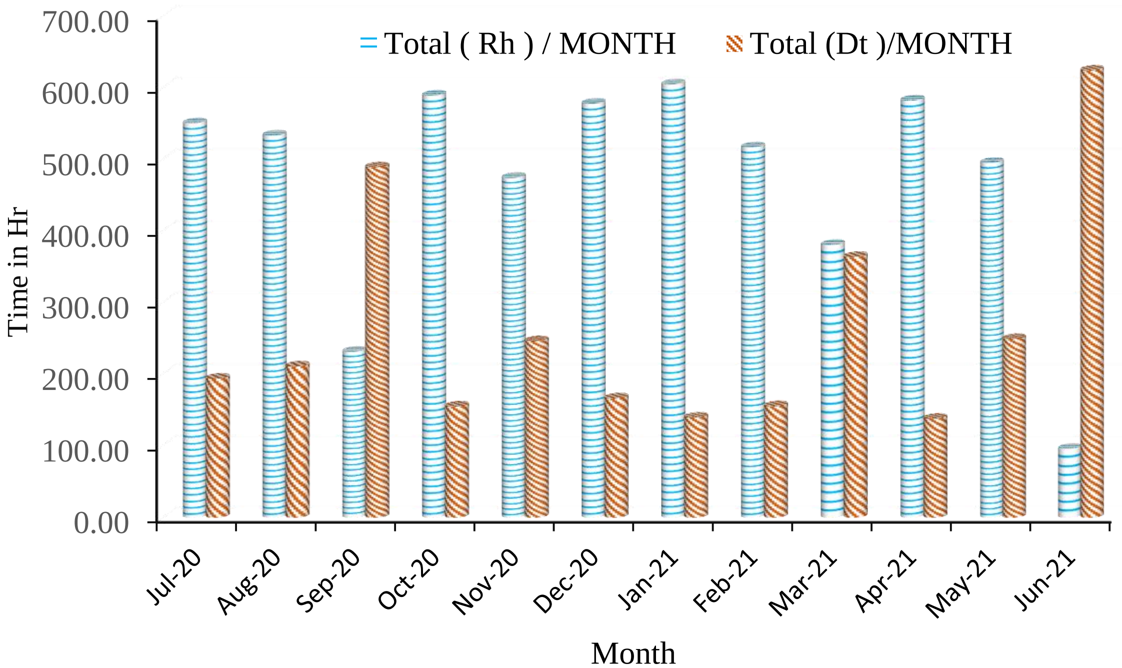


Figure 4-14: VRM total machinery running time versus down time from 2020-2021

Table 4-12: VRM total machinery running time versus down time from 2021-2022

MONTH	Total (Rh) / MONTH	Total (Dt)/MONTH
Jul-21	656.37	87.63
Aug-21	666.09	77.91
Sep-21	597.73	122.27
Oct-21	675.50	68.5
Nov-21	164.34	555.66
Dec-21	552.69	191.31
Jan-22	698.80	45.2
Feb-22	273.65	398.35
Mar-22	333.73	410.27
Apr-22	593.36	126.64
May-22		
Jun-22		
Total	5212.26	2083.74

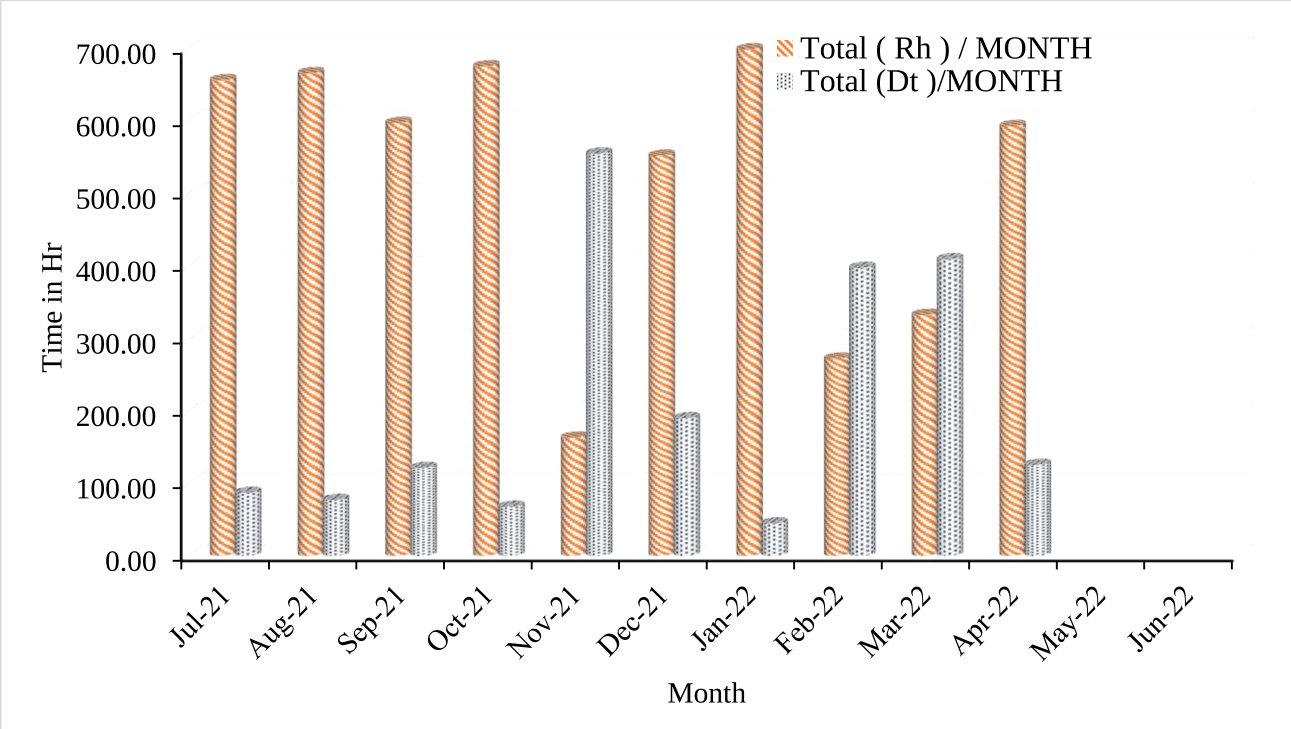


Figure 4-15: VRM total machinery running time versus down time from 2021-2022

Figure 4.13, 4.14 & 4.15 shows how much the down time was in the last three years. In the first two years almost, the down time was more than the running hour mechanical breakdown and power outage other than the three months the availability of machines or running hour was satisfactory. since Generally the total downtime that vertical raw mill was more than 50 % running hour in average like in 2019,2020, 2021 years; the total down time was respectively 3115.03 hr., 3129.03 and 2083.74 describes most of the time the machine was under maintenance due to break down, planned or external causes like power-cutoff. vertical raw mill was the critical machine which grind the raw materials so as to be used as input for kiln. Since the cement factory categorized as a line lay out plant. It affected directly the production of clinker was the main ingredient for the cement production.

Table 4-13: Three years of total running down time versus total downtime of VRM

year	Total running Hour	Total Down time	total running hour %	Total Down time %
2019- 2020	**5670.11**	**3115.03**	**63.51%**	**36.49%**
2020 - 2021	**5630.97**	**3129.03**	**63.07%**	**36.93%**
2021 - 2022	**5212.26**	**2083.74**	**58.38%**	**41.62%**

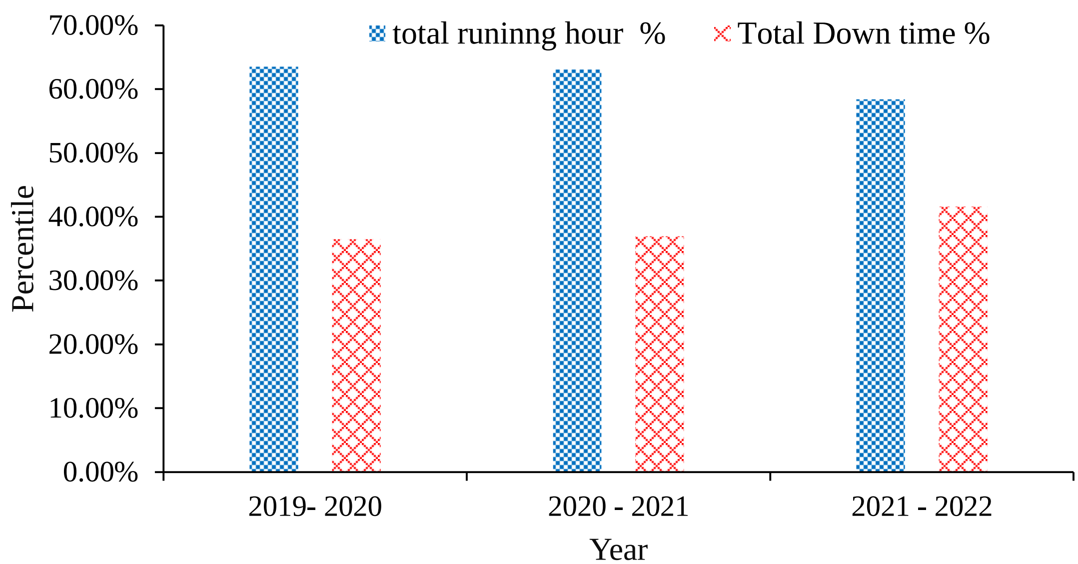


Figure 4-16: Three years of down time versus running time of Vertical raw mill

On table 4.13 and figure 4.16 observed that almost 8327.8 hr downtime which almost 50% downtime of the total runing hour which shows that there was down time is greater than the running hour in those last three years. Not only shows there was aproblem but there was unessesary failures of machin that could have been privented by implementing effective total quality management systems like kaizen, just in time, waste redution it incompasses(time,people,method). In addistion there was high maintenance cost in this three years interms of time, spareparts and production.

Table 4-14: Three years of planned, external and unplanned downtime versus total running hour

year	External causes of down time	Maintenance down time	Total Running hour	Total Down time
2019- 2020	**2355.68**	**452.47**	**5670.11**	**2662.56**
2020 - 2021	**2111.22**	**414.75**	**5630.97**	**2714.28**
2021 - 2022	**1543.8**	**329.31**	**5212.26**	**1754.43**

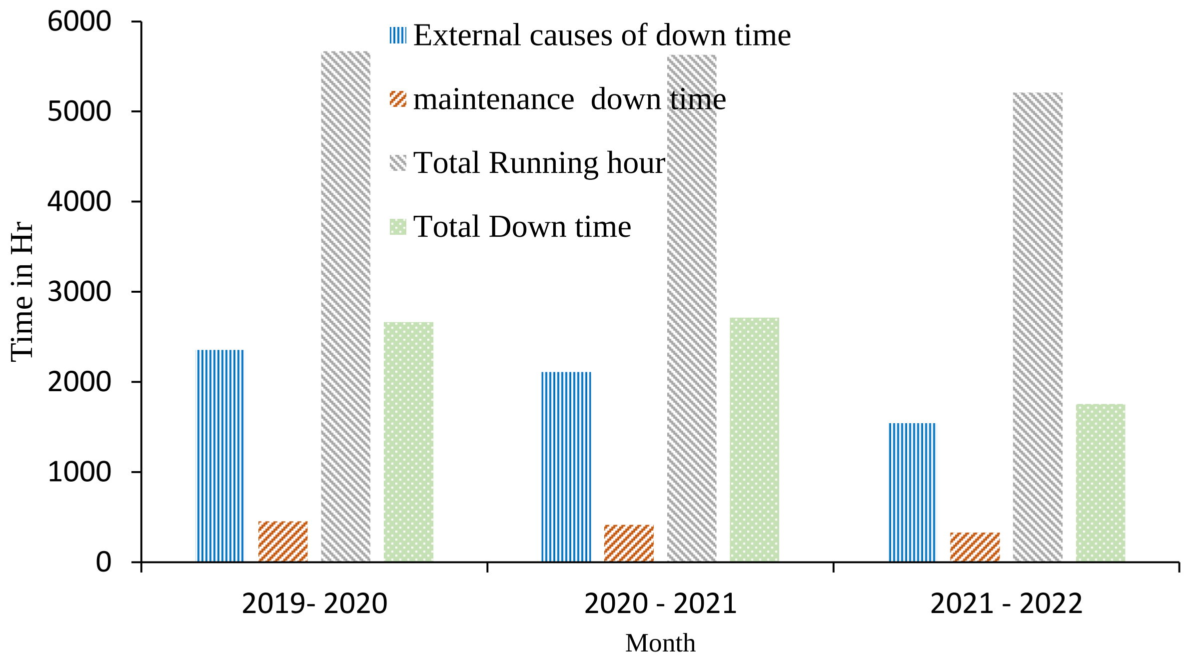


Figure 4-17: Three years of planned, external and unplanned downtime versus total running hour

On table 4-14 and figur 4.17 shows that in total of 6010.7 hr downtime in the last three years which almost 36% of the total runing hour caused mainly due to main power cutt off From EEPCO or fluctuation, and kiln sttopage due to atmospheric temprature increment which causes certain areas of machineris would heat up and coal shortage which was the main energy source for burning up and melting the different minirales so that it could be clinker as a final result. This clearly shows that if the kiln stopped then the Vertical raw mill chance of sttopage will be high because the out put for vertical raw mill would be the main input for rotary kiln. There should be a very critical plannend maintenance so as to maintain the production effectively.

4.2.1.2 Downtime Analysis for Vertical raw mill

Vertical raw mill used to grind lime stone, clay, coal and different raw material in to a fine powder so that it would be processed in to clinker which makes vertical raw mill the first in the line due to that the downtime of vertical raw mill were the major contributor for the down time of the rotary kiln and cement mill. Mainly affected by power cut off or fluctuation and raw material shortage. On the table 4.15 shows three years of monthly downtime data so that it could be analyzed and see the results.

Table 4-15: Three years of monthly down time of sample data for vertical raw mill

SAMPLE NUMBER	MONTH	Total (Rh) / MONTH	Total (Dt)/MONTH	Proportion defect	AVERAGE PROPORTION DEFECTIVE
1	**Jul-19**	**645.60**	**98.4**	**0.152**	**0.504**
2	**Aug-19**	**633.40**	**110.43**	**0.174**	**0.504**
3	**Sep-19**	**551.33**	**168.7**	**0.306**	**0.504**
4	**Oct-19**	**185.52**	**558.47**	**3.010**	**0.504**
5	**Nov-19**	**629.12**	**91.56**	**0.146**	**0.504**
6	**Dec-19**	**634.14**	**110.88**	**0.175**	**0.504**
7	**Jan-20**	**606.84**	**136.9**	**0.226**	**0.504**
8	**Feb-20**	**419.30**	**276.69**	**0.660**	**0.504**
9	**Mar-20**	**576.99**	**166.53**	**0.289**	**0.504**
10	**Apr-20**	**83.41**	**636.93**	**7.636**	**0.504**
11	**May-20**	**120.78**	**623.22**	**5.160**	**0.504**
12	**Jun-20**	**583.68**	**136.32**	**0.234**	**0.504**
13	**Jul-20**	**550.40**	**193.6**	**0.352**	**0.504**

14	Aug-20	533.30	210.7	0.395	0.504
15	Sep-20	231.07	488.93	2.116	0.504
16	Oct-20	589.22	154.78	0.263	0.504
17	Nov-20	474.15	245.85	0.519	0.504
18	Dec-20	577.78	166.22	0.288	0.504
19	Jan-21	604.68	139.32	0.230	0.504
20	Feb-21	516.78	155.22	0.300	0.504
21	Mar-21	380.38	363.62	0.956	0.504
22	Apr-21	582.29	137.71	0.236	0.504
23	May-21	495.10	248.9	0.503	0.504
24	Jun-21	95.82	624.18	6.514	0.504
25	Jul-21	656.37	87.63	0.134	0.504
26	Aug-21	666.09	77.91	0.117	0.504
27	Sep-21	597.73	122.27	0.205	0.504
28	Oct-21	675.50	68.5	0.101	0.504
29	Nov-21	164.34	555.66	3.381	0.504
30	Dec-21	552.69	191.31	0.346	0.504
31	Jan-22	698.80	45.2	0.065	0.504
32	Feb-22	273.65	398.35	1.456	0.504
33	Mar-22	333.73	410.27	1.229	0.504
34	Apr-22	593.36	126.64	0.213	0.504

35	**May-22**	**0.504**
36	**Jun-22**	**0.504**

By using the formula for variable sample size, we use:

$$\bar{P} = \sum_{i=1}^{k} x_i \Big/ \sum_{i=1}^{k} n_i \qquad (5.1)$$

$\sum_{i}^{k} Xi = 8327.8/\sum_{i}^{k} ni$=16513.34 = 0.504

q = 1- p= 1- 0.504 = 0.496

If a constant 'sample' size is being inspected, the *p*-control chart limits would remain the same for each sample. But when *p*-charts are being used with samples of varying sizes, the standard deviation and control limits change with *n*, and unique limits should be calculated for each sample size. However, for practical purposes, an average sample size (*n* –) may be used to calculate action and warning lines. These have been found to be acceptable when the individual sample or lot sizes vary from *n* – by no more than 25 per cent each way. For sample sizes outside this range, separate control limits must be calculated. There is no magic in this 25 per cent formula; it simple has been show to work. The next stage then in the calculation of control limits for the *p*-chart, with varying sample size, is to determine the average sample size (*n* –) and the range 25 per cent either side:

$\sum_{i=1}^{k} ni \Big/ K$ = 16513.34/36 = 458.7

ñ = n ± 0.25*n

= 344 up to 573.375

For sample sizes within this range, the control chart lines may be calculated using a value of σ given by:

δ = $\frac{\sqrt{p(1-p)}}{\sqrt{n}}$ = 0.023345

The action line = p ± 3δ

= 0.4339 to 0.574

The warning lines = p ± 2δ

= 0.45731 to 0.55069

Table 4-16: Calculation of p chart lines for sample size outside the range

SAMPLE NUMBER	MONTH	Total (Rh) / MONTH	Total (Dt)/MONTH	Proportion defect	AVERAGE PROPORTION DEFECTIVE	SIGMA	UAL(UCL)	UWL
1	**Jul-19**	**645.60**	**98.4**	**0.152**	**0.504**	**0.001549**	**0.508647**	**0.507098**
2	**Aug-19**	**633.40**	**110.43**	**0.174**	**0.504**	**0.001579**	**0.508736**	**0.507157**
4	**Oct-19**	**185.52**	**558.47**	**3.010**	**0.504**	**0.00539**	**0.52017**	**0.51478**
5	**Nov-19**	**629.12**	**91.56**	**0.146**	**0.504**	**0.001589**	**0.508768**	**0.507179**
6	**Dec-19**	**634.14**	**110.88**	**0.175**	**0.504**	**0.001577**	**0.508731**	**0.507154**
7	**Jan-20**	**606.84**	**136.9**	**0.226**	**0.504**	**0.001648**	**0.508943**	**0.507296**
9	**Mar-20**	**576.99**	**166.53**	**0.289**	**0.504**	**0.001733**	**0.509199**	**0.507466**
10	**Apr-20**	**83.41**	**636.93**	**7.636**	**0.504**	**0.011989**	**0.539966**	**0.527977**
11	**May-20**	**120.78**	**623.22**	**5.160**	**0.504**	**0.008279**	**0.528838**	**0.520558**
12	**Jun-20**	**583.68**	**136.32**	**0.234**	**0.504**	**0.001713**	**0.50914**	**0.507426**
13	**Jul-20**	**550.40**	**193.6**	**0.352**	**0.504**	**0.001817**	**0.50945**	**0.507634**
15	**Sep-20**	**231.07**	**488.93**	**2.116**	**0.504**	**0.004328**	**0.516983**	**0.512655**
16	**Oct-20**	**589.22**	**154.78**	**0.263**	**0.504**	**0.001697**	**0.509091**	**0.507394**
18	**Dec-20**	**577.78**	**166.22**	**0.288**	**0.504**	**0.001731**	**0.509192**	**0.507461**
19	**Jan-21**	**604.68**	**139.32**	**0.230**	**0.504**	**0.001654**	**0.508961**	**0.507307**
22	**Apr-21**	**582.29**	**137.71**	**0.236**	**0.504**	**0.001717**	**0.509152**	**0.507435**
24	**Jun-21**	**95.82**	**624.18**	**6.514**	**0.504**	**0.010436**	**0.535308**	**0.524872**
25	**Jul-21**	**656.37**	**87.63**	**0.134**	**0.504**	**0.001523**	**0.50857**	**0.507047**
26	**Aug-21**	**666.09**	**77.91**	**0.117**	**0.504**	**0.001501**	**0.508504**	**0.507002**
27	**Sep-21**	**597.73**	**122.27**	**0.205**	**0.504**	**0.001673**	**0.509019**	**0.507346**
28	**Oct-21**	**675.50**	**68.5**	**0.101**	**0.504**	**0.00148**	**0.508441**	**0.506961**
29	**Nov-21**	**164.34**	**555.66**	**3.381**	**0.504**	**0.006085**	**0.522254**	**0.516169**
31	**Jan-22**	**698.80**	**45.2**	**0.065**	**0.504**	**0.001431**	**0.508293**	**0.506862**
32	**Feb-22**	**273.65**	**398.35**	**1.456**	**0.504**	**0.003654**	**0.514962**	**0.511308**
33	**Mar-22**	**333.73**	**410.27**	**1.229**	**0.504**	**0.002996**	**0.512989**	**0.509993**
34	**Apr-22**	**593.36**	**126.64**	**0.213**	**0.504**	**0.001685**	**0.509056**	**0.507371**
35	**May-22**	**0.00**	**0**		**0.504**			
36	**Jun-22**	**0.00**	**0**		**0.504**			

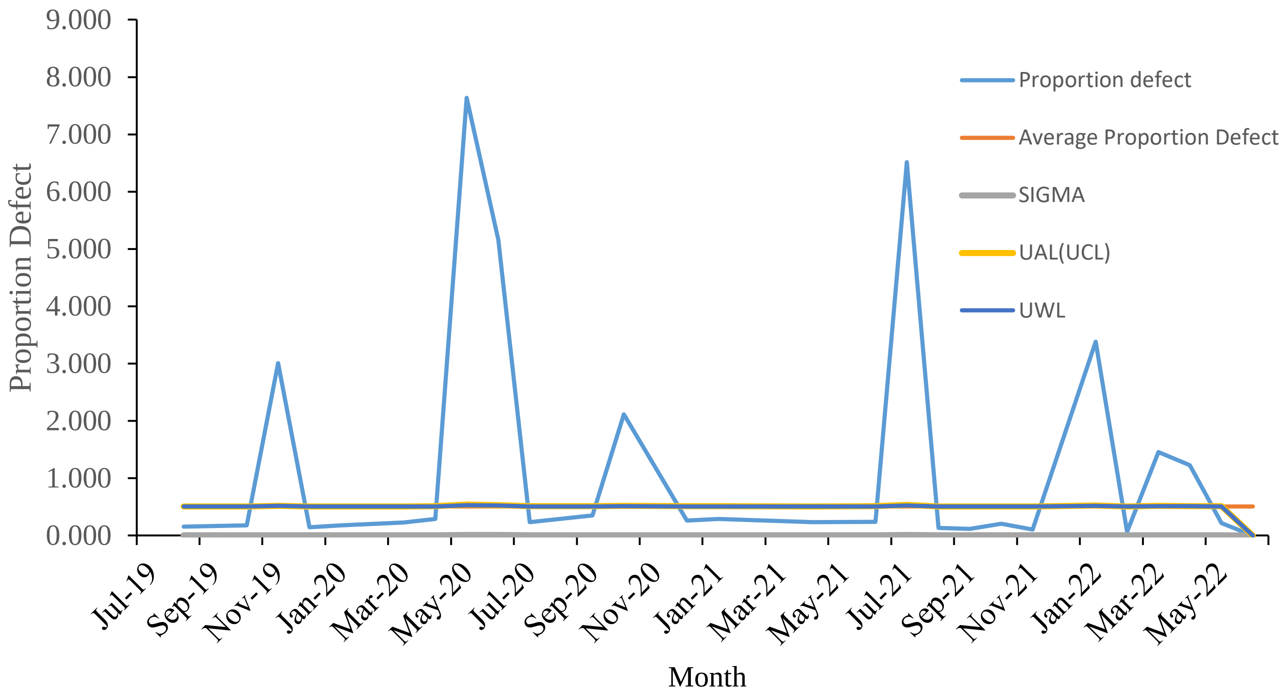
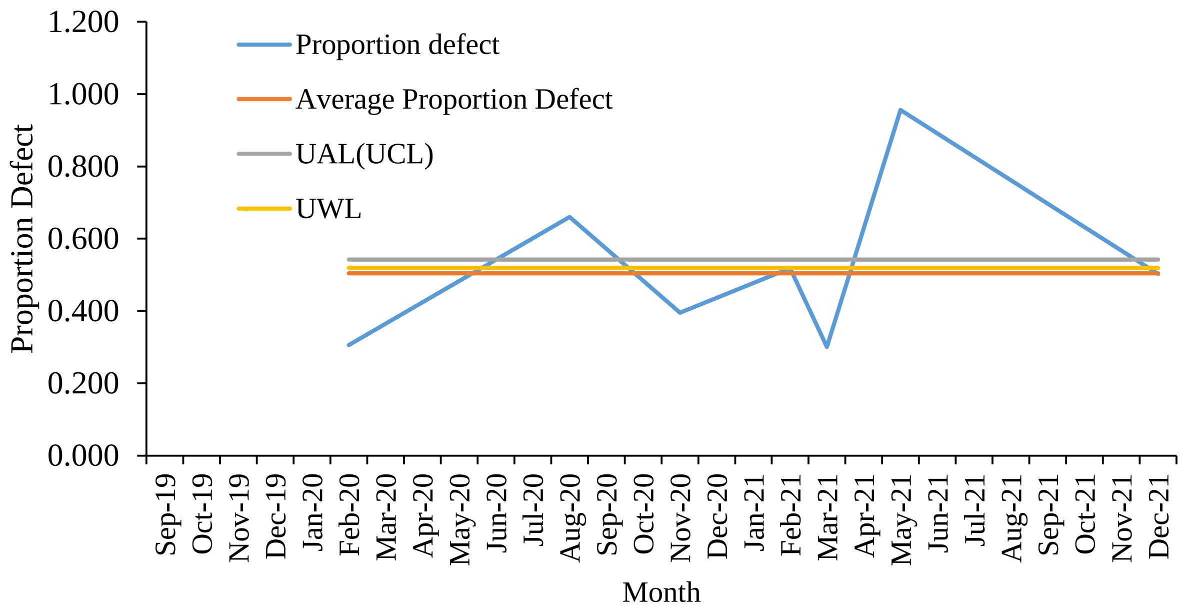


Figure 4-18: P chart for Vertical Raw Mill downtime out of the range



Note: UCL – upper control limit, UWL – upper warning limit

Figure 4-19 : P chart for vertical raw mill downtime within the range

Table 4.16 shows the detail of the calculations involved and the resulting action and warning lines. Figure 4.18 and 4.19 shows the *p*-chart plotted with the varying action and warning lines for the recorded data lies between the range as well as out of range data. It is evident that the design, calculation, plotting and interpretation of *p*-charts is more complex than that associated with *np*-charts. The cement plant VRM (vertical raw mill) downtime is out of control which is seen in the chart shown above. Clearly, in vertical raw mill area there are so many downtimes happened due to unpredictable breakdown happening which causes inefficiency for the plant since it is a line layout plant. from the chart shown above the 26 recorded data is out of control and are so many down times compared to the issue sample (downtime happened per month). On June 20 and august 21 the proportion defect was very high that shows the down time on those months were high that was caused due to power outage and raw material shortage.

4.2.2 Rotary Kiln

Cement kiln are used for the pyro-processing stage of manufacturing of port land and other types of hydraulic cement, in which calcium carbonate reacts with silica-bearing minerals to form calcium silicates. Over a billion tons of cement are made per year, and cement kilns are the heart of this production processes.

4.2.2.1 Root Causes of Rotary Kiln Downtime

The main root causes of rotary kiln down time were due to the unavailability of coal in our country so mostly uses imported coal. Now a days the coal was found in certain areas but still the quality was not enough to use it as energy source since the calorific value or carbon content were very low. So due to those reasons the stoppage of clinker is not advisable but on top of the coal shortage the machine would stop due to high atmospheric air temperature increment.

Table 4-17 : Kiln total machinery running time versus down time from 2019-2020

MONTH	Total (Rh) / MONTH	Total (Dt)/MONTH
Jul-19	731.83	12.1
Aug-19	739.86	4.13
Sep-19	608.12	111.87
Oct-19	221.97	522.03
Nov-19	706.94	13.05

Dec-19	700.09	43.86
Jan-20	719.79	24.2
Feb-20	551.68	144.33
Mar-20	726.76	17.23
Apr-20	131.73	588.26
May-20	129.87	614.13
Jun-20	692.80	28.1
Total	6661.44	2123.29

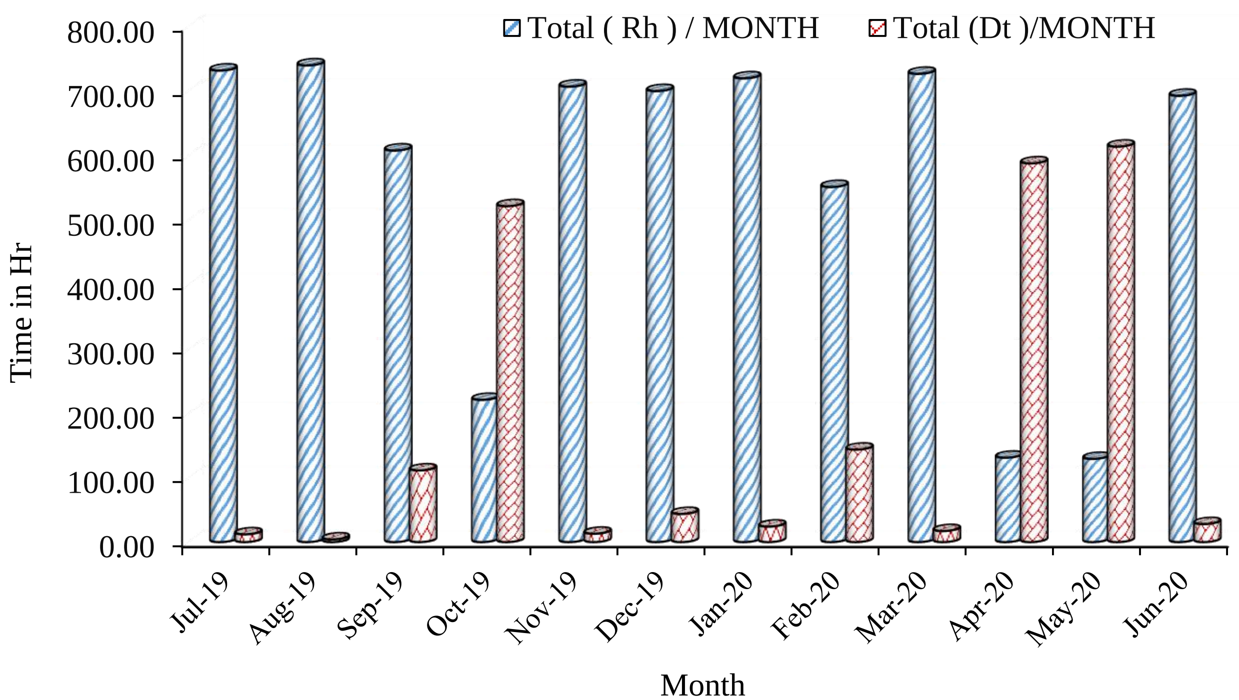


Figure 4-20 : Kiln total machinery running time versus down time from 2019-2022

Table 4-18 : Kiln total machinery running time versus down time from 2020-2021

MONTH	Total (Rh) / MONTH	Total (Dt)/MONTH
Jul-20	663.29	80.71
Aug-20	655.25	88.75
Sep-20	267.57	452.43
Oct-20	687.80	56.2

Nov-20	525.59	194.41
Dec-20	654.96	89.04
Jan-21	705.40	38.6
Feb-21	577.75	94.25
Mar-21	458.18	285.82
Apr-21	668.40	51.6
May-21	551.98	192.02
Jun-21	151.80	568.2
Total	6567.97	2192.03

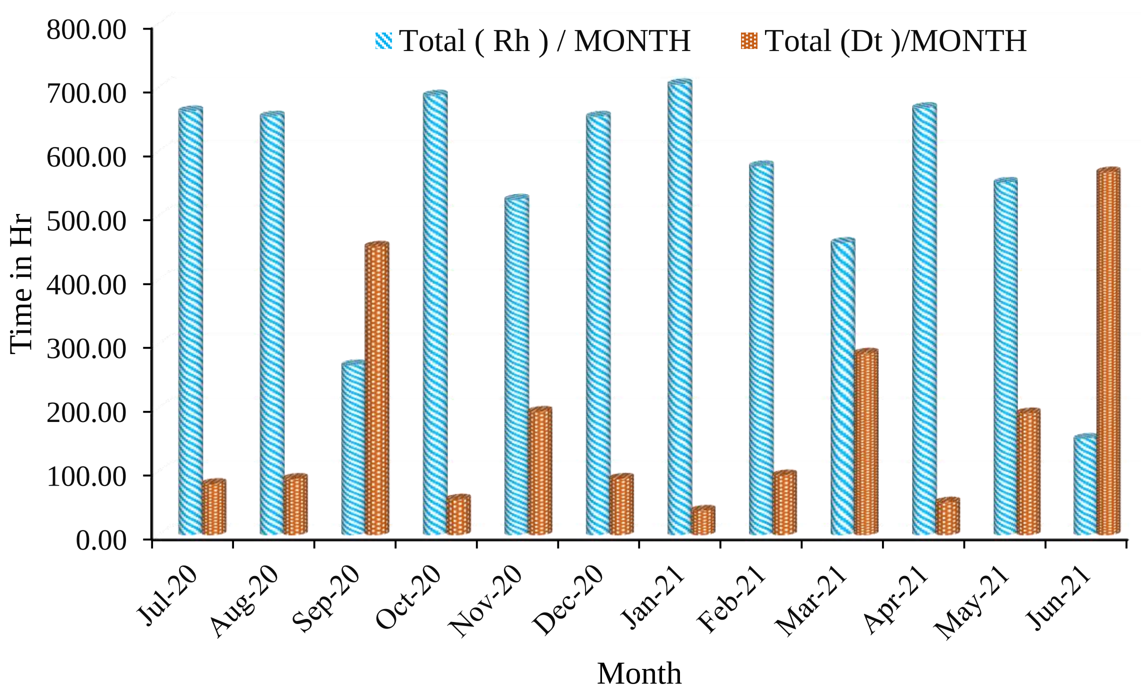


Figure 4-21 : Kiln total machinery running time versus down time from 2020-202

Table 4-19 : Kiln total machinery running time versus down time from 2021-2022

MONTH	Total (Rh) / MONTH	Total (Dt)/MONTH
Jul-20	723.29	20.71
Aug-20	731.60	12.4
Sep-20	648.48	71.52
Oct-20	733.76	10.24

Nov-20	181.25	538.75
Dec-20	605.38	138.62
Jan-21	699.20	44.8
Feb-21	304.51	367.49
Mar-21	408.11	335.89
Apr-21	663.62	56.38
May-21		
Jun-21		
Total	5699.20	1596.8

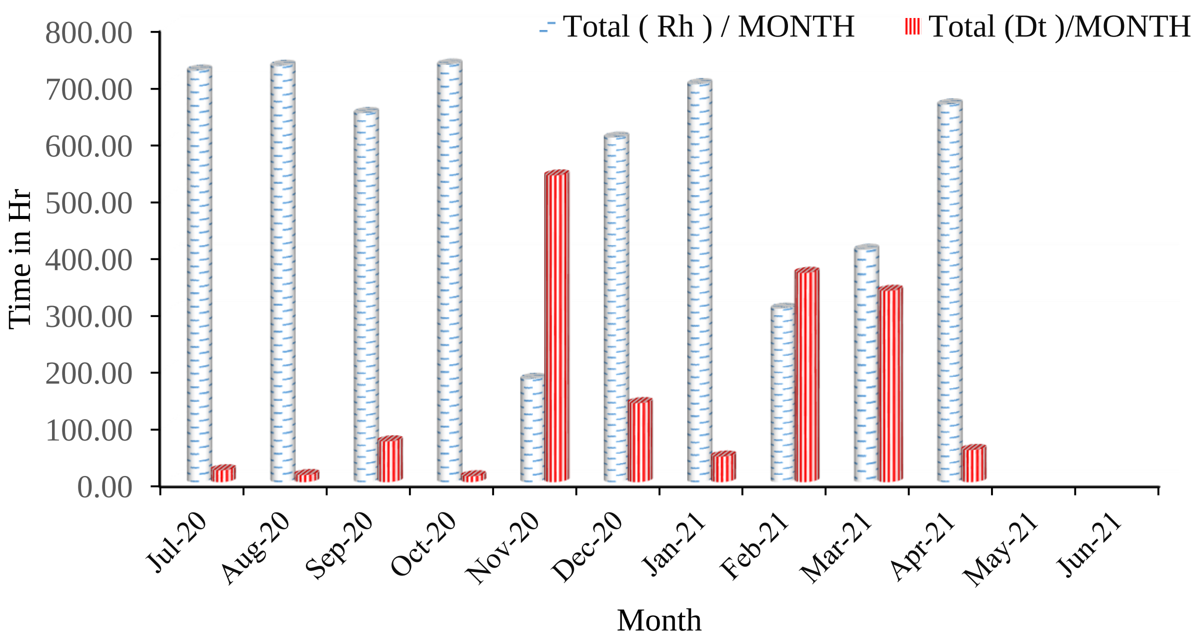


Figure 4-22 : Kiln total machinery running time versus down time from 2021-2022

In Figure 4.20, 4.21 & 4.22 shows how much the down time was in the last three years. As in the tables above shown the total downtime that the rotary kiln was 36% of running hour in average like in 2019,2020, 2021 the total down time was respectively 2123.29, 2192.03 and 1596.8 describes most that the down time was decreasing from 2019 to 202.which shows the rotary kiln was functional compared to the vertical raw mill but still the main cause for the stoppage for rotary kiln was shortage of quality coal and power-cutoff.

Table 4-20 : Three years of total running down time versus total downtime of rotary kiln

year	Total running Hour	Total Down time	total running hour %	Total Down time %
2019- 2020	6661.44	2123.29	74.61%	25.39%
2020 - 2021	6567.97	2192.03	73.57%	26.43%
2021 - 2022	5699.2	1596.8	63.84%	36.16%

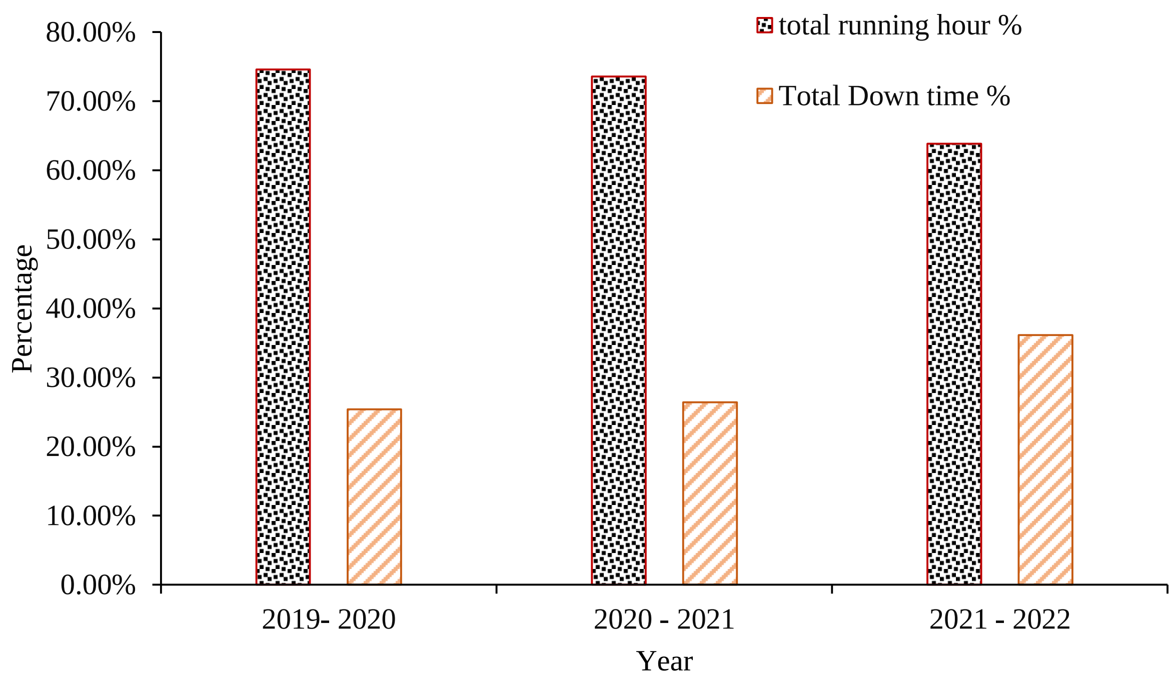


Figure 4-23 : Three years of down time versus running time of kiln

Table 4-21 : Three years of planned, external and unplanned downtime versus total running hour

year	External causes of down time	Maintenance down time	Total Running hour	unplanned Down time
2019- 2020	217.27	1693.52	6661.44	429.77
2020 - 2021	589.99	839.47	6567.97	1352.56

2021 - 2022	53.55	447.86	5699.2	1148.94

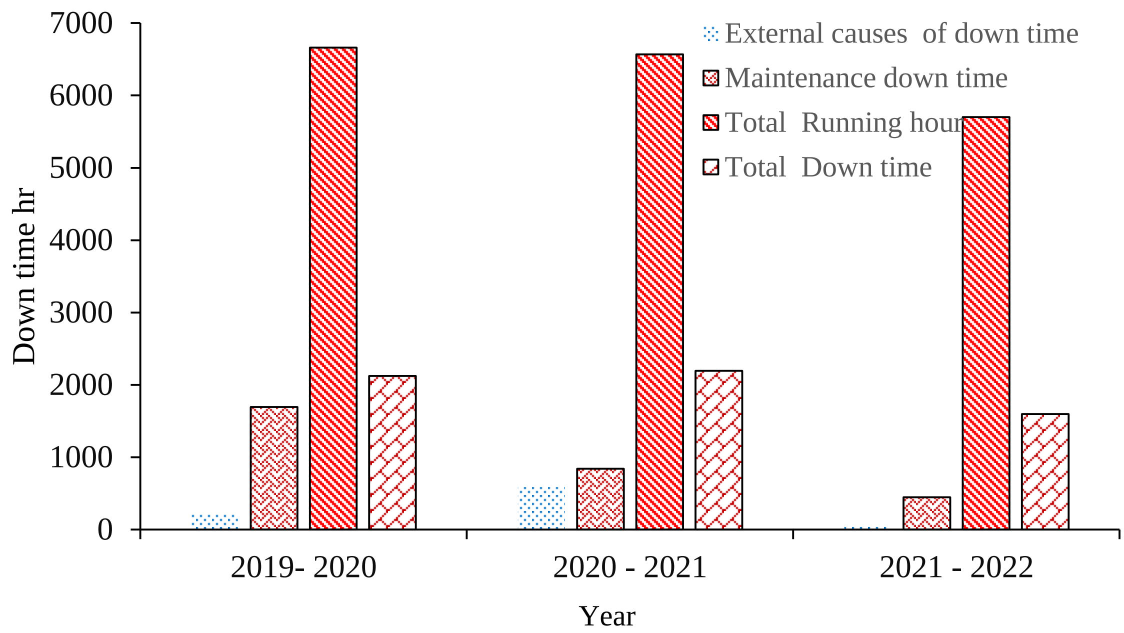


Figure 4-24 : three years of planned, external and unplanned downtime versus total running hour

On table 4.21 and figure 4.24 shows that in total of 2931.27 hr downtime in the last three years which was 29.3% of the total runing hour caused mainly due to main power cutt off From EEPCO or fluctuation, atmospheric temprature increment which causes certain areas of machineris would heat up and stop wortking. coal shortage which was the main energy source for the rotary kiln so that the different minirales so that it could be clinker as a final result.Which causes material inside the machineris losses its functionality. power consumption was also high due to the starting power when the power is down and released frequently due to the nature of machineries wanting more power at starting point it would be loss to the factory as well as for the country.

4.2.2.2 Downtime Analysis for Rotary Kiln

A rotary kiln used in cement production where limestone is decomposed into calcium oxide which forms the basis of cement clinker particles under high temperatures and also a physically large process in cement industry. Three years of monthly downtime data shown on table 4.22 could be analyzed below and find out the main reasons for the stoppage for the last three years.

Table 4-22 : three years of monthly down time sample data for rotary kiln

Sample Number	Month	Total (Rh) / Month	Total (Dt)/Month	Proportion Defect	Average Proportion Defective
1	Jul-19	731.83	12.1	0.017	0.312
2	Aug-19	739.86	4.13	0.006	0.312
3	Sep-19	608.12	111.87	0.184	0.312
4	Oct-19	221.97	522.03	2.352	0.312
5	Nov-19	706.94	13.05	0.018	0.312
6	Dec-19	700.09	43.86	0.063	0.312
7	Jan-20	719.79	24.2	0.034	0.312
8	Feb-20	551.68	144.33	0.262	0.312
9	Mar-20	726.76	17.23	0.024	0.312
10	Apr-20	131.73	588.26	4.466	0.312
11	May-20	129.87	614.13	4.729	0.312
12	Jun-20	692.80	28.1	0.041	0.312
13	Jul-20	663.29	80.71	0.122	0.312
14	Aug-20	655.25	88.75	0.135	0.312
15	Sep-20	267.57	452.43	1.691	0.312
16	Oct-20	687.80	56.2	0.082	0.312
17	Nov-20	525.59	194.41	0.370	0.312
18	Dec-20	654.96	89.04	0.136	0.312
19	Jan-21	705.40	38.6	0.055	0.312
20	Feb-21	577.75	94.25	0.163	0.312
21	Mar-21	458.18	285.82	0.624	0.312
22	Apr-21	668.40	51.6	0.077	0.312
23	May-21	551.98	192.02	0.348	0.312
24	Jun-21	151.80	568.2	3.743	0.312
25	Jul-21	723.29	20.71	0.029	0.312
26	Aug-21	731.60	12.4	0.017	0.312

27	Sep-21	648.48	71.52	0.110	0.312
28	Oct-21	733.76	10.24	0.014	0.312
29	Nov-21	181.25	538.75	2.972	0.312
30	Dec-21	605.38	138.62	0.229	0.312
31	Jan-22	699.20	44.8	0.064	0.312
32	Feb-22	304.51	367.49	1.207	0.312
33	Mar-22	408.11	335.89	0.823	0.312
34	Apr-22	663.62	56.38	0.085	0.312
35	May-22				0.312
36	Jun-22				0.312

By using the formula for variable sample size, we use: -

$$\bar{P} = {\sum_{i=1}^{k} x_i}\Big/{\sum_{i=1}^{k} n_i} \quad , \qquad \textbf{(5.2)}$$

$\sum_{i}^{k} Xi = 5912.12/\sum_{i}^{k} ni$=18928.61= 0.312

q = 1- p= 1- 0.312 = 0.688

If a constant 'sample' size is being inspected, the *p*-control chart limits would remain the same for each sample. But when *p*-charts are being used with samples of varying sizes, the standard deviation and control limits change with *n*, and unique limits should be calculated for each sample size. However, for practical purposes, an average sample size (*n* –) may be used to calculate action and warning lines. These have been found to be acceptable when the individual sample or lot sizes vary from *n* – by no more than 25 per cent each way. For sample sizes outside this range, separate control limits must be calculated. There is no magic in this 25 per cent formula; it simple has been show to work. The next stage then in the calculation of control limits for the *p*-chart, with varying sample size, is to determine the average sample size (*n* –) and the range 25 per cent either side:

${\sum_{i=1}^{k} ni}\Big/{K}$ = 18928.61/36 = 525.7948

ñ = n ± 0.25*n

= 394.3461 up to 627.2435

For sample sizes within this range, the control chart lines may be calculated using a value of σ given by:

$\delta = \frac{\sqrt{p(1-p)}}{\sqrt{n}}$ = 0.020211

The action line = p ± 3δ

= 0.251704 to 0.372971

The warning lines = p ± 2δ

= 0.271915 to 0.35276

Table 4-23 : calculation of p chart lines for sample size outside the range

Sample Number	Month	Total (Rh) / Month	Total (Dt)/Month	Proportion Defect	Average Proportion Defective	Sigma	UAL(UCL)	UWL
1	Jul-19	731.83	12.1	0.017	0.312	0.001267	0.3158	0.314533
2	Aug-19	739.86	4.13	0.006	0.312	0.001253	0.315758	0.314506
4	Oct-19	221.97	522.03	2.352	0.312	0.004176	0.324527	0.320352
5	Nov-19	706.94	13.05	0.018	0.312	0.001311	0.315933	0.314622
6	Dec-19	700.09	43.86	0.063	0.312	0.001324	0.315972	0.314648
7	Jan-20	719.79	24.2	0.034	0.312	0.001288	0.315863	0.314575
9	Mar-20	726.76	17.23	0.024	0.312	0.001275	0.315826	0.314551
10	Apr-20	131.73	588.26	4.466	0.312	0.007036	0.333109	0.326073
11	May-20	129.87	614.13	4.729	0.312	0.007137	0.333411	0.326274
12	Jun-20	692.80	28.1	0.041	0.312	0.001338	0.316014	0.314676
13	Jul-20	663.29	80.71	0.122	0.312	0.001397	0.316192	0.314795
15	Sep-20	267.57	452.43	1.691	0.312	0.003464	0.322392	0.318928
16	Oct-20	687.80	56.2	0.082	0.312	0.001348	0.316043	0.314695
19	Jan-21	705.40	38.6	0.055	0.312	0.001314	0.315942	0.314628
22	Apr-21	668.40	51.6	0.077	0.312	0.001387	0.31616	0.314773
24	Jun-21	151.80	568.2	3.743	0.312	0.006106	0.330318	0.324212
25	Jul-21	723.29	20.71	0.029	0.312	0.001281	0.315844	0.314563

26	Aug-21	731.60	12.4	0.017	0.312	0.001267	0.315801	0.314534
28	Oct-21	733.76	10.24	0.014	0.312	0.001263	0.31579	0.314526
29	Nov-21	181.25	538.75	2.972	0.312	0.005114	0.327342	0.322228
31	Jan-22	699.20	44.8	0.064	0.312	0.001326	0.315977	0.314651
32	Feb-22	304.51	367.49	1.207	0.312	0.003044	0.321132	0.318088
34	Apr-22	663.62	56.38	0.085	0.312	0.001397	0.31619	0.314793
35	May-22				0.312			
36	Jun-22				0.312			

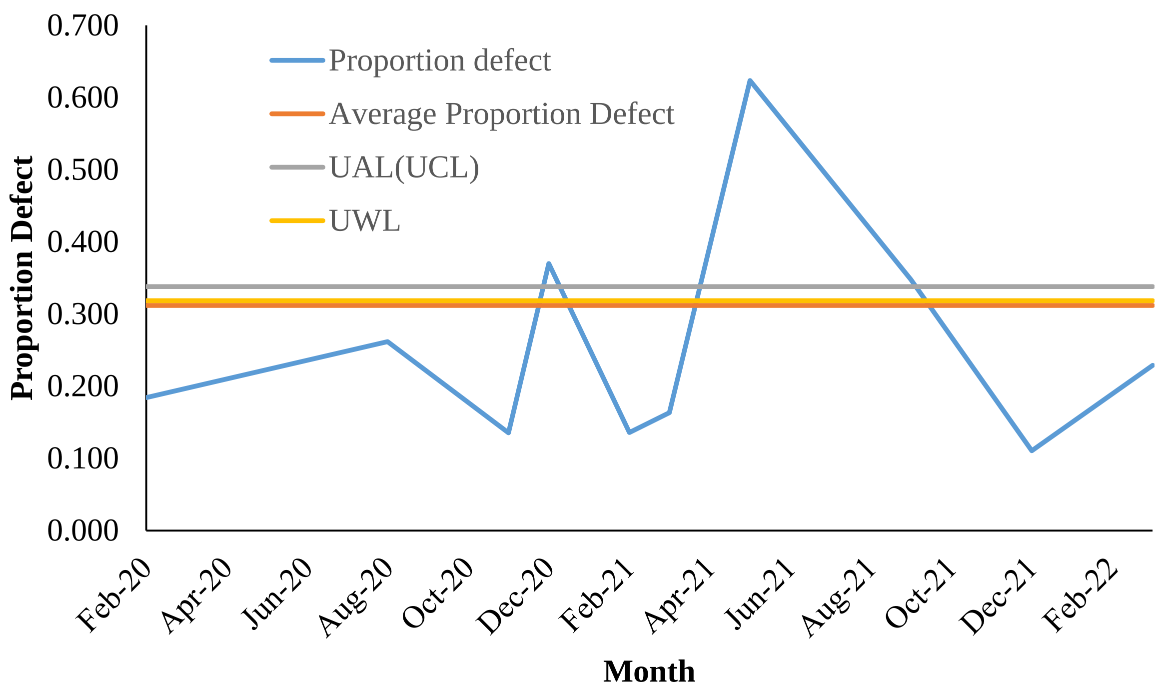


Figure 4-25 : P chart for rotary kiln downtime within the range

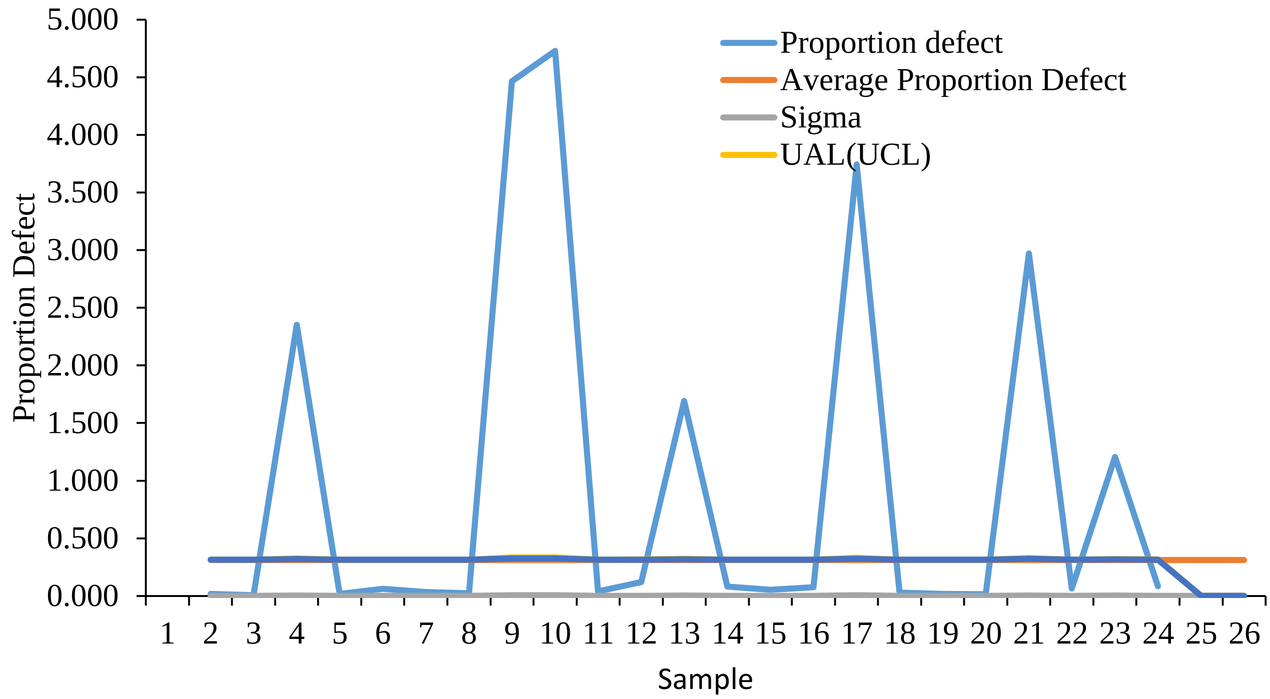


Figure 4-26 : P chart for rotary kiln downtime out of the range

Table 4-23 shows the detail of the calculations involved and the resulting action and warning lines. Figure 4-25 and 4-26 shows the *p*-chart plotted with the varying action and warning lines for the recorded data lies between the range as well as out of range data. It is evident that the design, calculation, plotting and interpretation of *p*-charts is more complex than that associated with *np*-charts. The cement plant rotary kiln downtime is out of control which is seen in the chart shown above. Clearly, in vertical raw mill area there are so many downtimes happened due to unpredictable brake down happening which causes inefficiency for the plant since it is a line layout plant. from the chart shown above the 25 recorded data was out of control and are so many down times compared to the issue sample (downtime happened per month). So, excluding the seven months out of upper control limit that show higher downtime caused due to mechanical, electrical, and external problems. The availability or running hour of vertical raw mill was very stable on the other months in figure 4.26 shows abnormal or very large downtime was recorded. Mostly due to maintenance time that it would take them to fix or maintain one machinery according to the type of machine should be limited and should be given to the mechanic the sop or standard operating procedure for maintenance. In which that will show him each procedure of how to maintain the machinery, the manpower needed and the time needed. By using this procedures downtime could be minimized

4.2.3 Cement mill line 1

A cement mill (or finish mill in North American usage) is the equipment used to grind the hard, nodular clinker from the cement kiln into the fine grey powder that is cement. Most cement is currently ground in ball mills and also vertical roller mills which are more effective than ball mills.

4.2.3.1 Root causes of downtime of cement mill

Base component failures are some of the main causes of equipment and machinery breakdowns. Vibration, misalignment, heat exposure, and general wear can all result in component problems that cause avoidable downtime.

The types of failures vary depending on the type of component and its placement:

- **Rotating equipment** - Vibration and misalignment affects pumps, gearboxes, fans, blowers, centrifuges and more.
- **Static equipment** - Leaks and misalignment in pipes, flanges, tanks and other static assets.
- **Electrical equipment** - Power overload, or electrical failures can stop a critical pump working that supplies essential water or hydraulic fluids to other components.

Manual maintenance mistakes, such as not spotting an oil leak early, as well as parts loosening or weakening over time due to excessive use, can lead to failure and downtime. In the global manufacturing industry, human error causes unplanned downtime 23% of the time, so proper training is vital. Machinery and equipment will wear out over time, so any aging machinery is more susceptible to parts or component failure, a common factor behind manufacturing downtime short periods of downtime may have less of an impact on your operations, but their effect on productivity and profit can soon add up. Common causes behind less severe downtime can include:

- Extended changeover times
- Excessive cleaning
- Early shutdowns
- Tool changes
- Personal breaks
-

Table 4-24 : total machinery time versus down time from 2019 - 2020

MONTH	**Total (Rh) / MONTH**	**Total (Dt)/MONTH**
7/31/2019	445.55	298.44
8/31/2019	435.45	308.55
9/30/2019	513.64	206.38
10/31/2019	496.19	247.82
11/30/2019	313.72	405.98
12/31/2019	525.88	218.12
1/31/2020	228.38	515.72
2/28/2020	181.68	514.31
3/31/2020	363.59	380.77
4/30/2020	402.00	317.78
5/31/2020	663.21	80.82
6/30/2020	669.45	50.18
Total	5238.74	3544.87

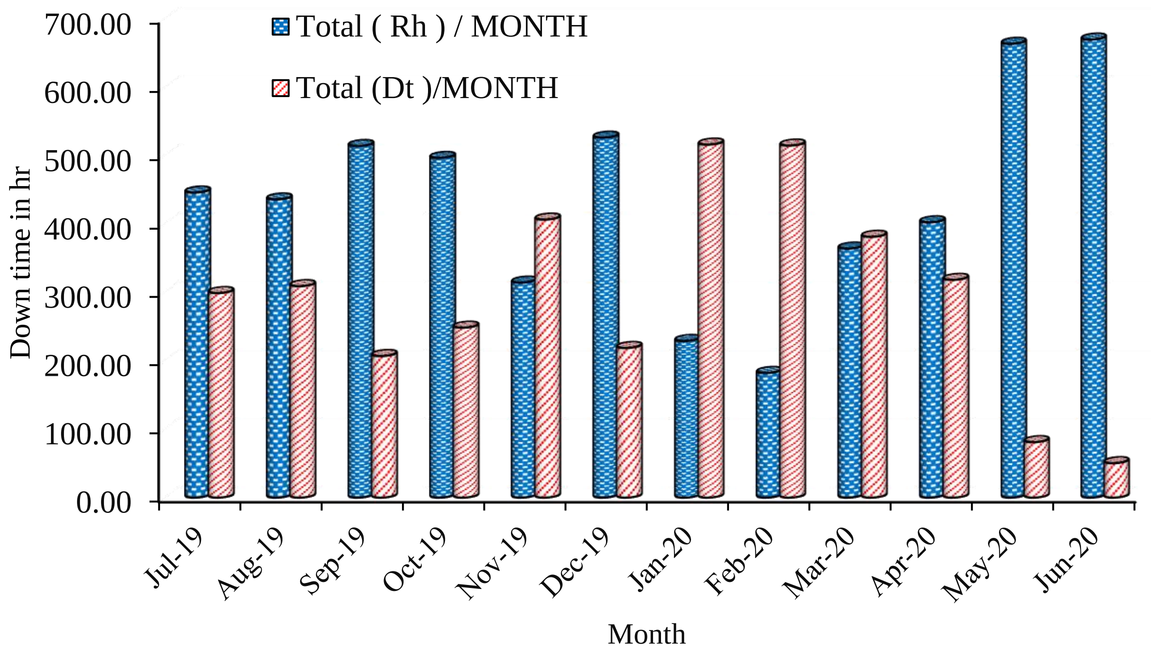


Figure 4-27 : total machinery running time versus down time from 2019-2020

Table 4-25 : total machinery running time versus down time from 2020-2021 years

MONTH	**Total (Rh) / MONTH**	**Total (Dt)/MONTH**
Jul-20	604.59	139.41
Aug-20	643.47	100.53
Sep-20	647.23	72.77
Oct-20	651.82	92.18
Nov-20	621.68	98.32
Dec-20	673.36	70.64
Jan-21	660.15	83.85
Feb-21	624.45	47.55
Mar-21	661.12	82.88
Apr-21	588.22	131.78
May-21	634.82	109.18
Jun-21	466.13	253.87
Total	7477.04	1282.96

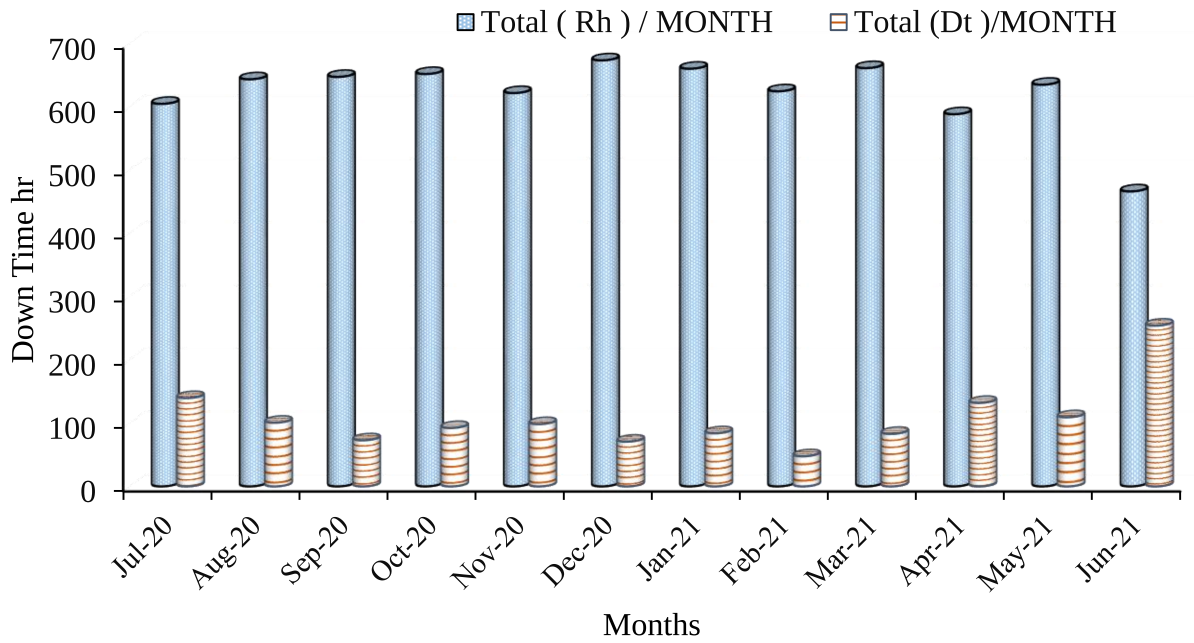


Figure 4-28 : total machinery running time versus down time from 2020-2021

Table 4-26 : total machinery running time versus down time from 2021-2022

Month	Total (Rh) / MONTH	Total (Dt)/MONTH
Jul-20	652.48	91.52
Aug-20	632.89	111.11
Sep-20	666.61	53.39
Oct-20	687.11	56.89
Nov-20	631.98	88.02
Dec-20	402.47	341.53
Jan-21	664.60	79.40
Feb-21	611.41	60.59
Mar-21	603.42	140.58
Apr-21	583.95	136.05
May-21		
Jun-21		
Total	6136.92	6136.92

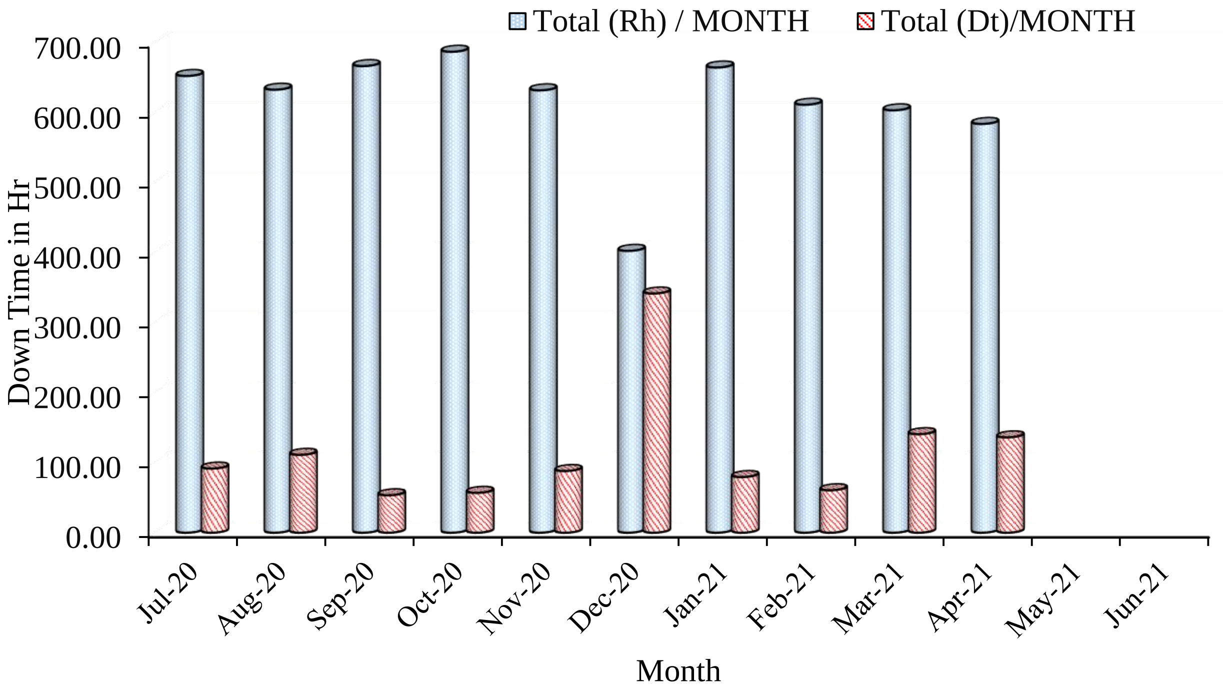


Figure 4-29 : total machinery running time versus down time from 2021-2022

On table 4.27 and figure 4-29 shows that in total of 2931.27 hr downtime in the last three years which was 29.3% of the total runing hour caused mainly due to main power cutt off From EEPCO or fluctuation, atmospheric temprature increment which causes certain areas of machineris would heat up and stop wortking. coal shortage which was the main energy source for the rotary kiln so that the different minirales so that it could be clinker as a final result.Which causes material inside the machineris losses its functionality. power consumption was also high due to the starting power when the power is down and released frequently due to the nature of machineries wanting more power at starting point it would be loss to the factory as well as for the country.

Table 4-27 : three years of total running down time versus total downtime of cement mill 1

year	Total running Hour	Total Down time	total running hour %	Total Down time %
2019- 2020	6661.44	2123.29	58.68%	39.70%
2020 - 2021	6567.97	2192.03	83.74%	14.37%

2021 - 2022	5699.2	1596.8	68.74%	12.98%

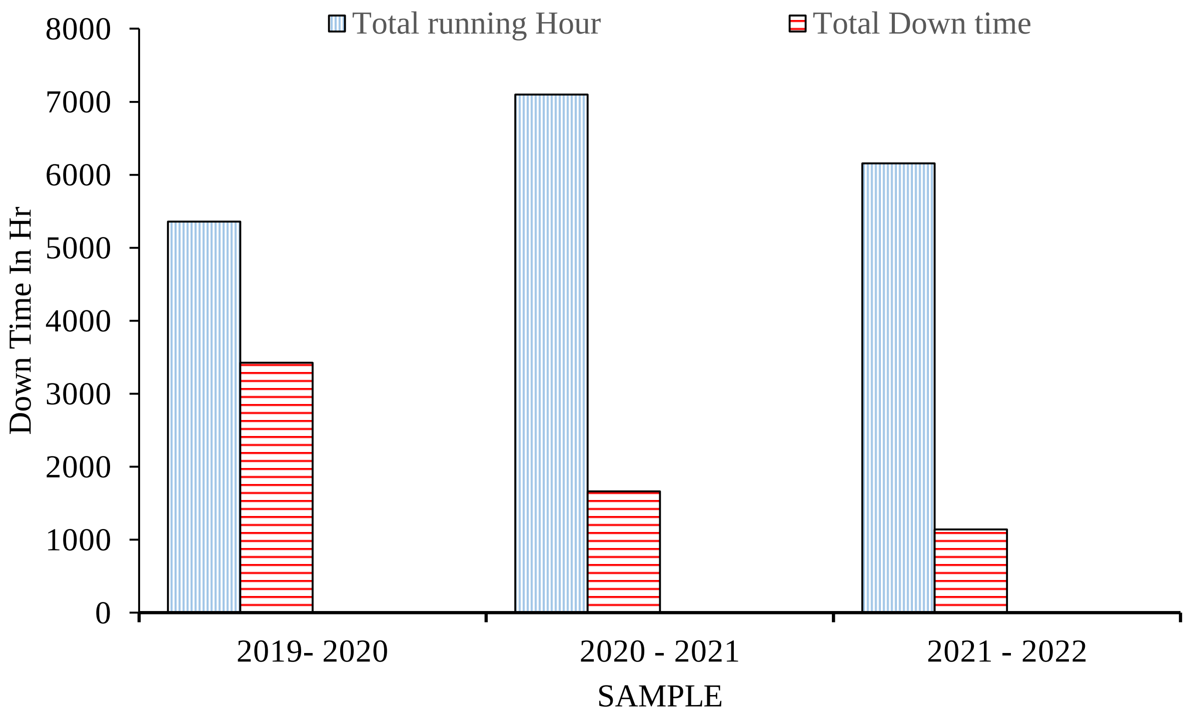


Figure 4-30 : three years of down time versus running time of cement mill 1

Table 4-28 : three years of planned, external and unplanned downtime versus total running hour

year	External causes of down time	Maintenance down time	Total Down time	Total Running hour
2019- 2020	2305.96	754.94	3544.87	4483.8
2020 - 2021	308.15	404.17	1282.96	7072.87
2021 - 2022	204.89	539.93	1159.08	5596.99

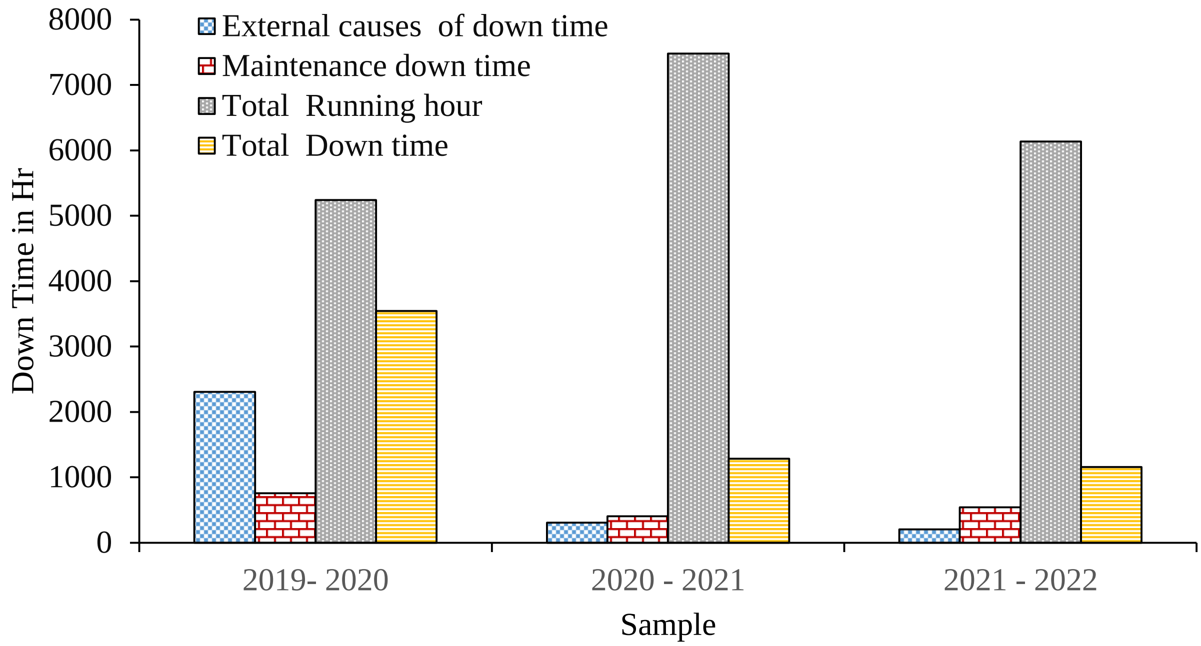


Figure 4-31 : three years of planned, external and maintenance downtime versus total running hour

Table 4.28 and figure 4.31 shows that in total of 2819 hr downtime in the last three years which was 22.35% of the total runing hour caused mainly due to main power cutt off From EEPCO or fluctuation, and 1699 hr was from atmospheric temprature change which caused machineris heat up and stop wortking. And most of the other down time was due to maintenance doun time and a breakdown due to poor follow up.

4.2.3.1.1 Downtime Analysis for Cement Line 1

Table 4.29 shows three years of monthly downtime data of cement mill 1 which was analyzed the upper and lower control limits and also the try to identify the higher downtime occurred and find out the main root cause.

Table 4-29 : three years of monthly down time sample data for cement mill line 1

Sample Number	Month	Total (Rh) / Month	Total (Dt)/Month	Proportion Defect	Average Proportion Defective
1	Jul-19	445.55	298.44	0.670	0.318
2	Aug-19	435.45	308.55	0.709	0.318

3	Sep-19	513.64	206.38	0.402	0.318
4	Oct-19	496.19	247.82	0.499	0.318
5	Nov-19	313.72	405.98	1.294	0.318
6	Dec-19	525.88	218.12	0.415	0.318
7	Jan-20	228.38	515.72	2.258	0.318
8	Feb-20	181.68	514.31	2.831	0.318
9	Mar-20	363.59	380.77	1.047	0.318
10	Apr-20	402.00	317.78	0.790	0.318
11	May-20	663.21	80.82	0.122	0.318
12	Jun-20	669.45	50.18	0.075	0.318
13	Jul-20	604.59	139.41	0.231	0.318
14	Aug-20	643.47	100.53	0.156	0.318
15	Sep-20	647.23	72.77	0.112	0.318
16	Oct-20	651.82	92.18	0.141	0.318
17	Nov-20	621.68	98.32	0.158	0.318
18	Dec-20	673.36	70.64	0.105	0.318
19	Jan-21	660.15	83.85	0.127	0.318
20	Feb-21	624.45	47.55	0.076	0.318
21	Mar-21	661.12	82.88	0.125	0.318
22	Apr-21	588.22	131.78	0.224	0.318
23	May-21	634.82	109.18	0.172	0.318
24	Jun-21	466.13	253.87	0.545	0.318
25	Jul-21	652.48	91.52	0.140	0.318
26	Aug-21	632.89	111.11	0.176	0.318
27	Sep-21	666.61	53.39	0.080	0.318
28	Oct-21	687.11	56.89	0.083	0.318
29	Nov-21	631.98	88.02	0.139	0.318
30	Dec-21	402.47	341.53	0.849	0.318
31	Jan-22	664.6	79.40	0.119	0.318
32	Feb-22	611.41	60.59	0.099	0.318
33	Mar-22	603.42	140.58	0.233	0.318

34	Apr-22	583.95	136.05	0.233	0.318
35	May-22			#DIV/0!	0.318
36	Jun-22			#DIV/0!	0.318

By using the formula for variable sample size, we use: -

$$\bar{P} = \sum_{i=1}^{k} x_i \Big/ \sum_{i=1}^{k} n_i \ , \qquad \textbf{(5.3)}$$

$\sum_i^k Xi = 5986.91/\sum_i^k ni$=18852.70= 0.318

q = 1- p= 1- 0.318 = 0.682

If a constant 'sample' size is being inspected, the *p*-control chart limits would remain the same for each sample. But when *p*-charts are being used with samples of varying sizes, the standard deviation and control limits change with *n*, and unique limits should be calculated for each sample size. However, for practical purposes, an average sample size (*n* –) may be used to calculate action and warning lines. These have been found to be acceptable when the individual sample or lot sizes vary from *n* – by no more than 25 per cent each way. For sample sizes outside this range, separate control limits must be calculated. There is no magic in this 25 per cent formula; it simple has been show to work. The next stage then in the calculation of control limits for the *p*-chart, with varying sample size, is to determine the average sample size (*n* –) and the range 25 per cent either side:

$\sum_{i=1}^{k} ni \Big/ K$ = 18852.70/36 = 523.6861

ñ = n ± 0.25*n

= 392.7646 up to 654.6076

For sample sizes within this range, the control chart lines may be calculated using a value of σ given by:

$\delta = \frac{\sqrt{p(1-p)}}{\sqrt{n}}$ = 0.020211

The action line = p ± 3δ

= 0.256534 to 0.378591

The warning lines = p ± 2δ

= 0.276877 to 0.358248

Table 4-30 : calculation of p chart lines for sample size outside the range

Sample Number	Month	Total (Rh) / Month	Total (Dt)/Month	Proportion Defect	Average Proportion Defective	Sigma	UAL(UCL)	UWL
5	Nov-19	313.72	405.98	1.294	0.318	0.002968	0.326903	0.323936
7	Jan-20	228.38	515.72	2.258	0.318	0.004077	0.33023	0.326154
8	Feb-20	181.68	514.31	2.831	0.318	0.005125	0.333374	0.328249
9	Mar-20	363.59	380.77	1.047	0.318	0.002561	0.325682	0.323121
11	May-20	663.21	80.82	0.122	0.318	0.001404	0.322212	0.320808
12	Jun-20	669.45	50.18	0.075	0.318	0.001391	0.322172	0.320782
18	Dec-20	673.36	70.64	0.105	0.318	0.001383	0.322148	0.320765
19	Jan-21	660.15	83.85	0.127	0.318	0.00141	0.322231	0.320821
21	Mar-21	661.12	82.88	0.125	0.318	0.001408	0.322225	0.320817
27	Sep-21	666.61	53.39	0.080	0.318	0.001397	0.32219	0.320793
28	Oct-21	687.11	56.89	0.083	0.318	0.001355	0.322065	0.32071
31	Jan-22	664.6	79.40	0.119	0.318	0.001401	0.322203	0.320802
35	May-22			#DIV/0!	0.318			
36	Jun-22			#DIV/0!	0.318			

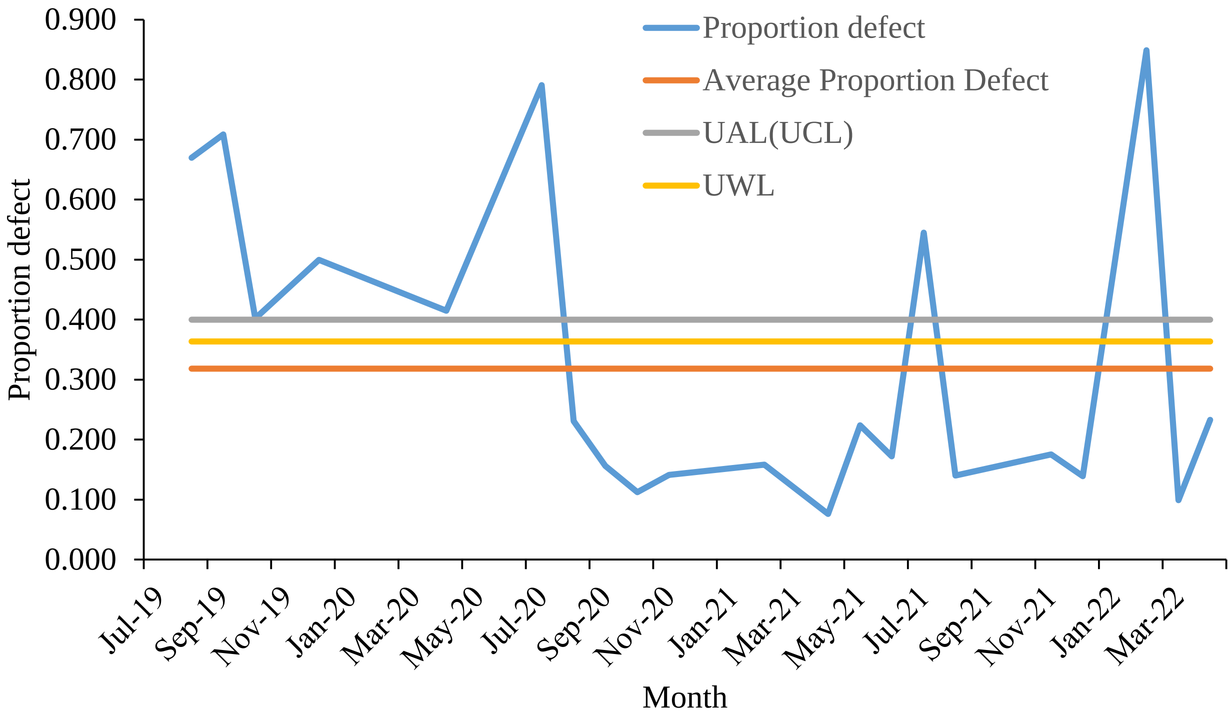


Figure 4-32 : P chart for cement mill line 1 downtime out of the range

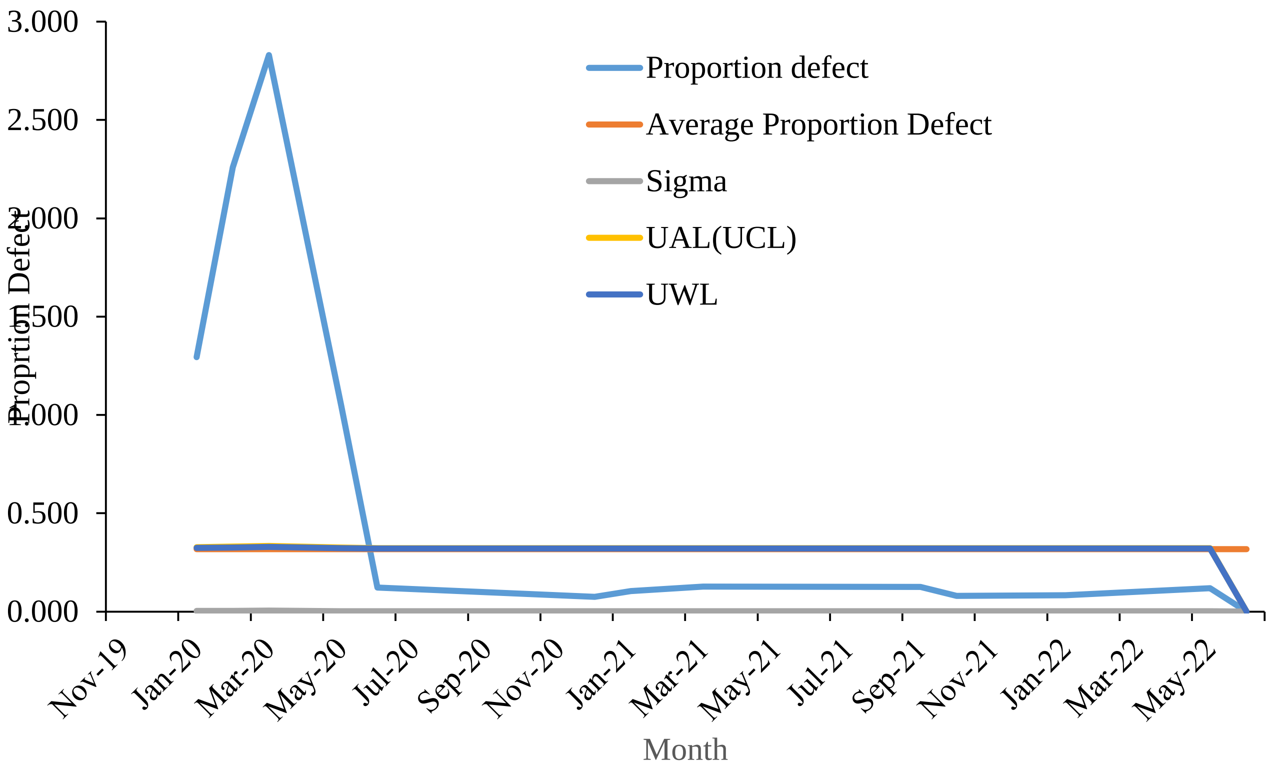


Figure 4-33 : p chart for cement mill line 1 downtime within the range

Table 4-30 shows the detail of the calculations involved and the resulting action and warning lines. Figure 4-32 and 4-33 shows the *p*-chart plotted with the varying action and warning lines for the recorded data lies between the range as well as out of range data. It is evident that the design, calculation, plotting and interpretation of *p*-charts is more complex than that associated with *np*-charts. The cement plant cement mill 1 downtime is out of control which is seen in the chart shown above. Clearly, in vertical raw mill area there are so many downtimes happened due to unpredictable brake down happening which causes inefficiency for the plant since it is a line layout plant. from the chart shown above the 14 recorded data is out of control and are so many down times compared to the issue sample (downtime happened per month).

4.2.4 Cement mill line 2

A cement mill (or finish mill in North American usage) is the equipment used to grind the hard, nodular clinker from the cement kiln into the fine grey powder that is cement. Most cement is currently ground in ball mills and also vertical roller mills which are more effective than ball mills.

Table 4-31 : CM 2 total machinery running time versus down time from 2019-2020

MONTH	Total (Rh) / MONTH	Total (Dt)/MONTH
Jul-19	488.65	255.81
Aug-19	506.09	237.92
Sep-19	228.26	491.58
Oct-19	496.6	247.26
Nov-19	415.34	304.66
Dec-19	519.9	224.05
Jan-20	365.01	379.01
Feb-20	360.08	335.65
Mar-20	181.04	562.97
Apr-20	446.89	273.21
May-20	681.37	62.68
Jun-20	669.45	50.18
Total	5358.676	3424.98

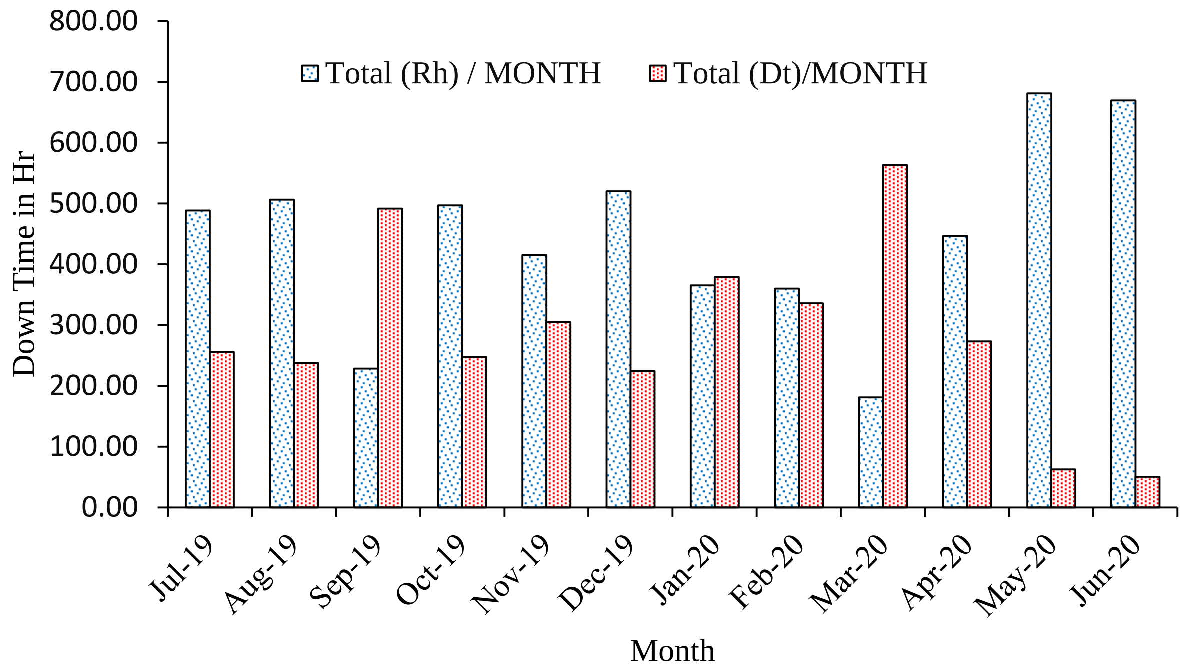


Figure 4-34 : CM 2 total machinery running time versus down time from 2019-2020

Table 4-32 : cm 2 total machinery running time versus down time from 2020-2021

MONTH	Total (Rh) / MONTH	Total (Dt)/MONTH
Jul-20	650.46	93.54
Aug-20	625.19	118.81
Sep-20	619.58	100.42
Oct-20	500.64	243.36
Nov-20	625.75	94.25
Dec-20	676.36	67.64
Jan-21	692.94	51.06
Feb-21	529.98	142.02
Mar-21	623.57	120.43
Apr-21	599.84	120.16
May-21	460.52	283.48
Jun-21	492.53	227.47
Total	7097.36	1662.64

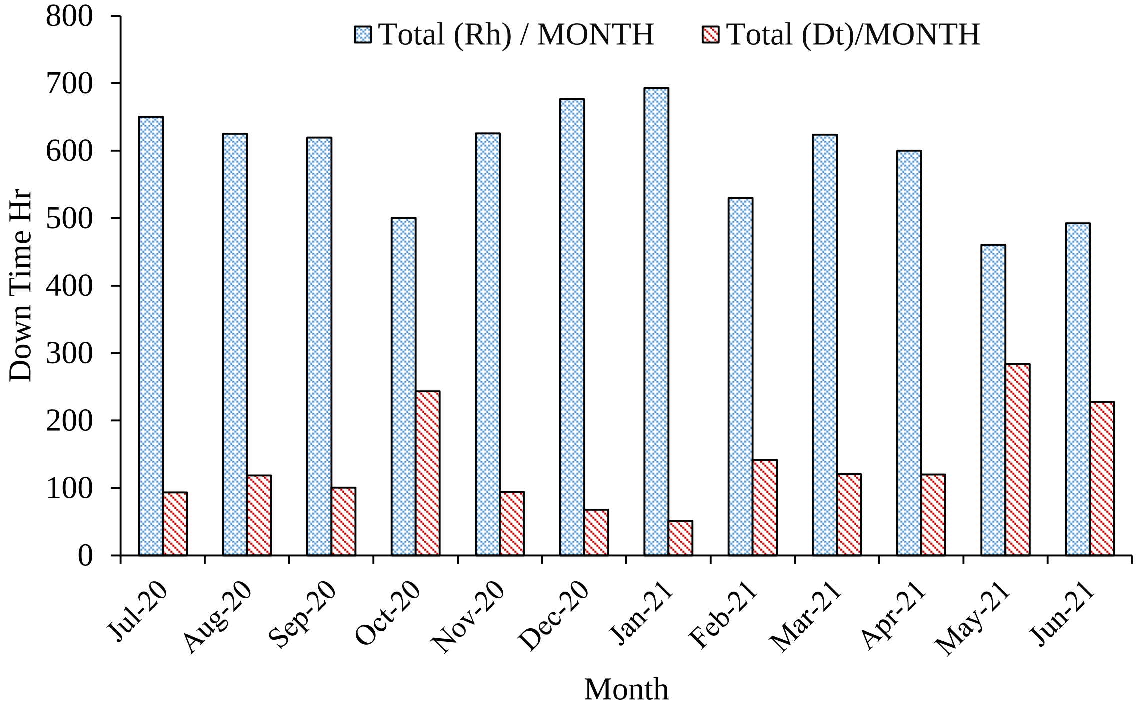


Figure 4-35 : cm 2 total machinery running time versus down time from 2020-2021

Table 4-33 : cm 2 total machinery running time versus down time from 2021-2022

MONTH	Total (Rh) / MONTH	Total (Dt)/MONTH
Jul-20	672.66	71.34
Aug-20	665.50	78.50
Sep-20	654.82	65.18
Oct-20	651.67	92.33
Nov-20	593.47	126.53
Dec-20	450.10	293.90
Jan-21	627.23	116.77
Feb-21	602.11	69.89
Mar-21	603.21	140.79
Apr-21	633.75	86.25
May-21		
Jun-21		
Total	6154.52	1141.48

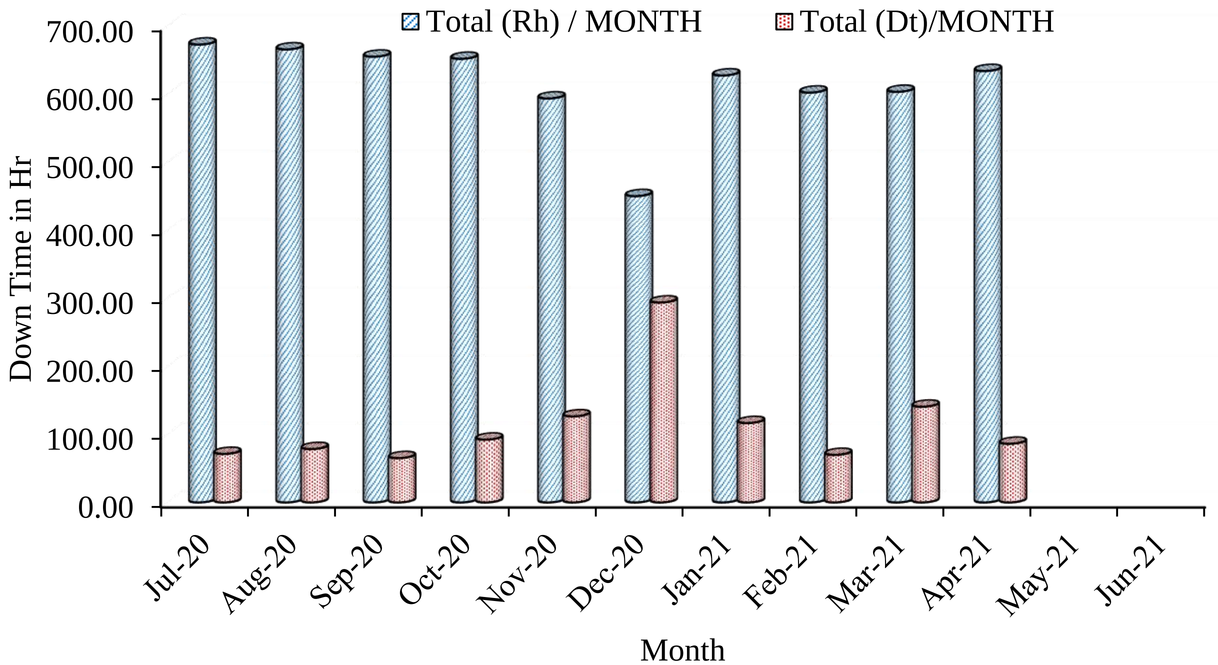


Figure 4-36 : CM 2 total machinery running time versus down time from 2021-2022

Table 4-34 : three years of total running down time versus total downtime of cm 2

year	Total running Hour	Total Down time	total running hour %	Total Down time %
2019- 2020	5358.676	3424.98	60.02%	38.36%
2020 - 2021	7097.36	1662.64	79.49%	18.62%
2021 - 2022	6154.52	1141.48	68.93%	12.78%

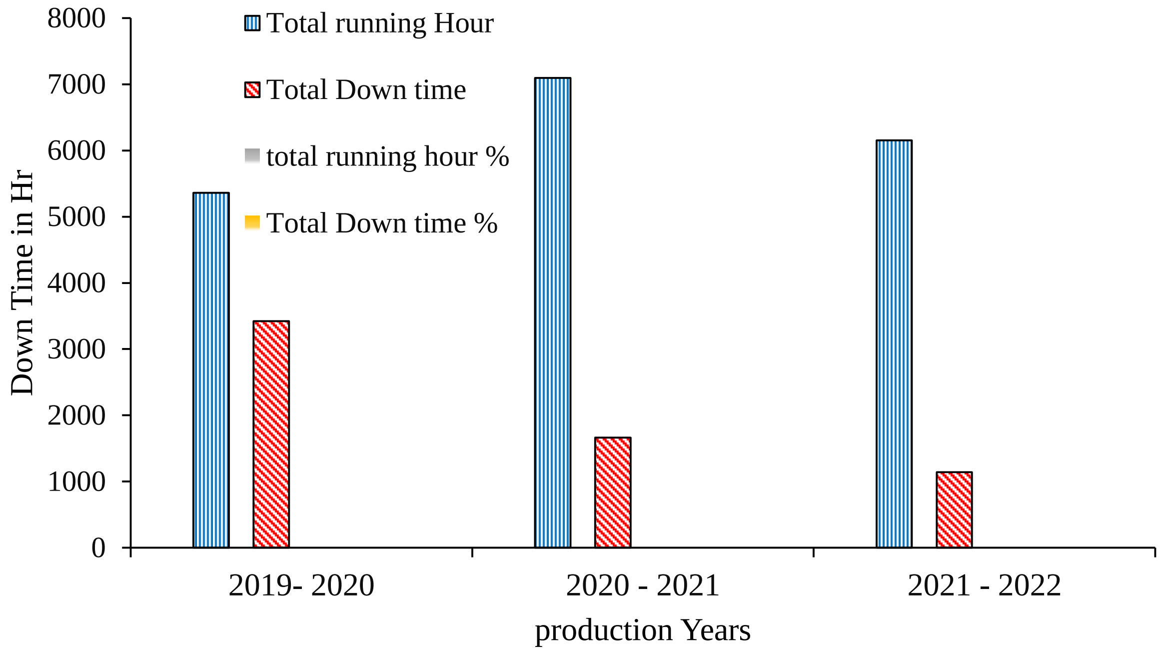


Figure 4-37 : three years of down time versus running time of cm 2

Table 4-35 : three years of planned, external and unplanned downtime versus total running hour

year	External causes of down time	Maintenance down time	Total down time	Total Running hour
2019- 2020	2061.93	747.58	2677.4	5358.676
2020 - 2021	320.32	635.41	1027.23	7097.36
2021 - 2022	209.72	411.78	729.7	6154.52

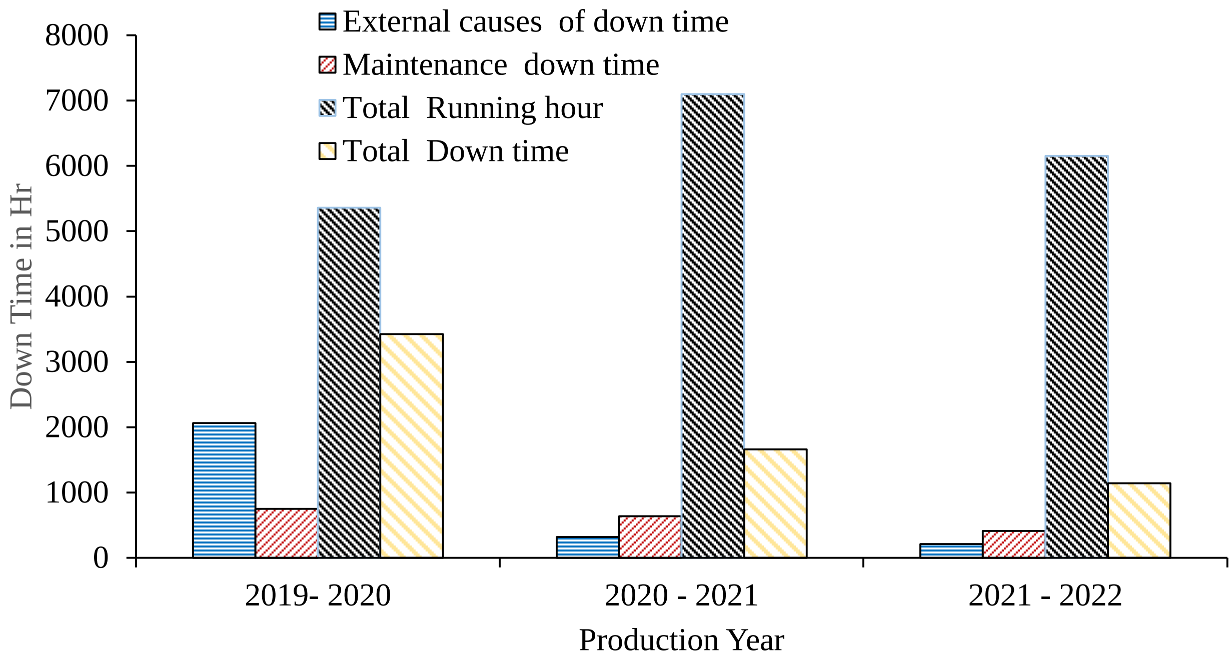


Figure 4-38 : three years of planned, external and unplanned downtime versus total running hour

4.2.4.1.1 Down time analysis for cement line 2

Table 4.36 shows three years of monthly downtime data of cement mill 1 which was analyzed the upper and lower control limits and also the try to identify the higher downtime occurred and find out the main root cause.

Table 4-36 : three years of monthly down time sample data for cement mill line 2

Sample Number	Month	Total (Rh) / Month	Total (Dt)/Month	Proportion Defect	Average Proportion Defective
1	Jul-19	488.65	255.81	0.524	0.335
2	Aug-19	506.09	237.92	0.470	0.335
3	Sep-19	228.26	491.58	2.154	0.335
4	Oct-19	496.6	247.26	0.498	0.335
5	Nov-19	415.34	304.66	0.734	0.335
6	Dec-19	519.9	224.05	0.431	0.335
7	Jan-20	365.01	379.01	1.038	0.335

8	Feb-20	360.08	335.65	0.932	0.335
9	Mar-20	181.04	562.97	3.110	0.335
10	Apr-20	446.89	273.21	0.611	0.335
11	May-20	681.37	62.68	0.092	0.335
12	Jun-20	669.45	50.18	0.075	0.335
13	Jul-20	650.46	93.54	0.144	0.335
14	Aug-20	625.19	118.81	0.190	0.335
15	Sep-20	619.58	100.42	0.162	0.335
16	Oct-20	500.64	243.36	0.486	0.335
17	Nov-20	625.75	94.25	0.151	0.335
18	Dec-20	676.36	67.64	0.100	0.335
19	Jan-21	692.94	51.06	0.074	0.335
20	Feb-21	529.98	142.02	0.268	0.335
21	Mar-21	623.57	120.43	0.193	0.335
22	Apr-21	599.84	120.16	0.200	0.335
23	May-21	460.52	283.48	0.616	0.335
24	Jun-21	492.53	227.47	0.462	0.335
25	Jul-21	672.66	71.34	0.106	0.335
26	Aug-21	665.50	78.5	0.118	0.335
27	Sep-21	654.82	65.18	0.100	0.335
28	Oct-21	651.67	92.33	0.142	0.335
29	Nov-21	593.47	126.53	0.213	0.335
30	Dec-21	450.10	293.9	0.653	0.335
31	Jan-22	627.23	116.7666667	0.186	0.335
32	Feb-22	602.11	69.89	0.116	0.335
33	Mar-22	603.21	140.79	0.233	0.318
34	Apr-22	633.75	86.25	0.136	0.318
35	May-22				0.318
36	Jun-22				0.318

By using the formula for variable sample size, we use: -

$\bar{P} = \sum_{i=1}^{k} x_i \Big/ \sum_{i=1}^{k} n_i$, **5.4**

$\sum_i^k Xi = 6229.096667/\sum_i^k ni$=18610.56= 0.335

q = 1- p= 1- 0.335 = 0.665

If a constant 'sample' size is being inspected, the *p*-control chart limits would remain the same for each sample. But when *p*-charts are being used with samples of varying sizes, the standard deviation and control limits change with *n*, and unique limits should be calculated for each sample size. However, for practical purposes, an average sample size (*n* –) may be used to calculate action and warning lines. These have been found to be acceptable when the individual sample or lot sizes vary from *n* – by no more than 25 per cent each way. For sample sizes outside this range, separate control limits must be calculated. There is no magic in this 25 per cent formula; it simple has been show to work. The next stage then in the calculation of control limits for the *p*-chart, with varying sample size, is to determine the average sample size (*n* –) and the range 25 per cent either side:

$\sum_{i=1}^{k} ni \Big/ K$ = 18610.56/36 = 516.96

ñ = n ± 0.25*n

= 387.72 up to 646.2

For sample sizes within this range, the control chart lines may be calculated using a value of σ given by:

$\delta = \frac{\sqrt{p(1-p)}}{\sqrt{n}}$ = 0.020754

The action line = p ± 3δ

= 0.272444 to 0.396971

The warning lines = p ± 2δ

= 0.293199 to 0.376216

Table 4-37 : calculation of p chart lines for sample size outside the range

Sample Number	Month	Total (Rh) / Month	Total (Dt)/Month	Proportion Defect	Average Proportion Defective	Sigma	UAL(UCL)	UWL
3	Sep-19	228.26	491.58	2.154	0.335	0.004135	0.347404	0.343269
7	Jan-20	365.01	379.01	1.038	0.335	0.002586	0.342757	0.340171
8	Feb-20	360.08	335.65	0.932	0.335	0.002621	0.342863	0.340242
9	Mar-20	181.04	562.97	3.110	0.335	0.005213	0.350639	0.345426
11	May-20	681.37	62.68	0.092	0.335	0.001385	0.339155	0.33777
12	Jun-20	669.45	50.18	0.075	0.335	0.00141	0.339229	0.33782
13	Jul-20	650.46	93.54	0.144	0.335	0.001451	0.339353	0.337902
18	Dec-20	676.36	67.64	0.100	0.335	0.001395	0.339186	0.337791
19	Jan-21	692.94	51.06	0.074	0.335	0.001362	0.339086	0.337724
25	Jul-21	672.66	71.34	0.106	0.335	0.001403	0.339209	0.337806
26	Aug-21	665.50	78.5	0.118	0.335	0.001418	0.339254	0.337836
27	Sep-21	654.82	65.18	0.100	0.335	0.001441	0.339324	0.337883
28	Oct-21	651.67	92.33	0.142	0.335	0.001448	0.339345	0.337896
35	May-22				0.318			
36	Jun-22				0.318			

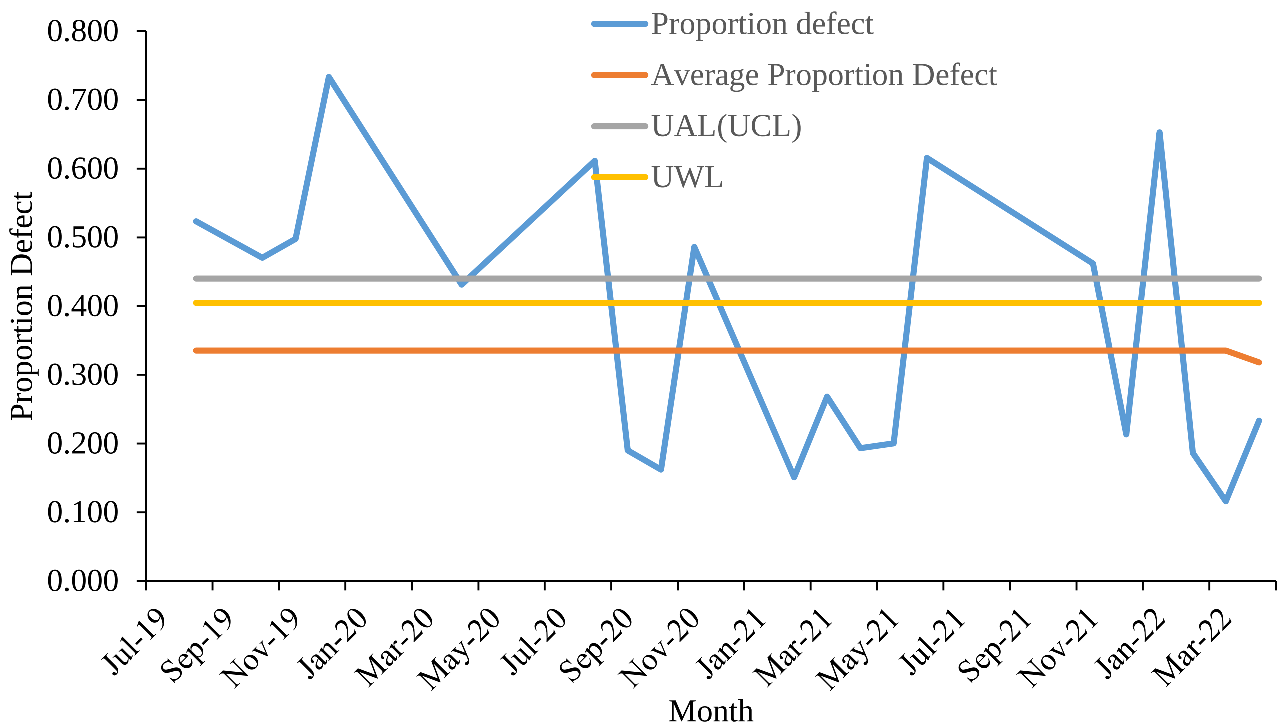


Figure 4-39 : P Chart for Cement Mill Line 2 Downtime Out of The Range

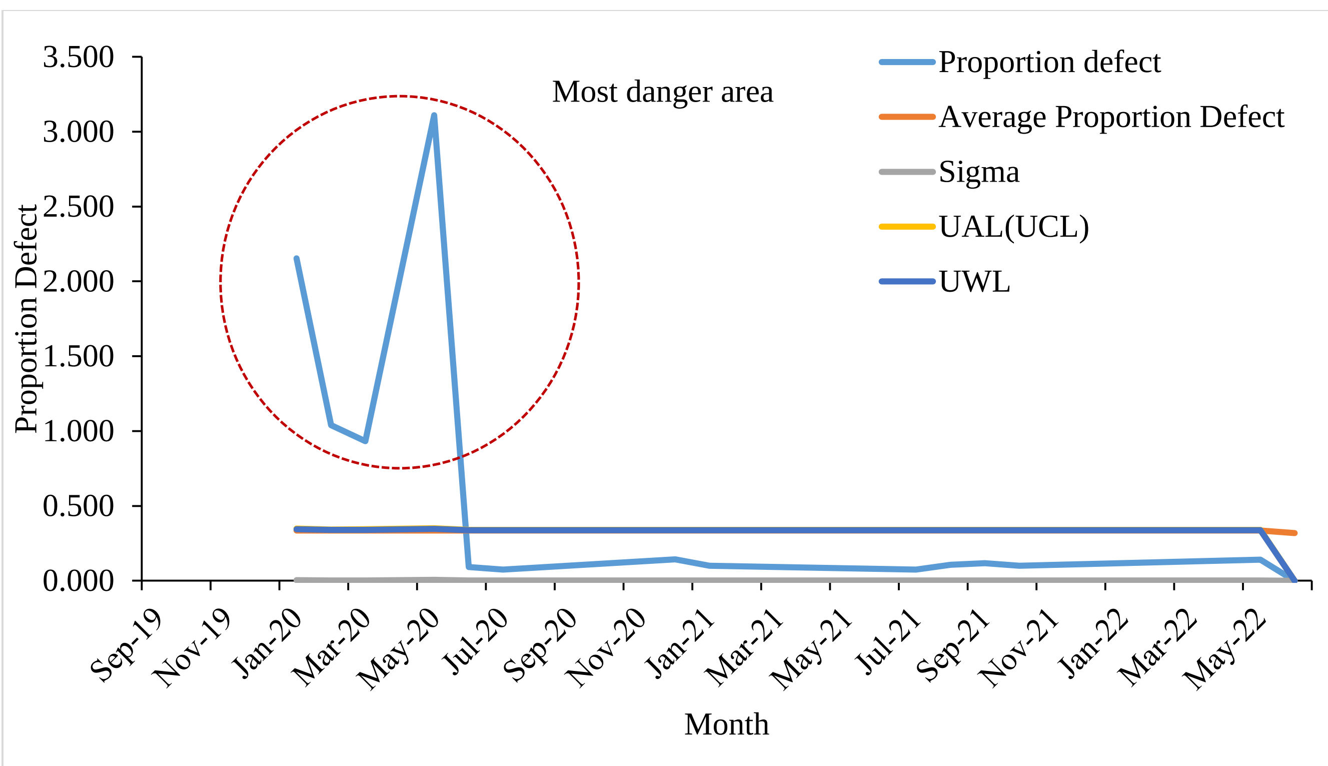


Figure 4-40 : p chart for cement mill line 1 downtime out of the range

Table 4-37 shows the detail of the calculations involved and the resulting action and warning lines. Figure 4-39 and 4-40 shows the *p*-chart plotted with the varying action and warning lines for the recorded data lies between the range as well as out of range data. It is evident that the design, calculation, plotting and interpretation of *p*-charts is more complex than that associated with *np*-charts. The cement plant VRM (vertical raw mill) downtime is out of control which is seen in the chart shown above. Clearly, in vertical raw mill area there are so many downtimes happened due to unpredictable brake down happening which causes inefficiency for the plant since it is a line layout plant. from the chart shown above the 15 recorded data is out of control and are so many down times compared to the issue sample (downtime happened per month).

4.3 Discussion and Results

4.3.1 In Control and Out of Control For VRM, Kiln and Cement Mill

Figure 4-41 up to 4-44 below shows the detail of the calculations involved and the resulting action and warning lines. It is evident that the design, calculation, plotting and interpretation of *p*-charts is more complex than that associated with *np*-charts. This type of control chart may improve substantially the dialogue and partnership between suppliers and customers.

From the general data analysis, that we have seen that the downtime which is out of control is very high as we can see in figure below and mostly caused due to the frequent power fluctuation which affects both the company due to stoppage and national grid as well due to high power consumption while starting to reduce the loss for more than the upper control line but for less than the lower control limits the company management should see in detail why the downtime is less or breakdown is less and need to work more on those efficiencies. Sample points falling below the lower action line also indicate a process which is out of control. Lower control lines are frequently omitted to avoid the need to explain to operating personnel why a very low proportion defectives are classed as being out-of-control. When the *p*-chart is to be used by management, however, the lower lines are used to indicate when an investigation should be instigated to discover the cause of an unusually good performance. This may also indicate how it may be repeated. The lower controls limits are given in figure bellow shown by the red dote on the chart which is less than the lower action line.

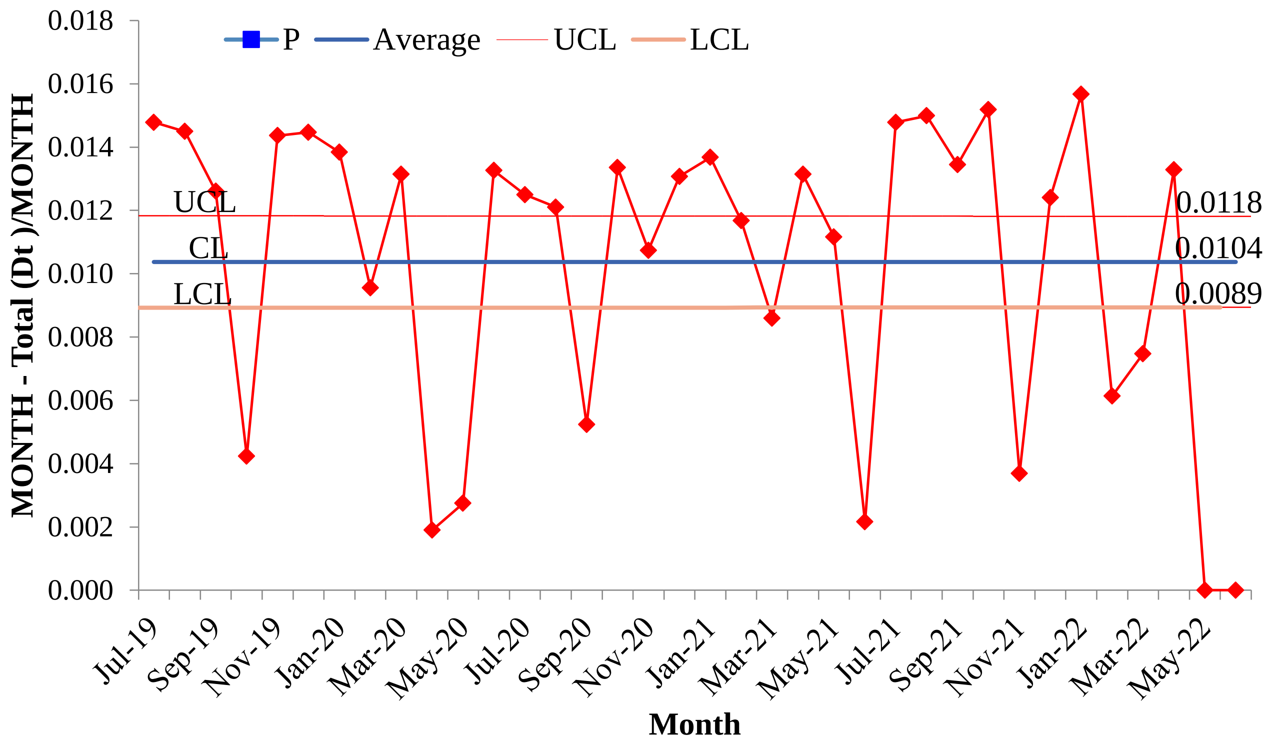


Figure 4-41 : Total running hour of vertical raw mill in control and out of control

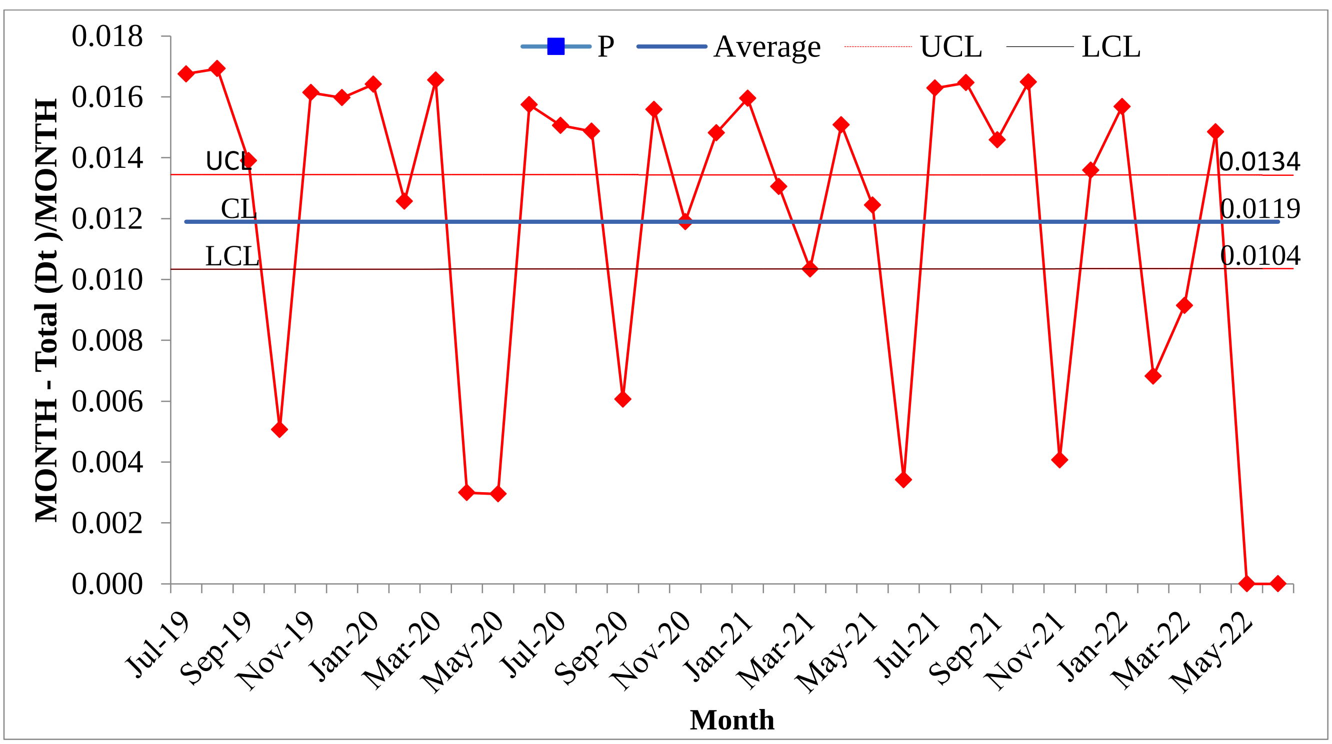


Figure 4-42 : Total running hour of kiln in control and out of control

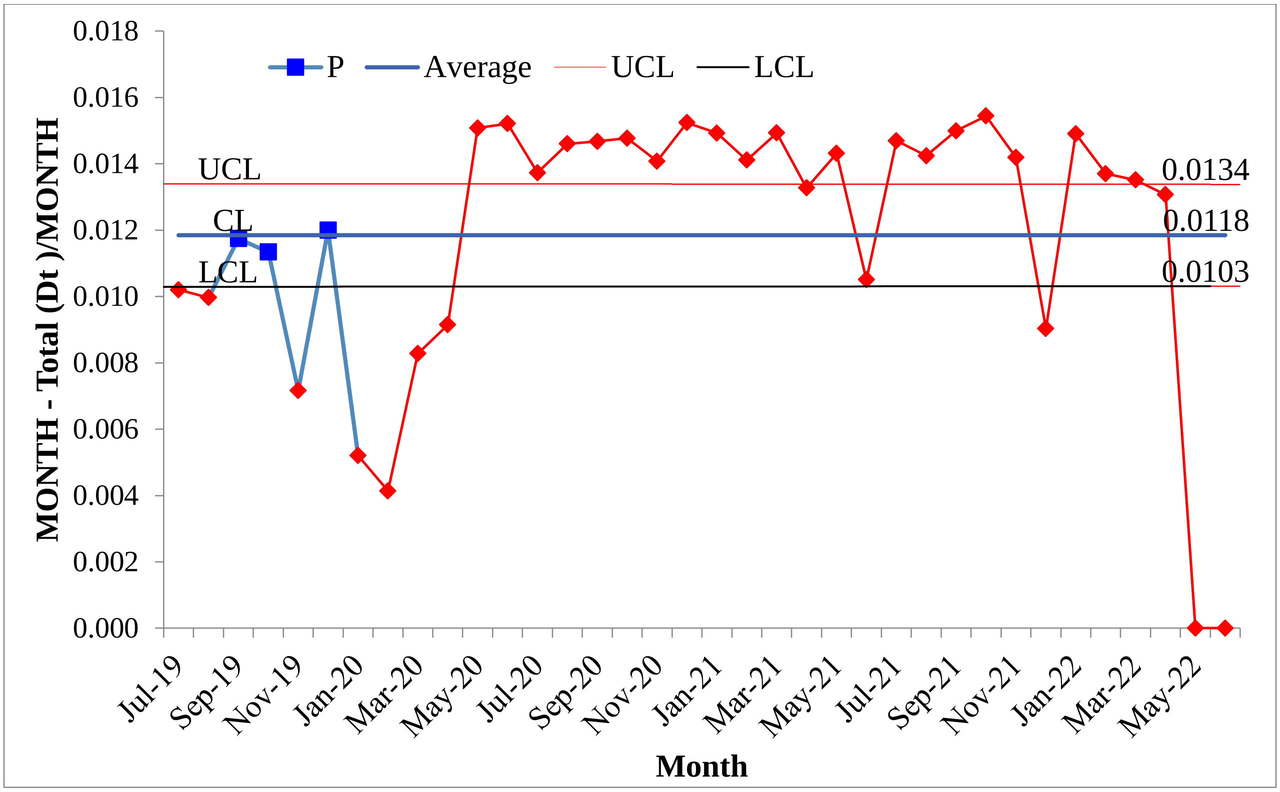


Figure 4-43 : Total running hour of cm1 in control and out of control

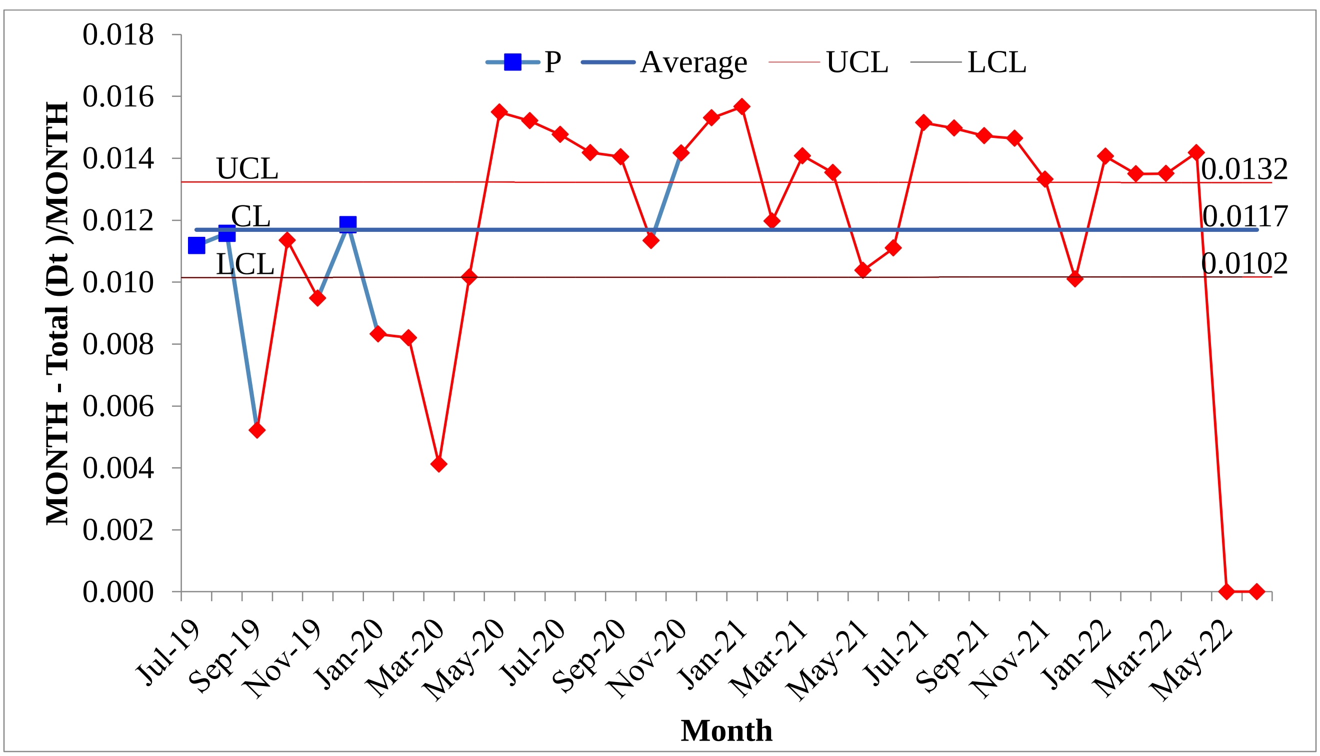


Figure 4-44 : Total running hour of cm2 in control and out of control

4.4 Main root causes for downtime

External causes

- ✓ Power fluctuation or cut off
- ✓ Man power
- ✓ Method of maintenance
- ✓ Coal shortage

Mechanical & electrical breakdown

- ✓ Due to Lubrications
- ✓ Inspection problems
- ✓ Not using predictive and proactive planning

4.5 Clinker and Cement Production

4.5.1 Clinker production

Cement kiln are used for the pyro-processing stage of manufacturing of port land and other types of hydraulic cement, in which calcium carbonate reacts with silica-bearing minerals to form calcium silicates. Over a billion tons of cement are made per year, and cement kilns are the heart of this production processes.Their capacity usually defines the capacity of cement plant. As the main energy consuming and greenhouse gas emitting stage of cement manufacture, improvement of kiln efficiency has been the central concern of cement manufacturing technology.

Table 4-38 : clinker production ton/month

Month	18-19 Year	19-20 Year	20-21 Year	21-22 Year
July	96441	92004	83399	89722
August	86444	90110	81476	91180
September	48174	75248	33259	82400
October	16231	27399	85710	91994
November	87291	89088	66230	22012
December	88113	87070	80700	76625
January	89634	90373	88021	86688
February	84930	66933	69510	37488
March	61778	92275	55843	47934
April	87265	14250	83940	74629

May	59560	15334	69406	55347
June	46495	85957	17621	
Total	852356	826042	815115	756019

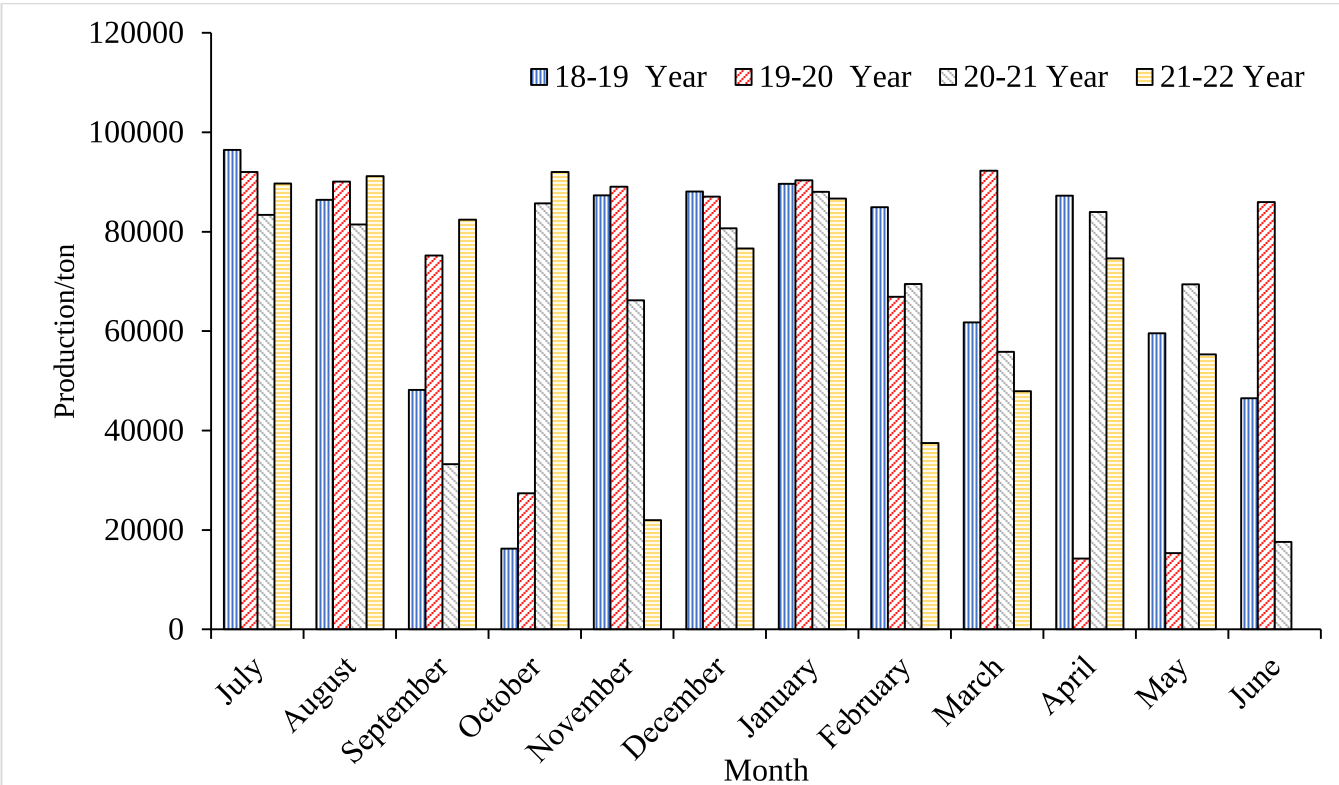


Figure 4-45 : clinker production ton/month

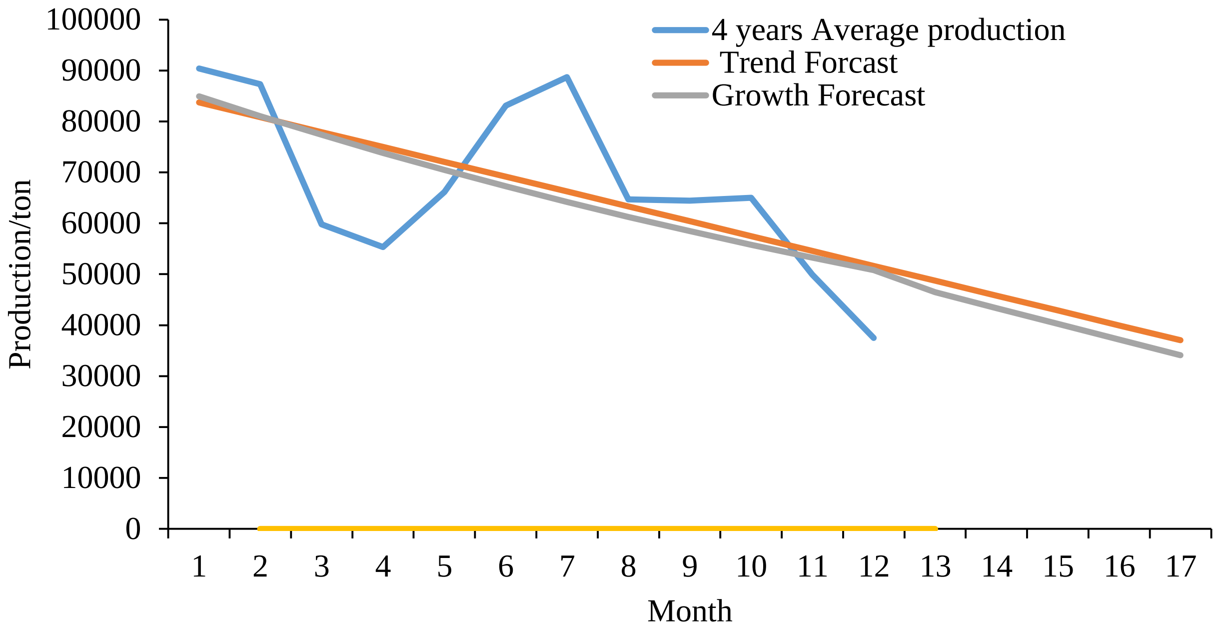


Figure 4-46 : growth forecast for clinker production

In table 4-38 shows that the total yearly production per ton of 85235, 826042, 815115,756019 respectively 2018, 2019,2020, 2021 and clinker in each month fluctuate frequently and there are some depths on the line shown in figure 4-46 which describes that there was low production rate due to different stoppage root causes from external, production, mechanical or raw material problems may arise. The production decreasing in the past four years which in turn affects the production of cement.in figure 4-46, shows that if the company was to continue using the current system it would increase the decrement of clinker production. The grey line shows how clinker production rate will be decreasing gradually.

4.5.2 Cement production

Cement manufacturing is a complex process that begins with mining and then grinding raw materials that include limestone and clay, to a fine powder, called raw meal, which is then heated to a sintering temperature as high as 1450 °C in a cement kiln. In this process, the chemical bonds of the raw materials are broken down and then they are recombined into new compounds. The result is called clinker, which are rounded nodules between 1mm and 25mm across. The clinker is ground to a fine powder in a cement mill and mixed with gypsum to create cement. The powdered cement is then mixed with water and aggregates to form concrete that is used in construction.in table 5.40 shows cement production ton/month for four years of data and on we could see that the production was fluctuating and decreasing due to different reasons and the downtime that were existing through the last year.

Table 4-39 : cement production ton/month

Month	18-19 Year	19-20 Year	20-21 Year	21-22 Year
July	85263	83197	107497	110258
August	74561	81855	109574	111054
September	76320	62728	100448	110002
October	47803	81267	97644.9	111928
November	99480	61712	109335	101363
December	117004	90130.6	121770	64989.1
January	83303	51158	118389	105495
February	71794	49604	97245.2	101492
March	92252	51841	112102	97298.4
April	92488	74725	109905	94340.8
May	63754	114623	91365	74871.7
June	74688	115931	83678	
Total	978710	918772	1258954	1083092

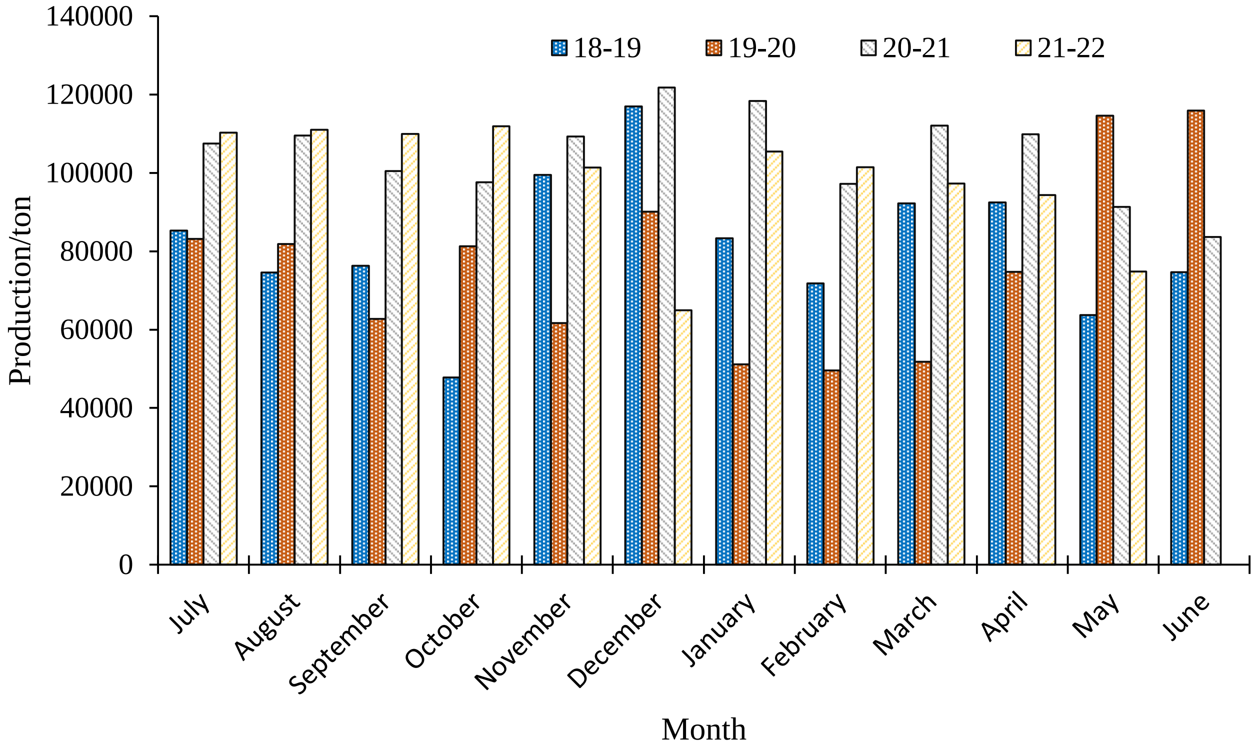


Figure 4-47 : cement production ton/month

On figure 4.47 illustrate that four years of cement production in national cement share company which clearly shows that the except from 2019-2020 in all the three year the cement production is decreasing due to machine availability and process instability which caused due to machine break down and week implementation of total quality management. In 2019-2020 year cement production need a further study why the company production increases and have a stable process.

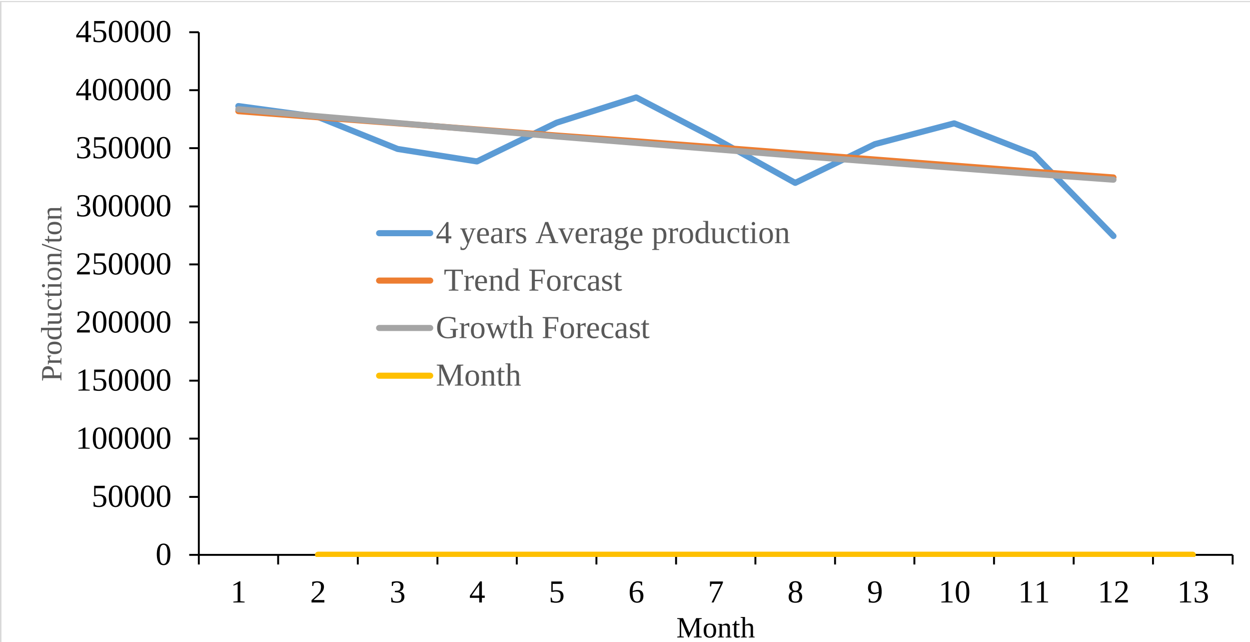


Figure 4-48 : growth forecast for cement production

On table 4-39 it can be seen that the total production rate is 4239527.6 ton per 4 years which shows almost in steady cement production throughout the last four years. In figure 4-48 also shows that in next 5 months the production can be increase if the working system is maintained. If not the production will be lower in each month.

4.5.3 Cost Analysis

According to the data shown in table 4-40,4-41,4-42 below shows how much money is lost per each month due to downtime. The cost of the clinker and cement that could be produced if the plant was running there wouldn't be any loss. But during the past three years the downtime caused a great loss. By taking 5200 birr/ton for clinker the company has lost more than 30% only from clinker production not to mention the coal (energy) consumption needed to restart the process when the kiln stops due to machine breakdown(downtime) the loss would be 3,842,878,000.00 (three billion eight hundred forty-two million eight hundred seventy-eight) in three years. In addition, on a cement production the loss would be more than 38% in which it would be 3,239,130,266.67 only from one cement mill.

Table 4-40 : analysis of cost loss for kiln due to down time caused by breakdown

PRICE LOSS DUE TO DOWNTIME OF KILN

Sample Number	Month	Kiln Total (Dt)/Month	Ton /Hr.	Ton	Birr/Ton	Cost
1	Jul-19	12.1	125	1512.5	5200	7,865,000.00
2	Aug-19	4.13	125	516.25	5200	2,684,500.00
3	Sep-19	111.87	125	13983.75	5200	72,715,500.00
4	Oct-19	522.03	125	65253.75	5200	339,319,500.00
5	Nov-19	13.05	125	1631.25	5200	8,482,500.00
6	Dec-19	43.86	125	5482.5	5200	28,509,000.00
7	Jan-20	24.2	125	3025	5200	15,730,000.00
8	Feb-20	144.33	125	18041.25	5200	93,814,500.00
9	Mar-20	17.23	125	2153.75	5200	11,199,500.00
10	Apr-20	588.26	125	73532.5	5200	382,369,000.00
11	May-20	614.13	125	76766.25	5200	399,184,500.00
12	Jun-20	28.1	125	3512.5	5200	18,265,000.00
13	Jul-20	80.71	125	10088.75	5200	52,461,500.00
14	Aug-20	88.75	125	11093.75	5200	57,687,500.00
15	Sep-20	452.43	125	56553.75	5200	294,079,500.00
16	Oct-20	56.2	125	7025	5200	36,530,000.00
17	Nov-20	194.41	125	24301.25	5200	126,366,500.00
18	Dec-20	89.04	125	11130	5200	57,876,000.00
19	Jan-21	38.6	125	4825	5200	25,090,000.00

20	Feb-21	94.25	125	11781.25	5200	61,262,500.00
21	Mar-21	285.82	125	35727.5	5200	185,783,000.00
22	Apr-21	51.6	125	6450	5200	33,540,000.00
23	May-21	192.02	125	24002.5	5200	124,813,000.00
24	Jun-21	568.2	125	71025	5200	369,330,000.00
25	Jul-21	20.71	125	2588.75	5200	13,461,500.00
26	Aug-21	12.4	125	1550	5200	8,060,000.00
27	Sep-21	71.52	125	8940	5200	46,488,000.00
28	Oct-21	10.24	125	1280	5200	6,656,000.00
29	Nov-21	538.75	125	67343.75	5200	350,187,500.00
30	Dec-21	138.62	125	17327.5	5200	90,103,000.00
31	Jan-22	44.8	125	5600	5200	29,120,000.00
32	Feb-22	367.49	125	45936.25	5200	238,868,500.00
33	Mar-22	335.89	125	41986.25	5200	218,328,500.00
34	Apr-22	56.38	125	7047.5	5200	36,647,000.00
35	May-22		125	0	5200	0.00
36	Jun-22		125	0	5200	0.00
TOTAL		5912.12	125	739015	5200	3,842,878,000.00

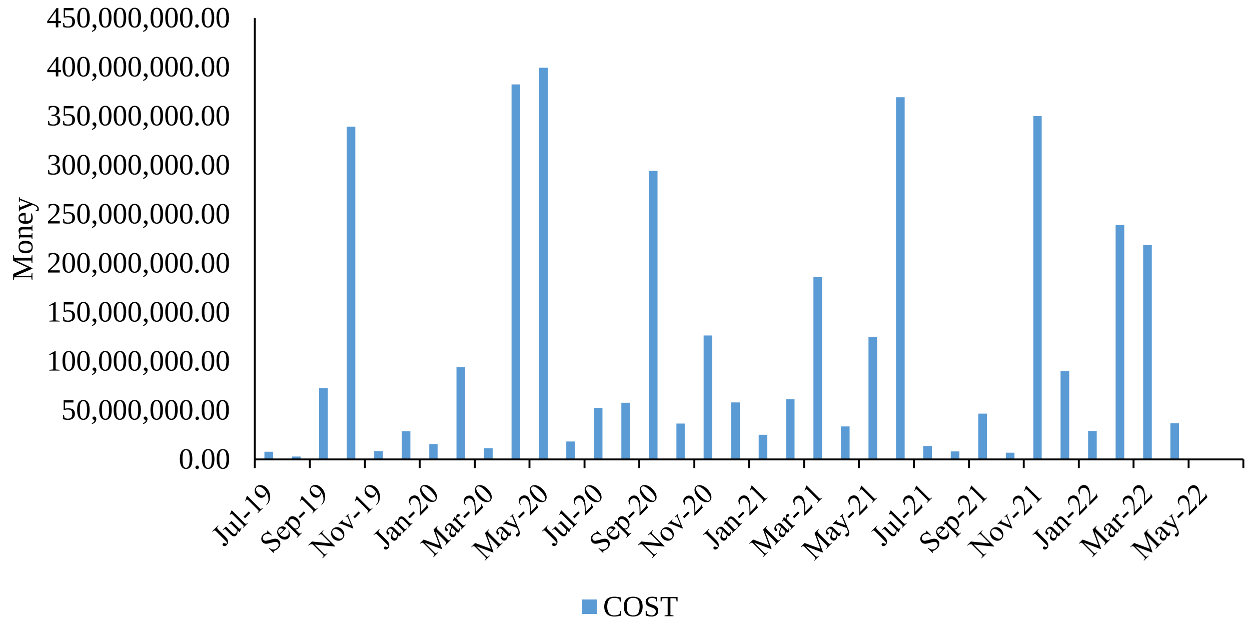


Figure 4-49 : shows analysis of cost loss per month for kiln

Table 4-41 : analysis of cost loss for cm 1 due to down time caused by breakdown

Price loss due to downtime

Sample Number	**Month**	**Cm1 Total (Dt)/Month**	**Ton /Hr.**	**Ton**	**Birr/Ton**	**Cost**
1	Jul-19	298.44	100	29844	5200	155,188,800.00
2	Aug-19	308.55	100	30855	5200	160,446,000.00
3	Sep-19	206.38	100	20638	5200	107,317,600.00
4	Oct-19	247.82	100	24782	5200	128,866,400.00
5	Nov-19	405.98	100	40598	5200	211,109,600.00
6	Dec-19	218.12	100	21812	5200	113,422,400.00
7	Jan-20	515.72	100	51572	5200	268,174,400.00
8	Feb-20	514.31	100	51431	5200	267,441,200.00

9	Mar-20	380.77	100	38077	5200	198,000,400.00
10	Apr-20	317.78	100	31778	5200	165,245,600.00
11	May-20	80.82	100	8082	5200	42,026,400.00
12	Jun-20	50.18	100	5018	5200	26,093,600.00
13	Jul-20	139.41	100	13941	5200	72,493,200.00
14	Aug-20	100.53	100	10053	5200	52,275,600.00
15	Sep-20	72.77	100	7277	5200	37,840,400.00
16	Oct-20	92.18	100	9218	5200	47,933,600.00
17	Nov-20	98.32	100	9832	5200	51,126,400.00
18	Dec-20	70.64	100	7064	5200	36,732,800.00
19	Jan-21	83.85	100	8385	5200	43,602,000.00
20	Feb-21	47.55	100	4755	5200	24,726,000.00
21	Mar-21	82.88	100	8288	5200	43,097,600.00
22	Apr-21	131.78	100	13178	5200	68,525,600.00
23	May-21	109.18	100	10918	5200	56,773,600.00
24	Jun-21	253.87	100	25387	5200	132,012,400.00
25	Jul-21	91.52	100	9152	5200	47,590,400.00
26	Aug-21	111.11	100	11111	5200	57,777,200.00
27	Sep-21	53.39	100	5339	5200	27,762,800.00
28	Oct-21	56.89	100	5689	5200	29,582,800.00
29	Nov-21	88.02	100	8802	5200	45,770,400.00

30	Dec-21	341.53	100	34153	5200	177,595,600.00
31	Jan-22	79.40	100	7940	5200	41,288,000.00
32	Feb-22	60.59	100	6059	5200	31,506,800.00
33	Mar-22	140.58	100	14058	5200	73,101,600.00
34	Apr-22	136.05	100	13605	5200	70,746,000.00
35	May-22	0	100	0	5200	0.00
36	Jun-22	0	100	0	5200	0.00
TOTAL		3843628252	100	598691	5200	3,113,193,200.00

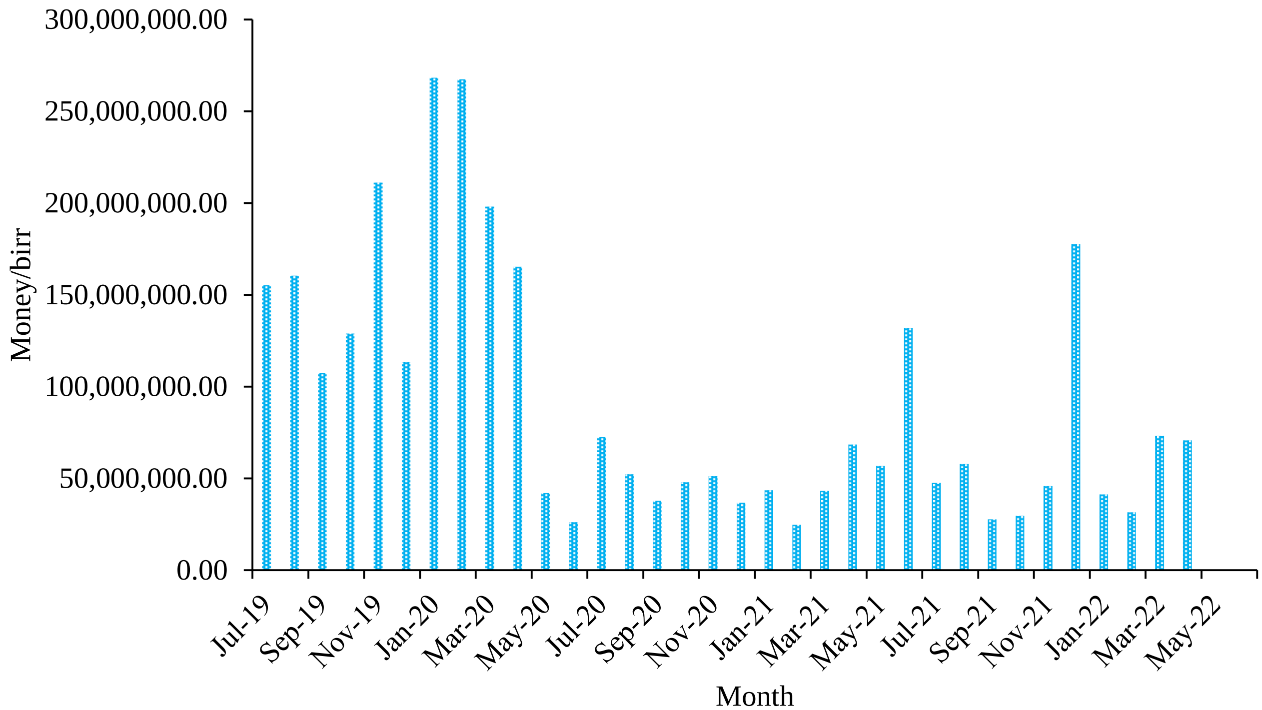


Figure 4-50 : shows analysis of cost loss per month for CM 1

Table 4-42 : analysis of cost loss for cm 2 due to down time caused by breakdown

PRICE LOSS DUE TO DOWNTIME

Sample Number	**Month**	**Cm2 Total (Dt)/Month**	**Ton /Hr.**	**Ton**	**Birr/Ton**	**Cost**
1	Jul-19	255.81	100	25581	5200	133021200
2	Aug-19	237.92	100	23792	5200	123718400
3	Sep-19	491.58	100	49158	5200	255621600
4	Oct-19	247.26	100	24726	5200	128575200
5	Nov-19	304.66	100	30466	5200	158423200
6	Dec-19	224.05	100	22405	5200	116506000
7	Jan-20	379.01	100	37901	5200	197085200
8	Feb-20	335.65	100	33565	5200	174538000
9	Mar-20	562.97	100	56297	5200	292744400
10	Apr-20	273.21	100	27321	5200	142069200
11	May-20	62.68	100	6268	5200	32593600
12	Jun-20	50.18	100	5018	5200	26093600
13	Jul-20	93.54	100	9354	5200	48640800
14	Aug-20	118.81	100	11881	5200	61781200
15	Sep-20	100.42	100	10042	5200	52218400
16	Oct-20	243.36	100	24336	5200	126547200
17	Nov-20	94.25	100	9425	5200	49010000
18	Dec-20	67.64	100	6764	5200	35172800

19	Jan-21	51.06	100	5106	5200	26551200
20	Feb-21	142.02	100	14202	5200	73850400
21	Mar-21	120.43	100	12043	5200	62623600
22	Apr-21	120.16	100	12016	5200	62483200
23	May-21	283.48	100	28348	5200	147409600
24	Jun-21	227.47	100	22747	5200	118284400
25	Jul-21	71.34	100	7134	5200	37096800
26	Aug-21	78.5	100	7850	5200	40820000
27	Sep-21	65.18	100	6518	5200	33893600
28	Oct-21	92.33	100	9233	5200	48011600
29	Nov-21	126.53	100	12653	5200	65795600
30	Dec-21	293.9	100	29390	5200	152828000
31	Jan-22	116.7666667	100	11676.66667	5200	60718666.67
32	Feb-22	69.89	100	6989	5200	36342800
33	Mar-22	140.79	100	14079	5200	73210800
34	Apr-22	86.25	100	8625	5200	44850000
35	May-22		100	0	5200	0
36	Jun-22		100	0	5200	0
TOTAL		6229.096667	100	622909.6667	5200	3,239,130,266.67

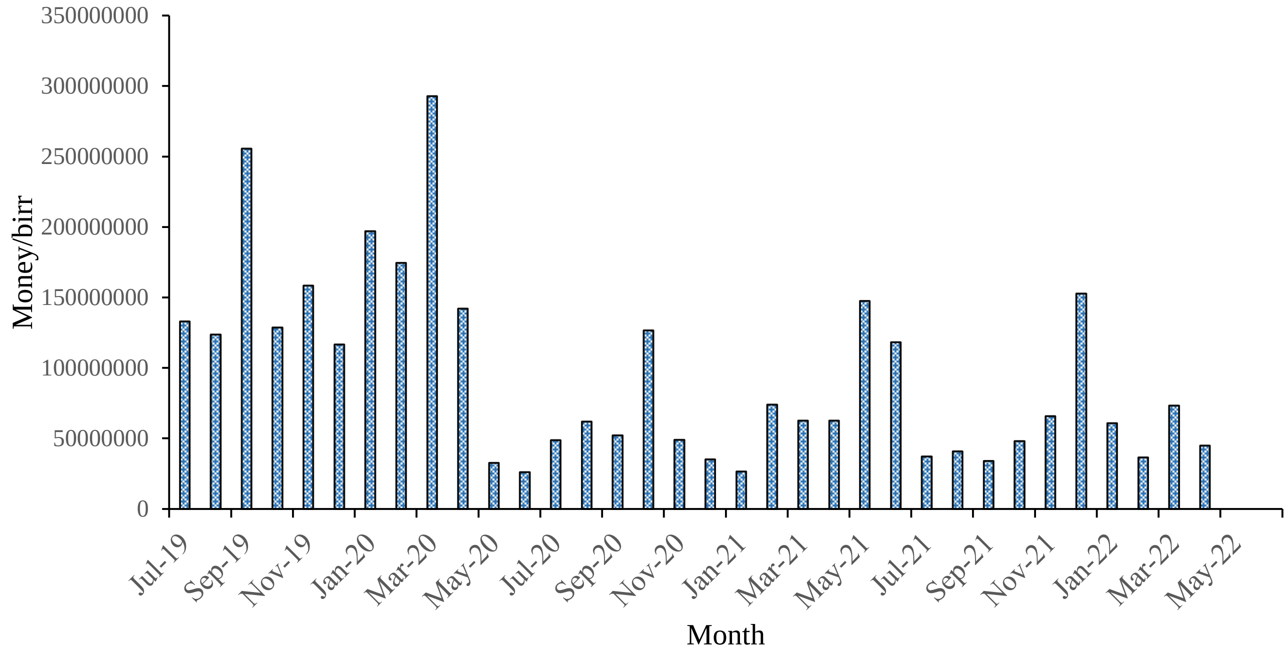


Figure 4-51 : shows analysis of cost loss per month for cm 2

Table 4-43 : Price Loss due to downtime

Machine	Birr gain /3 years	Birr loss/ 3 years	% Loss
Kiln	12,465,314,096.97	3,842,878,000.00	30.83%
Cm1	8,478,124,722.15	3,113,193,200.00	36.72%
Cm2	8,478,124,722.15	3,239,130,266.67	38.21%

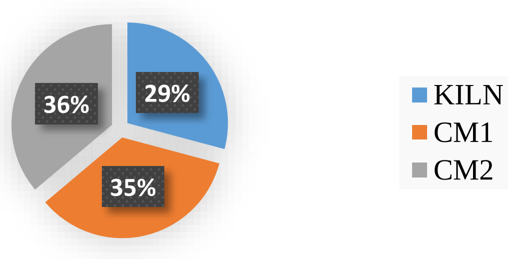


Figure 4-52 : % loss in terms of money / 3 years

5 Conclusion And Recommendation

5.1 Conclusion

The research concentrated on assessing and controlling the down time happened during clinker and cement production processing in national cement share company. In the study, factors associated with the causes of downtime and the effect was also discussed by taking three years data from 2019 - 2022 collected for the national cement share company. The main production line at risk was the kiln because for the cement factory the highest power consumption needed was for the kiln which was caused due to the pure coal unavailability in our country and in the available area also it was not done a very good job so the coal carbon content was not good enough to start the kiln and work at its full efficiency. In addition, coal was the highest cost consumption so the last three years the kiln stoppage time were high and due to that the production loss in terms of money was more than 3o% or 3,842,878,000.00 birr. And the other line more at risk was cement mill which the stoppage was caused due to power fluctuation or power cut off and cyclone the stoppage was caused due to employee negligence including raw material selection problem was one of the. And due to two cement mill downtime on the past three years almost together more than 70% or more than 9,000,000,000 birr which was a great loss for the company.

As we were checking the factory since it was line lay out the more problem was aroused in the data analysis and results, we can see that there are a lot of downtime during the clinker and cement production so it is advisable to concentrate on the downtime and the cause so that the company loss can be decreased in addition to this some ways to decrease the downtime are described in the recommendation. Also, the management should see and research on the low downtime happening moments (high running time) so as to develop that strong side and for good total quality management.

Factors causing the downtime from the research were external factor, machine factor, human factor, environmental factor, and material factor. As for machine factor more of rolling parts like gear, bearing failures were the main causes of downtime because of lubrication problem, from main machineries the In external factor frequent power cut off and power fluctuation was the main causes of the down time which was more than 50% of down time was caused due to external cause. Manpower factor was that the cement industry machineries need frequent follow up but due to poor follow up, negligence unproper spare part replacement, for maintenance rather than using standard or scientific methods the workers used old and only from their experience.

5.2 Recommendation

Maintenance scheduling software efficiently plan, schedule and assign work orders for greater control over maintenance processes. By utilizing the planning and scheduling tools within maintenance scheduling software, and managers will be greatly improved. Since, it is tedious to write on a paper every time when new machines are added to the workshop it also helps to record all information about the equipment's and refer it as required. It also has great contribution on making schedule for the machines with a given time. So, using different scheduling and data recorder software will make the work a lot easier.

Indeed, computers do not make mistakes the reliability of the machines will increase as well as the institute can get a big profit from using software since the machines are going to be time scheduled including predict before failures and the institute can easily control the machines.

1. **Preventive Maintenance (PM**)

PM has a vast scope. As the name implies, it may include any action to prevent equipment downtime/failure. And enhanced PM may include predictive maintenance (PDM), CBM, CMMS and proactive maintenance etc. also figure below shows the process flow for enhanced PM. The steps include review of existing PM or other maintenance program, analyses, assessing new reliability and other equipment with existing system if any, establishing system support requirements and configuration, define reimplementation plan and fixing performance monitoring metrics etc…

However, the conventional PM, using less of predictive and proactive maintenance is the oldest easily understood and extensively used form of maintenance.PM is the planned maintenance of plants and equipment (including and resulting from RM inspections other inspections/reports and condition monitoring etc.…) in order to prevent or minimize breakdowns and deterioration/depreciation rates. It covers a vast area and occasionally people get misled by its coverage. After PM repairs, the equipment's health is restored back nearly to its original conditions. However, it doesn't include much improvement and up-graduation jobs.

In general, the various components of PM are as follows: -

- ✓ Check drawing and installation of equipment including subsequent redesign and minor modification, depending on specific capture of problems
- ✓ Proper identification of all items, proper documentation and codification; check-history cards/records
- ✓ Spares catalogues, equipment catalogues and inventory lists
- ✓ Job manuals and standard maintenance and standard maintenance practice (SMP)
- ✓ Maintenance work orders and other pending work orders
- ✓ Periodic inspection of plant and equipment –use of checklists by inspectors and its frequency; shift-wise, daily, weekly and monthly etc.
- ✓ Well qualified and experienced inspectors, use necessary aids; test equipment vibration meters, ultrasonic and x-ray equipment
- ✓ Preparing total defect/failure list and its categorization
- ✓ Repetitive servicing, repairs, upkeep and overhaul
- ✓ Minor repairs
- ✓ Medium repairs-roughly around 50% of jobs of major overhaul
- ✓ Emergency repairs and or corrective repairs

PM schedules are normally of the following two types

- ➢ Fixed Time Maintenance (FTM) Schedule
- ➢ Condition Based Maintenance (CBM) Schedule

Majority of PM are FTM. Simple routines or cycles of workloads are established for different days, weeks, fortnights, months or quarter etc. and are followed regularly. Often all equipment may not work for same number of hours but for convenience of planning, organizing and control, equipment's are clubbed for PM schedule. Such a system simplifies control and filter and workmen can work with minimum supervision.

2. Predictive maintenance (PDM)

A predictive maintenance approach strives to detect the onset of equipment degradation and to address the problem as they are identified. This allows casual stressors to be eliminated or controlled, prior to any significant deterioration in the physical state of the component of equipment. PDM needs are based on the actual condition (normally measured quantitatively and qualitatively) of the equipment /asset rather than on some predetermined schedule. It involves predicting the failure before it happens and identifying the root cause of those failure symptoms and eliminating those before it occurs and results its extensive damage to equipment's. Thus, there are three distinct stages of PDM such as detection, analysis and correction.

Though PM and PDM have some overlapping areas and often supplement to each other, the main difference between them are as follows: -

- ✓ In PM overhauling of equipment is done at fixed time interval basis but in PDM overhauling of equipment is taken on the basis of condition of condition monitoring only before the equipment is going to fail or deteriorate.
- ✓ In PM the basis of jobs and frequency are the planner's judgment and past experience and equipment manufacturing recommendation and not much sophisticated monitoring tools are used regularly (at shorter interval or continuous manner)
- ✓ PM programmers are more suitable for industries/facility having large number of similar or near similar equipment. But PDM is more suitable for heavy costly and more critical equipment. But PDM is more suitable for heavy costly and more critical equipment were overhauling/repairs more downtimes
- ✓ PDM calls for regular and continuous inspection and monitoring of equipment's condition by collecting data and make analysis to find out the root causes of failure symptoms. Based on these several repair and adjustments jobs are planned and executed and necessary major jobs are also planned. Often such repairs are planned in some cyclic pattern which amounts to PM jobs. Consequent overlapping of PM and PDM

3. Proactive Maintenance

Dissimilar to preventive maintenance that is based on conditioning monitoring, proactive maintenance concentrates on the monitoring, and correction of root causes to equipment failures. The proactive maintenance strategies is also designed to extend the useful age of the equipment to reach the wear-out stage by adaptation a high masters level of operating precision. It takes a micro view on machines damage-concentration on the cause's instead of the symptoms of wear etc. proactive maintenance commission corrective actions aimed at the sources of failure. It is designed to extend the life of mechanical machinery as opposed to:-

- ✓ Making repairs when often nothing is broken
- ✓ Accommodating failures as routing and normal, and
- ✓ Preempting crisis failure maintenance – all of which are characteristics of the predictive/preventive strategies/disciplines.

Proactive maintenance relies on the use of electronic instrumentation and computerized programs to effectively pinpoint problems in rotating (also sliding) equipment. Because most problems are electrical and mechanical, vibration analysis has evolved as a leading as diagnostic tool in proactive maintenance to determine problems and their source. Other diagnostic system have made their debut and each has, in its own way, contributed to enlarge the scope of predicting potential problem in rotating equipment and structures. It also uses many other tools/techniques, few of which are given below-

- ✓ Infrared thermograph
- ✓ Ultrasonic leak detection
- ✓ Lube oil analysis, contamination, analysis, wear stability
- ✓ Laser shaft alignment
- ✓ Resonance correction
- ✓ Fluid chemical stability, fluid physical stability
- ✓ Capitation stability;
- ✓ Soft foot condition checking and correction

4. Risk based maintenance

This is not any specific maintenance strategies/ type but may be any or combination of above-mentioned strategies, but devoted to the risk factor of the plant/ equipment. Maintenance plays a pivotal role in managing risk and it is important that right risk assessment tools/techniques are applied to capture and evaluate the hazards at hand to allow functional risks-based approach. You have to examine how risk concept can be used in establishing preventive safety and management strategies, what type of tools are available and what gains can be made.

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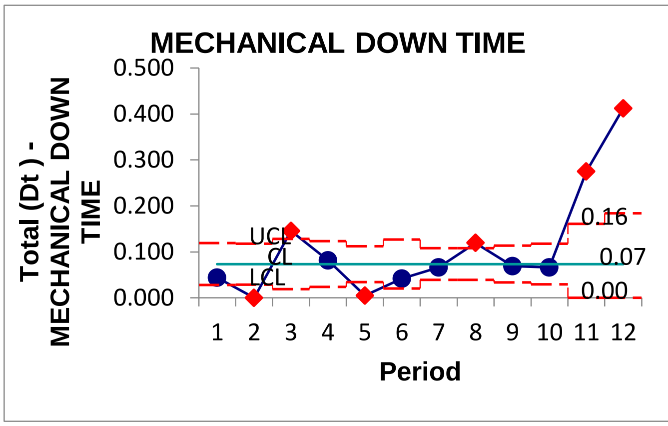
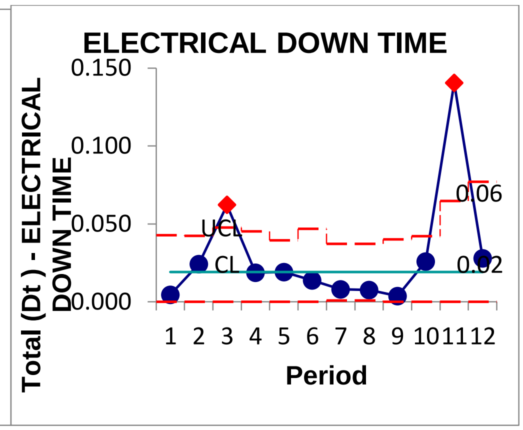
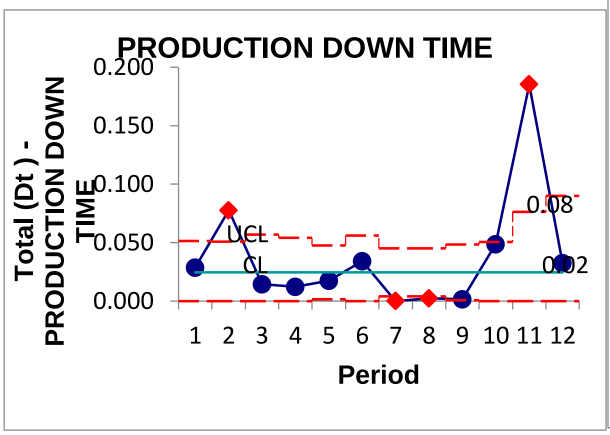
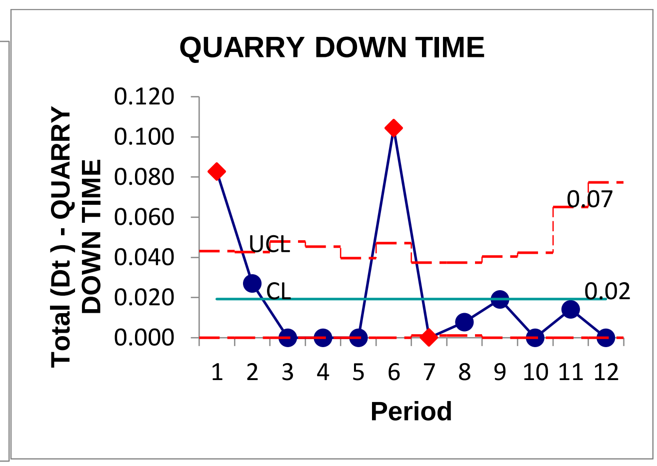
APENDIX

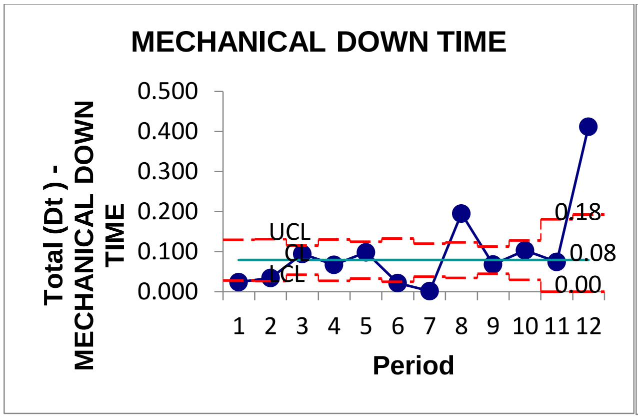


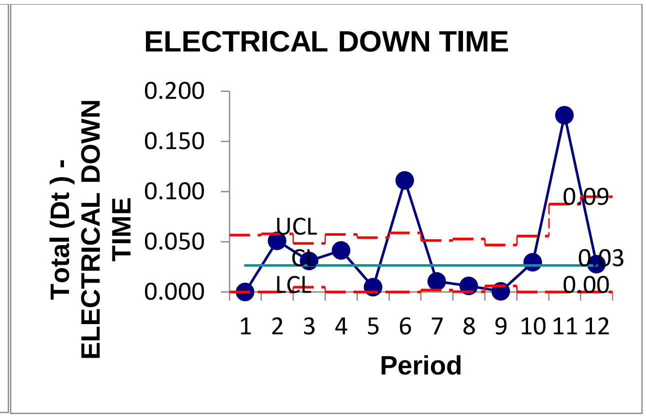


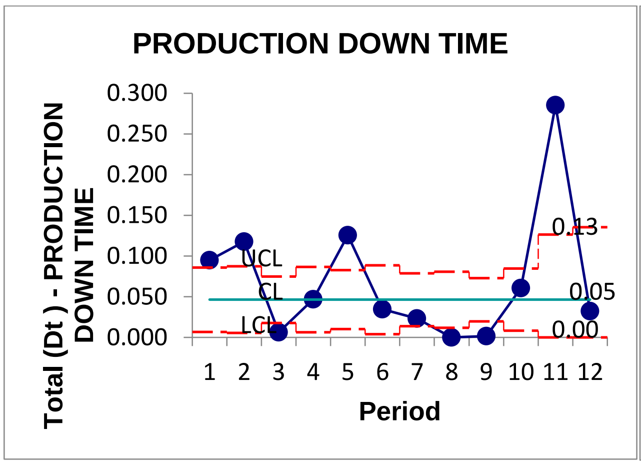


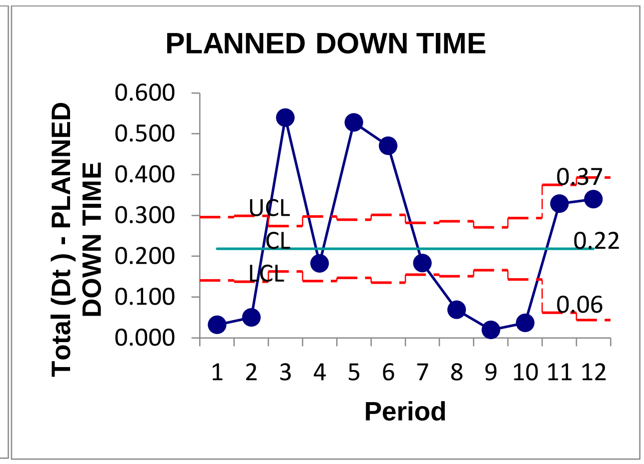


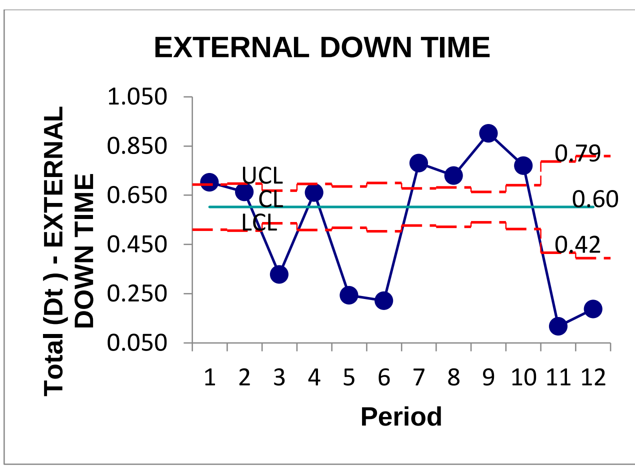
Cement mill line 2 2019 - 2020

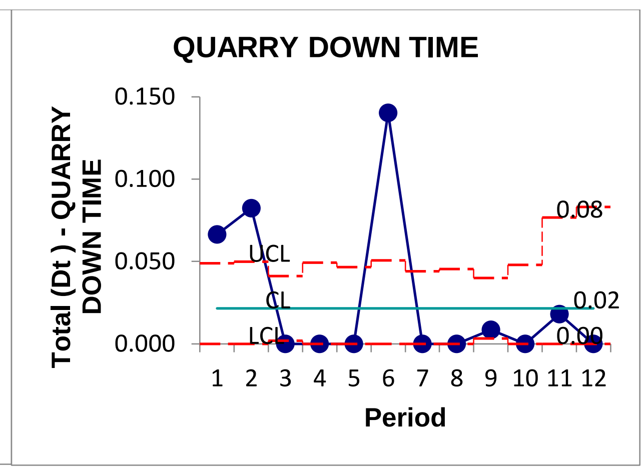

MECHANICAL DOWN TIME
Total (Dt) - MECHANICAL DOWN TIME
0.500
0.400
0.300
0.200
0.100
0.000
UCL
CL
LCL
0.18
0.08
0.00
1 2 3 4 5 6 7 8 9 10 11 12
Period


ELECTRICAL DOWN TIME
Total (Dt) - ELECTRICAL DOWN TIME
0.200
0.150
0.100
0.050
0.000
UCL
CL
LCL
0.09
0.03
0.00
1 2 3 4 5 6 7 8 9 10 11 12
Period


PRODUCTION DOWN TIME
Total (Dt) - PRODUCTION DOWN TIME
0.300
0.250
0.200
0.150
0.100
0.050
0.000
UCL
CL
LCL
0.13
0.05
0.00
1 2 3 4 5 6 7 8 9 10 11 12
Period


PLANNED DOWN TIME
Total (Dt) - PLANNED DOWN TIME
0.600
0.500
0.400
0.300
0.200
0.100
0.000
UCL
CL
LCL
0.37
0.22
0.06
1 2 3 4 5 6 7 8 9 10 11 12
Period


EXTERNAL DOWN TIME
Total (Dt) - EXTERNAL DOWN TIME
1.050
0.850
0.650
0.450
0.250
0.050
UCL
CL
LCL
0.79
0.60
0.42
1 2 3 4 5 6 7 8 9 10 11 12
Period


QUARRY DOWN TIME
Total (Dt) - QUARRY DOWN TIME
0.150
0.100
0.050
0.000
UCL
CL
LCL
0.08
0.02
0.00
1 2 3 4 5 6 7 8 9 10 11 12
Period

Questionnaire

Adama Science and Technology University

Master of Science (MSc)

PART I: QUESTIONNAIRE TO BE FILLED BY RESPONDENTS

Dear participant:

I am currently studying for a Master's degree in mechanical design and manufacturing (MSc) at Adama Science and Technology University I am undertaking a research project entitled - Investigation on Implementation of TQM in Cement Industry: Case Study in National Cement Share Company.

This questionnaire is designed to solicit information for purely academic purpose. This is to enable the researcher complete the thesis in partial fulfillment of the requirement for the degree of master of in mechanical design and manufacturing (MSc).

Your response is truly important to the success of this study. I would like to assure you that your response will be processed as 'Strictly Confidential'. So please try to answer all questions included. I would like to thank you very much in anticipation for your kind cooperation.

I look forward to receive your reply

Sincerely yours,

Note:

- ✓ No need to write your name in this questionnaire.
- ✓ Respond to the statement/question in this questionnaire based on your current level of knowledge and expertise.
- ✓ As you read each statement tick a box that corresponds to your level of agreement.

Thank you

SECTION A: BASIC DEMOGRAPHIC DATA (PLEASE TICK WHERE APPROPRIATE)

1. Sex Male ☐ Female ☐

2. Age

A) 18-30 ☐

B) 31 - 40 ☐

C) 41-50 ☐

D) 51-60 ☐

E) Above 61 ☐

3. Educational Back ground

A. High School ☐

B. Diploma ☐

C. First Degree ☐

D. Master Degree & above ☐

4. What is your position or work group in the organization?

A. Management group ☐

B. Non-management group ☐

SECTION B INFORMATION RELATED TO TOTAL QUALITY MANAGEMENT IN NATIONAL CEMENT SC

Instruction I: please put a tick mark (√) at the appropriate box to show below.

5. Do you have a knowledge about TQM?

YES NO

IF YOUR ANSWER IS YES

6. Describe your current tqm satisfaction.
   A. Less than 3 years

B. 3-6 years
C. 7-10 years
D. More than 10 years

7. Is TQM standardized in your organization?

Yes ☐ No ☐

8. what kind of total quality management philosophy is implemented in your organization?

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9. Does the company have access to training facilities?

Yes ☐ ☐ No

10. Which TQM key factor has been implemented in your company? (you can check more than one box)
11.
Continuous improvement ☐
Top management commitment ☐
Quality measurement and benchmarking ☐
Suppliers relationships ☐
Policy and strategic planning ☐
Quality information systems ☐
Organizational culture ☐
Customer focus and satisfaction ☐
Quality communications and structure ☐
12. Does Top Management assume active responsibility for the evaluation and improvement?

A. Agree ☐
B. Strongly agree ☐
C. Disagree ☐
D. Strongly Disagree ☐
E. Not sure ☐

13. Are the senior management committed to Total quality management?
A. Agree ☐
B. Strongly agree ☐
C. Disagree ☐
D. Strongly Disagree ☐
E. Not sure ☐

14. Is there an inclination of top management to allocate adequate resources and time for quality management efforts?
A. Agree ☐
B. Strongly agree ☐

C. Disagree
D. Strongly Disagree
E. Not sure

15. Do you think the Major elements of quality management structure are in place to facilitate the organization's quality strategy objectives?
    A. Agree
    B. Strongly agree
    C. Disagree
    D. Strongly Disagree
    E. Not sure
16. Is the average number of defects is decreasing in company productions?
    A. Agree
    B. Strongly agree
    C. Disagree
    D. Strongly Disagree
    E. Not sure

SECTION C ABOUT THE PRODUCTIVITY OF THE INDUSTRY

17. Is the existing operating system increase the productivity loss?

Yes No

If you choose yes

18. What do you think should be changed to decrease the production loss?

----

19. What are the main root causes for the production loss? (you can check more than one box)
    Mechanical breakdown
    Electrical breakdown
    Raw material shortage
    Production problem
    Environmental
20. Does the implementation of total quality management in your organization have a positive change in productivity as well as in resource management?

