A STUDY ON OVERALL CRITICAL FAILURE EQUIPMENT EFFICIENCY FOR COST EFFECTIVENESS IN OHCU CPCL

Submitted in partial fulfilment of the requirements for the award of

MASTER OF BUSINESS ADMINISTRATION

By

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SCHOOL OF MANAGEMENT STUDIES

SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)
Accredited with Grade "A" by NAAC I 12B Status by UGC I
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of AALBIN RICHARD A **41410002** who carried out the project entitled **"A study on overall critical failure equipment efficiency for cost effectiveness in OHCU unit CPCL**" under my supervision from January 2023 to March 2023.

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CERTIFICATE

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We wish him all success in his future endeavour.

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DECLARATION

I Aalbin Richard A 41410002 hereby declare that the Project Report entitled **"A study on critical failure equipment efficiency for cost effectiveness in OHCU CPCL"** done by me under the guidance **Dr. Gananath khilla M.A., M.Phil., Ph.D.** Professor, School of management studies, Sathyabama Institute of Science and Technology, Chennai is submitted in partial fulfilment of the requirements for the award of Master of Business Administration degree.

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TABLE OF CONTENTS

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	
1	INTRODUCTION	
	1.1 INTRODUCTION ABOUT THE STUDY	1
	1.2 INDUSTRY PROFILE	12
	1.3 COMPANY PROFILE	16
	1.4 HYDROCRACKER UNIT IN CPCL	31
	1.5 OVERALL EQUIPMENT EFFECTIVENESS IN HYDROCRACKER UNIT	38
	1.6 OBJECTIVES OF THE STUDY	42
	1.7 NEED FOR THE STUDY	43
	1.8 SCOPE OF THE STUDY	43
	1.9 LIMITATIONS OF THE STUDY	44
2	REVIEW OF LITERATURE	
	2.1 INTRODUCTION	45
	2.2 EQUIPMENT FAILURE ANALYSIS	45
3	RESEARCH METHODOLOGY	
	3.1 INTRODUCTION	50
	3.2 QUANTITATIVE METHOD	50
	3.3 SAMPLING METHODS	50
	3.4 DATA PROCESSING	51
	3.5 DATA COLLECTION	51
	3.6 HYPOTHESIS	52

	3.7 TOOLS FOR ANALYSIS	**53**
	3.8 ASSUMPTIONS CONSTRAINTS AND LIMITATION	**54**
4	**DATA ANALAYSIS**	
	4.1 INTRODUCTION	**55**
	4.2 DATA FINDING AND ANALYSIS	**55**
	4.3 ANALYSIS OF SURVEYS	**55**
	4.4 PERCENTAGE ANALYSIS	**56**
	4.5 CHI SQUARE	**68**
	4.6 LINEAR AGGRESSION	**70**
	4.7 ANOVA	**70**
	4.8 DATA PROCESSING	**71**
	4.9 MEAN OEE	**72**
	4.10 MEAN OEE OF G PUMP	**74**
	4.11 CAPACITY UTILIZATION	**76**
	4.12 OPERATIONAL FACTOR	**77**
	4.13 VGO FEED ANALYSIS	**78**
5	**CONCLUSION**	**81**
	5.1 FINDINGS	**82**
	5.2 SUGGESTIONS	**83**
	5.3 REFERENCES	**84**

LIST OF TABLES

TABLE NO	TITLE	PAGE NO
1	AGE DISTRIBUTION FOR THE QUESTIONNAIRE	56
2	GENDER DISTRIBUTION FOR THEQUESTIONNAIRE	57
3	EDUCATIONAL QUALIFICATION DISTRIBUTION FOR THE QUESTIONNAIRE	58
4	JOB ROLE DISTRIBUTION FOR THEQUESTIONNAIRE	59
5	RESPONDENTS ON REGULAR INSPECTION OF THE CRITICAL FAILURE EQUIPMENT TO ENSURE IT IS IN GOOD WORKING CONDITION	60
6	RESPONDENTS ON TRAINING EMPLOYEES ONTHE PROPER USE AND MAINTENANCE OF CRITICAL FAILURE EQUIPMENT IS CRUCIAL TO PREVENT ACCIDENTS AND DOWNTIME	61
7	RESPONDENTS ON INVESTING IN HIGH-QUALITY CRITICAL FAILURE EQUIPMENT ISWORTH THE COST TO ENSURE RELIABILITYAND SAFETY	62
8	RESPONDENTS ON REGULARLY SCHEDULEDMAINTENANCE AND REPAIRS ON CRITICAL FAILURE EQUIPMENT SHOULD BE A TOP PRIORITY FOR ANY ORGANIZATION	63
9	RESPONDENTS ON EFFECTIVE COMMUNICATION BETWEEN MAINTENANCESTAFF AND OPERATORS IS NECESSARY TO ENSURE CRITICAL FAILURE EQUIPMENT IS PROPERLY MAINTAINED AND SERVICED	64

10	**RESPONDENTS ON IT IS IMPORTANT TO REGULARLY INSPECT THE CRITICAL FAILUREEQUIPMENT TO ENSURE IT IS IN GOOD WORKING CONDITION**	**65**

11	**RESPONDENTS ON IT IS ACCEPTABLE TO SACRIFICE PRODUCT QUALITY TO MEET PRODUCTION TARGETS OR REDUCE COSTS**	**66**
12	**RESPONDENTS ON IT IS THE RESPONSIBILITYOF ALL EMPLOYEES IN THE PETROLEUM INDUSTRY TO REPORT ANY SAFETY CONCERNS OR VIOLATIONS THEY WITNESS**	**67**
13	**CHI-SQUARE TESTS**	**68**
14	**ASSOCIATION BETWEEN EDUCATION ANDPRODUCT QUALITY - CHI- SQUARE TESTS**	**69**
15	**ASSOCIATION BETWEEN GENDER AND SAFETY – CHI-SQUARE TESTS**	**69**
16	**LINEAR REGRESSION**	**70**
17	**LINEAR REGRESSION 2**	**70**
18	**MEAN OEE**	**72**
19	**OVERALL EQUIPMENT PERFORMANCE**	**74**
20	**MEAN OEE OF G PUMP**	**74**
21	**TOTAL AVAILABILITY**	**75**
22	**CAPACITY UTILIZATION**	**76**
23	**OPERATING FACTOR**	**77**
24	**VGO FEED ANALYSIS**	**78**

LIST OF FIGURES

FIGURE NO	TITLE	PAGE NO
1	HYDROCRACKING UNIT AT CPCL	7
1.2	SCHEMATIC DIAGRAM	14
1.3	BREAKDOWN OF PRODUCTS	15
1.3	LOGO OF CPCL	16
1.4	CATALYST SYSTEM R1	35
1.5	OPERATING SYSTEM	36
1.6	CPCL FEED COMBUSTION	37
1.7	OVERALL EQUIPMENT EFFICIENCY INHYDROCRACKER UNIT	38
1.8	G PUMP OEE	39
1.9	VGO FEED ANALYSIS	40
1.10	COST ANALYSIS	42
4.1	AGE DISTRIBUTION FOR THEQUESTIONNAIRE	56
4.2	GENDER DISTRIBUTION	57
4.3	EDUCATIONAL QUALIFICATION DISTRIBUTION	58
4.4	JOB ROLE DISTRIBUTION	59
4.5	RESPONDENTS ON REGULAR INSPECTION OF THE CRITICAL FAILURE EQUIPMENT TOENSURE IT IS IN GOOD WORKING CONDITION	60
4.6	RESPONDENTS ON TRAINING EMPLOYEESON THE PROPER USE AND MAINTENANCE OF CRITICAL FAILURE EQUIPMENT IS CRUCIAL TO PREVENT ACCIDENTS AND DOWNTIME	61

4.7	**RESPONDENTS ON INVESTING IN HIGH- QUALITY CRITICAL FAILURE EQUIPMENTIS WORTH THE COST TO ENSURE RELIABILITY AND SAFETY**	**62**
4.8	**RESPONDENTS ON REGULARLY SCHEDULED MAINTENANCE AND REPAIRSON CRITICAL FAILURE EQUIPMENT SHOULD BE A TOP PRIORITY FOR ANY ORGANIZATION**	**63**
4.9	**RESPONDENTS ON EFFECTIVE COMMUNICATION BETWEEN MAINTENANCE STAFF AND OPERATORS ISNECESSARY TO ENSURE CRITICAL FAILURE EQUIPMENT IS PROPERLY MAINTAINED AND SERVICED**	**64**
4.10	**RESPONDENTS ON IT IS IMPORTANT TO REGULARLY INSPECT THE CRITICAL FAILURE EQUIPMENT TO ENSURE IT IS INGOOD WORKING CONDITION**	**65**
4.11	**RESPONDENTS ON IT IS ACCEPTABLE TO SACRIFICE PRODUCT QUALITY TO MEET PRODUCTION TARGETS OR REDUCE COSTS**	**66**
4.12	**RESPONDENTS ON IT IS THE RESPONSIBILITY OF ALL EMPLOYEES IN THE PETROLEUM INDUSTRY TO REPORTANY SAFETY CONCERNS OR VIOLATIONSTHEY WITNESS**	**67**
4.13	**OEE ANALYSIS**	**73**
4.14	**MEAN OEE OF G PUMP**	**74**
4.15	**CAPACITY UTILIZATION**	**76**
4.16	**OPERATING FACTOR**	**77**
4.17	**VGO FEED ANALYSIS**	**78**

ABSTRACT

This study aims to investigate the critical failure equipment efficiency and its impact on the cost-effectiveness of Chennai Petroleum Corporation Limited (CPCL). The study uses a quantitative research approach and analyzes data collected from CPCL's equipment failure reports and maintenance records. The overall critical failure equipment efficiency is calculated based on the ratio of total operating time to total downtime, and its relationship with maintenance costs is examined. The study finds that critical failure equipment efficiency has a significant impact on maintenance costs and overall cost-effectiveness. The study recommends strategies for improving critical failure equipment efficiency to reduce maintenance costs and increase cost-effectiveness in CPCL. The findings of this study are expected to contribute to the optimization of maintenance strategies and improve the operational efficiency of CPCL.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Overall Equipment Effectiveness (OEE) is a key performance indicator used to measure the productivity and efficiency of manufacturing equipment. It is a ratio that takes into account three factors: availability, performance, and quality.

Availability measures the percentage of time that equipment is available for production, Performance measures the velocity at which the equipment operates in contrast to its designed capacity, and Quality measures the percentage of products that meet the required specifications.

The formula for OEE is:

OEE = Availability x Performance x Quality

OEE can be used to identify areas for improvement and also optimize the performance of the equipment. By analysing the data from OEE, manufacturers can identify the root causes of downtime, performance losses, and quality issues, and take steps to address them.

In addition to measuring the efficiency of individual machines, OEE can also be used to measure the overall effectiveness of a production line or facility. By monitoring OEE over time, manufacturers can display the influence of process enhancements and equipment upgrades, and make data-driven decisions to optimize their operations.

Overall Equipment Effectiveness (OEE) is a powerful figure for manufacturers to measure and improve the performance of their equipment and production processes. OEE provides a comprehensive picture of how well equipment is being utilized, including factors such as downtime, speed, and quality.

By tracking OEE over time, manufacturers can identify areas for improvement and take targeted actions to increase productivity, reduce waste, and improve product quality. OEE data can also be used to prioritize maintenance activities, identify equipment that needs to be replaced or upgraded, and optimize production schedules.

Furthermore, OEE is a treasured tool for benchmarking and evaluating performance across different production lines, facilities, or even companies in the same industry. This permits

manufacturers to discover great practices and areas for improvement and to learn from the successes and disasters of others.

The OEE score is a metric that measures the overall performance of manufacturing equipment or a production line. It is calculated by multiplying three factors: Availability, Performance, and Quality.

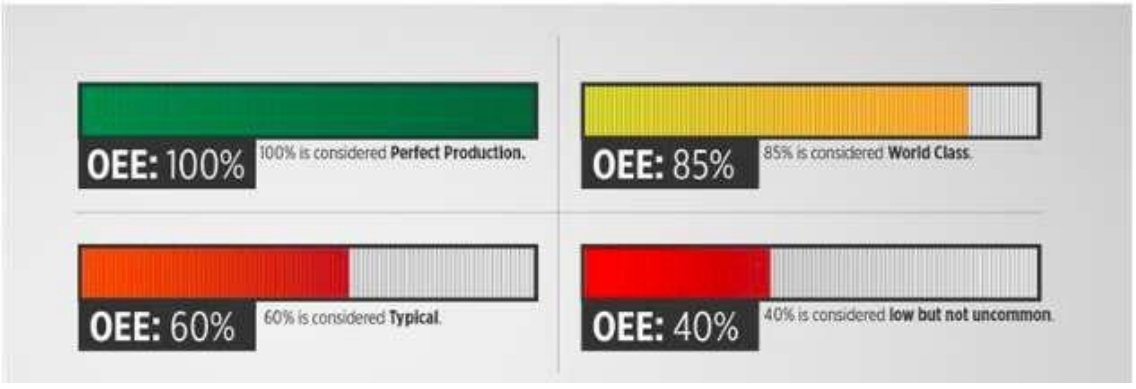
Each of these factors is expressed as a percentage. Availability measures the amount of time the equipment is available for production, Performance measures the rate at which the equipment is producing units compared to its theoretical maximum rate, and Quality measures the proportion of products that meet the required specifications.

For example, if a machine has an availability of 90%, a performance rate of 80%, and a quality rate of 95%, its OEE score would be:

OEE = 0.90 (availability) x 0.80 (performance) x 0.95 (quality) = 0.684 or 68.4%

An OEE score of 100% indicates that the equipment is operating at maximum efficiency with no downtime, no performance losses, and no quality defects. However, achieving a perfect score is rare, and most manufacturers strive to achieve an OEE score of at least 85% to indicate optimal performance.

The OEE score is a useful tool for measuring the overall effectiveness of manufacturing equipment or a production line and figuring out areas for improvement. It gives a clear picture of how well the equipment is being utilized and lets in manufacturers to take focused moves to increase productivity, reduce waste, and improve product quality.



The impact of Overall Equipment Effectiveness (OEE) is not limited to managers or plant managers; it can also have a significant impact on employees working on the plant floor. Here are some ways OEE can affect employees:

- Increased accountability: OEE provides a transparent measure of equipment performance and can be used to hold operators and maintenance teams accountable for machine downtime, performance, and quality issues. This can motivate employees to take ownership of their work and to strive for better performance.
- Improved job satisfaction: When equipment is running at optimal efficiency, employees can focus on their primary tasks, which can reduce stress and frustration. This can lead to increased job satisfaction and employee retention.
- Increased engagement: OEE data can be used to identify opportunities for process improvement and to involve employees in problem-solving and continuous improvement activities. This can increase employee engagement and foster a culture of innovation and collaboration.
- Skills development: By analysing OEE data, employees can gain insights into the performance of equipment and the factors that affect its efficiency. This can lead to opportunities for skills development, training, and cross-functional collaboration.

Overall, OEE is a effective device for improving equipment performance and optimizing manufacturing processes. It can have a positive impact on employees working on the plant floor by increasing accountability, job satisfaction, engagement, and skills development.

There are two main ways to calculate Overall Equipment Effectiveness (OEE):

- OEE as a product of three separate factors: Availability, Performance, and Quality:

This method involves calculating each of the three factors individually and multiplying them together to arrive at the OEE score.

Availability = Operating Time / Planned Production Time

Performance = (Ideal Cycle Time x Total Count) / Operating Time

Quality = Good Count / Total Count

OEE = Availability x Performance x Quality

- OEE as a ratio of actual output to maximum possible output:

This method involves comparing the actual output of the equipment to the maximum possible output, based on the design of the equipment and the time available for production.

OEE = (Actual Output / Maximum Possible Output) x 100%

Maximum Possible Output = (Operating Time x Ideal Cycle Time) / Planned Production Time

The two methods produce similar results, but the second method is simpler and requires fewer calculations. However, it is important to note that both methods require accurate and reliable data on equipment downtime, performance, and quality.

Break down the six losses into the three main OEE categories.

- Availability Losses:

Equipment breakdowns

Setup and adjustment time

- Performance Losses:

Reduced speed due to equipment wear and tear

Suboptimal equipment operation

- Quality Losses:

Defects in raw materials or finished products

Start-up waste due to testing or calibration

These six losses are often used to calculate the Overall Equipment Effectiveness (OEE) of a manufacturing process. By identifying and addressing these losses, manufacturers can improve their OEE, increase productivity, and reduce costs.

There are several benefits of using Overall Equipment Effectiveness (OEE) to improve production. Here are five of them:

- Increased efficiency: OEE helps manufacturers identify areas of waste and inefficiency in their production processes, enabling them to take action to eliminate those inefficiencies. This can lead to increased productivity and improved efficiency in production.
- Improved quality: By measuring quality losses as part of OEE, manufacturers can identify and address quality issues more quickly, reducing the number of defects in their finished products.

- Reduced downtime: OEE can help manufacturers identify the root causes of equipment breakdowns and other sources of downtime, enabling them to take proactive steps to reduce downtime and keep their production lines running smoothly.
- Better decision-making: OEE provides manufacturers with actionable data that they can use to make informed decisions about how to improve their production processes. This can help them prioritize improvement initiatives and allocate resources more effectively.
- Increased profitability: By improving efficiency, reducing downtime, and improving quality, manufacturers can increase their profitability and gain a competitive advantage in their market. OEE can help them achieve these goals by providing a framework for continuous improvement and optimization.

1.1.1 Critical Failure

A critical failure is a significant and severe malfunction or breakdown that can have a essential impact on the operation or safety of a system or process. It is often an unexpected and unplanned event that requires immediate attention and corrective action to prevent further damage or harm.

In many industries, such as aviation, healthcare, and manufacturing, critical failures can have serious consequences that include injury, loss of life, or significant financial losses. Examples of critical failures may include a plane engine failure, a clinical device malfunction, or a power plant explosion.

To prevent critical failures, organizations often implement risk management strategies, such as safety protocols, regular maintenance and inspections, and contingency planning. It is also important to have procedures in place to quickly identify and respond to critical failures, including emergency response plans and communication protocols.

Equipment critical analysis (ECA)

Equipment critical analysis (ECA) is a technique of identifying and analysing the critical equipment in a facility or operation, identifying the potential consequences of failure, and developing strategies to minimize the risk of failure. One critical component of any effective ECA is a robust and well-planned maintenance program.

Here are some reasons why an effective maintenance program is essential for ECA:

Reducing the risk of equipment failure: Regular maintenance can help detect and address potential equipment failures before they occur, reducing the risk of critical failures and the associated costs and downtime.

Improving equipment reliability: A well-executed maintenance program can help improve equipment reliability, increasing uptime and productivity.

Enhancing safety: Proper maintenance can help ensure that equipment is operating safely, reducing the risk of accidents or injuries.

Prolonging equipment life: Regular maintenance can help prolong the life of critical equipment, delaying the need for costly replacements or repairs.

Cost savings: By reducing the likelihood of critical failures and increasing equipment reliability, a well-planned maintenance program can help organizations save money on repair and replacement costs, as well as reducing the costs associated with downtime and lost productivity.Overall, an effective maintenance program is crucial to the success of ECA. By ensuring that critical equipment is properly maintained, organizations can reduce the risk of critical failures, increase safety and reliability, and save money in the long run.

1.1.2 Hydrocracker Unit

A hydrocracker unit is a type of refining process used in the petroleum industry to convert heavy oils into lighter, extra treasured products, such as gasoline, diesel, and jet fuel. The process uses hydrogen gas and a catalyst to break down the long-chain hydrocarbons in heavy crude oil into shorter, more beneficial molecules.

The hydrocracker unit consists of a number of key components, including a reactor vessel, high-pressure pumps, heat exchangers, and separators. The process begins with the feedstock being heated and pressurized earlier than being combined with hydrogen gas and fed into the reactor vessel. The reactor vessel contains the catalyst, which facilitates the chemical reactions that break down the heavy hydrocarbons into lighter molecules.

The product flow from the reactor vessel is then cooled and separated into different fractions using a collection of heat exchangers and separators. The lighter fractions, such as gasoline and diesel, are typically sent to further processing or storage, while the heavier fractions may be recycled back into the reactor vessel for further cracking.

The hydrocracker unit is an important part of the petroleum refining process, as it enables refineries to convert heavy, low-value feedstocks into high-value products. However, it is also a complex and expensive process, requiring careful management and maintenance to ensure safe and efficient operation.

Figure 1 : Hydrocracking unit at CPCL

The cracking technique is a chemical process used in the petroleum refining industry to break down larger hydrocarbon molecules into smaller, extra treasured molecules. The process is used to produce a variety of products, which includes gasoline, diesel, jet fuel, and petrochemicals.

There are two primary types of cracking processes: thermal cracking and catalytic cracking.

Thermal cracking: This process consists of heating heavy hydrocarbons to high temperatures, typically above 750 °F (400 °C), in the absence of oxygen. This breaks down the long-chain hydrocarbons into smaller molecules, including olefins, which are used in the production of gasoline and other petrochemicals. Thermal cracking can be done using either a batch process or a continuous process.

Catalytic cracking: This process uses a catalyst, which is typically a zeolite or silica-alumina, to break down heavy hydrocarbons at lower temperatures, typically between 500 and 700 °F (260-370 °C). The catalyst accelerates the chemical reactions that break down the hydrocarbons, resulting in a higher yield of lighter products, such as gasoline and diesel. Catalytic cracking is typically done in a fluidized bed reactor, where the catalyst is suspended in a fluid and mixed with the feedstock.

Both thermal and catalytic cracking are important processes in the petroleum refining industry, as they enable refineries to produce high-value products from lower-value feedstocks. However, they are also complex and energy-intensive processes that require careful management and maintenance to ensure safe and efficient operation.

Catalyst manufacturing can be done by a variety of methods, depending on the type of catalyst and the intended application.

Some common methods of catalyst manufacturing include:

Impregnation: This method involves soaking a support material, that includes alumina or silica, in a solution containing the catalyst precursor, such as a metal salt. The support material is then dried and calcined to remove any residual water and activate the catalyst.

Extrusion: This method involves mixing the catalyst precursor with a support material and extruding the mixture into a specific shape, such as a cylinder or sphere. The extruded catalyst is then dried and calcined to activate the catalyst.

Sol-gel: This method involves the hydrolysis of metal alkoxides to form a gel, which is then dried and calcined to form the catalyst. Sol-gel is often used to produce high-surface-area catalysts with uniform particle size.

Spray drying: This method involves atomizing a solution containing the catalyst precursor and a support material into a hot gas stream, which evaporates the solvent and forms small particles. The particles are then collected and calcined to activate the catalyst.

Chemical vapor deposition: This method involves depositing a thin layer of catalyst material onto a support material using a chemical reaction in the vapor phase. This method is often used to produce catalysts with very high surface areas and precise control over the catalyst composition.

Overall, the choice of catalyst manufacturing method depends on a variety of factors, including the type of catalyst, the intended application, and the desired properties of the final catalyst product.

The hydrocracking process equipment typically includes the following components:

- Reactor: The reactor is the main equipment in the hydrocracking process, where the feedstock is mixed with hydrogen gas and the catalyst is used to initiate the chemical

reaction. The reactor is typically a high-pressure vessel made of materials that can withstand the high temperatures and pressures involved in the process.

- Catalyst: The catalyst used in the hydrocracking process is typically a combination of metal oxides, such as cobalt, molybdenum, and nickel, supported on a high-surface-area material, such as alumina. The catalyst is usually in the form of small pellets or beads, which provide a large surface area for the chemical reactions to occur.
- Hydrogen supply system: Hydrogen gas is an essential component of the hydrocracking process, as it helps to break down the heavy hydrocarbons in the feedstock into lighter, more valuable molecules. The hydrogen supply system typically includes compressors, storage tanks, and distribution lines to deliver the hydrogen gas to the reactor.
- Heat exchangers: The hydrocracking process generates a essential amount of heat, which must be controlled to maintain the desired reaction temperature. Heat exchangers are used to transfer the heat between the reactor and other process streams, such as the hydrogen gas and the product streams.
- Separation equipment: The product streams from the hydrocracking process typically include a mixture of gases, liquids, and solids, which must be separated and purified. Separation equipment, such as distillation columns, filters, and centrifuges, are used to separate the various components of the product streams.
- Control systems: The hydrocracking process requires precise control of the process variables, such as temperature, pressure, flow rates, and catalyst activity, to maintain optimal operation and maximize product yields. Control systems, including sensors, instruments, and automation software, are used to monitor and control the process parameters.Overall, the hydrocracking process equipment is complex and requires careful design, operation, and maintenance to ensure safe and efficient operation.

1.1.3. HYDROCRACKER UNIT CHALLENGES

Hydrocracker units can face a number of challenges, including:

- Corrosion: The high temperatures, pressures, and aggressive chemical environment in the hydrocracker unit can cause corrosion of the equipment and piping, leading to leaks and failures.

- Fouling: The catalyst used in the hydrocracking process can become fouled over time, reducing its activity and efficiency. Fouling can also occur in heat exchangers and other equipment due to the build-up of contaminants and impurities.
- Catalyst deactivation: The catalyst used in the hydrocracking process can become deactivated over time, reducing its effectiveness and requiring replacement or regeneration.
- Feedstock variability: The composition and quality of the feedstock can vary over time, requiring adjustments to the process conditions and catalyst to maintain optimal operation.
- Product quality and yield: The hydrocracking process can produce a wide range of product streams with different quality and yield characteristics. Optimization of the process conditions and catalyst is required to maximize the production of desirable products and minimize the production of undesirable products.
- Safety and environmental concerns: The hydrocracker unit operates at high temperatures and pressures and uses highly flammable and toxic materials, presenting safety and environmental risks. Proper safety systems and procedures must be in place to prevent accidents and minimize the impact of any incidents that do occur.

To address these challenges, hydrocracker unit operators must have a thorough understanding of the process and the equipment, as well as effective maintenance, monitoring, and control systems. Regular inspections, testing, and analysis can help identify and address potential issues before they lead to equipment failures or production losses.

1.1.4. Optimize Hydrocracker Unit Operations to Reduce Costs

Hydrocracker units can face a number of challenges, including:

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Feedstock variability: The composition and quality of the feedstock can vary over time, requiring adjustments to the process conditions and catalyst to maintain optimal operation.

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1.2 INDUSTRY PROFILE

1.2.1. PETROLEUM INDUSTRY

The petroleum industry is one of the world‟s largest industries, and is very important to our everyday activities. The petroleum industry can be divided into four major branches. The first branch is the upstream petroleum industry, which includes oil exploration and extraction activities, responsible for recovering the oil and bringing it to the surface of the oil fields. The transportation sends crude oil from the oil fields to the refineries. The oil refining branch processes crude oil into useful products. While the marketing branch sells and distributes the petroleum products to the consumers.

1.2.2. Crude Oil Production

The upstream petroleum industry starts with oil exploration, in which oil geologists study the geological structures and rock formations on and below the earth‟s surface to determine where petroleum might be found. In the next step, the petroleum engineers, drill, and complete an oil well, which means bringing the well into production. After that, crude oil is recovered in much the same way as underground water is obtained.

In 2011 more than 30 billion barrels of crude oil were produced in the world. The average worldwide oil production rate is 88 million barrels a day (bpd) according to the U.S. Energy Information Administration. This massive global production of oil requires a huge number of oil refineries, to turn it into useful products.

1.2.3. Transportation

Most oil fields are located in desert areas or rugged areas or at sea at a considerable distance from the refineries that convert crude oil into usable products, and therefore, the oil must be transported in pipelines and tankers. Most crude oil needs some form of treatment near the reservoir, before it can be carried considerable distances through the pipelines or in tankers. Due to a decrease in the pressure and temperature of crude oil on the surface after production, gases are liberated from the oil in addition to the associated gases. Therefore, the transportation requires airtight tanks for storage, and leak-proof pipes or trucks. Due to the difficulty in transporting the crude oil from each well in separate pipe, the transportation of crude oil is further simplified by blending crude oil from several wells, homogenizing the feedstock to the refinery. Over one-half of the oil produced was moved by tankers on fixed maritime routes. In terms of the volume of oil transit, the Strait of Hormuz leading out of the

Arabian Gulf and the Strait of Malacca linking the Indian and Pacific Oceans, are two of the world's most strategic chokepoints. The global oil market is dependent upon reliable transport. The blockage of a choke point, even temporarily, can lead to substantial increases in total oil costs. In addition, chokepoints leave oil tankers vulnerable to theft from pirates, terrorist attacks, and political unrest in the form of wars or hostilities as well as shipping accidents that can lead to disastrous oil spills.

1.2.4. Oil Refining

Once the crude oil is pumped from the oil wells, it is transported through pipes for storage tanks and then to the refineries. Petroleum refining is a complete process involves physical, thermal, and chemical separation, to convert crude oil into useful petroleum products. Petroleum refineries range in size from small plants that process around 150 barrels of crude oil per day to giant complexes with a capacity of more than 600,000 bpd (Wong and Hung 2006). The petroleum products such as liquefied petroleum gas (LPG), gasoline, kerosene, aviation turbine fuels, diesel fuels, fuel oil, lubrication oils, petroleum waxes, and bitumen are very important in our day to day activities. It is used in many industries, and we cannot dispense with the use of petroleum products. Till this date, there is no appropriate alternative to petroleum product and in fact the world economy is based on the crude oil asset.

In petroleum refinery process, each unit operation/process consumes large quantities of water, and about 80-90% of water consumed in refinery process comes out as wastewater. Due to the advancement in science and technology, the major portion of wastewater generated in refining process can be recycled. The wastewater containing a high percentage of crude oil can be reprocessed in the refining, while the wastewater containing a high proportion of hydrocarbons, which resulted after refining can be used in burners and furnaces after being separated from the water. The wastewater containing low levels of soluble hydrocarbons and organic material can be recycled in the cooling towers after a number of treatments. The residuals must be reduced to a minimum in accordance with international regulations before the wastewater can be reused (Prather 1970). Figure 1.1 shows the usage, recycling and reuse of water in a typical petroleum refinery (modified from IPIECA 2010).

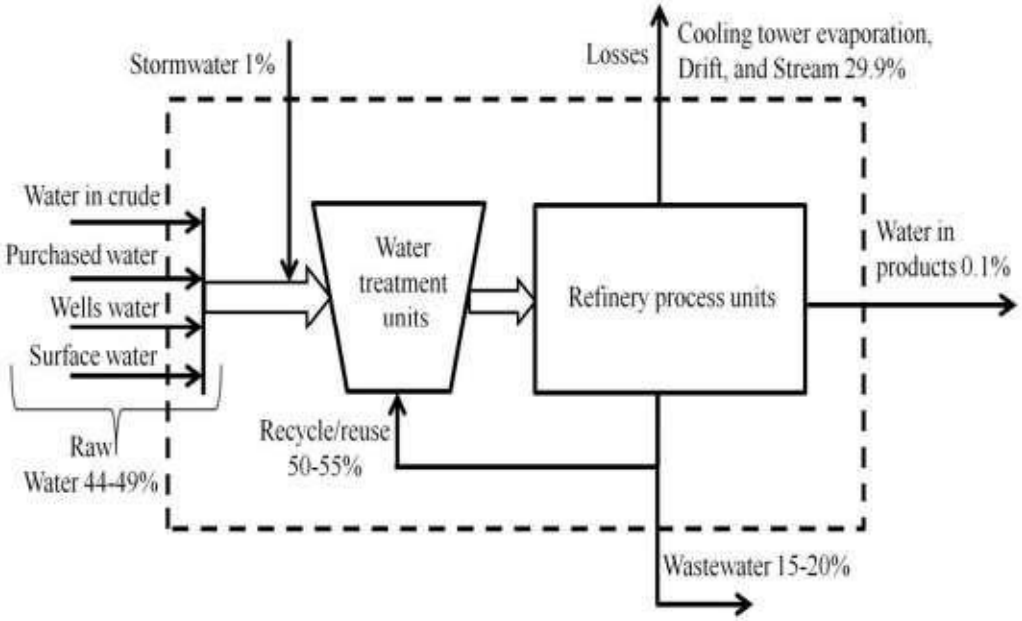

Figure 1.2 Schematic diagram of the typical water usage in a petroleum refinery

Every articulation of the oil industry, whether at the stage of production or transportation or refining or even marketing, generate considerable amount of solid, liquid, and gaseous waste, causes global concern. The world has been on the lookout for ways that minimize the environmental impact resulting from the use of oil products. The search began at the beginning of the industrial revolution with the increasing industrial demand for petroleum products.

1.2.5. PETROLEUM REFINERY

The petroleum refinery is the third branch (downstream) of the petroleum industry after oil exploration, production (upstream), and transportation, as mentioned in chapter one. India, one of the countries interested in oil refineries, tries to exploit crude oil to the maximum, generating poor quality products at cheaper prices, thereby leading to environmental problems. The recent industrial revolution, change in lifestyle in India has led to an increased demand for petroleum products to five times. The gross import of crude oil and petroleum products in India was 121.672 million tons 2007-2008. India imports three-quarters of the crude it refines, at an estimated 2.6 million barrels per day and exports refinery products of roughly ten percent of its production. This huge use of crude oil, has made India occupy the sixth place, in terms of the global consumption of crude oil, and is projected to replace South Korea and emerge as the fourth largest consumer of energy after the United States, China and

Japan. The petroleum refinery industry is one of the largest and the core industrial sector in India. It requires highly capitalized and huge amounts of water. On the other hand, refinery is a highly polluting process for land, air, and water, requires substantial investments in pollution control equipment‟s.

The main goal of typical petroleum refineries is to convert crude oil into useful and profitable products. The quality of crude oils processed by petroleum refineries is expected to decrease gradually with an increase in the sulfur contents and densities, due to increasing oil production to meet the demand, especially with increasing prices. The increase in the poor quality of crude oil increases the amount of heavy products, and reflects on the quality of wastewater generated. Hence, the quality of wastewater generated by the petroleum refinery is heavily loaded with organic matter, acute toxicity and poor biodegradability.

1.2.6. PETROLEUM REFINERY PRODUCTS

The crude oil is an extremely complex mixture of hydrocarbon compounds, sulfur, nitrogen, oxygen, salts, metals, and other elements, which may vary widely in volatility, specific gravity, and viscosity. In addition, the properties of crude oil vary widely as do its colour, from colourless to black. Thus, petroleum is not used in its raw state. A wide variety of processing steps are required to convert petroleum from its raw state to products that have well-defined properties. The major products of oil refineries are asphalt, diesel fuel, fuel oils, gasoline, jet fuel, kerosene, liquefied petroleum gas (LPG), lubricating oils, paraffin wax, tar, petrochemicals. Figure 1.2 shows the breakdown of the products from one barrel of crude oil.

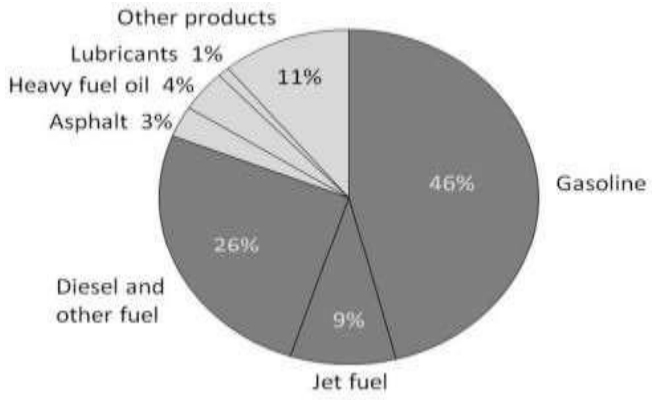

Figure 1.3 A breakdown of the products delivered from a barrel of crude oil (US EPA 2008).

1.3. COMPANY PROFILE

Figure 1.3 : Logo of CPCL

Chennai Petroleum Corporation Limited (CPCL) is a world-class energy company with a dominant presence in South India. Formerly known as Ma1dras Refineries Limited (MRL), it was formed as a joint venture between the Government of India (GOI), AMOCO and the National Iranian Oil Company (NIOC) in 1965 to set up a refinery at Manali, Chennai. AMOCO disinvested CPCL equity in favor of the Government of India in 1985. Later, the Government of India transferred its equity to Indian Oil, and CPCL became a subsidiary of Indian Oil in 2001. The present capacity of the Manali refinery is 10.5 MMTPA. The Nelson Complexity of the refinery is 9.71.

CPCL Manali Refinery is one of the most complex refineries in India, with Fuel, Lube, Wax and Petrochemical feedstock production facilities. The 5.8 MGD Sea Water Desalination Plant set up to augment the water requirements of the refinery was the first of its kind in the industry. CPCL has also made pioneering efforts in Energy and Water Conservation by setting up a Wind Farm and Sewage Reclamation plant, where 5 MGD of sewage water from Chennai city is processed to meet the raw water requirements of the refinery.

CPCL has a Wax Plant of 30,000 metric tons (MT) per annum to produce paraffin wax for manufacturing candle wax, waterproof formulations, and match wax. This unit supports the livelihood of 30,000 beneficiaries, mainly from domestic and Micro, Small & Medium Enterprises. A Propylene Plant was commissioned in 1988 with an initial capacity of 17000 MT per annum to supply petrochemical feedstock to neighboring downstream industries. The unit was revamped to enhance the propylene production capacity to 30,000 MT per annum in 2004.

The Company‟s main products are LPG, Motor Spirit, Superior Kerosene, Aviation Turbine Fuel, High-Speed Diesel, Naphtha, Bitumen, Lube Base Stocks, Paraffin Wax, Fuel Oil, Hexane, and Petroleum Coke. CPCL is also a mother industry supplying Linear Alkyl Benzene Feedstock (LABFS) and many other Petrochemical feedstocks to downstream units. CPCL Manali Refinery is accredited with ISO-9001:2008, ISO- 14001:2004 and OHSAS 18001:2007.

CPCL had a second refinery, located at Nagapattinam, which was commissioned in 1993. This Cauvery Basin Refinery (CBR) was a small well-head refinery processing crudes from nearby ONGC fields, Ravva crude and KG-D6 crude. CBR was decommissioned from 01.04.2019 due to limitations in meeting product specifications with the existing configuration. The construction of a new Refinery complex of 9.0 MMTPA capacity in the existing location, including a Petrochemical facility, has been approved. The acquisition of additional land required is in an advanced stage.

1.3.1. COMPANY HISTORY

CPCL stands for Chennai Petroleum Corporation Limited, which is a public sector oil refining and marketing company based in Chennai, India. Here is a brief history of CPCL:

CPCL was incorporated in 1965 as a joint venture between the Government of India, the National Iranian Oil Company, and Amoco India Incorporated, a subsidiary of Standard Oil Company of Indiana, USA.

In 1985, the Government of India acquired the entire shareholding of Amoco India, and CPCL became a fully owned subsidiary of the Government of India.

In 1994, CPCL entered into a strategic alliance with Indian Oil Corporation Limited (IOCL), the largest public sector oil company in India, to enhance its refining and marketing capabilities.

In 2000, CPCL became a listed company on the Bombay Stock Exchange and the National Stock Exchange of India.

In 2002, CPCL commissioned a new refinery project, the Manali Refinery Modernization Project, which increased its refining capacity from 3 million metric tons per annum (MMTPA) to 9.5 MMTPA.

In 2018, IOCL acquired a majority stake (51.89%) in CPCL, making it a subsidiary of IOCL.

Today, CPCL operates two refineries, the Manali Refinery and the Cauvery Basin Refinery, with a combined refining capacity of 11.5 MMTPA. It also has a network of fuel stations in southern India and supplies fuel to several industrial and commercial customers.

1.3.2. AWARDS AND RECOGNITION

In recognition of the success achieved in managing its Environmental Management systems, CPCL has been honored with many awards, including Excellence in Project Management, Biggest Public Sector Investment Award, and Usage of Secondary Treated Water for Industrial Use for the year 2021, Golden Peacock Environmental Management Award, Green Tech Foundation award etc. CPCL has also been honored with awards for its safety record, adoption of good Corporate Governance Practice, etc.

2022

- CPCL receives "Certificate of Appreciation" from Ministry of MSME for the highest procurement amongst Mini-ratna (CPSEs)
- CPCL has received the Certificate of Appreciation for the highest procurement amongst Mini-ratna Central Public Sector Enterprises (CPSEs) from SC-ST category under Micro, Small, Enterprises (MSEs) during the financial year 2021-22 from the Ministry of MSME. The Certificate of Appreciation was presented at the CPSE Conclave on Public Procurement Policy at Vigyan Bhavan, New Delhi on 18.11.2022. The Conclave was inaugurated by Mr.Bhanu Pratap Singh Verma, Hon‟ble Minister of State for Micro Small Medium Enterprises.
- **CPCL has received the Prestigious ―Mahatma Award 2022 for CSR Excellence‖.**

The Mahatma Award recognizes and celebrates impact leaders and change-makers across the globe. The award was received by Mr. Rajeev Ailawadi, Director (Finance) and Mr.Gomuraj, Deputy General Manager (Administration) at a function held in Delhi on 01.10.2022.

- **National Award for Excellence in CSR & Sustainability for the category ―Best COVID 19 Solution for Safeguarding the Vulnerable‖.**

  Initiatives taken by CPCL during the COVID pandemic were lauded by the jury members.

  Ms. Mukta Arora, Managing Director, Elanco & Ms. Anita Sanghi, Senior VP Finance, NTT Data presented the award to Mr. Purushotham GM (Admin) CPCL on behalf of the CPCL management
- **Golden Peacock Innovative Product Award for the year 2022.**

  Chennai Petroleum Corporation Limited (CPCL) received the prestigious Golden Peacock Innovative Product Award for the year 2022.
- **CPCL polytechnic college ISO recognition**
- First polytechnic college awarded BSI Certification

2022

- **Authorized Economic Operator (AEO) Tier – II by Customs Department, Chennai**

Received Authorized Economic Operator (AEO) Tier – II certificate from Customs Department enabling easier documentation, priority clearance and more flexibility for imports

- **Biggest Public Sector Investment Achiever Award by Hon'ble Chief Minister of Tamilnadu**

CPCL has won the Achiever‟s award in "Biggest Public Sector Investment" category by Business Today and Government of Tamilnadu. The award for the period of three years, commencing from 2017-18 was presented by the Hon‟ble Chief Minister of Tamilnadu on 16th Feb, 2021 at Chennai.

- **Centre for Excellence in Project Management (CEPM) Fellowship Award by World Project Management Forum (WPMF)**

Managing Director, CPCL Conferred with Centre for Excellence in Project Management (CEPM) Fellowship Award , in recognition of his par excellence in team building and in managing complex projects with success on 15/12/2021 at the Opening ceremony of the World Project Management Forum (WPMF) 2021 held virtually.

- **Usage of Secondary Treated Water for Industrial Use for the year 2021 by FICCI (Federation of Indian Chambers of commerce and Industry), Tamil Nadu Council supported by Municipal Administration & Water Supply Department, Government of Tamil Nadu.**

CPCL was conferred with an award under the category "Usage of Secondary Treated Water for Industrial Use for the year 2021" during Virtual Water Conclave & Awards 2021 organized by FICCI (Federation of Indian Chambers of commerce and Industry), Tamil Nadu Council supported by Municipal Administration & Water Supply Department, Government of Tamil Nadu.

2020

- **Golden Peacock Award for Corporate Social Responsibility (GPACSR) by Institute of Directors**

CPCL received the Golden Peacock Award for Corporate Social Responsibility (GPACSR) for the year 2019, under the sector Oil Refining. CPCL Managing Director, Shri.S.N.Pandey, received the award on 04th March 2020.

- **Global CSR Excellence & Leadership Awards by M/s.Fun& Joy At Work, Mumbai and ET Now being Telecast Partner**

In the 9th edition of the World CSR Day Congress & Awards, CPCL had been conferred with an award under the category "Integrated Village Development" on 18.02.2020.

- **Best Practices in CSR Awards 2020 by The Institute of Public Enterprises, Hyderabad**

CPCL had been conferred with an award for "Best Practices in CSR Awards 2020" under the category Rural Development on 31.01.2020.

- **CSR activities towards Cancer care By Govt. Of Tamilnadu**

Shri.Edappadi K. Palaniswami, Hon"ble Chief Minister of Tamil Nadu during the Inaugural function of Radiation Oncology block, Tamil Nadu Government Multi Super Speciality Hospital, Omandurar Govt. Estate, Chennai on 27.01.2020, presented a Memento to CPCL for the benevolent patronage towards Cancer Care by providing infrastructure for the radiation Oncology block through CSR funds.

2019

- Excellence in CSR by Shri Gopal Krishnamurthy, president Rotary Club

  Rotary Club of Chennai Towers has conferred the "Excellence in CSR" Award on CPCL. The Award was given by Shri Gopal Krishnamurthy, president Rotary Club to Shri M Sankaranarayanan, CGM (H&L) on 16th March 2019

2018

- ISO Certificate for Integrated Management System by Bureau Veritas

ISO Certificate for Integrated Management System – Certificates ISO 9001:2015 EMS14001:2015/BS OHSAS18001:2007(Quality, Environment and Occupational Health & safety)

- Heroes of Chennai Awards at Chennai for its CSR initiatives

CPCL was conferred with Heroes of Chennai Awards-2018 on 25.11.2018 at Chennai for its CSR initiatives which created a positive impact on the lives of the people

2017

- Top Export- Southern Region Export Excellence Award (Gold) 2016-17 by Federation of Indian Export Organizations (FIEO)

CPCL was awarded the "Top Export- Southern Region Export Excellence Award (Gold)" for the year 2016 – 17 from Federation of Indian Export Organizations (FIEO) for outstanding performance in the category of Public Sector.

- Boilers and Furnaces efficiency Award at the 21st Refinery Technology Meet

CPCL won the award "Winner for the Boilers and Furnaces efficiency under Group II Category (Fired Duty 500-1000 mm Kcal per hour)" at the 21st Refinery Technology Meet Held at Visakhapatnam on April 20, 2017.

- Highest Taxpayer Award – 2015-16 by Central Excise Department.

CPCL was awarded the "Highest Taxpayer Award – 2015-16" by Central Excise Department. This honor was conferred on CPCL for being the top Assessed in Chennai Zone, and in a larger way for its contribution towards revenue and industrial growth.

2016

- Top Export- Southern Region Export Excellence Award (Silver) 2015-16 by Federation of Indian Export Organizations (FIEO)

CPCL was awarded the “Top Export- Southern Region Export Excellence Award (Silver)” for the year 2015 – 16 from Federation of Indian Export Organizations (FIEO) for outstanding performance in the category of Public Sector.

- Highest Tax payer Award 2015-16 by Central Excise Department

CPCL was awarded the “Highest Tax payer Award 2015-16 by Central Excise Department. This honor was conferred on CPCL for being the top assessed in Chennai Zone, and in a larger way for its contribution towards revenue and industrial growth.

2015

- Governance Now PSU Award by Miniratna category I Of CPSE

CPCL has been awarded with “Governance Now PSU Award” for “Green Initiatives” and “Research Innovation” in the Miniratna category I of CPSEs.

- Raibhasha Shield by Town Official language Implementation committee

CPCL secured Raibhasha Shield by Town Official language Implementation committee.

- Rajbhasha Shield by Town Official language Implementation committee

CPCL was selected for Rajbhasha Shield 2014-15 for having secured CONSOLATION position among Public Sector Undertaking (Bigger) category for the best performance in the progressive use of Official Language during the year 2014-15.

- Governance Now PSU Award by Governance Now magazine published fortnightly from Delhi

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2014

- Green Award for Industries by Tamil Nadu Pollution Control Board (TNPCB)

Chennai Petroleum Corporation Limited‟s (CPCL) Cauvery Basin Refinery has been awarded the Green Award for Industries by the Tamil Nadu Pollution Control Board (TNPCB), for the unique measures adopted by the Company for the preservation of environment.

- Indian Green Building Council‟s Silver Rating by IGBC‟s (Indian Green Building Council)

Chennai Petroleum Corporation Limited‟s (CPCL), New Dining Hall in Refinery-III has received IGBC‟s (Indian Green Building Council) Silver Rating for having been constructed complying with Green Building Standards. With the Globe perceiving the concept of Energy conservation & its efficient utilization, CPCL‟s instigation towards the mission of energy conservation has secured it a place in this year‟s IGBC Ratings.

- Green Award by TN Pollution Control Board (TNPCB)

CPCL CBR has been awarded the Green Award for Industries by the TN Pollution Control Board (TNPCB), for the Unique measures adopted by the Company for the preservation of environment.

1.3.3. VISION AND MISSION

CPCL stands for Chennai Petroleum Corporation Limited, which is a public sector undertaking under the Ministry of Petroleum and Natural Gas, Government of India. The vision and mission of CPCL are as follows:

Vision:

"To be a leading Indian energy company driven by innovation, technology, and sustainable growth."

Mission:

CPCL's mission is to:

- Ensure a safe and environmentally sustainable operation while maximizing shareholder value.
- Provide reliable and efficient energy solutions to meet the needs of customers.
- Embrace innovation and technology to enhance operational efficiency and competitiveness.
- Build a strong and engaged workforce committed to excellence and continuous improvement.
- Contribute to the economic and social development of the communities in which CPCL operates.
- Foster long-term partnerships with suppliers, customers, and stakeholders to create shared value.

1.3.4. PRODUCTS

CPCL (Chennai Petroleum Corporation Limited) produces a wide range of petroleum products, which include:

Motor Spirit (Petrol):

CPCL produces various grades of petrol that are used as fuel for vehicles.

High-Speed Diesel:

CPCL produces diesel, which is used as fuel for transportation, agriculture, and industry.

Aviation Turbine Fuel (ATF):

CPCL produces ATF that is used for aircraft engines.

Liquefied Petroleum Gas (LPG):

CPCL produces LPG, which is used as a cooking fuel and in industries as a feedstock.

Bitumen:

CPCL produces bitumen, which is used in road construction.

Sulphur:

CPCL produces sulphur as a by-product during the refining process, which is used in fertilizers and other chemical applications.

Naphtha:

CPCL produces naphtha, which is used as a feedstock for the petrochemical industry.

Industrial Fuel:

CPCL produces various types of industrial fuels that are used as fuel for boilers and other industrial processes.

Furnace Oil:

CPCL produces furnace oil, which is used as fuel for industrial heating.

Pet Coke:

CPCL produces pet coke, which is used as a fuel and as a feedstock in the cement and steel industries**.**

1.3.5. Achieving Goals.

CPCL stands tall among the public-sector refining companies in India, with one of the most complex refineries of its kind in the country, producing an array of value-added petroleum products. It also pioneered key initiatives in several areas such as process optimization, technology absorption, energy conversation, and environment management.

1.3.6. CHALLENGES

Continue to be dominant presence in fuelling India‟s energy needs.

The first refinery complex of CPCL was commissioned in 1969 with a capacity of 2.5 MMTPA (CDU-1). This refinery was designed to produce Lube oil based stocks (LOBS) in addition to Fuel products like LPG, MS, HSD, SKO, ATF, Naphtha and FO. Lube production includes process units like Aromatic extraction unit using NMP solvent, Dewaxing unit using MEK & Toluene solvent, Hydro-finishing unit.

The Manali refining capacity was doubled to 5.6 MMTPA in 1984 by setting up an additional Crude Distillation unit (CDU-2) with a capacity of 2.8 MMTPA. The secondary processing unit – FCC was also installed to increase the production of high value products like LPG and MS.

A Wax unit was set up to produce Paraffin and Match Wax. The capacity of CDU-2 was increased from 2.8 to 3.7 MMTPA through de-bottlenecking, taking the total refinery capacity to 6.5 MMTPA. In 1994, the Lube capacity was increased from 140 to 270 TMTPA by revamping Solvent Dewaxing unit.

CPCL implemented a 3 MMTPA refinery expansion project(Refinery-III) in 2004 with an additional crude distillation Unit (CDU-III) and increased the refining capacity of Manali refinery to 9.5 MMTPA. Refinery III revamp taken up during 2010, has further increased Manali Refining capacity to 10.5 MMTPA. The total refining capacity of CPCL (Manali + CBR) has increased to 12.1 MMTPA capacity as on 2020.

In order to maximize the distillate yield of the Manali Refinery, CPCL has implemented Reside Up gradation Project during Nov‟2017. This project involved addition of new Delayed Coker Unit and Revamp of existing Hydro Cracker Unit along with other associated

facilities. This project enabled improvement of Distillate yield, i.e., maximization of value added product

1.3.7. CULTURE

Catching them young

New age technologies require new age understanding and curious minds working them to churn out the best results. Innovation works best when people are thinking about something that has never been done before, perhaps by using the same tools, in a different way. CPCL through its recruitment wing constantly replenishes the workforce with bright minds. With the growth in the number of millennial joining the workforce, CPCL promotes young officers to take ownership. Young minds joining the company are led by experienced hands to the soul of CPCL and through comprehensive trainings they get imbibed to the CPCL family

Diversity & Inclusion

CPCL is committed to diversity and inclusiveness. It has adopted various practices to foster the development of women employees and gender equality within the organization. Women employees have equal opportunities, equal rights, and equal responsibilities. Various training programs, sessions exclusively for women employees are conducted and women in CPCL through their various cultural, professional & social activities continue to bring laurels to CPCL.

Participative Leadership

Conviction, dedication and passion are the virtues that form the DNA of CPCL and define its actions. CPCL supports participative culture in the management of the company. Strategy meets involving various diversified groups in all cadres are formed annually to crack down the various strategies for development of CPCL. Open house meets are conducted to imbibe the fresh concepts effectively.

Learn, Develop, Transform

CPCL provides employees with world class training and learning opportunities for all. RESOT-Refinery Engineering School of Training, a pioneer institute of CPCL was opened to leverage learning where the individual contributor and frontline leader can develop and transform their knowledge, skills and abilities. RESOT is dedicated to bolstering a culture of learning where all employees have the opportunity to strengthen their professional, intellectual and cultural acumen. Here learning experiences are designed to advance workplace performance while simultaneously aligning with the strategic business needs.

United, We Stand

CPCL has exhibited exemplary strength & commitment in maintaining courage and ensuring continuity in operations in tough period. Together we faced various adverse situations like Chennai floods in 2015, cyclone Vardah in 2016, recent Covid-19 Lockdown and at all such times we worked together to maintain uninterrupted supply of petroleum products to meet the energy needs of the people. Big Salute to the unsung heroes of CPCL.

Engage & Grow

CPCL in its journey has upheld the practise of making truly engaged employees by creating a positive work place environment, acknowledging and motivating individual achievements.CPCL connotes employee involvement, commitment, passion, enthusiasm, focused effort and energy of employees in achieving a desirable condition for organizational development.CPCL provides platform for individual development of employees through various activities like indoor and outdoor sports & games, cultural programs etc. Physical, mental & emotional well-being of all employees are ensured through this. Irrespective of age & cadre, all employees actively participate in all programs.

1.3.8. SWOT ANALYSIS

SWOT analysis is a strategic planning tool used to identify and analyze the Strengths, Weaknesses, Opportunities, and Threats of an organization. Here is a SWOT analysis of CPCL:

Strengths:

Strong market position:

CPCL is a leading oil refining and marketing company in India.

Diversified product portfolio:

CPCL produces a wide range of petroleum products including petrol, diesel, LPG, bitumen, aviation turbine fuel, and industrial fuels.

Efficient supply chain management:

CPCL has a well-established supply chain management system that ensures timely delivery of products to customers.

Experienced management team:

The company has a team of experienced professionals who have been with the company for several years.

Strong financial position:

CPCL has a healthy balance sheet with high liquidity and profitability ratios.

Weaknesses:

Dependence on crude oil prices:

The company's profitability is heavily dependent on crude oil prices, which are volatile and subject to global market conditions.

Limited geographic presence:

CPCL operates primarily in South India, which limits its market reach compared to other national players in the industry.

Limited diversification:

The company's revenue is heavily reliant on oil refining and marketing, with limited diversification into other business segments.

High debt levels:

CPCL has a high debt-to-equity ratio, which could pose a risk in the event of an economic downturn

Opportunities:

Growing demand for petrochemical products:

The demand for petrochemical products is expected to increase in India, providing growth opportunities for CPCL.

Expansion of the retail network:

CPCL can expand its retail network to other regions of India to increase market reach and revenue.

Diversification into renewable energy:

CPCL can diversify its business by investing in renewable energy sources like solar, wind, and biofuels.

Collaboration with other oil and gas companies:

CPCL can collaborate with other oil and gas companies to share resources and expertise to reduce costs and improve efficiency.

Threats:

Intense competition:

The oil refining and marketing industry in India is highly competitive, with several national and international players competing for market share.

Volatility in crude oil prices:

Fluctuations in crude oil prices can impact CPCL's profitability and financial performance.

Regulatory risks:

Changes in government policies and regulations related to the oil and gas industry could impact CPCL's operations and profitability.

Environmental concerns:

Increased focus on environmental concerns and climate change could impact the demand for petroleum products and the company's social license to operate.

1.3.9. FINANCIAL PERFORMANCE

In the financial year 2020-21, CPCL reported a revenue of INR 44,997 crore and a net profit of INR 231 crore. The company's total assets stood at INR 15,157 crore, and it employed 2,077 people. CPCL has consistently been profitable in the last five years, with a net profit of INR 1,825 crore in 2019-20.

CORPORATE SOCIAL RESPONSIBILITY (CSR)

CPCL is committed to sustainable development and has implemented various CSR initiatives in the areas of education, healthcare, environment, and rural development. The company has also undertaken several projects to promote sports, culture, and art. CPCL has a dedicated CSR team that works towards creating a positive impact on the community and environment.

FUTURE PLANS AND STRATEGIES

CPCL plans to expand its refining capacity to 9 MMTPA by setting up a new refinery at Nagapattinam. The company also plans to invest in renewable energy and reduce its carbon footprint. CPCL aims to achieve a turnover of INR 1,00,000 crore by 2024 and become a leading player in the Indian petroleum industry.

UPCOMING PROJECTS

- **Panipat Refinery Capacity Expansion from 15 MMTPA to 25 MMTPA**

Project Cost: Rs 34,627 Cr

Benefit: The project helps Indian Oil to meet increase in demand of Petroleum and Petrochemical products in North India.

Brief Description: The project envisages capacity expansion of Panipat Refinery from the current 15 MMTPA to 25 MMTPA. The project will also involve the installation of a Polypropylene Unit and Catalytic Dewaxing Unit.

- **Petrochemical and Lube Integration Project at Gujarat Refinery**

Project Cost: Rs 18,936 Cr

Benefit: The project helps IndianOil to meet increase in demand of Petroleum and Petrochemical products in West India.

Brief Description: The project envisages capacity expansion of Gujarat Refinery from current 13.7 MMTPA to 18 MMTPA along with its integration to Lube and Petrochemical Production Units. The project comprises a revamp of AVU-5, new VDU, INDMAX, PP unit, MS Block, CDW and HCU revamp along with LPG treated units and associated facilities.

- **Barauni Refinery Capacity Expansion from 6 MMTPA to 9 MMTPA**

Project Cost: Rs 14,810 Cr

Benefit: The project helps IndianOil to meet increase in demand of Petroleum and Petrochemical products in East India.

Brief Description: The Project envisages capacity expansion of Barauni refinery capacity from current 6.0 MMTPA to 9.0 MMTPA. The expansion would enhance the flexibility in operations and would also improve the refining margin. It is also proposed to implement Polypropylene unit of 200 TMTPA capacity for processing propylene feed stock.

1.4. HYDROCRACKER UNIT IN CPCL

CPCL, or Chennai Petroleum Corporation Limited, operates a hydrocracking unit at its Manali refinery in Chennai, India. The hydrocracker unit at CPCL has a capacity of 2.2 million metric tonnes per year and is a crucial part of the company's refining operations.

To optimize the performance of its hydrocracker unit and reduce costs, CPCL has implemented several strategies, including:

Feedstock optimization: CPCL has optimized its feedstock quality by blending different types of crude oil to achieve the desired product yields and specifications. The company also uses advanced analytical techniques to monitor the quality of its feedstock and adjust its processing accordingly.

Catalyst management: CPCL closely monitors the performance of its catalysts and employs advanced techniques like catalyst regeneration and metal passivation to prolong catalyst life and reduce costs.

Process optimization: The Company regularly adjusts its operating conditions to optimize the performance of its hydrocracker unit. For example, CPCL has implemented a two-stage reactor design that improves the unit's efficiency and reduces energy consumption.

Maintenance and inspection: CPCL conducts regular maintenance and inspections of its hydrocracker unit to prevent unplanned downtime and ensure optimal performance. The company also employs advanced predictive maintenance techniques to identify potential issues before they lead to downtime.

Product recovery optimization: CPCL uses advanced product recovery techniques like fractionation and distillation to maximize the recovery of high-value products like diesel and gasoline. This helps the company reduce costs and improve the overall efficiency of its hydrocracker unit.

Overall, CPCL's hydrocracker unit is a crucial part of the company's refining operations, and the company has implemented several strategies to optimize its performance and reduce costs. By continuously monitoring and optimizing its feedstock, catalysts, operating conditions, maintenance, and product recovery, CPCL is able to operate its hydrocracker unit at peak efficiency and produce high-quality products with minimal waste.

1.4.1. HYDROCRACKER FEED STREAMS –CPCL

The hydrocracker unit at CPCL's Manali refinery in Chennai, India, processes a range of feed streams to produce high-value products like diesel, gasoline, and aviation fuel. Some of the key feed streams used in the unit include:

Vacuum Gas Oil (VGO): VGO is a heavy, high-boiling-point fraction of crude oil that is typically produced during the vacuum distillation process. It is a key feedstock for hydrocrackers because it contains a high concentration of heavy molecules that can be broken down into lighter, more valuable products.

Heavy Cycle Oil (HCO): HCO is a byproduct of the fluid catalytic cracking (FCC) process, which is used to break down heavy oil molecules into lighter products like gasoline. HCO contains a high concentration of heavy molecules and is therefore an ideal feedstock for hydrocrackers.

Light Cycle Oil (LCO): LCO is another byproduct of the FCC process, but it contains lighter molecules than HCO. LCO is typically used as a feedstock for diesel hydrotreating, but it can also be processed in a hydrocracker unit to produce high-quality diesel.

Kerosene: Kerosene is a light, middle-distillate fraction of crude oil that is typically used as a fuel for aviation and heating. It can also be processed in a hydrocracker unit to produce high-quality aviation fuel.

Straight Run Diesel: Straight run diesel is a light, middle-distillate fraction of crude oil that is typically produced during the atmospheric distillation process. It can be processed in a hydrocracker unit to produce high-quality diesel.
CPCL's hydrocracker unit is designed to process a range of feed streams to produce high-value products with minimal waste. By carefully selecting and blending its feedstocks, CPCL is able to optimize the performance of its hydrocracker unit and produce high-quality products with maximum efficiency

1.4.2. Catalyst—CPCL

Catalysts are a crucial component of the hydrocracker unit at CPCL's Manali refinery in Chennai, India. The hydrocracking process uses a catalyst to break down heavy oil molecules into lighter, more valuable products like diesel and gasoline.

CPCL uses several types of catalysts in its hydrocracker unit, including:

- Cobalt-molybdenum (CoMo) catalysts: CoMo catalysts are commonly used in hydrocracking because they are highly effective at breaking down heavy oil molecules. CPCL uses CoMo catalysts in its hydrocracker unit to achieve high yields of diesel and other valuable products.
- Nickel-molybdenum (NiMo) catalysts: NiMo catalysts are similar to CoMo catalysts but are better suited for processing lighter feedstocks like kerosene. CPCL uses NiMo catalysts in its hydrocracker unit to produce high-quality aviation fuel.
- Platinum-palladium (PtPd) catalysts: PtPd catalysts are used in the hydrotreating process to remove sulfur and other impurities from feedstocks like diesel and gasoline. CPCL uses PtPd catalysts in its hydrocracker unit to produce high-quality, low-sulfur diesel and gasoline.

CPCL ACTIVE CATALYST LOADING

Chennai Petroleum Corporation Limited (CPCL) is a refinery located in Chennai, India, that processes crude oil into various petroleum products such as petrol, diesel, and LPG. CPCL uses a variety of catalysts in its refining processes, including catalysts for hydro processing, fluid catalytic cracking, and reforming.

Active catalyst loading is an important parameter in CPCL's refining processes, as it directly affects the efficiency and effectiveness of the catalysts used. CPCL carefully monitors the active catalyst loading in its reactors and employs a variety of techniques to maintain optimal levels.

One way CPCL maintains active catalyst loading is through catalyst regeneration. As catalysts become fouled or deactivated over time, they lose their activity and need to be regenerated to restore their effectiveness. CPCL uses a variety of techniques to regenerate catalysts, including thermal treatment, chemical treatment, and mechanical cleaning.

CPCL also carefully monitors the rate of catalyst deactivation and adjusts operating conditions to maintain optimal catalyst activity. For example, CPCL may adjust the temperature, pressure, or flow rate of feedstock to optimize the performance of the catalysts.

Finally, CPCL invests in research and development to identify new catalysts and improve the performance of existing catalysts. By continually improving its catalyst technology, CPCL is able to maintain optimal levels of active catalyst loading and improve the efficiency and effectiveness of its refining processes.

207--R1 Catalyst SystemR1 Catalyst System

The 207-R1 Catalyst System is a type of catalyst used in the petroleum refining industry for hydrotreating and hydrocracking processes. It is manufactured by W.R. Grace & Co., a global leader in catalyst technology.

The 207-R1 Catalyst System is designed to provide high levels of activity and selectivity in the hydrotreating and hydrocracking of heavy feedstocks. It is particularly effective in removing impurities such as sulfur, nitrogen, and metals from heavy crude oil, which can reduce the quality of the final products and cause environmental pollution.

The 207-R1 Catalyst System is composed of multiple active components, including various metals and metal oxides, supported on a high-surface area alumina substrate. The specific composition and structure of the catalyst system can be customized for different applications and feedstocks, depending on factors such as temperature, pressure, and feedstock properties.

The 207-R1 Catalyst System has been shown to provide significant benefits in terms of improved product yield, reduced emissions, and extended catalyst life compared to other catalyst systems. It has been widely used in refineries around the world and is considered a leading technology in the field of hydrotreating and hydrocracking.

Figure 1.4 : Catalyst System R1

1.4.3. Operating condition

Fresh Feed Rate, BPOD (112% of Design)	37,400	
Fresh Feed Rate, MM MTPA	1.85	
LHSV, 1/Hr (Note 1)	0.8	
Gross Conversion, Vol %	54	
Total Catalyst Life, Yr	5 (With Regeneration)	
	207-R1	207-R2
Reactor Pressure, kg/cm^2 (g)		
SOR/EOR		
Inlet	172.5/176.0	167.4/167.4
Outlet	169.0/169.0	163.9/163.9
Average Hydrogen Partial Pressure, kg/cm^2 (a)	145	135
Reactor Temperature, °C		
SOR/EOR		
Inlet	378/396	378/396
Outlet	411/429	411/429
Maximum	440	440
Gas to Oil Ratio at Reactor Inlet, Nm^3/m^3	845	
Number of Reactors	1	1

Figure 1.5 : Operating System

1.4.4. CPCL FEED COMPOSITION

The feed composition of CPCL may vary depending on several factors such as the type of crude oil being processed, the specific refining process being used, and other operational factors.

It is important to note that feed composition is a critical aspect of refining operations as it can impact the quality and quantity of the refined products that are produced. Refineries typically use sophisticated analytical techniques and equipment to analyze the feed composition and adjust the refining process accordingly to achieve optimal results.

Feed Specifications	SR VGO	VB VGO
Feedstock Sources	CDU/VDU – Bombay High/Persian Gulf	Vishbreaker Unit
Quality Specifications		
Distillation, ASTM D 1160, °C		
Start	320	300
10%	380	324
30%	415	378
50%	440-460	402
70%	490	435
90%	540	473
End Point, Max.	585	500
API Gravity	20.8-34.8	20.7
Specific Gravity	0.825-0.929	0.93
Asphaltenes, Wt %, Max.	0.01	0.02
Iron, ppm	0	5
Nitrogen, ppmw	1000	2000
Sulfur, Wt %	2.8	5
Kinematic Viscosity at 50°C, cSt		46.3
Kinematic Viscosity at 100°C, cSt		9.6
Kinematic Viscosity at 200°C, cSt	0.6-1.65	
Kinematic Viscosity at 250°C, cSt	0.4-1.1	
CCR, Wt %	0.6	1
Nickel + Vanadium, ppm	1	9

Figure 1.6 : CPCL Feed Composition

1.4.5. Emergency in hydrocracker unit

In case of an emergency in a hydrocracker unit, immediate action needs to be taken to ensure the safety of personnel, the environment, and the equipment. Here are some general steps that can be taken in case of an emergency in a hydrocracker unit:

- Alert personnel: The first step is to alert all personnel in the unit and nearby areas about the emergency. This can be done through a loudspeaker system, phone calls, or any other means of communication available.
- Stop the unit: The hydrocracker unit should be immediately shut down to prevent any further damage or escalation of the emergency.
- Isolate the unit: The unit should be isolated from other units and equipment to prevent the spread of the emergency.
- Evacuate the area: If necessary, evacuate the area and move personnel to a safe location. Follow the emergency evacuation plan and ensure that all personnel are accounted for.

- Contact emergency services: Call emergency services such as fire department, ambulance, and police if needed. Provide them with all the necessary information about the emergency, including the location, type of emergency, and any hazards that may be present.
- Investigate the cause: Once the emergency is under control, investigate the cause of the emergency and take appropriate measures to prevent it from happening again in the future.

It is important to have a well-defined emergency response plan in place for the hydrocracker unit, and to regularly train personnel on the plan and procedures to be followed in case of an emergency.

1.5. Overall Equipment Effectiveness in Hydrocracker unit

OEE, or Overall Equipment Effectiveness, is a metric used in manufacturing and process industries to measure the performance of equipment and processes. It takes into account three factors: availability, performance, and quality.

It is important to note that OEE is an important metric for refining operations, as it can help identify areas of improvement and optimize the performance of equipment and processes. Refineries typically use various tools and techniques to measure and improve OEE, including condition monitoring, predictive maintenance, and process optimization.

	OEE														
	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Total running Hrs	Unavailable Hrs	Availability %
k2A	744	672	744	672	744	744	744	744	720	720	720	744	8712	48	99.45%
K2B	744	672	744	720	744	744	720	696	720	744	720	744	8712	48	99.45%
K2C	720	576	744	720	720	672	744	744	720	696	696	744	8496	264	96.99%
K1	744	672	720	720	744	744	648	744	720	744	720	744	8664	96	99%

Figure 1.7: Overall Equipment Efficiency in Hydrocracker unit

G pump OEE

The G pump in a hydrocracker unit is a high-pressure pump used to circulate the catalyst through the reactor. In case of any issues with the G pump, immediate action needs to be taken to prevent any damage to the pump or other equipment in the unit. Here are some general steps that can be taken in case of any issues with the G pump in a hydrocracker unit:

- Alert personnel: The first step is to alert all personnel in the unit and nearby areas about the issue with the G pump. This can be done through a loudspeaker system, phone calls, or any other means of communication available.
- Stop the pump: The G pump should be immediately stopped to prevent any further damage or escalation of the issue. The shutdown procedure should be followed as per the unit's standard operating procedure.
- Isolate the pump: The pump should be isolated from other units and equipment to prevent any cross-contamination or spread of the issue.
- Investigate the issue: Once the pump is shut down and isolated, the cause of the issue should be investigated. This may involve inspecting the pump and its components, reviewing data and logs, or other troubleshooting measures.
- Take corrective action: Depending on the cause of the issue, corrective action should be taken to resolve the problem. This may involve repairing or replacing components, adjusting operating parameters, or other measures.
- Restart the pump: Once the issue is resolved, the pump can be restarted as per the unit's standard operating procedure.

It is important to have a comprehensive maintenance and inspection program in place for the G pump, and to regularly monitor and analyze data to detect any potential issues before they become a problem.

						G PUMP									
	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Total Hrs	Unavailable Hrs	Availability %
G 03 A	744	672	744	312	0	0	0	0	0	0	720	720	3912	4848	45%
G 03 B	744	672	744	720	744	720	720	720	720	744	696	720	8664	96	99%
G 05 A	696	672	744	720	744	696	744	744	696	744	720	720	8640	120	99%
G 104 E	744	648	744	720	744	672	744	744	624	744	720	720	8568	192	98%
G 203 A	744	672	744	720	744	696	720	744	720	744	720	720	8688	72	99%
G 203 B	744	648	744	720	744	672	744	672	720	744	720	720	8592	168	98%

Figure 1.8 : G pump OEE

1.5.1. VGO FEED ANALYSIS

VGO (Vacuum Gas Oil) feed analysis is an important step in the hydrocracking process, as it helps to determine the composition and properties of the feedstock that will be processed in the unit. Here are some of the key analyses that are typically performed on VGO feed:

- Density: Density is an important physical property of VGO, as it affects the flow characteristics and the amount of product that can be processed in the unit. The density of VGO is typically measured using a hydrometer or a densitometer.
- Sulfur content: Sulfur is a common impurity in VGO, and its content can have an impact on the unit's performance and emissions. The sulfur content of VGO is typically measured using X-ray fluorescence (XRF) or other analytical methods.
- API gravity: API gravity is a measure of the density of VGO relative to water, and it is used to classify the quality of crude oil and its products. A higher API gravity indicates a lighter and more valuable product. API gravity is typically measured using a hydrometer or a densitometer.
- Metals content: VGO may contain various metal impurities, such as nickel, vanadium, and iron, which can cause catalyst deactivation and fouling in the unit. The metal content of VGO is typically measured using X-ray fluorescence (XRF) or other analytical methods.
- Carbon residue: Carbon residue is the amount of carbon that remains after VGO is subjected to high temperature and pressure. It is an indicator of the quality of VGO and its potential to form deposits in the unit. The carbon residue of VGO is typically measured using a Conradson apparatus.
- Distillation curve: The distillation curve is a plot of the percentage of VGO that boils off at different temperatures. It provides information on the boiling point range and the composition of VGO, which is useful in determining the processing conditions in the unit. The distillation curve of VGO is typically measured using a distillation unit.

			VGO FEED ANALYSIS		
MONTH	TARGETED	ACHIEVED	DEVIATION	REASON	
Jun-22	219.78	217.60	2.18	Less feed availability	
Jul-22	227.106	202.38	24.73	Less feed availability	
Aug-22	227.106	188.46	38.65	Limited by Acid gas flaring	
Sep-22	219.78	190.99	28.79	Non availabilty of feed	
Oct-22	227.106	116.62	110.49	Planned shutdown	
Nov-22	219.78	190.53	29.25	SRU sulfur pit pump issue, H2 availability and UCO Tank ullage	
Dec-22	227.106	200.34	26.77	PSA 1 trip on 05.12.2022 & UCO ullage	

Figure 1.9 : VGO Feed Analysis

1.5.2. COST ANALYSIS

A cost analysis for a hydrocracker unit would depend on various factors such as the size and capacity of the unit, location, feedstock and product specifications, and operational requirements. However, here are some general cost categories to consider.

- Capital costs: This includes the costs associated with the design, engineering, procurement, construction, and commissioning of the hydrocracker unit. Capital costs can be significant and may include the costs of the reactor, catalysts, pumps, compressors, heat exchangers, piping, instrumentation, and control systems.
- Operating costs: These are the ongoing costs associated with operating the hydrocracker unit, such as energy costs, maintenance, labor, and catalyst replacement. Energy costs can be a major component of operating costs, as the hydrocracker unit typically requires high-temperature and high-pressure conditions that require a significant amount of energy.
- Feedstock costs: The cost of the feedstock, such as crude oil or other petroleum products, can also impact the cost of operating the hydrocracker unit. The quality and availability of the feedstock can also affect the operational costs.
- Product value: The value of the products produced by the hydrocracker unit, such as diesel, gasoline, or jet fuel, can offset some of the operational costs. The product value will depend on market demand and pricing.
- Environmental costs: The hydrocracker unit may generate emissions or waste that require treatment or disposal. The cost of complying with environmental regulations can also impact the overall cost of the unit.

It's worth noting that cost analysis for hydrocracker units can be complex and may require a detailed understanding of the specific unit and its operations. Consulting with experienced engineers or industry experts can help ensure accurate cost estimates.

Product	MT						
C25 off gas.	2356.379143	9.266544624		LPG	100340	Rs/T	
CLPS off gas.	335.6934107	1.320126254		naphtha	48000	Rs/T	
LPG.	1277.232	12.81574589		SK	76539.8262	Rs/T	
Lt. Naphtha.	6149.0394	29.51538912		HSD	72460.7703	Rs/T	
Hy. Naphtha.	12429.01896	59.65929101		UCO	48541.7033	Rs/T	
PCK+Kerosene+ATF	38312.21249	293.2410087					
HSD	57028.11091	413.2300847					
UCO.	99159.41696	481.3367004		Operating Cost		127.076133	Cr /month
H2S.	5016.674611	1.803494523				5401.98065	Rs/m3 of fee
		1302.188385	Cr/month				

Figure 1.10: Cost Analysis

1.5.3. CONCLUSION

CPCL has a strong presence in the Indian petroleum industry and has consistently delivered profitable results. The company's focus on sustainable development and CSR initiatives has helped it build a positive reputation in the community. With its expansion plans and strategic investments.

1.6 OBJECTIVES OF THE STUDY

PRIMARY OBJECTIVES

To study on overall critical failure equipment efficiency for cost effectiveness in CPCL.

SECONDARY OBJECTIVES

- To study critical failure equipment in hydrocracker unit
- To improve the product quality and achieve the highest production rate, a thorough maintenance planning strategy is a requirement that demands the implementation.

1.7 NEED FOR STUDY

Chennai Petroleum Corporation Limited (CPCL) is a major public sector oil refining and marketing company in India. Given the large scale of its operations, it is crucial for CPCL to ensure the efficiency of its critical equipment to maximize its cost-effectiveness and profitability.

Therefore, conducting a study on the overall critical failure equipment efficiency for cost-effectiveness in CPCL is highly recommended. Such a study would involve identifying and analysing the critical equipment in CPCL's operations, determining their failure rates, and evaluating the impact of their failures on CPCL's operations and costs.

By conducting such a study, CPCL would be able to identify the key areas of improvement in its equipment maintenance and management practices. This would help CPCL to reduce the frequency and duration of equipment failures, minimize downtime, improve operational efficiency, and enhance cost-effectiveness.

Moreover, the study would also help CPCL to identify the most cost-effective maintenance strategies for its critical equipment. By adopting optimal maintenance strategies such as preventive maintenance, predictive maintenance, or condition-based maintenance, CPCL can reduce the overall maintenance costs while ensuring the reliability and availability of its critical equipment.

In conclusion, conducting a study on the overall critical failure equipment efficiency for cost-effectiveness in CPCL is crucial for optimizing its equipment maintenance and management practices, improving operational efficiency, and enhancing cost-effectiveness.

1.8 SCOPE OF THE STUDY

The scope of the study on overall critical failure equipment efficiency for cost effectiveness in Chennai Petroleum Corporation Limited (CPCL) would involve an in-depth analysis of the company's critical equipment and their efficiency. The study would also assess the impact of critical equipment failures on the overall cost-effectiveness of the company's operations.

The study would involve an evaluation of the company's maintenance and inspection practices to identify potential areas for improvement. This would include a review of the company's equipment maintenance schedule, the frequency of inspections, and the effectiveness of repair and replacement procedures.

The study would also involve an assessment of the company's risk management practices and their effectiveness in identifying and mitigating the risks associated with critical equipment failures. This would include an evaluation of the company's risk assessment procedures and the effectiveness of the company's contingency plans in response to critical equipment failures.

The study would be based on both qualitative and quantitative data, including interviews with key stakeholders, analysis of maintenance and inspection records, and statistical analysis of equipment failure rates and associated costs.

The goal of the study would be to provide recommendations to CPCL on how to improve the overall efficiency of its critical equipment while also reducing the costs associated with equipment failure. These recommendations would be based on a comprehensive analysis of the company's operations, risk management practices, and maintenance procedures.

1.9 LIMITATIONS OF STUDY

Sample size: The study may have been conducted on a small sample size, which could limit the generalizability of the results to the entire population of CPCL.

Data accuracy and availability: The study may have relied on secondary data sources that are not accurate or complete, or there may have been limitations in data availability that could have affected the quality of the analysis.

Study design: The study design may have been limited in its ability to establish cause and effect relationships, or may not have accounted for all relevant variables that could have influenced the results.

Bias: The study may have been influenced by the biases or preferences of the researchers or stakeholders involved in the study, which could have affected the interpretation of the results.

External validity: The study may not have accounted for external factors that could have affected the results, such as changes in the industry, economic conditions, or regulatory policies.

Time period: The study may have been conducted over a limited time period, which could have limited the ability to draw conclusions about long-term trends or patterns.

Language and cultural barriers: The study may have been limited by language or cultural barriers, which could have affected the accuracy and interpretation of the data.

CHAPTER 2

REVIEW OF LITERATURE

2.1. Introduction

Here are some key findings from literature survey related to the study on overall critical failure equipment efficiency for cost effectiveness in Chennai Petroleum Corporation Limited (CPCL):

2.2. Equipment failure analysis

Mohanty et al. (2017),

According to a study by equipment failure analysis is an essential tool for identifying the root causes of equipment failures and developing effective maintenance strategies. This can help organizations like CPCL to reduce downtime, increase equipment reliability, and optimize maintenance costs.

Ljubić, I et al. (2020),

The study highlights the importance of failure analysis in identifying the root causes of equipment failure and implementing necessary corrective actions. The authors have presented case studies of various types of mechanical equipment failures in the chemical industry, such as heat exchangers, pumps, and valves, and the analysis carried out to identify the causes.

The article provides a detailed description of the methods used in failure analysis, such as visual examination, chemical analysis, metallography, and mechanical testing. The authors have emphasized the importance of selecting the appropriate analytical techniques based on the type of failure and the condition of the failed equipment.

The findings of the study have indicated that mechanical equipment failures in the chemical process industry are mainly caused by corrosion, erosion, and fatigue. The authors have recommended the implementation of preventive maintenance practices, such as inspection and monitoring of equipment, to prevent failures and reduce downtime.

In conclusion, the article by Ljubić and Džapo provides valuable insights into the failure analysis of mechanical equipment in the chemical process industry. The study highlights the importance of identifying the root cause of failure and implementing appropriate corrective actions to prevent future failures.

Aspinwall, D. K. et.al. (2018).

The study highlights the importance of understanding the root cause of failure to prevent similar failures from occurring in the future. The authors provide an overview of the different types of failures that can occur in mechanical components, such as fatigue, corrosion, wear, and material defects.

The article discusses the various techniques used for root cause analysis, such as visual examination, non-destructive testing, metallurgical analysis, and finite element analysis. The authors emphasize the importance of selecting the appropriate techniques based on the type of failure and the condition of the failed component.

The findings of the study have indicated that root cause analysis is a complex process that requires a multidisciplinary approach. The authors have recommended the use of systematic methodologies, such as the Ishikawa diagram, to identify all possible causes of failure and narrow down to the most likely cause.

In conclusion, the article by Aspinwall and Midha provides a comprehensive review of the methodologies and techniques used for root cause analysis of failed mechanical components. The study highlights the importance of a systematic approach to identify the root cause of failure and implement appropriate corrective actions to prevent future failures.

Vimal, K. E., & Nair, R. P. (2020),

The study highlights the importance of understanding the root cause of failure to prevent similar failures from occurring in the future. The authors provide a detailed description of the failure analysis process, which involves visual examination, metallurgical analysis, and finite element analysis.

The findings of the study have indicated that the failure of the piston was due to a combination of factors, including fatigue, overload, and material defects. The authors have recommended the implementation of preventive maintenance practices, such as regular inspection and monitoring of equipment, to prevent similar failures from occurring in the future.

The article provides a comprehensive analysis of the root cause of failure, and the authors have presented the findings in a clear and concise manner. The study highlights the

importance of a systematic approach to failure analysis and root cause analysis, which can be applied to various types of mechanical equipment.

In conclusion, the article by Vimal and Nair provides valuable insights into the failure analysis and root cause analysis of an air compressor piston. The study emphasizes the importance of identifying the root cause of failure and implementing appropriate corrective actions to prevent future failures.

Bhandari, A., & Kumar, R. (2021),

The study highlights the importance of understanding the root cause of failure in rotating machinery to prevent similar failures from occurring in the future. The authors provide an overview of the different types of failures that can occur in rotating machinery, such as fatigue, wear, corrosion, and material defects.

The article discusses the various techniques used for failure analysis of rotating machinery, such as visual examination, vibration analysis, oil analysis, and thermography. The authors emphasize the importance of selecting the appropriate techniques based on the type of failure and the condition of the machinery.

The findings of the study have indicated that failure analysis of rotating machinery is a complex process that requires a multidisciplinary approach. The authors have recommended the use of a systematic approach to identify the root cause of failure and implement appropriate corrective actions to prevent future failures.

In conclusion, the article by Bhandari and Kumar provides a comprehensive review of the techniques used for failure analysis of rotating machinery. The study highlights the importance of a systematic approach to identify the root cause of failure and implement appropriate corrective actions to prevent future failures. The article provides valuable insights into the various techniques that can be applied to rotating machinery, which can be useful for engineers and technicians involved in maintenance and reliability of rotating machinery.

A.K.M. Masud et al. Conducted a case study of a garment factory in Bangladesh that reported low productivity and less profit. By implementing Total Productive Maintenance, the causes of low productivity and opportunities for improvement were identified. They have studied the various departments of the industry to identify and reduce equipment losses to maximize overall equipment efficiency (OEE) by using Total Productive Maintenance

(TPM) techniques. The prominent losses were identified as minor stoppages, set up time, and adjustment time.

Abhijit Gosavi et al., have reported that organizing planned maintenance activities is a key to the success of Total Productive Maintenance (TPM) which can reduce the mean and variability of manufacturing lead time. They have proposed two different statistical models, the first based on the renewal model and the second based on the semi-Markov decision process and reported that budget-sensitive preventive maintenance criteria surpass the risk-averse and variance-penalized approaches.

Balasaheb and Milind have reviewed the most used maintenance strategies applied in various studies. They have reported that the multiple-criteria approach facilitates better decision-making in maintenance strategy selection and provides a better understanding of the problem statement. In the case of maintenance management, the techniques like corrective, preventive, and condition-based maintenance techniques are commonly used.

Neha Gupta has performed a detailed study in various departments of a textile unit to identify the possible quality-related problems. The seven major operations involved in yarn manufacturing were identified, the possible defects in each operation, and how preventive maintenance methods can reduce the defects generated in the processes are reported. It was also reported that checking and inspecting defective products at various points in a production cycle and executing specific changes at those points in production can reduce defects.

Osama Taisir R. Almeanazel reviewed the goals and benefits of implementing Total Productive Maintenance and focused on identifying the overall equipment effectiveness of a steel company in Jordan. He has also discussed the six big losses of the industry that are categorized under quality, availability, and speed. Various techniques such as computer maintenance management system and production planning were suggested to the unit after calculating the OEE to improve their maintenance procedures and improve productivity.

Muchiri and Pintelon explain the challenges associated with improving productivity in the current global competitive environment that has emphasized the necessity to define performance measurement systems for production processes. They have identified that apart from the six big losses there are several other losses that affect the overall production loss. They also describe OEE as a performance measurement tool that can be used to measure various types of production losses and identify specific areas for process improvement.

Pradeep Kumar et al. describes Total Productive Maintenance as a technique that is intended at maximizing the effectiveness of a production unit. They ascertain that total productive maintenance ascertains a system of practices, that covers the whole life cycle of machinery, covers all the functions of the manufacturing unit, demands the contribution of all employees irrespective of role, and promotes small group autonomous activities. They have also reported that even a minor improvement in OEE can significantly improve profits.

Fore suggests that repeated machine failures, low plant availability, and higher over time pose a larger threat to a production unit as it significantly increases the operational cost. The study concludes that committed management and implementation of suitable TPM techniques can improve Overall Equipment Effectiveness (OEE) to a greater extent.

Soheil et al. describe that one of the most prominent and vital requirements for continuous improvement of manufacturing systems is performance evaluation and Overall Equipment Effectiveness is the most applied technique in the production industries. Their study focuses on identifying the three OEE losses such as availability, performance, and quality in a continuous production line of an oil refining company

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This Chapter presents how the methodology of the project was planned and performed. Various research methods are described followed by the best method being chosen for this study. It also presents a clear view how data were collected through literature, observations, interviews and discussions. Research approaches are often classified into two main types namely quantitative and qualitative. These methods of research is a step-by-step plan of action giving direction to thoughts and efforts that would conduct a systematic research and on schedule to produce quality and detailed report. It has to do with staying focused, a reduction in frustration, a better quality while saving time and resources. Both methods would be carried out in this study.

Choosing an appropriate method for collecting data is another essential issue to be cleared out when initiating research. Most scientific research could differentiate two data collection techniques into quantitative and qualitative.

3.2 Quantitative method

Primarily, this method deals with numerical information being generated and emphasized. This method is a collection of limited variables known as group sample and from a representing sample, comparing with a few variables in the group of samples.

A quantitative study based on overall equipment effectiveness (OEE) was chosen and well explained in details.

3.3 SAMPLING METHODS

The accuracy of the study depends upon the sample design. The study was conducted using convenience sampling which comes under Convenience sampling method. Samples of 98 individuals were picked for this research.

3.4 DATA PROCESSING

Data collection is the process of collecting the responses that is needed to carry out the survey. The type of data collected for this study consists only Primary data since the study focused in studying the management level employees‟ responses and behaviour at the present time. A well-structured Questionnaire was formulated & survey was conducted using it. The first mode being offline live hardcopy of questionnaire distributed & collected. The second mode is online through creation of questionnaire through google forms and sent to participants through email and responses are collected from it. The collected responses were processed and tabulated using Google sheets and various statistical tools were used to draw out conclusions from the tabulated response data of the respondents.

3.5 Data collection

Collection of data refers to the registration of values for a certain variable. Questions need to be put in place as to what data should be registered, how and when. Data can be registered manually or automatically and, in some cases, there can be done simultaneously. Automatic measures used to collect information are probably relevant in the long run. The method used in the collection of data is a vital aspect needed in the calculation of OEE. Data collection can vary from manual to much automated, as correct input of parameters acquired from the production system is essential for OEE calculations.

Manual data collection which mainly happens in low-tech industries consists of a registry, where operators are required to fill in the causes and duration of breakdowns as well as reliable comments about minor stoppages and speed losses. In high-tech industries, an automatic OEE calculation system is governed by sensors linked to the equipment, automatically recording the start time and duration of stoppages while prompting the operator to make available the system with correct information about their specific downtime causes. With automatic method, opportunities are made available for operators to set up lists of potential downtime causes, scheduling the available operating time and constructing an automatic OEE calculation for any specific time period. So long as the data input are provided in the system, it is not only possible to provide OEE results but makes it easier to retrieve a variety of reports of production performance and visualization of the performance results from the system. However, too much information in the system can be a waste of time for the operators and they will have to search for each downtime cause. Reluctance against

data collection from operators and foremen are some of the major challenges faced by many industries.

Necessary to convince operators as some do believe that some disturbances have a major impact on efficiency which later measurements show that to be completely wrong. With automatic data collection, the system is quite expensive, complex and is collected at an aggregated level. On the contrary, manual data collection can be very detailed as losses can be fully examined. It is necessary to introduce both manual and automatic data collection methods coupled with training of the operators of OEE as a performance measure, and on various parameters affecting the OEE outcome. Main reasons for this would be to qualify the quality of input data in line with an increase in the competence of operators and creating a better involvement of the operators in identifying potential performance loss factors as well as providing system with accurate information. Quantitative measurements for the OEE calculation were collected from many machines in the various industries under a period of three months. Machine stops were registered with a use of computer by the help of the operators as suggested.

3.6 HYPOTHESIS

The present study is an exploratory study with emphasis on development of techniques of data integration.

Appropriate hypotheses shall be framed and tested regarding these interactions. Research Hypotheses:

A hypothesis is an inference or implied interpretation made as a starting point for further research on the basis of minimal proof. It is an observation surrounding a population's certain characteristics. The researcher must formulate hypotheses and test them for an analysis that is to be definitive.

H1: Association between Job role and the activity considered important for ability to efficiently manage critical equipment failures
H2: Association between education and product quality
H3: Association between gender and safety

3.7. TOOLS FOR ANALYSIS

The tools that are to be used for the study are the statistical tools that are readily available to perform the analysis.

They are

1 Percentage analysis
2 Chi-square analysis
3 Linear regression
4 One way annova

Percentage analysis

Percentage analysis is applied to create a contingency table from the frequency distribution and represent the collected data for better understanding. The formula used for carrying out percentage analysis is

% of a category = (Number of respondents in that category/ Total number of respondents) x 100

Chi-Square Analysis

Chi-square is an important non-parametric test and such no rigid assumptions are necessary in respect of the type of population. We require only degree of freedom for using this test. As non-parametric test, chi-square can be used. In order that we may apply the chi-square test either as a test of goodness of fit or as a test to judge the significance of association between the attributes, it is necessary that the observed as well as theoretical or expected frequencies must be grouped in the same way and theoretical distribution must be adjusted to give the same total frequency as we find in case of observed distribution.

X2 is then calculated as follows:

$$X2 = \sum \{(Oi - Ei)2 / Ei\}$$

Where, Oi = Observed Frequency, Ei = Expected Frequency.

As already stated, degree of freedom plays an important role in using the chisquare distribution and the test based on it, one must correctly determine the degree of freedom.

D.F = (C - 1) * (R - 1)

Where „C" means the number

3.8 ASSUMPTIONS, CONSTRAINTS AND LIMITATIONS

Assumptions

Assuming that participants have answered the survey questions in an honest and candid manner. Inclusion criteria of the sample are appropriate and therefore, assuming that the participants have all experienced the same or similar phenomenon of the research studies. Participants have a sincere interest in participating in survey and do not have any other motives.

Constraints

Due to the time constraint of the project duration of 2 months, it was possible to do the study in only one company.

Limitations

A restriction of transversal investigations is the possibility of bias. Other events such as therapy and risk factors might be included as variables linked with suffering if bigger samples of patients were analysed. Transversal research has failed to find these events.

CHAPTER 4

DATA ANALYSIS

4.1 Introduction

This chapter presents the most significant part of this thesis by analysing the feedbacks and the answers of the participants of the surveys and the interviews. In order to make sure that the reader to have enough information about the obstacle and give an overview, the researcher ought to divide it into following sections: Obstacles in collecting data, overview of data collection, required information for research criteria, analysing data and findings.

4.2 Data Finding and Analysis

This part will let the reader to know about the results of the data collected through aquestionnaire or the interview.

4.3 Analysis of Surveys

Random sampling was adopted and the statistical program for social sciences (SPSS) software was used. Results for the descriptive data about the respondents were as in the followings: 74% of the respondents were male, and 26% were female shown in table #3 In terms of age, variety was well perceived with 28% are between 18-25 years old, 39% are between 25-35 years old, 19% is representing employees at ages between 35-45, while the rate for age 46 and above is 14% .

4.4 PERCENTAGE ANALYSIS

4.4.1. AGE

AGE	RESPONDENTS	PERCENTAGE
18-25	25	28
25-35	35	39
35-45	17	19
45 & ABOVE	13	14
TOTAL	**90**	**100**

Table 1 : Age distribution for the Questionnaire

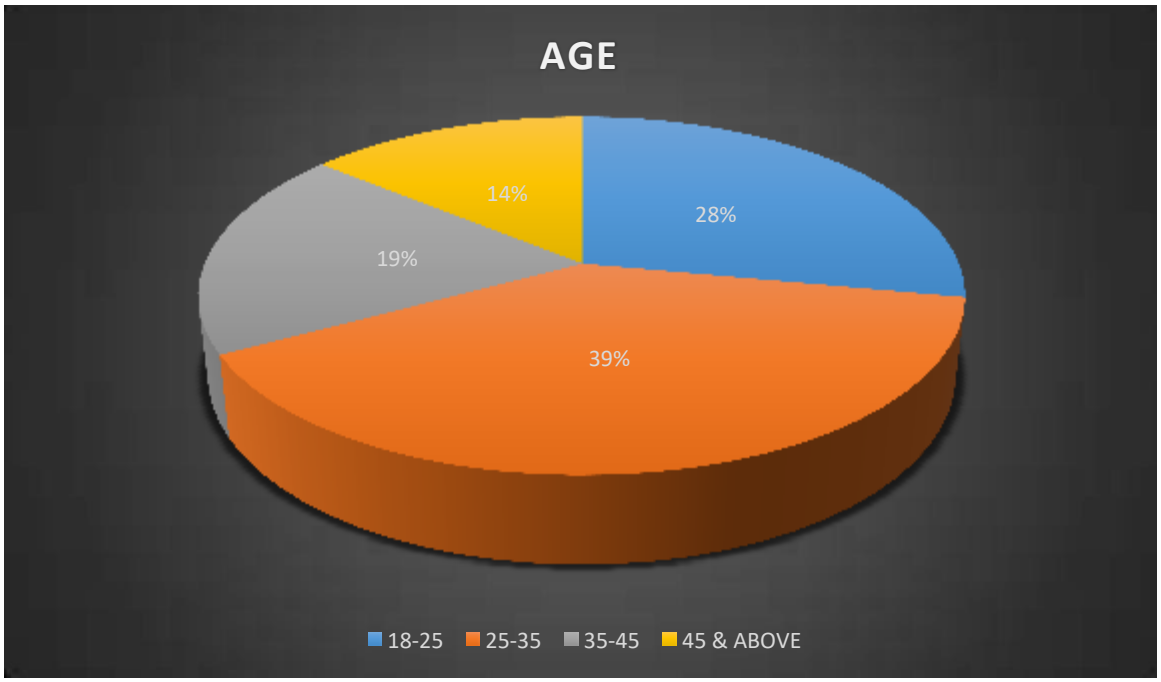

Figure 4.1 : Age distribution for the Questionnaire

4.4.2. GENDER

GENDER	RESPONDENTS	PERCENTAGE
MALE	67	74
FEMALE	13	26
TOTAL	**90**	**100**

Table 2 : Gender distribution for the Questionnaire

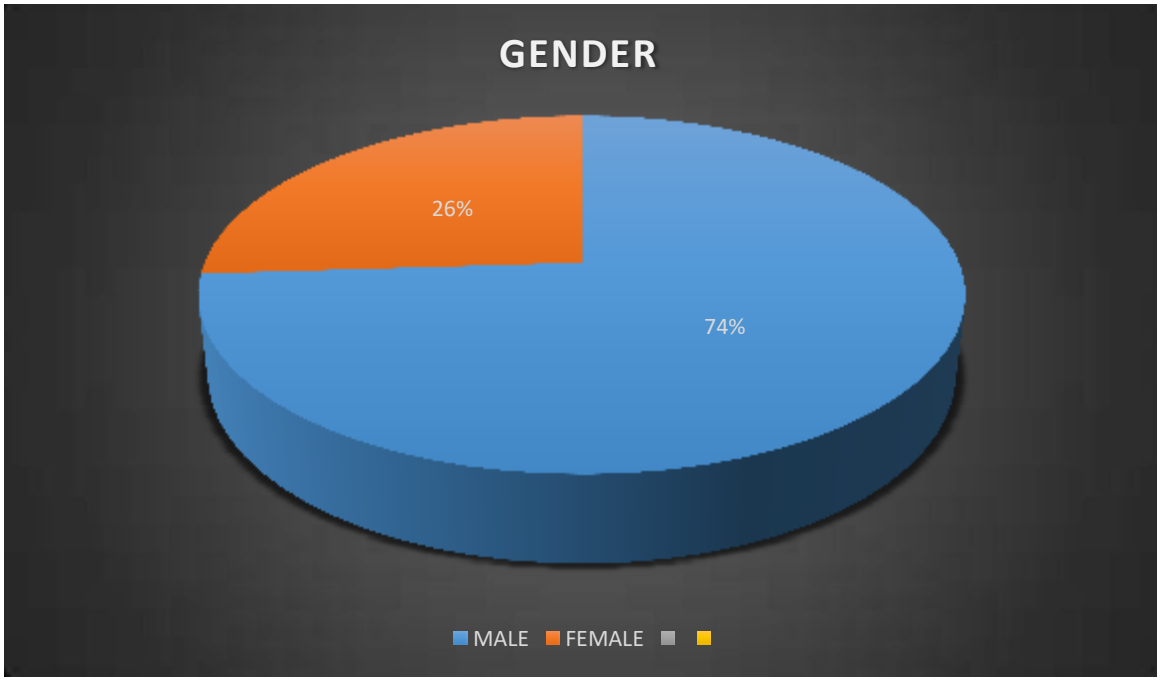

Figure 4.2 : Gender distribution for the Questionnaire

4.4.3. EDUCATION QUALIFICATION

QUALIFICATION	RESPONDENTS	PERCENTAGE
Diploma	29	33
Graduate	29	33
Post Graduate	32	34
TOTAL	**90**	**100**

Table 3 : Educational Qualification distribution for the Questionnaire

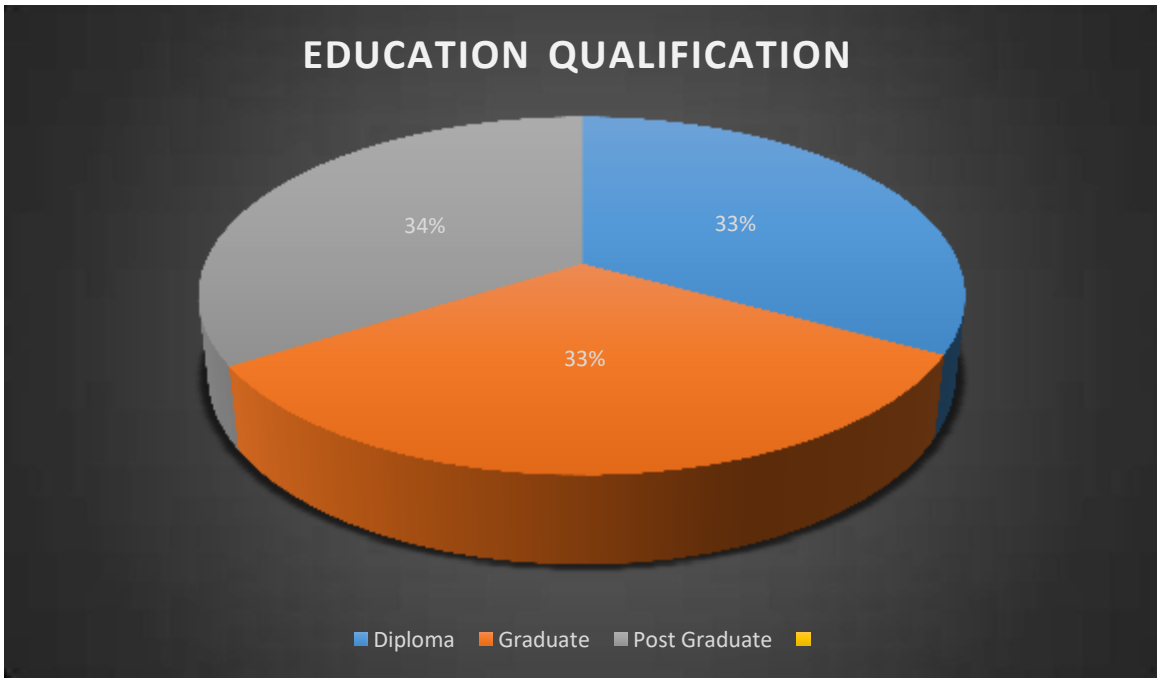

Figure 4.3 : Educational Qualification distribution for the Questionnaire

From the above data it is found that 34% of the respondents were from Diploma completed employees, 33% of the respondents were from the under graduation completed employees and 33% of the respondents were from the postgraduation completed employees.

4.4.4 JOB ROLE

JOB ROLE	RESPONDENTS	PERCENTAGE
Manager	16	18
Operator	25	28
Student	1	1
Supervisor	27	30
Technician	23	26
TOTAL	**90**	**100**

Table 4 : Job Role distribution for the Questionnaire

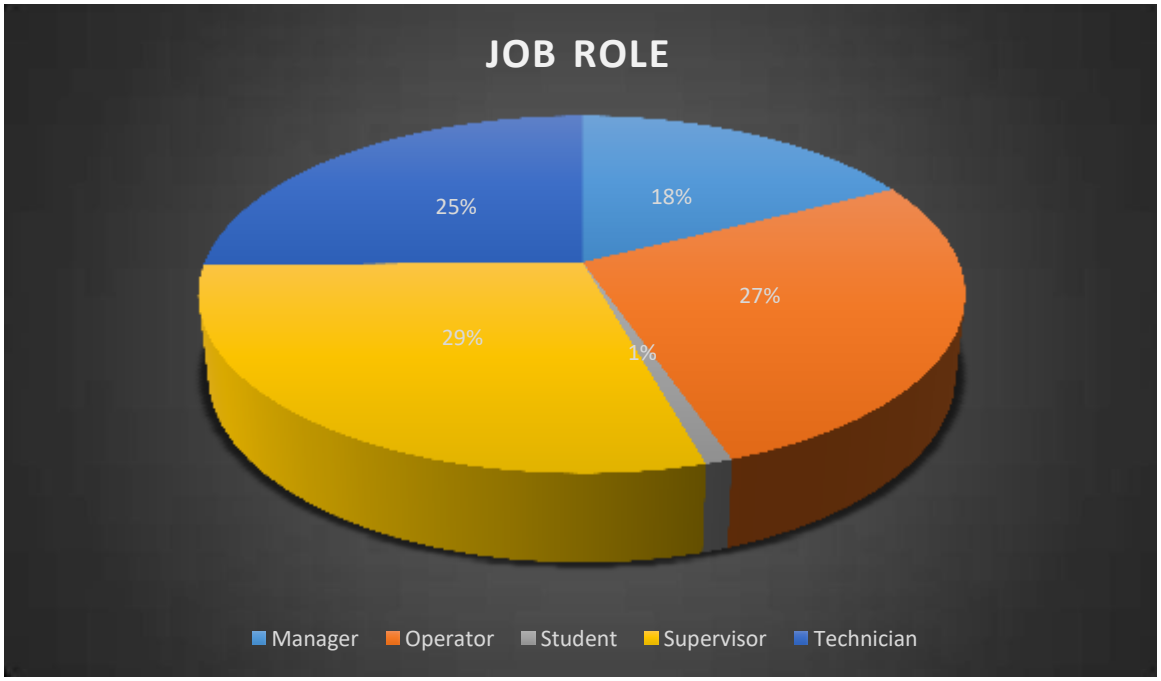

Figure 4.4 : Job Role distribution for the Questionnaire

Position wise, 30% are from the supervisors, 28% are from the operators, 26% are from the technician, 18% are from the manager and 1% from a student as it is shown in table 4. The position was involved in order to make sure those different levels of management and non- management level to interpret the findings about the awareness on critical equipment failure of the equipments..

4.4.5. Awareness of Critical failure equipment

It is important to regularly inspect the critical failure equipment to ensure it is in good working condition	RESPONDENTS	PERCENTAGE
Strongly Agree	1	1
Agree	47	52
Neutral	7	7
Disagree	16	18
Strongly Disagree	19	22
TOTAL	**90**	**100**

Table 5 : Respondents on regular inspection of the critical failure equipment to ensure it is in good working condition

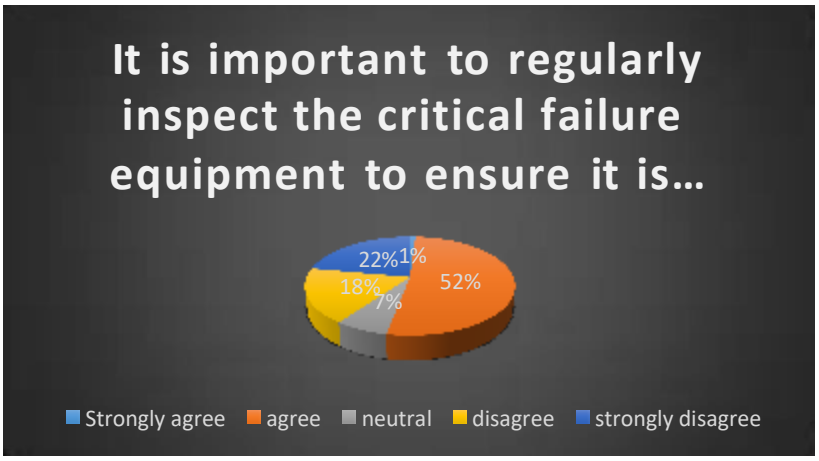

Figure 4.5 : Respondents on regular inspection of the critical failure equipment to ensure it is in good working condition

In order to find out the awareness of critical equipment failure, participants were asked the above question. The majority responded with 1% strongly agree, 52% agree, 7% responded natural, 18% disagree, and only 22% were strongly disagree. Based on that, the majority of employees agreed that it is important to regularly inspect the critical failure equipment to ensure it is in good working condition.

Training employees on the proper use and maintenance of critical failure equipment is crucial to prevent accidents and downtime	RESPONDENTS	PERCENTAGE
Strongly Agree	4	1
Agree	0	0
Neutral	22	24
Disagree	35	39
Strongly Disagree	29	34
TOTAL	**90**	**100**

Table 6 : Respondents on training employees on the proper use and maintenance of critical failure equipment is crucial to prevent accidents and downtime

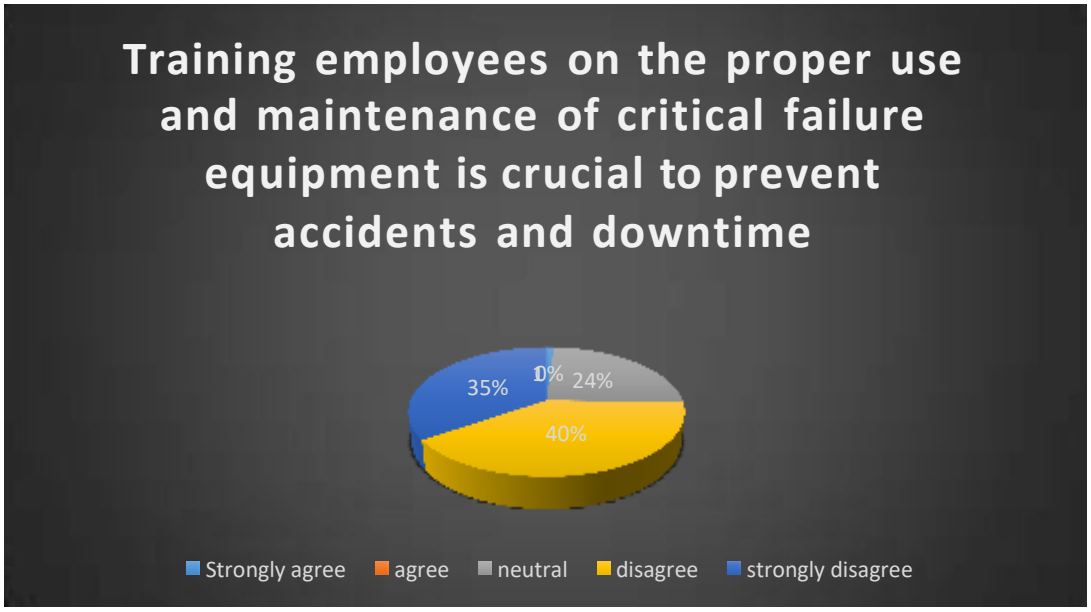

Figure 4.6 : Respondents on training employees on the proper use and maintenance of critical failure equipment is crucial to prevent accidents and downtime

In order to find out the awareness of critical equipment failure, participants were asked the above question. The majority responded with 1% strongly agree, 0% agree, 24% responded natural, 39% disagree, and 34% were strongly disagree. Based on that, the majority of employees disagreed that it is important to train employees on the proper use and maintenance of critical failure equipment is crucial to prevent accidents and downtime.

Investing in high-quality critical failure equipment is worth the cost to ensure reliability and safety	RESPONDENTS	PERCENTAGE
Strongly disagree	0	0
disagree	9	1
Neutral	14	24
Agree	35	39
Strongly Agree	32	34
TOTAL	**90**	**100**

Table 7 : Respondents on investing in high-quality critical failure equipment is worth the cost to ensure reliability and safety

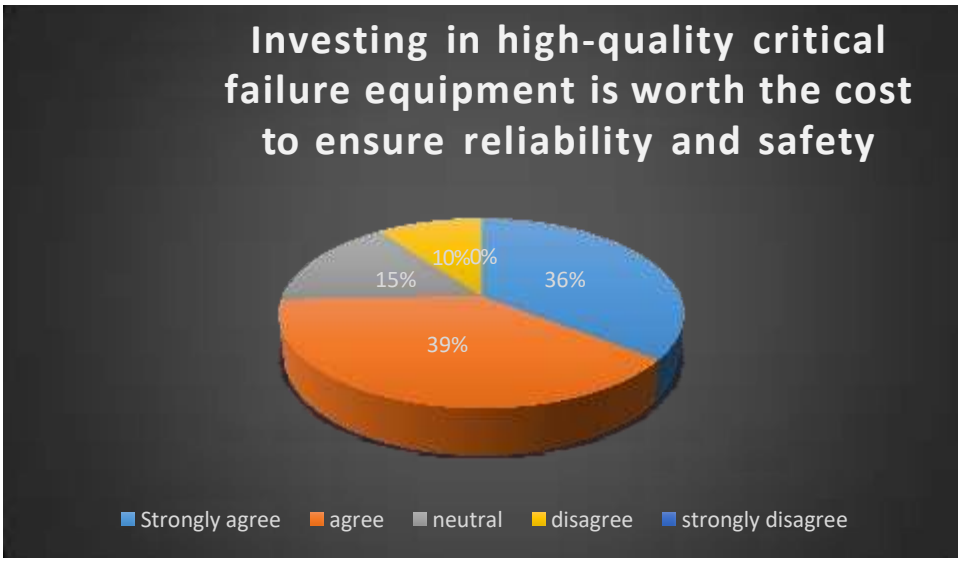

Figure 4.7 : Respondents on investing in high-quality critical failure equipment is worth the cost to ensure reliability and safety

In order to find out the awareness of critical equipment failure, participants were asked the above question. The majority responded with 34% strongly agree, 39% agree, 24% responded natural, 1% disagree, and 0% were strongly disagree. Based on that, the majority of employees agreed that it is important to invest in high-quality critical failure equipment is worth the cost to ensure reliability and safety.

Regularly scheduled maintenance and repairs on critical failure equipment should be a top priority for any organization	**RESPONDENTS**	**PERCENTAGE**
Strongly disagree	10	0
disagree	24	1
Neutral	22	24
Agree	20	39
Strongly Agree	16	34
TOTAL	**90**	**100**

Table 8 : Respondents on regularly scheduled maintenance and repairs on critical failure equipment should be a top priority for any organization

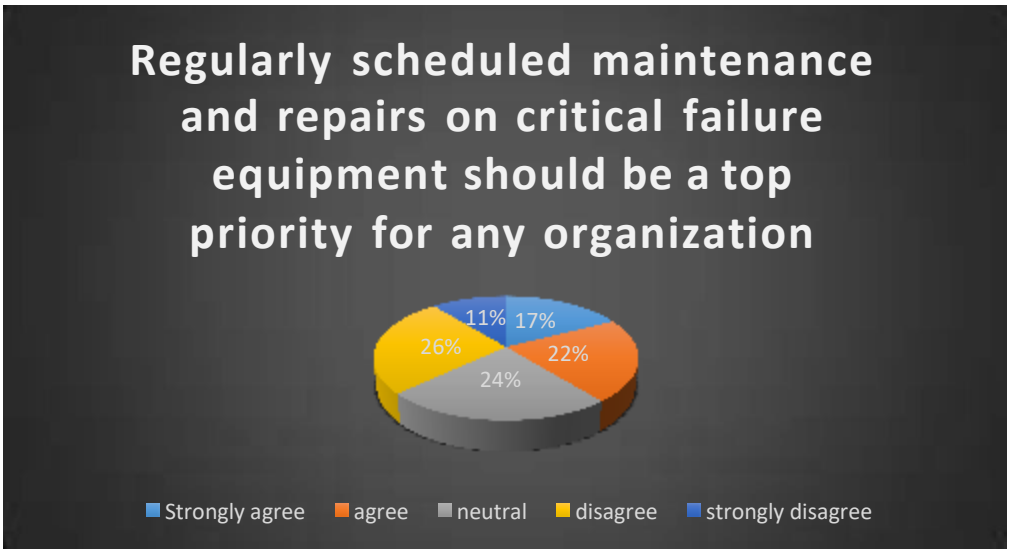

Figure 4.8 : Respondents on regularly scheduled maintenance and repairs on critical failure equipment should be a top priority for any organization

In order to find out the awareness of critical equipment failure, participants were asked the above question. The majority responded with 34% strongly agree, 39% agree, 24% responded natural, 1% disagree, and 0% were strongly disagree. Based on that, the majority of employees agreed that it is important to regularly schedule maintenance and repairs on critical failure equipment should be a top priority for any organization.

Effective communication between maintenance staff and operators is necessary to ensure critical failure equipment is properly maintained and serviced	**RESPONDENTS**	**PERCENTAGE**
Strongly disagree	11	12
disagree	20	22
Neutral	20	22
Agree	20	22
Strongly Agree	19	22
TOTAL	**90**	**100**

Table 9 : Respondents on effective communication between maintenance staff and operators is necessary to ensure critical failure equipment is properly maintained and serviced

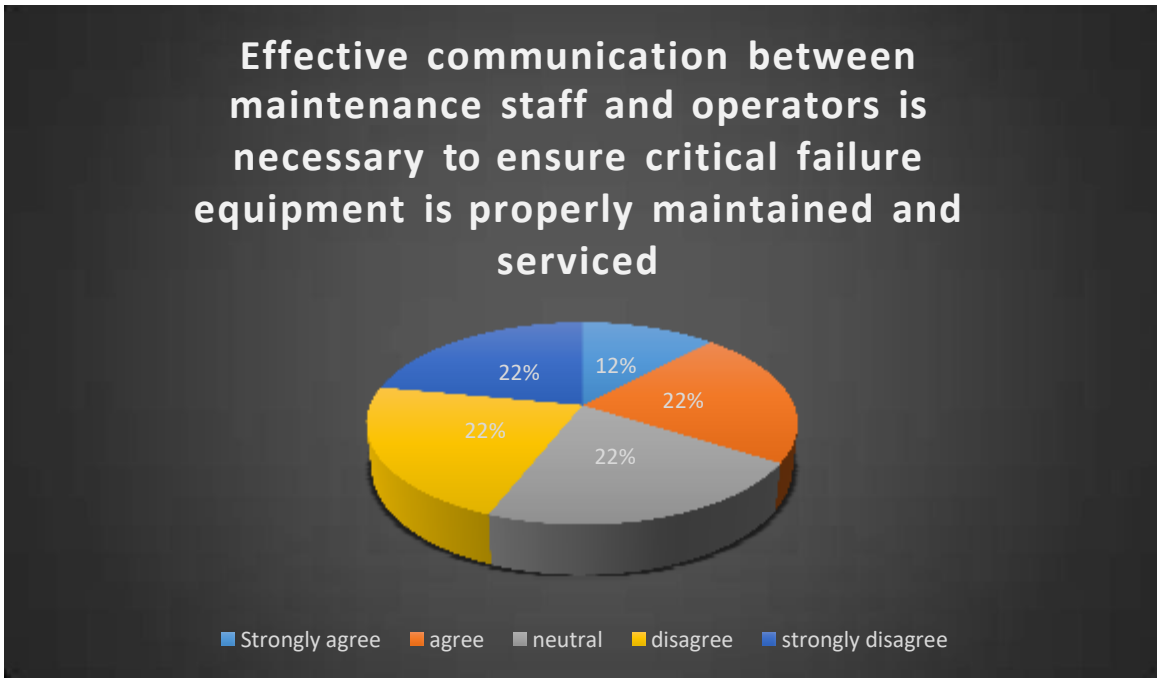

Figure 4.9 : Respondents on effective communication between maintenance staff and operators is necessary to ensure critical failure equipment is properly maintained and serviced

In order to find out the awareness of critical equipment failure, participants were asked the above question. The majority responded with 22% strongly agree, 22% agree, 22% responded natural, 22% disagree, and 12% were strongly disagree. Based on that, the majority of employees agreed that it is important for Effective communication between maintenance staff and operators is necessary to ensure critical failure equipment is properly maintained and serviced.

It is important to regularly inspect the critical failure equipment to ensure it is in good working condition	**RESPONSE**	**PERCENTAGE**
Strongly Disagree	11	12%
Disagree	11	12%
Neutral	15	16%
Agree	26	28%
Strongly Agree	30	32%
TOTAL	93	100%

Table 10: Respondents on it is important to regularly inspect the critical failure equipment to ensure it is in good working condition

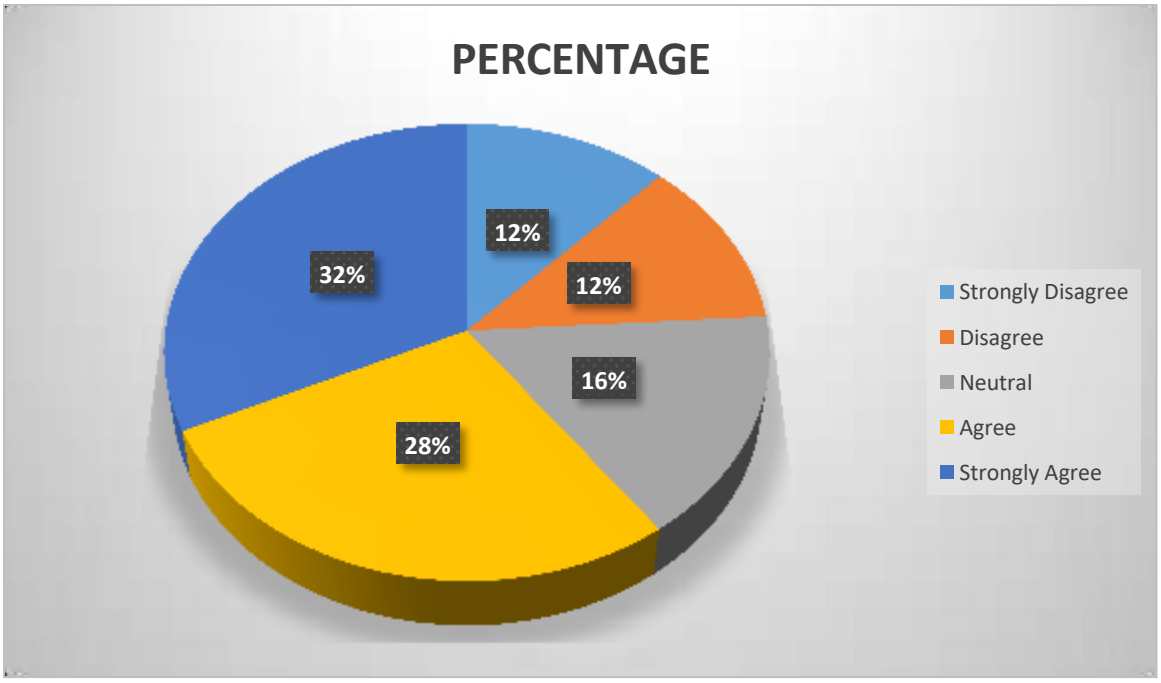

Figure 4.10 : Respondents on it is important to regularly inspect the critical failure equipment to ensure it is in good working condition

In order to find out the awareness of critical equipment failure, participants were asked the above question. The majority responded with 32% strongly agree, 28% agree, 16% responded natural, 12% disagree, and 12% were strongly disagree. Based on that, the majority of employees agreed that it is important to regularly inspect the critical failure equipment to ensure it is in good working condition.

It is acceptable to sacrifice product quality to meet production targets or reduce costs	**RESPONSE**	**PERCENTAGE**
Strongly Disagree	11	12%
Disagree	11	12%
Neutral	11	12%
Agree	30	32%
Strongly Agree	30	32%
TOTAL	93	100%

Table 11: Respondents on it is acceptable to sacrifice product quality to meet production targets or reduce costs

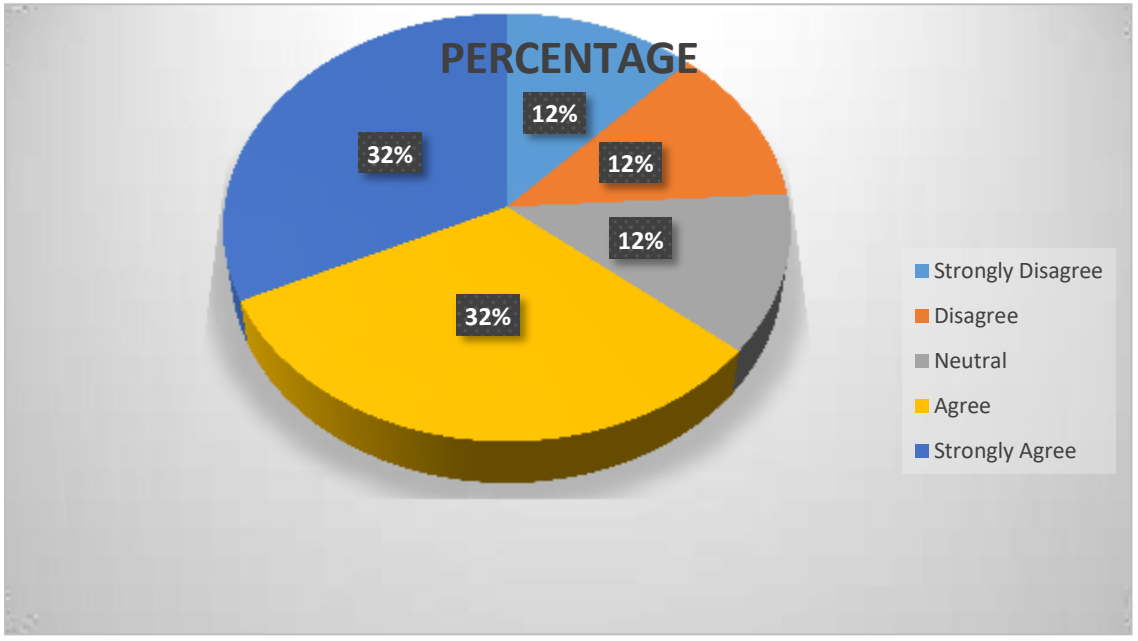

Figure 4.11.: Respondents on it is acceptable to sacrifice product quality to meet production targets or reduce costs

In order to find out the awareness of critical equipment failure, participants were asked the above question. The majority responded with 32% strongly agree, 32% agree, 12% responded natural, 12% disagree, and 12% were strongly disagree. Based on that, the majority of employees agreed that it is acceptable to sacrifice product quality to meet production targets or reduce costs.

It is the responsibility of all employees in the petroleum industry to report any safety concerns or violations they witness	**RESPONSE**	**PERCENTAGE**
Strongly Disagree	11	12%
Disagree	11	12%
Neutral	11	12%
Agree	30	32%
Strongly Agree	30	32%
TOTAL	93	100%

Table 12 : Respondents on it is the responsibility of all employees in the petroleum industry to report any safety concerns or violations they witness

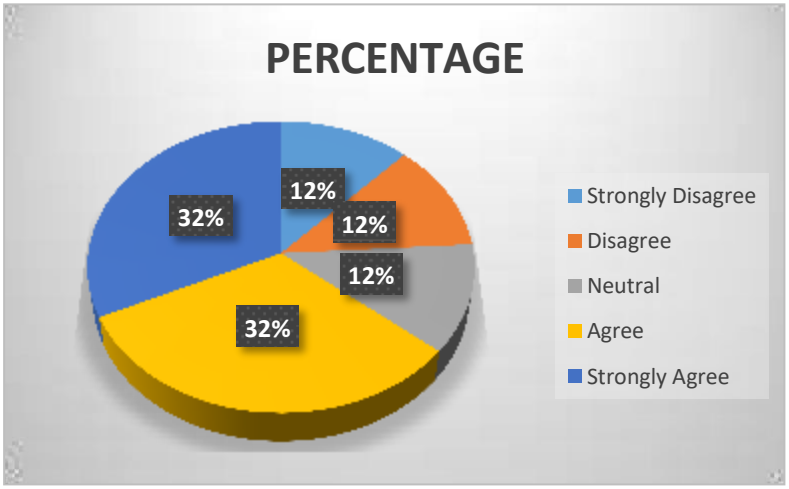

Figure 4.12 : Respondents on it is the responsibility of all employees in the petroleum industry to report any safety concerns or violations they witness

In order to find out the awareness of critical equipment failure, participants were asked the above question. The majority responded with 32% strongly agree, 32% agree, 12% responded natural, 12% disagree, and 12% were strongly disagree. Based on that, the majority of employees agreed that it is the responsibility of all employees in the petroleum industry to report any safety concerns or violations they witness.

4.5 CHI-SQUARE

Association between Job role and the activity considered important for ability to efficiently manage critical equipment failures

Chi Square:

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	14.083[a]	12	.295
Likelihood Ratio	16.899	12	.153
N of Valid Cases	90		

a. 12 cells (60.0%) have expected count less than 5. The minimum expected count is .03.

Table 13 : Chi-Square tests

From the above table, it is inferred that the p value is 0.295 which is less than 0.05. Hence, null hypothesis is accepted at 5% significant level and alternative hypothesis is rejected. Therefore, there is no association between respondents job role considered important for ability to efficiently manage critical equipment failures.

HYPOTHESIS 2

Association between education and product quality

Chi-Square test

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.486[a]	6	.746
Likelihood Ratio	3.402	6	.757
N of Valid Cases	90		

a. 3 cells (25.0%) have expected count less than 5. The minimum expected count is 2.80.

Table 14 : Association between Education and product quality - Chi- Square tests

In the table p value is 0.746. This value is bigger than 0.05. So H0 remains accepted and H1 is rejected. There is no relevant association between education and knowledge about the product quality

Association between gender and safety

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.739[a]	6	.841
Likelihood Ratio	3.021	6	.806
N of Valid Cases	90		

a. 7 cells (58.3%) have expected count less than 5. The minimum expected count is .12.

Table 15: Association between gender and safety – Chi-Square tests

In the table p value is 0.841. This value is bigger than 0.05. So H0 remains accepted and H1 is rejected. There is no relevant association between gender and safety of the petroleum.

4.6. LINEAR REGRESSION

Regression

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	2.Gender[b]	.	Enter

a. Dependent Variable: 5. It is important to regularly inspect the critical failure equipment to ensure it is in good working condition

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.135[a]	.018	.007	.895

a. Predictors: (Constant), 2.Gender

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.284	1	1.284	1.603	.209[b]
	Residual	69.660	87	.801		
	Total	70.944	88			

a. Dependent Variable: 5. It is important to regularly inspect the critical failure equipment to ensure it is in good working condition

b. Predictors: (Constant), 2.Gender

Table 16 : Linear Regression

From the above table, this value is bigger than 0.05. So there is no significant difference between gender vs awareness of critical failure equipment.

4.7 Anova

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.190	1	9.190	3.979	.049[b]
	Residual	198.628	86	2.310		
	Total	207.818	87			

a. Dependent Variable: 11. It is acceptable to sacrifice product quality to meet production targets or reduce costs

b. Predictors: (Constant), 2.Gender

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	3.231	.422		7.665	<.001
	2.Gender	-.911	.457	-.210	-1.995	.049

a. Dependent Variable: 11. It is acceptable to sacrifice product quality to meet production targets or reduce costs

Table 17 : Anova

From the above table, this value is lower than 0.05. So there is significant difference between gender vs product qualtity awareness of equipment.

4.8 Data Processing

After obtaining the required data then the data is processed. The processing steps are as follows:

1. **Calculates the OEE value**

   OEE is a common approach for the measurement of production equipment efficiency and originated in the frame of lean management with the introduction of Total Productive Maintenance . OEE value is a value as a measuring tool to determine the value of the effectiveness of the machine. The value of OEE is the multiplication of the value of availability, performance efficiency, and rate of quality. So before we have to search for these three values. OEE involves the process of monitoring the availability, performance, and quality of manufacturing equipment and/or facilities. Performance of the operation to each of the three components to planned levels gives managers information about where and how management decisions should be focused to improve productivity and profitability. The data provide the foundation for quantitative validation of choices as dissimilar as setting optimal maintenance schedules and calculating the value of investing in new process control systems. As a tool for process improvement, OEE connects the converter‟s operation to a global body of best practices and benchmarking information.

2. **Availability**

   Continuous availability of reliable sophisticated equipment with precision with precision is need of the competitive market. Overall equipment effectiveness (OEE) is an important performance measure metric for equipment effectiveness. An attempt has been done to measure and analyse existing overall equipment effectiveness of critical machinery producing important automobile components like serration cap, hose air cleaner. Which are using by leading automobile company. The value of availability is so that we can know what percent availability of effectiveness on the machine. To find availability value using available time data, planned downtime, breakdown time, and set up time. After the data is available the processed meal uses the following equation.

$$\text{Availability (ketersediaan)} = \frac{\text{Operation Time}}{\text{Loading Time}} \times 100\%$$

$$= \frac{\text{Loading Time} - \text{Downtime}}{\text{Loading time}}$$

3. **Performance efficiency**

The global speed of change within the manufacturing industry forces companies to constantly improve production performance. In that effort, performance measures are critical for driving and managing production improvements. Two of the most commonly used measures in operations are productivity and overall equipment efficiency (OEE). However, the potential of using these measures as improvement drivers is not fully utilized in industry today due, for example, to ambiguities in definitions and their interpretation. At this stage done data processing to determine the value of the performance of the effectiveness of the machine. To calculate the value of performance efficiency requires data cycle time, operation time, and total production data. For performance, efficiency calculation can use the following equation.

$$\text{Performance efficiency} = \frac{\text{Theoretical Cycle Time x Processed Amount}}{\text{Operating Time}} \times 100\%$$

4.9. MEAN OEE

	OEE														
	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Total running Hrs	Unavailable Hrs	Availability %
K2A	744	672	744	672	744	744	744	744	720	720	720	744	8712	48	99.45%
K2B	744	672	744	720	744	744	720	696	720	744	720	744	8712	48	99.45%
K2C	720	576	744	720	720	672	744	744	720	696	696	744	8496	264	96.99%
K1	744	672	720	720	744	744	648	744	720	744	720	744	8664	96	99%

Table 18 : Mean OEE

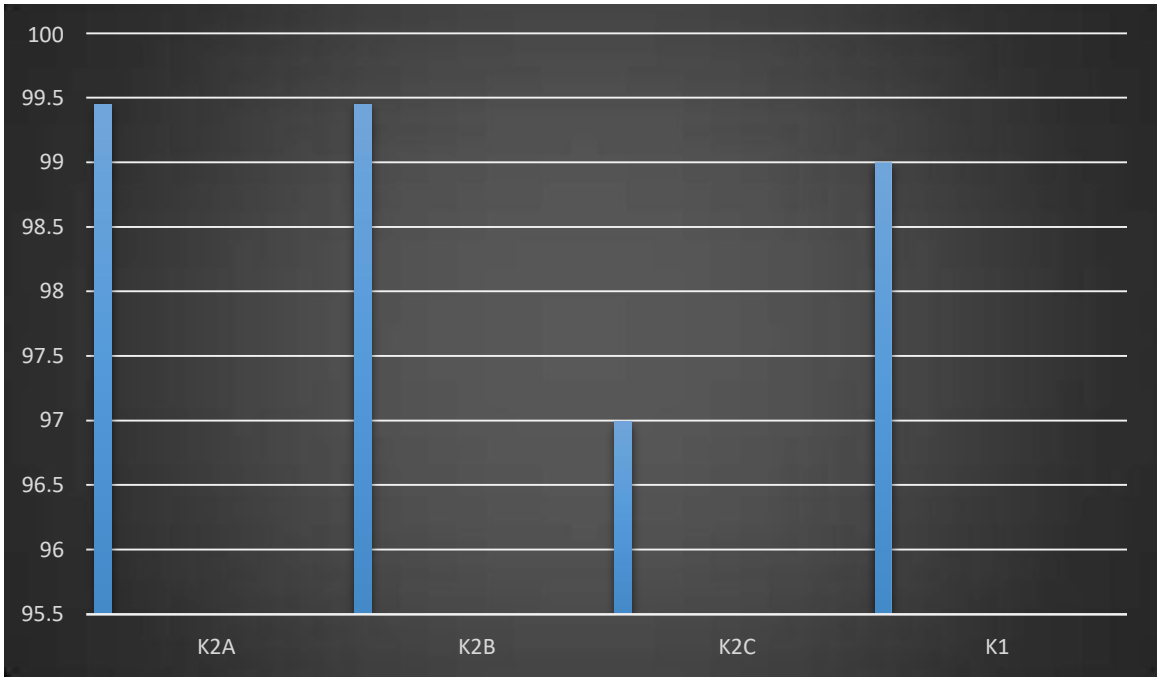

Figure 4.13 : OEE analysis of between the month of Jan to dec 2022shows a significant increase in their individual average OEE values on machines K2A, K2B, K2C,K1.

Variations of OEE values within these months are caused as a result of losses which were either planned (planned factor), availability related losses known as unplanned losses, performance, and quality related losses. Performance and quality had higher OEE values in the machines.

Factor	Losses	Stoppage reasons
Availability	Planned Losses	Machines/Techniques
		Shift changes and breaks
		Planned service/Maintenance
		Other planned stops
		Lack of accessories
		Shortage of personnel
		Personal time
		Problems with internal material
		Problems with external material
Total		
Availability	Unplanned Losses	Equipment breakdown/ Unplanned production
		Setup/Changeover
Total		
Performance	Minor idling losses	Micro stoppage
Quality	Defect and rework	Quality issues/Reworks
No reason code	Unknown losses	Unknown

Table 19 : Overall Equipment Performance

4.10. MEAN OEE OF G PUMP

						G PUMP									
	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Total Hrs	Unavailable Hrs	Availability %
G 03 A	744	672	744	312	0	0	0	0	0	0	720	720	3912	4848	45%
G 03 B	744	672	744	720	744	720	720	720	720	744	696	720	8664	96	99%
G 05 A	696	672	744	720	744	696	744	744	696	744	720	720	8640	120	99%
G 104 E	744	648	744	720	744	672	744	744	624	744	720	720	8568	192	98%
G 203 A	744	672	744	720	744	696	720	744	720	744	720	720	8688	72	99%
G 203 B	744	648	744	720	744	672	744	672	720	744	720	720	8592	168	98%

Table 20: Mean OEE of G Pump

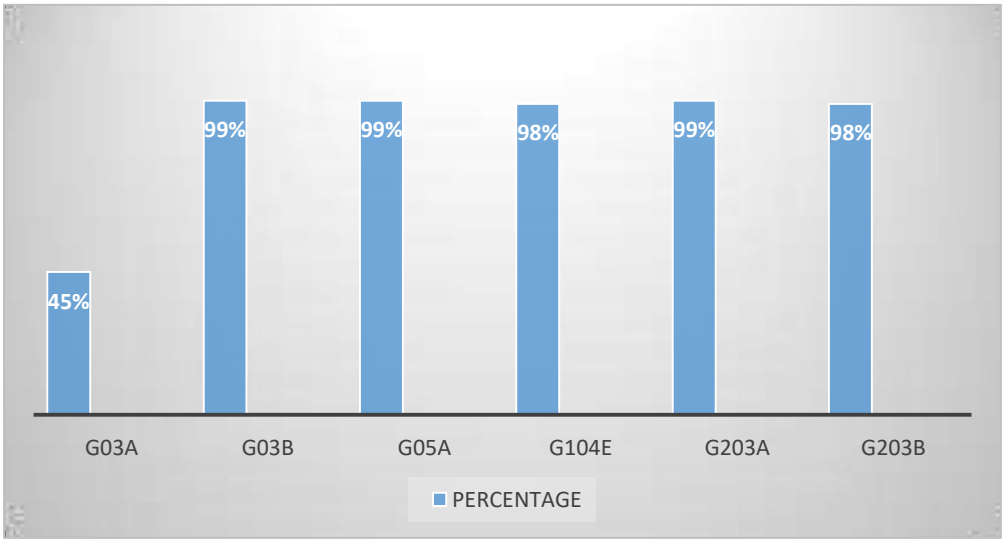

Figure 4.14: OEE analysis of between the month of Jan to dec 2022shows a significant increase in their individual average OEE values on G PUMP GA03A, G03B, G05A, G104E, G203A, G203B.

Variations of OEE values within these months are caused as a result of losses which were either planned (planned factor), availability related losses known as unplanned losses, performance, and quality related losses. Performance and quality had higher OEE values in the machines.

Factor	Losses	Stoppage reasons	Percentage(s)
Availability	Planned Losses	Machines/Techniques	9%
		Shift changes and breaks	6%
		Planned service/Maintenance	4%
		Other planned stops	1%
		Lack of accessories	1%
		Shortage of personnel	2%
		Personal time	0%
		Problems with internal material	1%
		Problems with external material	1%
Total			**25%**
Availability	Unplanned Losses	Equipment breakdown/ Unplanned production	3%
		Setup/Changeover	13%
Total			**16%**
Performance	Minor idling losses	Micro stoppage	5%
Quality	Defect and rework	Quality issues/Reworks	2%
No reason code	Unknown losses	Unknown	52%

Table 21 : Total Availability

4.11 CAPACITY UTILIZATION

Month	capacity utilization
Jun-22	105.8
Jul-22	95.5
Aug-22	90.7
Sep-22	94.8
Oct-22	62.3
Nov-22	95.6
Dec-22	95.1

Table 22: Capacity Utilization

Figure 4.15 : Capacity Utilization between June to December month 2022

Capacity utilization refers to the extent to which an organization or a system is using its available resources to produce goods or services relative to its maximum potential capacity. It is a measure of how much of the available resources are being utilized to generate output. Capacity utilization is usually expressed as a percentage and is calculated by dividing actual output by potential output and then multiplying the result by 100.

For example, if a manufacturing plant has the capacity to produce 10,000 units per month and it produces 8,000 units in a month, then the capacity utilization rate is 80%. A high-capacity utilization rate indicates that the organization is using its resources effectively, while a low-capacity utilization rate suggests that there is room for improvement in the utilization of resources. Capacity utilization is an important factor in evaluating the efficiency and profitability of an organization.

4.12. OPERATING FACTOR

Month	Operating Factor
Jun-22	100.0
Jul-22	100.0
Aug-22	100.0
Sep-22	100.0
Oct-22	66.7
Nov-22	100.0
Dec-22	94.8

Table 23 : Operating Factor from the month of July 22 to December 22

Figure 4.16 : Operating Factor from the month of July 22 to December 22

Operating factor refers to the ratio of actual operating time to the total available time for a piece of equipment or a system. It is a measure of the efficiency with which equipment or systems are utilized to generate output. The operating factor is usually expressed as a percentage and is calculated by dividing the actual operating time by the total available time and then multiplying the result by 100.

For example, if a machine has a total available time of 8 hours in a day but operates only for 6 hours, then the operating factor is 75% (6/8 * 100). A high operating factor indicates that the equipment or system is being utilized effectively, while a low operating factor suggests that there is room for improvement in the utilization of equipment or system.

The operating factor is an important factor in determining the efficiency and productivity of equipment or systems. A higher operating factor indicates that more output is being generated from the available resources, leading to improved efficiency and profitability. On the other hand, a lower operating factor may indicate that the equipment or system is underutilized, resulting in lower productivity and increased costs.

4.13. VGO FEED ANALYSIS

			VGO FEED ANALYSIS	
MONTH	TARGETED	ACHIEVED	DEVIATION	REASON
Jun-22	219.78	217.60	2.18	Less feed availability
Jul-22	227.106	202.38	24.73	Less feed availability
Aug-22	227.106	188.46	38.65	Limited by Acid gas flaring
Sep-22	219.78	190.99	28.79	Non availabilty of feed
Oct-22	227.106	116.62	110.49	Planned shutdown
Nov-22	219.78	190.53	29.25	SRU sulfur pit pump issue,H2 availability and UCO Tank ullage
Dec-22	227.106	200.34	26.77	PSA 1 trip on 05.12.2022 & UCO ullage

Table 24 : VGO Feed Analysis

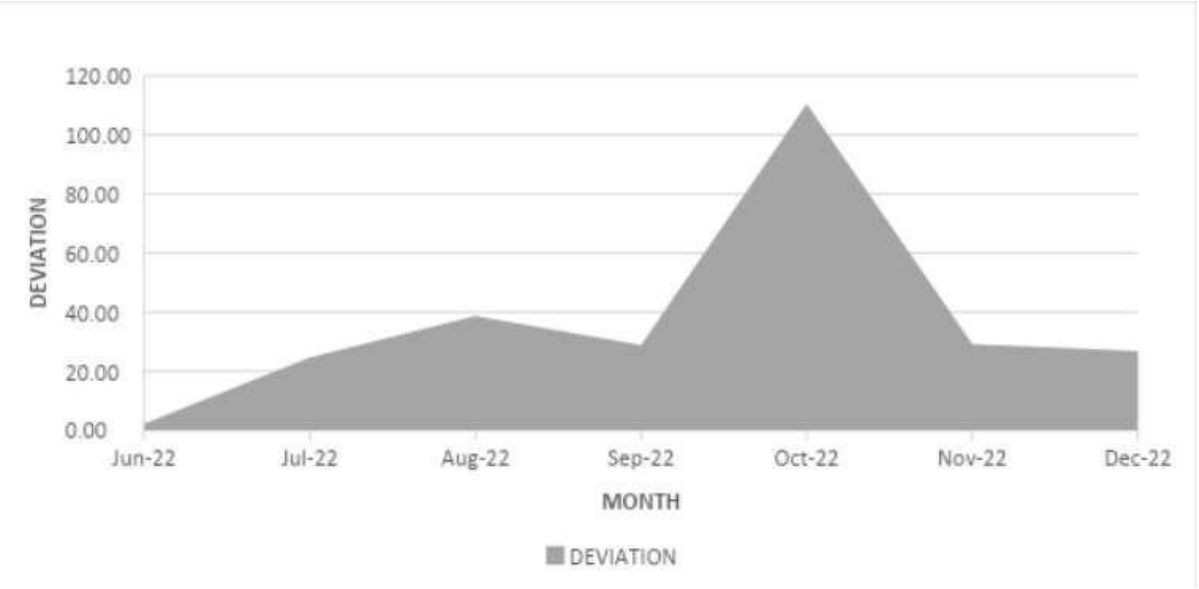

Figure 4.17 : VGO Feed Analysis

Table 25 : Monthly VGO Analysis

VGO (Vacuum Gas Oil) feed analysis is an important step in the hydrocracking process, as it helps to determine the composition and properties of the feedstock that will be processed in the unit.

4.14. COST ANALYSIS

Basis	217.596897	TMT of feed processed		235239.8895	m3 of feed processed							
FO	Rs.	34751	per KL	36580	Rs/T	FoE	0.983					
H2	Rs.	29	per Nm3									
Feed												
Total Feed	217.6	TMT	KL	Cost								
VGO	181.780684	TMT	196519.6586	682.9254656								
HCGO	35.8193158	TMT	37704.54296	131.0270572								
H2	4.67292599	TMT	52369481.61	151.8714967								
				965.8240195	Cr/month							
				41056.98322	Rs/m3 of feed							
Product												
		MT										
C25 off gas.		2356.379143	9.266544624							LPG	100340	Rs/T
CLPS off gas.		335.6934107	1.320126254							naphtha	48000	Rs/T
LPG.		1277.232	12.81574589							SK	76539.8262	Rs/T
Lt. Naphtha.		6149.0394	29.51538912							HSD	72460.7703	Rs/T
Hy. Naphtha.		12429.01896	59.65929101							UCO	48541.7033	Rs/T
PCK+ Kerosene+ATF		38312.21249	293.2410087									
HSD		57028.11091	413.2300347									
UCO.		99159.41696	481.3367004							Operating Cost		127.076133 Cr /month
H2S.		5016.674611	1.803494523									5401.98065 Rs/m3 of fe
			1302.188385	Cr/month								
			55355.7642	Rs/m3 of feed								

Table 26 : Cost Analysis

OEE (Overall Equipment Effectiveness) is a measure of how effectively a manufacturing operation is being utilized. It is typically calculated as the product of three factors: availability, performance, and quality.

To conduct a cost analysis for OEE, you would need to gather data on the costs associated with the manufacturing operation and how those costs relate to OEE. Here are some steps you could take:

Determine the costs associated with each factor of OEE: availability, performance, and quality. For example, the costs associated with availability could include the cost of maintaining and repairing equipment, the cost of idle time due to breakdowns, and the cost of lost production. The costs associated with performance could include the cost of production speed or efficiency, the cost of scrap or rework, and the cost of downtime due to changeovers or adjustments. The costs associated with quality could include the cost of scrap or rework, the cost of customer complaints, and the cost of warranty claims.

Calculate the total cost of each factor of OEE. This will give you a sense of the overall cost of the manufacturing operation.

Calculate the OEE for the manufacturing operation. This will give you a sense of how effectively the operation is being utilized.

Analyze the relationship between OEE and costs. Look for patterns in the data that may suggest areas of inefficiency or areas where improvements could be made. For example, if you notice that downtime due to equipment breakdowns is driving up costs, you may want to invest in better maintenance procedures or equipment upgrades.

Develop a plan to improve OEE and reduce costs. Based on your analysis, develop a plan to improve OEE and reduce costs. This may involve making changes to equipment, processes, or staffing.

Overall, a cost analysis for OEE can help you identify areas of inefficiency in your manufacturing operation and develop a plan to improve efficiency and reduce costs.

CHAPTER 5

CONCLUSION

The strength of OEE is to improve competitiveness in any manufacturing industry by creating a better return on investment (ROI) and producing increased productivity. A world class value of overall OEE is 85 percent where availability is expected to be 90 percent, performance 95 percent and quality 99, 9 percent. This value is greatly influenced by potential losses since it is the difference between ideal and actual states. The only OEE parameter that suits this value is the average quality factor. The average OEE values are affected by their average availability and performance rates. This is highly affected by their overwhelming losses or based on limitations based on the unknown losses that were not recorded. Though quality related losses have been the lowest within the corresponding to the suggested world class quality value of OEE, the biggest losses in are recorded as "unknown" and therefore create a sense of irresponsibility between all the industries which is of great significance since it could affect average OEE value for the different sectors. This calls for an awareness and possible training all parties on the importance of information within all the different sectors within the industries. The reasons for measurement are important since it helps in decision making and help creates a benchmark for potential improvements. There is need for finding out why stoppage reasons were not being provided and this research could be extended in answering this. As a matter of fact, average OEE on these industries have been poor. This indicates that they are not working according to the OEE concepts and employing fundamental

5.1 FINDINGS

principles of its theory. Potential reasons could be;

• That they think (through guessing) they have a better equipment efficiency than they actually, have and see no direct need to measure their processes

• That untrained operators do not understand how the system put in place is used.

• That the system is too complex (so many stoppage reasons) and difficult to understand.

• Based on procrastination.

• Because operators think it could be used in measuring their own performance instead.

• That the system itself is not functioning properly.

• Those operators do not really care about the system or its benefits towards them.

• That previous data were not used by the management and it is not really relevant.

• Based on change on management and so much change of systems.

• Misunderstood and misused.

• It is not really being used for future improvement but simply book keeping.

Potential difficulty in personnel‟s resistance to change can be overcome by devoting great efforts towards internal communication and making messages understood. This can improve current performance to gaining sustainable competitiveness.

5.2 SUGGESTIONS

Future recommendation would be informing all the operators and personnel before any of these

solutions are implemented. Since people are sometimes resistant to change, the need to

motivate as well as providing a clear reason for these changes should first be brought forward.

Training and empowering the staff creates awareness and promotes a sense of responsibility on

their part. A system should also be designed in other to fit the specific process in any industry.

Qualitative research can be carried out in gathering data based on interviews (through phone or

face-to-face), through questionnaires addressed to operators and the entire management teams.

Data from a build cross-functional team work could help create a more reliable and valuable data.

Further unplanned measures due to breakdowns of machines might require preventive

maintenance, or vibration analysis.

Future research may be done to explore;

• Operation and production design.

• The dynamics of translating equipment effectiveness or loss of effectiveness in terms of

cost.

• Machine design or mechanical design.

• Frequency studies on man hours (Human OEE).

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Appendix 2: Research Questionnaire

Subject: Questionnaire about The Study on overall critical failure equipment efficiency for cost effectiveness in CPCL

The purpose of this questionnaire is to understand better how you feel towards the overall critical failure equipment efficiency foe cost effectiveness in CPCL. To achieve this, you are asked to answer the questions below by marking the box or circling the number choice that best represents your opinion.

Please answer every question honestly. If you are not certain about a question, please use your best efforts to select the most reasonable answer.

This survey is fully anonymous and no identifying information is required. The collected data from this survey will be used only for academic purpose.

DEMOGRAPHIC INFORMATION

1) Name : _____

2) Age

   a) 18 - 25 b) 25-35

   c) 35-45 d) 46 & Above

3) Gender

   a) Male b) Female

4) Qualification

   a) Diploma b) Post Graduate

   b) Others _____

5) Job Role

a) Operator b) Supervisor

c) Manager d) Technician

e) Other_____

6) It is important to regularly inspect the critical failure equipment to ensure it is in good working condition .

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

7) Training employees on the proper use and maintenance of critical failure equipment is crucial to prevent accidents and downtime

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

8) Investing in high- quality critical failure equipment is worth the cost to ensure reliability and safety

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

9) Regularly scheduled maintenance and repairs on critical failure equipment should be a top priority for any organisation

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

10) Effective communication between maintenance staff and operators are necessary to ensure critical failure equipment is properly maintained and serviced.

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

11) Implementing a robust quality control system can help minimize product defects.

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

12) It is acceptable to sacrifice product quality to meet production targets or reduce costs.

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

13) Investing in new technology and equipment can improve product quality

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

14) Safety should be the top priority for all employees in the petroleum industry.
Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

15) Proper training and education for all employees can help reduce accidents and injuries in the petroleum industry.

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

16) The petroleum industry should prioritise the mental and well-being of its employees, especially those working in high stress or high-risk positions.

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

17) It is the responsibility of all employees in the petroleum industry to report any safety concerns or violations they witness.

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

18) Developing a robust maintenance planning strategy is essential.

Please select the most appropriate number using the following scale when choosingyour answer:
1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree
5 = Strongly Disagree

19) Maintenance planning should take into account the criticality of the equipment.

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree
2 = Agree
3 = Natural
4 = Disagree

5 = Strongly Disagree

20) The maintenance planning strategy should be integrated into the overall business strategy of the petroleum industry, with a focus in maximizing profitability and minimizing risk.

Please select the most appropriate number using the following scale when choosingyour answer:

1 = Strongly Agree

2 = Agree

3 = Natural

4 = Disagree

5 = Strongly Disagree

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