Internship Report

Machinery Unit - PFL, Multan

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Mentor

Engr. Ahmed Khan Babar

Submitted by

Mohammad Hamza

NFC INSTITUTE OF ENGINEERING & TECHNOLOGY MULTAN

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Acknowledgement

This report has been prepared for the internship that has been done in the Machinery Unit, **Pak Arab Fertilizers Limited, Multan** to study the practical aspect of the course and implementation of the theory in the field with the purpose of fulfilling the requirements of the course of Bachelors of Mechanical Engineering. I would like to express my sincere gratitude to our Mentor **"Engineer Ahmed Khan Babar"**, Unit Manager **"Shahid Ansari"**, Section Head **"Muneeb Hussain"**, Engineers, Sub-Engineers, Technicians and Machinery Department Employees for their kind support and encouragement.

Executive Summary

During my 4-weeks internship at Pak Arab Fertilizers Multan, I had the opportunity to gain valuable insights into various aspects of the organization's operations. The internship exposed me to a diverse range of tasks and responsibilities, providing me with practical experience in different areas. One of the key areas I was involved in was the maintenance of equipment. I had the chance to witness and participate in overhauling activities, which gave me a deeper understanding of the importance of regular maintenance to ensure the efficient functioning of industrial equipment.

During the internship, I also gas turbine, steam turbine, compressors, gear box, coupling, various bearings and seals. This exposure enhanced my knowledge of machinery work and their critical role in industrial processes. Moreover, I gained valuable experience in reading and interpreting engineering drawings, which proved to be a fundamental skill in the field of engineering. A significant part of my internship involved learning about gas turbines. Understanding the principles and working of gas turbines provided me with valuable insights into power generation processes and their applications in the industry.

Another essential aspect of my internship was the opportunity to learn about the Maintenance of Ammonia Plant, Nitro Phosphate (NP), Calcium Ammonium Nitrate (CAN) and Power Production at Utilities West. I gained in-depth knowledge of the production and purification of Ammonia, a crucial component in the fertilizer industry. Additionally, learning about Ammonia allowed me to comprehend the significance of Ammonia in Pak Arab Fertilizers industrial applications. The internship not only strengthened my theoretical knowledge but also instilled in me a sense of responsibility and adaptability in a professional working environment. I am confident that the knowledge and experiences gained during this internship will contribute significantly to my future career in the field of engineering and beyond.

Chapter - 1

1. Overview of The Organization

1.1 Pak Arab Fertilizers Limited

Pak Arab Fertilizers Limited was incorporated on November 12, 1973 by joint Venture between Government of Pakistan and Abu Dhabi National Oil Company Limited (ADNOC). Subsequently, Pakistan Industrial Development Corporation, PIDC assigned 52% of its shares to National Fertilizer Corporation (NFC) of Pakistan and ADNOC assigned 48% of its shares to International Petroleum Investment Company, with a paid-up capital of PKR 743.061 Million.

1.1.1 Company Overview

For the last 38 years, Pak Arab Fertilizers Limited has been the only fertilizer company in Pakistan producing compound fertilizers, Calcium Ammonium Nitrate (CAN) and Nitro Phosphate (NP). The Plant also produces Urea. Fatima Group has undertaken extensive modernization at Pak Arab Fertilizers Limited and new improved processes have been introduced to maximize the output while minimizing the negative impacts on the environment. Clean Development Mechanism (CDM) plant was first project of its kind in Pakistan by Fatima Group for the abatement of NOX emissions from the stack gases of Nitric Acid plant. The efforts and investments for the reduction of green-house gases show Fatima Group's commitment towards a cleaner and healthier environment for the future generations of Pakistan.

1.1.2 Plants & Process

- Ammonia Plant
- CAN Plant
- NP Plant
- Urea Plant
- Carbon dioxide Plant
- Nitric Acid Plant

Chapter - 2

2. Introduction

During the course of my internship at Pak Arab Fertilizers Limited Multan, I had the valuable opportunity to explore world of mechanical systems within power generation and industrial applications. This experience allowed me to gain a comprehensive understanding of essential components such as Gas Turbines, Steam Turbines, Gearboxes, Compressors, Bearings, and Seals, all of which play pivotal roles in ensuring efficient and reliable operation across a range of industries. In addition, a thorough understanding of the processes behind the Ammonia Plant, Nitro Phosphate (NP) Plant, Calcium Ammonium Nitrate (CAN) Plant and Utilities West Plant was acquired.

The aim of this internship report is to present the key learning outcomes derived from my hands-on exposure to these critical mechanical components. Through the observation, analysis, and practical involvement in the maintenance, troubleshooting, and optimization of these systems, I have developed a multifaceted skill set that encompasses not only technical knowledge but also problem-solving abilities, teamwork, and effective communication within a professional engineering environment.

The following sections outline the specific learning outcomes achieved in each of these domains:

2.1 Gas Turbines

Throughout my internship, I developed a comprehensive understanding of gas turbines, including their operational principles, thermodynamics, and combustion processes. By actively participating in maintenance tasks and fault diagnosis, I improved my skills in identifying issues and performing necessary repairs. Additionally, I acquired proficiency in assessing turbine performance and optimizing efficiency, thereby contributing to the overall productivity of the system.

2.2 Steam Turbines

My involvement with steam turbines provided insights into the mechanism of steam-driven systems. I learned about turbine blade design, steam flow control, and the intricacies of steam cycle thermodynamics. The experience of diagnosing and rectifying issues within steam turbines has equipped me with practical skills to ensure continuous and reliable operation.

2.3 Gear Box

During my internship, I engaged in the disassembly, inspection, and maintenance of gearboxes, understanding their role in transmitting power between different parts of machinery. Through hands-on activities, I gained proficiency in gear alignment, lubrication systems, and identifying signs of wear and tear. This practical exposure enabled me to contribute to the longevity and efficiency of equipment reliant on gear mechanisms.

2.4 Compressors

My involvement with compressors allowed me to comprehend their role in increasing gas pressure for various industrial processes. By actively participating in compressor maintenance and performance assessments, I acquired knowledge of rotor dynamics, compression efficiency, and vibration analysis. These skills are crucial for ensuring optimal compressor operation and preventing potential malfunctions.

2.5 Bearings and Seals

The internship provided me the opportunity to explore more about different bearings and seals, fundamental components that facilitate smooth machinery operation while minimizing friction and preventing leaks. I witnessed bearing inspection, lubrication strategies, and seal integrity maintenance. This knowledge is essential for enhancing equipment reliability and reducing operational downtime.

Chapter - 3

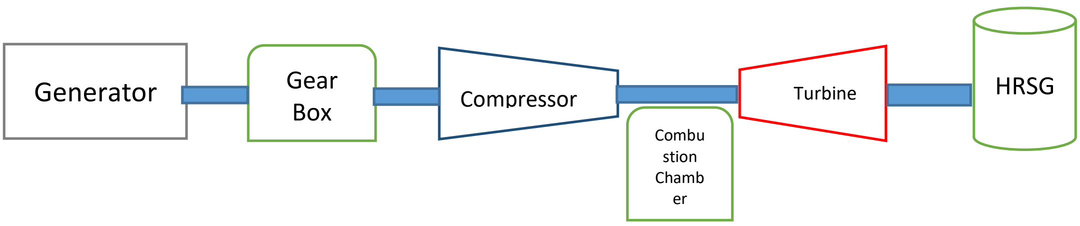
3. Learning Outcomes

Exploring the different mechanical equipment's and components used in various plant sites at Pak Arab Fertilizers, I gained a deep knowledge and practical understanding about many maintenance procedures and analysis made at plant sites. These learnings are further explained into various sections according to their respective period of my internship. Here is are some specific learning outcomes at different points of my internship.

3.1 Utilities West

3.1.1 Gas Turbine - Generator

Gas Turbine Generator (GTG-01) is the train of Gas Turbine, Compressor, Generator, Gear Box and Combustion Chamber at Utilities West, PFL having a rated capacity of 11 MW which is used for power production contributing 6.5 MW power in the main power resources. The total usage of power is 20 MW, out of which, 1/3 proportion is covered by GTG-01. An overview for the Gas Turbine - Generator is shown above:



a) Components

Following are the components included in a gas turbine generator which are further explained according to their specifications and workings

- **Generator**

Type	:	GSCT 900 Z4
Speed	:	1,500 rpm
Runaway Speed	:	1,800 rpm
Rated voltage	:	11,000 V ±5%
Rated power	:	14,065 kVA (11,252 kW)

- **Gear Box**

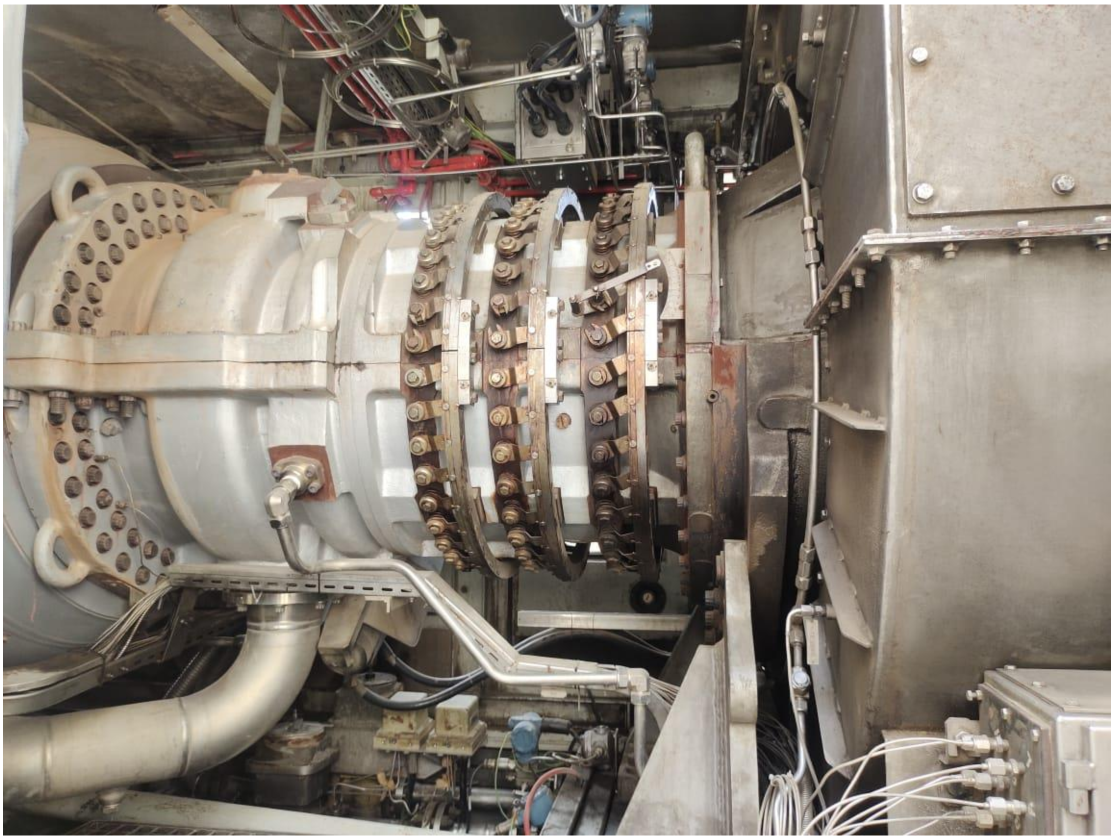
The basic elements of the Allen Gears Star Type Gear are as follows:

1. Central Sun Wheel/High Speed Shaft.
2. Central Sun Wheel/High Speed Shaft.
3. Internal Gear (annulus) Rings (2 off).
4. Fixed Star Carrier.
5. Low Speed Assembly

- **Compressor**

Make	:	GE
Flow Type	:	Axial Flow
Stages	:	11
Speed	:	11,000 rpm
Components	:	Inlet Guide Vanes

		Rotating Blades
		Stator Blades
		Exit Guide Vanes



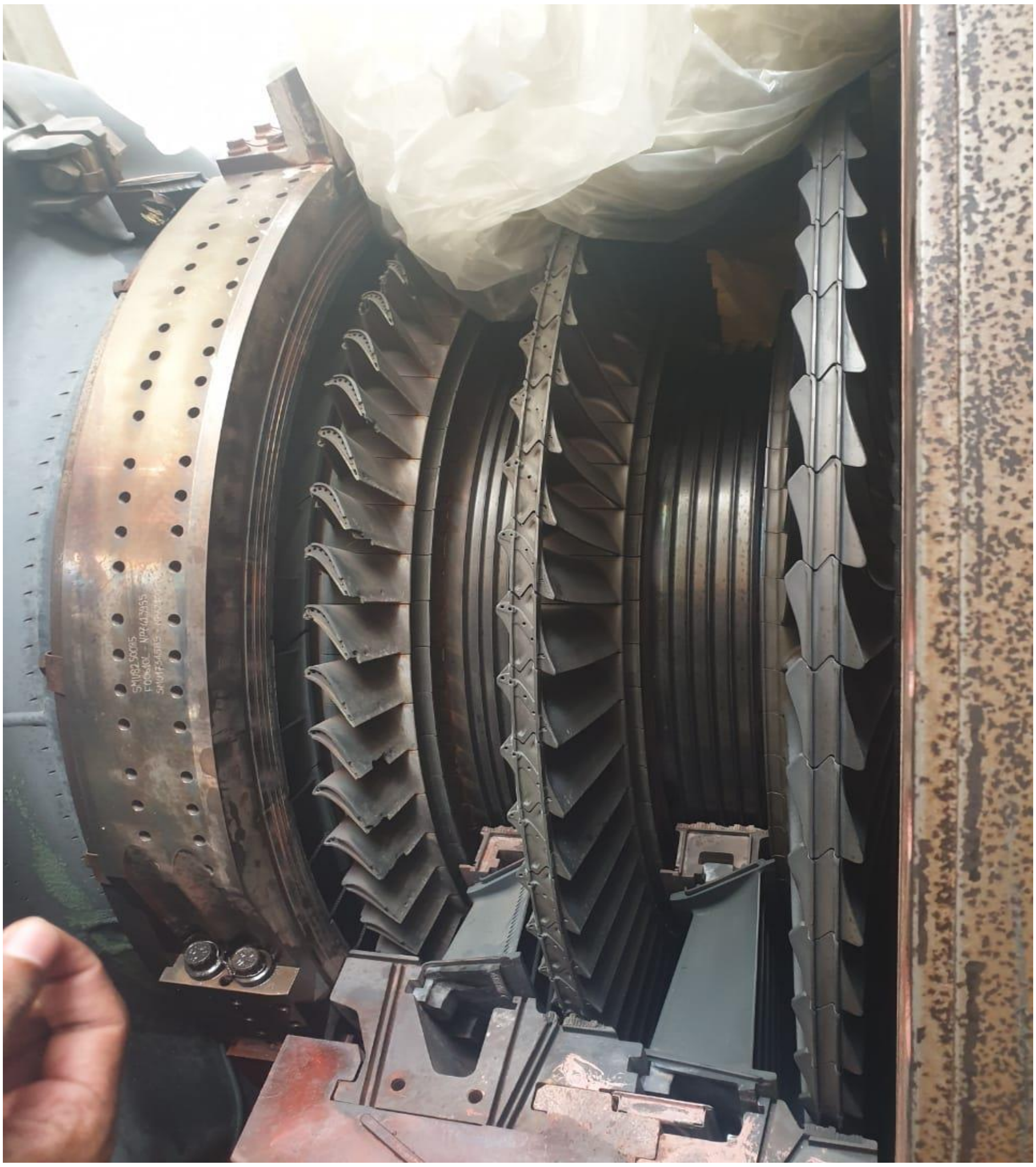
- **Combustion Chamber**

Make	:	General Electric
Type	:	Horizontal CC
Components	:	Liner
		Transition Piece
		Fuel Nozzle (Primary & Tertiary)
		Spark Plug, Actuator

- **Turbine**

Number of stages	:	3
Rotation speed	:	11,000 rpm

Fuel	:	Natural Gas
Shaft Rotation Direction	:	looking at the turbine from the intake to the exhaust.



3.2 Case Study

During the internship, an event occurred in which Combustion Chamber Inspection was to perform in order to change the liner as it exceeded its recommended operational hours. I discovered the complete inspection of Combustion Chamber along with the methodological review of how this protocol was developed and rectification was adopted.

3.2.1 Planned Operation

Developed an Efficient Combustion Chamber Inspection Protocol for GTG-01 at Utilities West, PFL, beyond specified running hours: Investigated the impact of extended operation on combustion chamber integrity and designing a comprehensive inspection methodology to ensure safe and reliable performance post the recommended operational hours.

3.2.2 Objective

It was to ensure safe, efficient and reliable operation of the equipment. The inspection aims to identify and address any issues that could potentially impact the combustion process, performance and overall integrity of the combustion chamber.

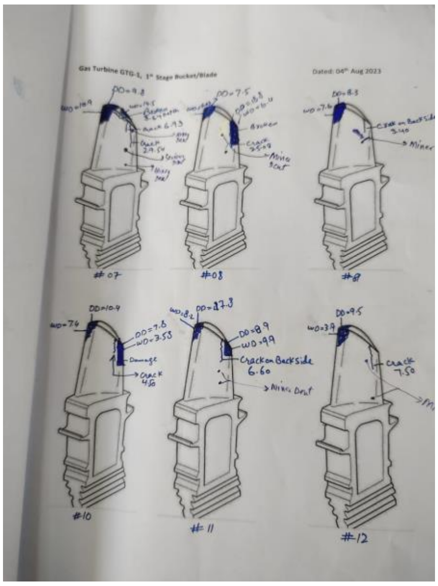
3.2.3 Methodology

a) Observations:

- Cracks & Dents

b) Data Gathering & Logging:

- Record the condition of blades
- mapping of blade defects
- number, location & extent of segments damaged



c) Analysis

- Blades require refurbishment as spares not available
- approached a short term solution (i.e. Grinding of blades to curtail the advancement of defects - Crack Propagation)
- this activity was already performed and found successful on GTG-2 & 3.
- Solution / Rectification of Defects

d) Dressing

- Edge Smoothing
- Grinding, & Chipping off already damaged blades

e) Balancing

- Volumetric Sampling of segments/blades before grinding & after grinding
- identifying locations requiring more grinding, in light of analysis.

f) Assurance

- Post-Maintenance Review - Quality Checklists
- Inspections
- Vendor Service Manager (VSM) availability on-site
- Correspondence with Original Equipment Manufacturer (OEM)

3.2.4 Combustion Chamber Inspection

There are several methods of combustion chamber inspection, including visual inspection, and borescope inspection. Before the opening of Combustion Chamber for inspection - a procedure is adopted for disassembling CC which is discussed in further steps:

I. In order to inspect combustion chamber, the roof and wall safety housing of CC is removed through slinging method.

II. Guide pins were adjusted after removing bolts and the CC Head sided through guide pin.

III. Remove the combustion (cold) head from the combustion chamber

IV. After removing the head, proper measures were taken to check flange overlapping between CC Head & Liner using Vernier Caliper. The value for overlapping was 9.8mm.


V. Losing the bolts using Hellen Key, of tertiary piping attached with nozzles. These nozzles were flexible, hence, easily disassembled by using force.

VI. Clearing the area, liner was taken out and ready to go through inspection.

3.2.5 Extended Operation

Operation of GTG-01 on post recommended hours, it was necessarily declared to replace the liner of combustion chamber. However, due to certain reasons, it was decided to extend the operation to perform a Borescope Inspection (BI) on GTG-01.

a) Borescope Inspection Analysis

Through Borescope Inspection, it was analysed:

- Bolt head de-attached from combustion head basket entered inside the turbine
- Major Cracks appeared on 1st stage blades
- Minor Dents appeared on 2nd stage blades

Keeping the circumstances in consideration, a Hot Gasses Path Inspection (HGPI) Protocol was developed.

b) Hot Gasses Path Inspection (HGPI)

HGPI Protocol checks includes:

1. Visual Inspection
2. Borescope Inspection
3. Dye Penetrant Testing

c) Process

The procedure adopted to complete this process includes:

- Loosening bolts
- Removing HP Turbine Casing
- Disassembling 1st Stage Nozzle Casing
- Dye Penetrant Testing
- Mapping
- Cleaning, Grinding & Chipping
- Borescope Inspection
- Re-Assembling

3.3 Ammonia Plant

3.3.1 Compressors Hall

The production of Ammonia is controlled and processed using three main compressors which are turbine-driven namely Air Process Compressor (101J), Ammonia Refrigeration Compressor (105J), and Synthesis Gas Compressor (103J). The Ammonia attained from this processing is further used in other plants operations to produce required products. Main details and processing of these compressors is further explained above:

a) Air Process Compressor-101J

- Stage Compressor (1LP+2HP)
- Atmospheric Suction
- Intercoolers installed between each stage
- Lube Oil Pump installed
- Induction Gear Box
- Steam Turbine - driven
- Over speed Trip
- It compresses air and discharge the processed air towards 103J.

b) Synthesis Gas Compressor-103J

- Stage Compressor (1LP-10 impellers + 2HP - 7 impellers - 1 recycler)
- Air and Natural Gas (Methane) Inlet
- Intercoolers installed between each stage
- Steam Turbines - driven
- Induction Gear Box
- Lube Oil Pump installed
- Over speed Trip
- It breaks downs Methane and mix it with 101J discharge.

c) Ammonia Refrigeration Compressor-105J

- Stage Compressor
- Steam Turbine - driven
- Over speed Trip
- It refrigerates ammonia and converts it into liquid form.

3.4 Nitro Phosphate & Calcium Ammonium Nitrate

3.4.1 Steam Turbine

An incident occurred at NP & CAN which involve the pinion gears helical threading to break down. In order to rectify the problem, quality maintenance protocol was performed. The Steam Turbine at NP & CAN contains the following details:

- Single Stage Turbine
- Impulse Wheel
- Reversing Chamber
- Tachometer
- Over Speed Trip
- Governor
- Servomotor
- Main Lube Oil Pump
- Reduction Gear Box
- Stuffing Box Installed
- General, 2 General Come Thrust Bearings
- Flexible Jaw Coupling
- It transports Cold Brine Solution to the Plant for Process as it drives a pump.

Chapter - 4

4. Analysis

4.1 Gas Turbine

During the internship, the exposure to gas turbines provided a dynamic learning experience. The theoretical understanding of operational principles gained through academic studies was solidified by hands-on engagement with real-world turbines. By actively participating in maintenance tasks and fault diagnosis, I was able to bridge the gap between theory and practice. The challenges encountered, such as identifying and rectifying issues in combustion processes, not only tested my technical knowledge but also enhanced my problem-solving skills. This experience highlighted the importance of efficient maintenance schedules in ensuring consistent and reliable turbine performance. Moreover, the opportunity to optimize turbine efficiency through performance assessments underscored the practical significance of thermodynamics concepts. This holistic understanding of gas turbines has equipped me with a comprehensive skill set to contribute effectively in the field.

4.2 Steam Turbine

Working with steam turbines illuminated the intricate interplay between theoretical knowledge and practical application. The theoretical foundation in steam cycle thermodynamics was put to the test as I engaged in diagnosing and addressing mechanical and thermal issues in real steam turbine systems. The complexity of blade design, steam flow control, and the role of steam turbines in power generation became more apparent during hands-on tasks. This experience was a testament to the significance of meticulous maintenance in preventing downtime and optimizing energy conversion efficiency. The challenges faced, such as balancing steam flow rates and addressing turbine blade erosion, emphasized the need for interdisciplinary problem-solving skills and effective communication within a team. As a result, my ability to integrate theory and practice in the realm of steam turbines has been significantly enhanced.

4.3 Gear Box

The practical exposure to gearboxes underscored the importance of precision and attention to detail in mechanical systems. While academic knowledge provided a foundation, the disassembly, inspection, and maintenance of gearboxes demonstrated the practical nuances involved in maintaining efficient power transmission. Challenges encountered, such as ensuring proper gear alignment and addressing signs of wear, illuminated the importance of preventive maintenance in minimizing unplanned downtime. This experience reinforced the value of teamwork and collaboration, as effective communication was essential for accurate gearbox reassembly. Overall, the gearbox engagement enhanced my understanding of mechanical components' critical role in overall machinery performance.

4.4 Compressor

The engagement with compressors provided insights into the dynamic nature of gas compression processes. While the theoretical understanding of rotor dynamics and compression efficiency formed the basis, hands-on experiences revealed the challenges of maintaining optimal compression performance. The analysis of compressor vibrations for early detection of potential malfunctions showcased the practical applications of vibration analysis techniques. Additionally, the importance of timely maintenance in ensuring consistent operation was evident as I participated in compressor maintenance tasks. This exposure underscored the need for adaptability and quick decision-making, particularly in diagnosing and rectifying unforeseen issues.

4.5 Bearings & Seals

Working with bearings and seals emphasized the significance of friction reduction and system integrity. The hands-on examination and maintenance of bearings demonstrated the practicality of minimizing friction for machinery longevity. The challenges of seal maintenance highlighted the crucial role of meticulous attention to detail in preventing leaks and ensuring safe operations. This experience showcased the direct correlation between effective maintenance practices and equipment reliability. The understanding gained in this domain reinforced the broader perspective of mechanical components' contribution to overall system efficiency and safety.

In addition, the analysis of my internship experiences in Gas Turbines, Steam Turbines, Gearboxes, Compressors, Bearings, and Seals highlights the profound integration of theoretical knowledge with practical application. The challenges faced, skills honed, and lessons learned have collectively contributed to my growth as a proficient mechanical engineer, well-equipped to address complex industrial challenges and contribute effectively to various engineering endeavours. The hands-on engagement has bridged the gap between academic learning and real-world scenarios, fostering a comprehensive skill set crucial for a successful engineering career.

Chapter - 5

5. Recommendations

- ✓ **Continuous Skill Enhancement:** To further strengthen the skills acquired during this internship, I recommend engaging in continuous learning and professional development. This could involve attending workshops, seminars, or pursuing relevant certifications in the fields of gas turbines, steam turbines, mechanical components, and maintenance techniques.
- ✓ **Cross-Functional Collaboration:** Given the interdisciplinary nature of mechanical systems, collaborating with professionals from other engineering disciplines, such as electrical and control systems engineers, can provide valuable insights and a more comprehensive approach to problem-solving.
- ✓ **Data-Driven Maintenance:** Embrace data-driven maintenance strategies by utilizing sensor data, predictive analytics, and condition monitoring tools. This can significantly enhance the effectiveness of maintenance routines, reduce downtime, and improve overall system reliability.
- ✓ **Process Optimization:** Collaborate with process engineers to explore opportunities for system optimization and efficiency improvement. By understanding how mechanical components interact with overall processes, you can contribute to more streamlined and productive operations.

Chapter - 6

6. Conclusions

The internship experience in Gas Turbines, Steam Turbines, Gearboxes, Compressors, Bearings, and Seals has been transformative and enlightening. The hands-on engagement has allowed me to bridge the gap between theoretical knowledge and practical application, fostering a holistic understanding of complex mechanical systems.

Through the challenges encountered and skills honed, I have not only gained technical proficiency but also developed critical problem-solving, communication, and teamwork skills. These competencies are essential for successfully navigating the dynamic landscape of engineering and industry.

This internship has reaffirmed my passion for mechanical engineering and has positioned me as a more capable and confident engineer. The exposure to diverse components and systems has broadened my perspective and equipped me to contribute effectively to a wide range of industrial applications.

As I move forward in my engineering journey, I am committed to applying the knowledge and experiences gained during this internship to drive innovation, optimize operations, and contribute to the continued advancement of mechanical engineering practices. I am immensely grateful for the opportunity to have learned from experienced professionals, and I look forward to translating this experience into meaningful contributions to the engineering field.

Assessment Tasks

Assignment - 1

Centrifugal compressor:

A centrifugal compressor is a type of dynamic compressor used in variouss applications to increase the pressure and flow rate of gases or vapors. It operates based on the principle of centrifugal force.

Components:

- Inlet
- Impeller
- Diffuser
- Volute casing
- Outlet
- Shaft
- Seals
- Lubrication system
- Bearing

1. Impeller:

The impeller is a rotating component that consists of curved blades or vanes. It accelerates the gas or air by imparting kinetic energy to it.

2. Casing:

The casing or housing encloses the impeller and provides a flow path for the gas. It is designed to control the gas flow and direct it to the next stage of compression. The casing is usually shaped in a volute or diffuser configuration.

3. Inlet Guide Vanes (IGV):

The IGVs are adjustable vanes located at the inlet of the compressor. They control the gas flow by adjusting the angle of the vanes. IGVs are used to optimize the compressor performance by matching the compressor's operating conditions to changing demands.

4. Diffuser:

The diffuser is a section of the casing located **after** the impeller. Its purpose is to convert the high-velocity, low-pressure gas exiting the impeller into high-pressure, low-velocity gas by decelerating and diffusing the flow.

5. Discharge Outlet:

The discharge outlet is the point where the compressed gas exits the compressor and is delivered to the downstream system or process.

6. Bearings:

Centrifugal compressors require bearings to support the rotating shaft and reduce friction. These bearings can be either journal bearings or thrust bearings, depending on the design and load requirements.

7. Shaft:

The shaft connects the impeller to the driver, which can be an electric motor, a steam turbine, or a gas turbine. It transmits the mechanical energy from the driver to the impeller.

8.Seals:

Various types of seals, such as labyrinth seals or mechanical seals, are used to minimize gas leakage between the rotating and stationary components of the compressor.

8. Lubrication System: Centrifugal compressors require a lubrication system to provide lubricating oil to the bearings and other rotating parts for smooth operation and to reduce wear.

2. Bearing seals:

Bearing seals, also known as shaft seals or rotary seals, are devices used to prevent the leakage of lubricants and contaminants from the bearing housing or the entry of contaminants into the bearing assembly.

Types:

Inter stage seals:

It is the seals that is used to maintain the pressure difference of gasses between stages of compressor. It prevents the high pressure gas form leaking into the low pressure gas.

Labyrinth Seals:

Labyrinth seals are widely used in compressors due to their simple design and effectiveness in preventing leakage. They consist of a series of interlocking grooves or fins on both the stationary and rotating parts of the bearing housing. The grooves create a tortuous path for the oil or gas, reducing the chances of leakage.

Carbon Ring Seals:

Carbon ring seals are also commonly employed in compressors. They consist of a set of carbon rings that create a seal between the rotating shaft and the stationary housing and prevent oil leakage.

Mechanical Face Seals:

Mechanical face seals, also known as floating or floating-ring seals, are used in applications where there are high-pressure differentials and extreme operating conditions. They consist of two flat sealing faces pressed against each other by springs or other means.

End Seal:

An end seal is a type of seal used to prevent leakage at the ends of a compressor. It is typically located at the interface between the rotating shaft and the stationary housing or casing of the compressor. It is design to contain high pressure of gas or fluid with in the compressor and prevent from escaping into the environment.

Oil Seal:

An oil seal, also known as a shaft seal or lip seal, is a specialized type of seal used to prevent the leakage of lubricating oil from the bearing housing or other rotating components of a compressor. It is typically located around the rotating shaft and provides a barrier between the lubricant and the external environment. It helps maintain proper lubrication of the compressor's bearings and prevents contaminants from entering the bearing housing.

3. Types of thermocycles:

a) Otto cycle:

The Otto cycle is the idealized cycle used in spark-ignition engines, such as gasoline engines. It consists of four processes: adiabatic compression, constant-volume heat addition, adiabatic expansion, and constant volume heat rejection.

b) Rankine cycle:

The Rankine cycle is the idealized cycle used in steam power plants. It consists of four processes: heat addition at constant pressure (isobaric heat addition), adiabatic expansion, heat rejection at constant pressure, and adiabatic compression. The Rankine cycle is commonly employed in power generation using steam turbine.

c) Diesel cycle:

The Diesel cycle is the idealized cycle used in compression ignition engines, also known as diesel engines. It includes four processes:

adiabatic compression, constant-pressure heat addition, adiabatic expansion, and

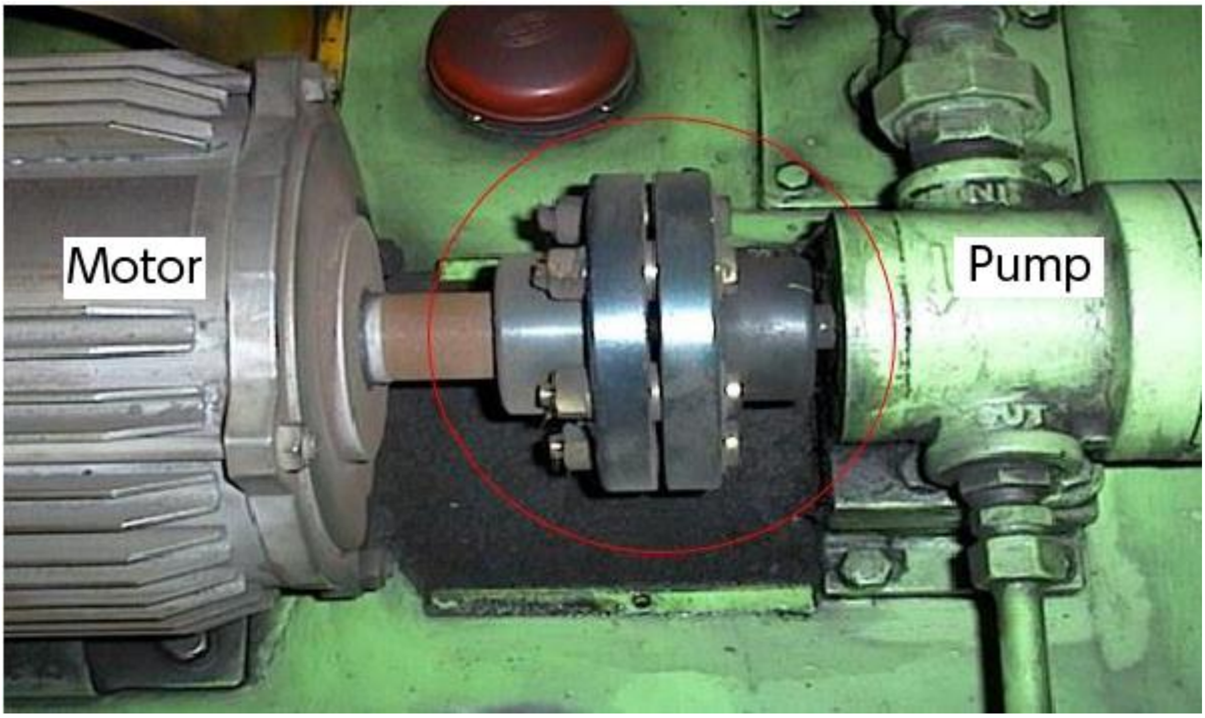
constant-volume heat rejection.

Brayton cycle:

The Brayton cycle, also known as the gas turbine cycle, is utilized in gas turbine engines. It involves four processes: isentropic compression, constant-pressure heat addition, isentropic expansion, and constant-pressure heat rejection. This cycle is commonly used in aircraft engines and power plants that employ gas turbines.

Assignment - 2

Coupling is a device or mechanism used to join two shafts for power transmission. It can be temporary or permanent. The primary purpose of a coupling is to allow smooth and efficient transfer of rotary motion, torque, or power between two rotating components, while also accommodating slight misalignments that may occur between them.



Types of coupling:

1. **Rigid coupling**

   These couplings are designed to provide a solid and rigid connection between the shafts, allowing precise alignment and efficient power transmission. However, they do not accommodate misalignments and may transmit more vibrations. There are further types of rigid coupling.

   - **Sleeve Coupling:** A sleeve coupling, also known as a muff coupling, is a simple type of rigid coupling. It consists of a solid cylinder (sleeve) with a bore on each end that fits tightly onto the shafts to be connected. The two shafts are aligned and joined together by fasteners, such as bolts or set screws, through the sleeve coupling.
   - **Clamp or Split Coupling:** This type of rigid coupling features a split design, allowing it to be installed and removed without disturbing the shafts' alignment. It consists of two semi-circular halves that fit around the shafts and are tightened together with bolts, creating a rigid connection.

- **Flanged Coupling:** Flanged couplings are composed of two flanges that are connected with bolts or studs. Each flange is attached to the end of a shaft, and when the two flanges are bolted together, they create a rigid connection.
- **Compression Coupling:** Compression couplings are used when the two shafts to be connected have axial movement relative to each other. The coupling has threaded holes at both ends, and each shaft is inserted into the coupling and secured by nuts, compressing the coupling onto the shaft ends.
- **Tapered Shaft Coupling:** Tapered shaft couplings are designed with a taper on the inside bore, and the shafts have matching tapers on their ends. When the shafts are pushed together, they create a tight and rigid connection.
- **Marine or Clamp-Type Coupling:** This type of rigid coupling is often used in marine applications. It consists of two halves with a keyway that fit around the shafts and are drawn together by bolts, providing a secure connection.

2. **Flexible coupling**

   Flexible coupling is used to connect two shafts that are not aligned with each other's. Flexible are good for when the shafts are a little bit off angular displacement between them.

   - **Oldham Coupling:** Oldham couplings use three interconnected disks - two outer disks with slots and a central disk with tabs. The slots of the outer disks engage with the tabs of the central disk, allowing angular misalignment between the shafts while transmitting torque.
   - **Gear Coupling:** Gear couplings use toothed gears on the mating hubs to transmit torque between the shafts. They offer high torque transmission capacity and can accommodate angular, axial, and parallel misalignments.
   - **Grid Coupling:** Grid couplings employ a flexible grid made of spring steel or other materials between two hubs. The grid allows for angular and axial misalignment, offering good shock absorption and vibration damping.

- **Diaphragm Coupling:** Diaphragm couplings consist of two hubs connected by a thin, flexible diaphragm made of metal or elastomeric material. The diaphragm allows for angular misalignment while maintaining torsional stiffness.
- **Disc Coupling:** Disc couplings use a series of thin, metallic or elastomeric discs stacked between two hubs. The discs allow for angular, axial, and parallel misalignments while providing good torsional stiffness.
- **Universal Joint:** A universal joint, also known as a Cardan joint, is used to transmit power between two shafts that are not in a straight line with each other. It consists of two yokes connected by a cross-shaped member, allowing for angular misalignment.

On The Basis of Lubrication

Lubricating and non-lubricating couplings are mechanical devices used to connect two shafts in order to transmit power and torque between them. They are essential components in various industrial applications and machinery where rotational motion needs to be transferred efficiently and smoothly. The main difference between these two types of couplings lies in whether they require a lubricating medium for their operation.

Lubricating Couplings

Lubricating couplings, as the name suggests, utilize a lubricant or a lubricating medium to reduce friction and wear between the connected shafts. The presence of lubrication helps in minimizing heat generation and ensures smoother and more efficient power transmission. There are several types of lubricating couplings, some of which include:

- **Gear Couplings**: Gear couplings consist of two interlocking gear teeth that mesh together. They are known for their ability to transmit high torque and accommodate misalignment between the shafts.

- **Fluid Couplings**: Fluid couplings use hydraulic fluid to transmit torque between the input and output shafts. They provide smooth power transmission and are often used in applications where shock and overload protection are required.
- **Disc Couplings**: Disc couplings use thin metal discs to transmit torque between shafts. They are flexible and can accommodate misalignment while maintaining high torsional stiffness.

Non-Lubricating Couplings

Non-lubricating couplings, on the other hand, do not require any lubricating medium for their operation. These couplings typically rely on mechanical connections without the need for fluid or lubricating films. They are often used in situations where the introduction of lubricants might be undesirable or impractical. Some examples of non-lubricating couplings include:

- **Clamp or Compression Couplings:** Clamp couplings use compression forces to hold two shafts together. They are simple and easy to install but may not be suitable for high-torque applications.
- **Chain Couplings:** Chain couplings use roller chains to connect two shafts. They are commonly used in applications where misalignment is minimal.
- **Universal Joints (Cardan Joints):** Universal joints connect two shafts at an angle and are often used in automotive applications to transmit power from the engine to the wheels. They can handle misalignment and are non-lubricated in many cases.

In summary, lubricating couplings rely on a lubricating medium to reduce friction and wear, while non-lubricating couplings do not require any lubrication for their operation. The choice between these types of couplings depends on the specific application, load requirements, misalignment considerations, and other factors. Each type has its advantages and limitations, and engineers must carefully select the appropriate coupling for given applicateon

Assignment - 3

Q. Why babbet is used in journal bearings?

A. Babbitt is used in journal bearings due to its favorable properties that make it an excellent material for supporting rotating shafts. Journal bearings are used to reduce friction between a rotating shaft and its stationary housing, ensuring smooth operation and preventing damage due to metal-to-metal contact. Babbitt, a soft and white metal alloy, is commonly used for this purpose for several reasons:

1. **Low Friction:** Babbitt has a low coefficient of friction, which means it allows the rotating shaft to move smoothly with minimal resistance against the stationary housing. This reduces wear and heat generation, increasing the efficiency and lifespan of the bearing.
2. **Load-Bearing Capacity:** Babbitt is capable of supporting heavy loads, making it suitable for various industrial applications where significant forces are involved.
3. **Embed ability:** Babbitt has a unique property known as "embed ability," which allows it to conform and mold to the surface of the rotating shaft. This creates a thin film of lubrication between the shaft and the bearing, further reducing friction and wear.
4. **Softness:** Babbitt is softer than the metal shaft it supports. This softness ensures that if there is a temporary interruption in lubrication or a misalignment of the shaft, the Babbitt material is sacrificial and will wear away instead of damaging the harder shaft, preventing catastrophic failure.
5. **Corrosion Resistance:** Babbitt has good corrosion resistance, which is important for maintaining the integrity and performance of the bearing over time.
6. **Compatibility:** Babbitt can be easily cast into various shapes, making it suitable for manufacturing custom bearings to fit specific applications.

Q. What is thumb rule for shaft and bearing clearance?

A. The thumb rule for shaft and clearance of a bearing is often referred to as the "Rule of Thumb" in engineering. It provides a general guideline for selecting the appropriate clearance between the shaft and the bearing, especially in applications where specific engineering calculations are not feasible or necessary. The Rule of Thumb for shaft and bearing clearance is as follows.

Radial Clearance: The radial clearance, also known as the bearing clearance, is the gap between the outer diameter of the shaft and the inner diameter of the bearing. It is typically expressed as a percentage of the bearing's bore diameter. The Rule of Thumb suggests a radial clearance of about 1% to 3% of the bearing bore diameter.

Diametric Clearance: The diametric clearance is twice the radial clearance and represents the total space between the shaft's diameter and the bearing's inner diameter. For journal bearings, the diametric clearance is typically in the range of 2% to 6% of the bearing bore diameter.