भारत हेवी इलेक्ट्रिकल्स लिमिटेड
BHARAT HEAVY ELECTRICALS LTD.
RC PURAM, HYDERABAD

ANALYSIS OF STEAM TURBINE MANUFACTURING AND ASSEMBLY PROCESSES WITH A BASIC OVERVIEW ON GAS TURBINE

AT

BHARAT HEAVY ELECTRICALS LIMITED,

HYDERABAD

TRAINING REPORT

Submitted in Partial Fulfilment of the Requirement for

Awarding the Degree

Of

BACHELOR OF TECHNOLOGY

In

AERONAUTICAL ENGINEERING

By

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Under the guidance of

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ACKNOWLEDGEMENT

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DECLARATION

We **Tirumala Sai Nithin, Rudraksha Bhavya Shree, Pranay Pyaga, Morisetty Lakshmi Prasanna** hereby declare that the Training Report entitled, **"ANALYSIS OF STEAM TURBINE MANUFACTURING AND ASSEMBLY PROCESSES WITH A BASIC OVERVIEW ON GAS TURBINE"**, submitted to **"Malla Reddy College of Engineering and Technology (MRCET)"** in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology is a record of original training undergone by us during the period of 15 days i.e from **"18-07-2023** to **01-08-2023"** under the supervision and guidance of **Mr. ANUP KUMAR MAITY, DY.MANAGER,** Technical Department, BHEL, and it has not formed the basis for the award of any Degree/Fellowship or other similar title to any candidate of any University.

Place:

Date:

[Signature and Name of the Students **]**

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<u>INTRODUCTION – BHEL HYDERABAD</u>

Bharat Heavy Electricals Limited (BHEL) Hyderabad is one of the major manufacturing units of BHEL, a prestigious and prominent engineering and manufacturing enterprise in India. BHEL Hyderabad is located in the city of Hyderabad, the capital of the state of Telangana.

Here is an introduction to BHEL Hyderabad:

1. Background: BHEL is a leading public sector company that was established in 1964. It is a Maharatna company under the Government of India and is involved in the design, engineering, manufacturing, construction, testing, and commissioning of a wide range of power generation, transmission, and transportation equipment and systems.

2. Location: BHEL Hyderabad is situated in the Ramachandrapuram area of Hyderabad, covering a vast area dedicated to various manufacturing and service facilities.

3. Products and Services: BHEL Hyderabad is primarily engaged in the manufacturing of heavy electrical equipment, including steam turbines, gas turbines, hydro turbines, generators, heat exchangers, and transformers. It caters to various sectors such as power generation, industry, transportation, oil and gas, and more.

4. Power Generation Equipment: The Hyderabad unit specializes in the manufacturing of turbines, generators, and associated equipment used in thermal power plants, hydroelectric power plants, and combined cycle power plants.

5. Industrial Equipment: BHEL Hyderabad also manufactures industrial equipment, including heat exchangers, pressure vessels, and industrial valves.

6. Service and After-Sales Support: In addition to manufacturing, BHEL Hyderabad provides maintenance, repair, and refurbishment services for its products throughout their lifecycle, ensuring the longevity and efficiency of the equipment.

7. Research and Development: BHEL Hyderabad focuses on continuous research and development to enhance product performance, efficiency, and environmental sustainability. It collaborates with various research institutions and academia to stay at the forefront of technological advancements.

8. Quality and Certifications: BHEL Hyderabad adheres to stringent quality standards and has obtained ISO 9001, ISO 14001, and OHSAS 18001 certifications for its commitment to quality, environmental protection, and occupational health and safety.

9. Contributions to Power Sector: BHEL Hyderabad's contributions have been instrumental in supporting India's power sector growth by providing reliable and technologically advanced equipment for various power projects across the country.

10. Global Presence: BHEL Hyderabad has also made its mark in the international market, exporting its products and services to several countries around the world.

BHEL Hyderabad's commitment to technological excellence, innovation, and sustainable development has made it a key player in the power and heavy engineering industry in India and beyond. The unit continues to contribute significantly to the country's energy infrastructure and economic growth.

Major products of BHEL Hyderabad includes the following:

1. Gas turbines

2. Steam turbines

3. Compressors

4. Turbogenerators

5. HeatExchangers

6. Pumps

7. Pulverizes

8. Switch Gears

9. Gear Boxes

AN OVERVIEW

Bharat Heavy Electricals Limited (BHEL) Hyderabad is a major manufacturing unit of BHEL, one of India's largest engineering and manufacturing companies. BHEL Hyderabad is located in the Ramachandrapuram area of Hyderabad, Telangana. As one of the premier manufacturing facilities of BHEL, it plays a vital role in the production of power generation equipment and industrial products. Here is an overview of BHEL Hyderabad:

1. Establishment: BHEL Hyderabad was established in 1965 as a state-of-the-art manufacturing facility to cater to the increasing demand for power generation equipment and industrial products in India.

2. Infrastructure: The unit covers a vast area and has modern manufacturing facilities equipped with advanced machinery and technologies. It has a dedicated workforce of skilled engineers, technicians, and support staff.

3. Product Range: BHEL Hyderabad specializes in the design, engineering, and manufacturing of a wide range of heavy electrical equipment and systems, including:

- Steam Turbines: BHEL Hyderabad produces steam turbines for thermal power plants, nuclear power plants, and other industrial applications.

- Gas Turbines: It manufactures gas turbines used in combined cycle power plants and other industrial installations.

- Hydro Turbines: BHEL Hyderabad is involved in the production of hydro turbines for hydroelectric power generation projects.

- Generators: The unit manufactures generators used in various power plants to convert mechanical energy into electrical energy.

- Heat Exchangers: BHEL Hyderabad produces heat exchangers for industrial applications, including oil refineries and chemical plants.

- Transformers: The facility manufactures power and distribution transformers for electrical power transmission and distribution networks.

4. Power Generation Projects: BHEL Hyderabad's equipment has been instrumental in the development of various power generation projects in India and abroad. It has contributed significantly to India's power capacity expansion, enabling the country to meet its increasing energy demands.

5. Research and Development: The unit has a dedicated research and development (R&D) center that focuses on technology innovation, product improvement, and developing new products that align with the latest industry standards and environmental regulations.

6. Quality and Certifications: BHEL Hyderabad maintains a strong emphasis on quality assurance and has received various certifications, including ISO 9001, ISO 14001, and OHSAS 18001, for its commitment to quality, environmental sustainability, and workplace safety.

7. Global Presence: BHEL Hyderabad has made significant strides in the international market and exports its products and services to several countries, contributing to India's presence in the global energy and engineering sector.

8. After-Sales Support: Apart from manufacturing, BHEL Hyderabad offers comprehensive after-sales services, including maintenance, repair, and refurbishment of its products, ensuring long-term operational efficiency and customer satisfaction.

BHEL Hyderabad continues to be a key player in India's power and heavy engineering industry. With its focus on innovation, research, and manufacturing excellence, the unit remains committed to supporting the country's energy infrastructure and contributing to India's economic growth and energy security.

FACTORIES OF BHEL AND THEIR PRODUCTS

1. **BHEL Trichy (Tiruchirappalli, Tamil Nadu):**
    - Steam Turbines
    - Boilers
    - Hydro Turbines
    - Heat Exchangers
2. **BHEL Haridwar (Haridwar, Uttarakhand):**
    - Power Transformers
    - Electrical Equipment
3. **BHEL Bhopal (Bhopal, Madhya Pradesh):**
    - Gas Turbines
    - Steam Generators
    - Electric Motors
4. **BHEL Hyderabad (Hyderabad, Telangana):**
    - Steam Turbines
    - Gas Turbines
    - Hydro Turbines
    - Generators
    - Heat Exchangers
    - Transformers
5. **BHEL Jhansi (Jhansi, Uttar Pradesh):**
    - Electrical Equipment.
6. **BHEL Ranipet (Ranipet, Tamil Nadu):**
    - Seamless Steel Tubes

<u>SHOP - PRODUCT/ PROCESS AREAS</u>:

01-Steam Turbines, Gas Turbines & Centrifugal Compressors

02- Turbo Generators and Exciters etc.

03-SwitchGears

04- Ferrous Foundry

05- Non – Ferrous Foundry

06- Heat Exchangers

07- Tool Room

08- Heat Treatment

09- Pattern Shop

10 Spares Manufacturing

11 Oil Field Equipment's (Oil Rigs)

51-CoalPulverizes

70-Centrifugal Pumps

<u>201 – Shop TURBINES</u>:-

Bay 1: Super Heavy Machine Shop

Bay-2: Heavy machine shop

Bay-3: Blade Shop

Bay-4: M&S/Rotor Shop

Bay-5: Welding/GT Wheel Shop

Bay-6: Medium Machine Shop

Bay-7: GT Machine shop

Fig. Classification of Steam Turbines

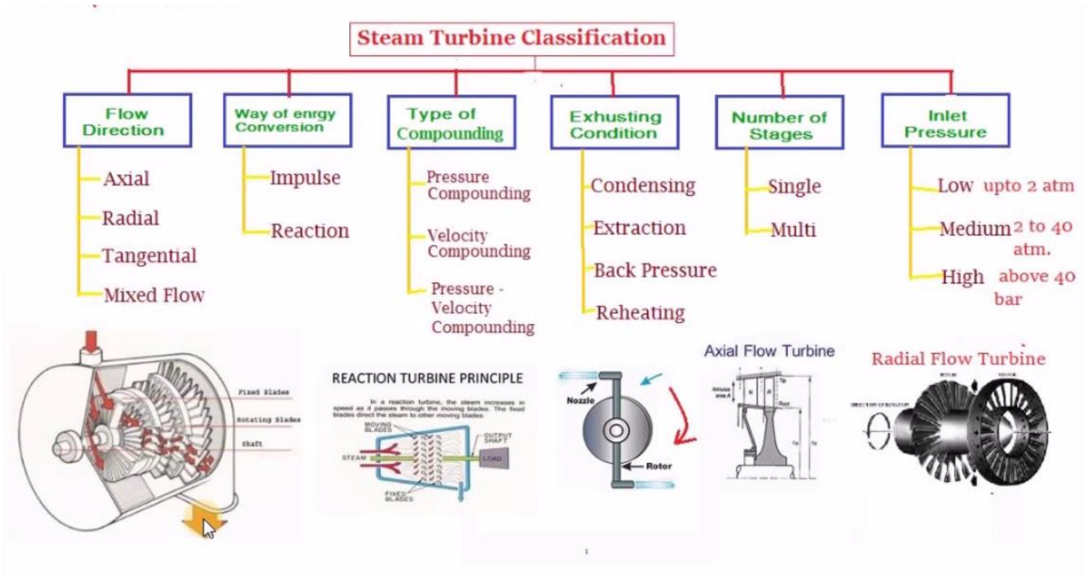
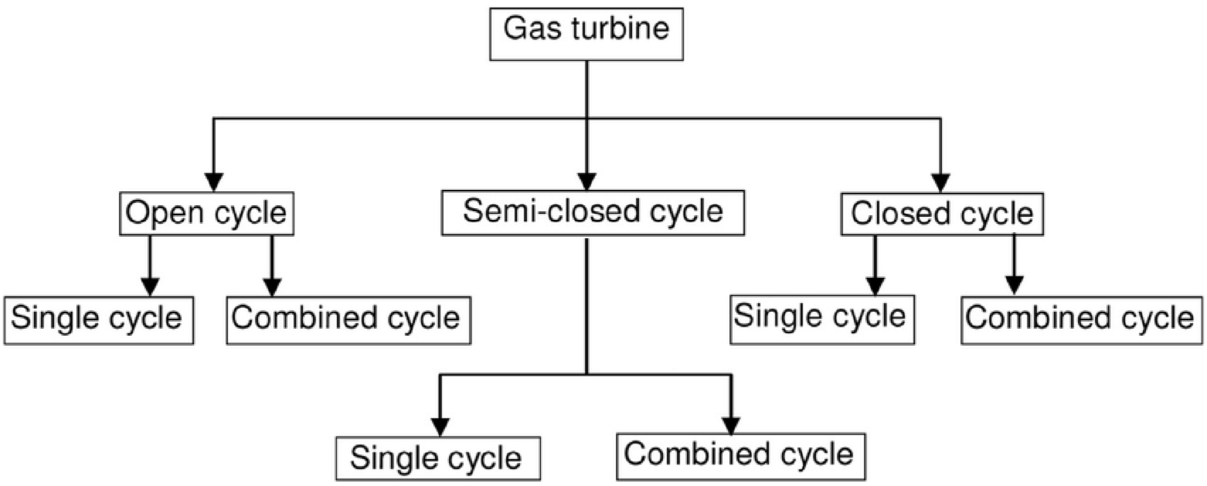


Fig. Classification of Gas Turbines



ACCORDING TO BHEL HYDERABAD:

They manufacture:

1. UTILITY TURBINES

2. INDUSTRIAL TURBINES

3. DRIVE TURBINES

- **In UTILITY TURBINES**, max. capacity is 150MW and is mainly for power generation.
- **In INDUSTRIAL TURBINES** capacity varies according to customer requirements i.e. from SMW to 70MW
- **In DRIVE TURBINES**, it doesn't generate power but only used for driving mechanical components like pumps, compressors etc.

THERMAL POWER PLANT SYSTEM

Definition:

A thermal power plant, also known as a coal-fired power plant or steam power plant, is a facility that generates electricity by converting heat energy into electrical energy through the combustion of fossil fuels, primarily coal. The process of electricity generation in a thermal power plant involves several stages and equipment, and it is one of the most common methods of electricity production worldwide.

Working principle:

The working principle of a thermal power plant involves the conversion of heat energy from the combustion of fossil fuels, primarily coal, into electrical energy. It is a cyclic process that goes through several stages to produce electricity efficiently.

Working Process:

The working principle of a thermal power plant involves the conversion of heat energy from the combustion of fossil fuels, primarily coal, into electrical energy. It is a cyclic process that goes through several stages to produce electricity efficiently. Here's a step-by-step explanation of the working principle of a thermal power plant:

1. Fuel Combustion: The primary fuel used in thermal power plants is coal. Other fossil fuels, such as oil or natural gas, may also be used. The fuel is burned in a combustion chamber or a furnace, generating high-temperature gases.

2. Boiler: The heat produced from fuel combustion is used to boil water and produce high-pressure steam in a boiler. The boiler is a large vessel where water is heated, and the resulting steam is at a very high temperature and pressure.

3. Steam Turbine: The high-pressure steam from the boiler is directed to a steam turbine. The steam's pressure and temperature cause the turbine blades to rotate, converting the thermal energy of the steam into mechanical energy.

4. Generator: The rotating turbine shaft is connected to a generator, which consists of coils of wire within a magnetic field. As the turbine spins the generator rotor, it induces an electric current in the coils, converting mechanical energy into electrical energy.

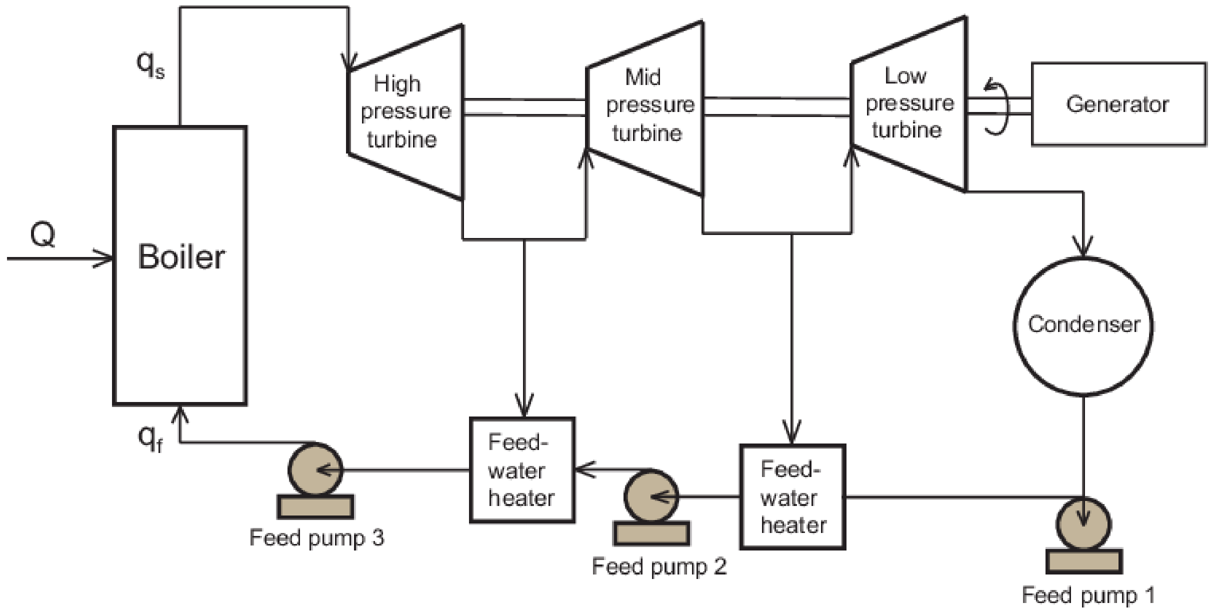
5. Condenser: After passing through the turbine, the low-pressure steam is condensed back into water using a condenser. This process reduces the pressure and temperature of the steam, enabling its reuse in the boiler.

6. Cooling System: The thermal power plant requires a cooling system to dissipate waste heat. Water from nearby sources, such as rivers or cooling towers, absorbs the excess heat from the condenser and returns to the plant for reuse.

7. Electrical Transmission: The electrical energy generated by the generator is then transformed into a higher voltage for efficient transmission over long distances through high-voltage transmission lines.

8. Distribution: Finally, the electricity is stepped down to lower voltages for distribution to homes, industries, and businesses through a network of power lines and substations.

The process described above is known as the Rankine cycle, and it is the fundamental principle behind the operation of most thermal power plants. The thermal power plant operates in a continuous loop, with the same water being used repeatedly in the boiler, turbine, and condenser, making it an efficient way to generate electricity. However, thermal power plants are known for their significant emissions of greenhouse gases and other pollutants, which has led to increased efforts to develop cleaner and more sustainable energy sources.



Boiler Section:

The boiler section of a thermal power plant is a critical component responsible for converting water into high-pressure steam. This high-pressure steam is then used to drive a steam turbine, which generates mechanical energy to drive a generator and produce electricity. Here's an overview of the boiler section:

1. Boiler Design and Construction: The boiler is a large, closed vessel designed to withstand high pressure and temperature. It is typically made of steel and consists of a thick-walled shell with various internal components.

2. Fuel Combustion and Heat Generation: The primary fuel used in the boiler is coal, but other fuels like oil, natural gas, or biomass may also be used. The fuel is burned in the boiler's combustion chamber, generating high-temperature gases and a significant amount of heat.

3. Water and Steam Circulation: The boiler is surrounded by a network of tubes that circulate water and steam. Water enters the boiler through the feedwater system and travels through the tubes, absorbing heat from the combustion gases.

4. Steam Generation and Separation: As water absorbs heat, it undergoes phase change, transforming into high-pressure steam. Steam is separated from the remaining water and directed to the steam turbine.

5. Superheating: In some advanced boilers, steam is further superheated to increase its temperature and energy content.

6. Boiler Auxiliaries: The boiler section is equipped with various auxiliary systems, such as fuel supply systems, combustion air fans, soot blowers, and ash handling systems, which support the efficient operation of the boiler.

7. Economizer and Air Preheater: Economizers recover waste heat from the flue gases to preheat the feedwater, while air preheaters preheat the combustion air before it enters the furnace.

8. Boiler Control and Safety: The boiler section is equipped with sophisticated control systems to regulate fuel and air supply, maintain proper water level and pressure, and ensure safe and stable operation.

9. Insulation and Refractories: The boiler's outer surface is insulated to minimize heat loss, while refractories are used inside the combustion chamber to withstand high temperatures and protect the boiler's steel structure.

Turbine Section:

The turbine section of a thermal power plant is a crucial component responsible for converting high-pressure steam energy into mechanical work, which, in turn, drives the generator to produce electricity. The turbine section plays a vital role in the overall efficiency and power generation process of the thermal power plant. Here's an overview of the turbine section:

1. Steam Inlet: High-pressure steam generated in the boiler section enters the turbine section through the steam inlet. The steam must be at a sufficiently high pressure and temperature to ensure efficient energy conversion.

2. Turbine Blades: The turbine section consists of a set of blades mounted on a rotor. These blades are designed to extract energy from the high-pressure steam as it flows through them. The turbine blades are shaped to efficiently convert the kinetic energy of the steam into mechanical rotation.

3. Steam Expansion and Energy Conversion: As the high-pressure steam flows through the turbine blades, it undergoes adiabatic expansion. This process results in a decrease in pressure and temperature but an increase in velocity.

The kinetic energy gained during expansion is converted into mechanical work, causing the turbine rotor to rotate.

4. Turbine Stages: In large thermal power plants, the turbine section is often divided into multiple stages. Each stage consists of a set of stationary blades called stator blades and a set of rotating blades (turbine rotor blades). The steam passes through each stage successively, and its energy is further converted into mechanical work.

5. Condensing and Non-Condensing Turbines: Some thermal power plants use condensing turbines, where the exhaust steam is condensed back into water and returned to the boiler. Others use non-condensing turbines, where the exhaust steam is released into the atmosphere.

6. Steam Exhaust: After passing through the turbine blades, the steam's energy has been largely extracted, and it exits the turbine section through the steam exhaust. In a condensing turbine, the exhaust steam is directed to a condenser to be condensed back into water. In a non-condensing turbine, the exhaust steam is released to the atmosphere.

7. Turbine Control: Sophisticated control systems are employed to regulate the turbine's speed and power output to match the electricity demand. The control systems ensure stable operation and prevent overspeed or under speed conditions.

8. Turbine Efficiency: The efficiency of the turbine section is crucial for maximizing the power plant's overall efficiency. Modern turbines are designed for high efficiency, with advanced materials and aerodynamic designs to minimize energy losses during steam expansion.

9. Maintenance and Monitoring: The turbine section requires regular maintenance and monitoring to ensure its proper functioning and longevity.

Condenser Section:

The condenser section of a thermal power plant is responsible for converting the exhaust steam from the turbine back into water. It achieves this by cooling the steam using a cooling medium, such as water, which causes the steam to condense and release its latent heat. The condensed water, known as condensate, is then recycled as feedwater for the boiler, improving overall efficiency and conserving water resources. The condenser operates under a vacuum to maximize the temperature difference between the cooling medium and the steam, enhancing the condensation process. Efficient condenser operation is crucial for optimal power plant performance and sustainability.

Efficiency of Thermal Power Plant:

The efficiency of a thermal power plant is a measure of how effectively it converts the energy contained in the fuel (e.g., coal) into electricity. It is expressed as a percentage and is an essential factor in determining the plant's performance and overall cost-effectiveness.

Efficiency = (Electrical Output / Heat Input) x 100

$$\text{Thernal Efficiency, } \eta_{thermal} = \frac{\text{Heat equivalent of mechanical energy transmitted to turbine shaft}}{\text{Heat of coal combustion}}$$

RANKINE CYCLE

The Rankine cycle is a thermodynamic cycle used in many steam power plants, including most thermal power plants that use coal, natural gas, or nuclear fuel. It serves as the theoretical basis for understanding the operation of steam power plants and helps optimize their efficiency. The Rankine cycle consists of four main processes:

1. Isentropic Compression: The cycle starts with the compression of water in the feed pump. The water is pressurized, increasing its temperature to prevent it from boiling at lower pressures.

2. Isobaric Heat Addition: The high-pressure water from the feed pump enters the boiler, where it is heated at constant pressure. The heat transfer causes the water to boil and convert into high-pressure steam.

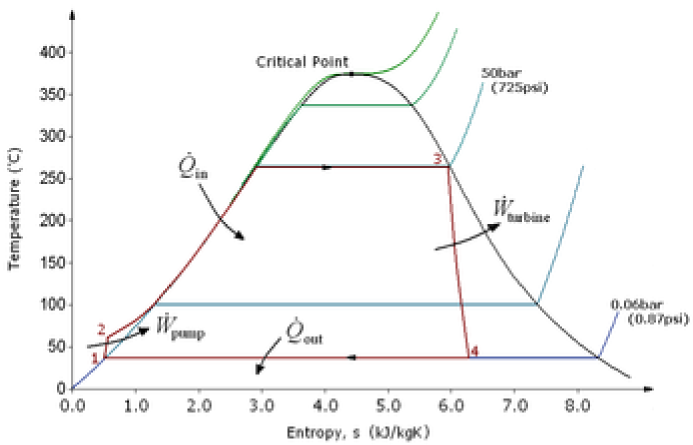
3. Isentropic Expansion: The high-pressure steam is then directed to the steam turbine, where it undergoes an isentropic (reversible adiabatic) expansion. As the steam expands, it loses pressure and temperature but gains velocity, which drives the turbine's rotating blades.

4. Isobaric Heat Rejection: After passing through the turbine, the low-pressure, low-temperature steam is directed to the condenser. In the condenser, the steam is condensed back into water at constant pressure, releasing latent heat. The condensation process reduces the volume of the steam significantly.

The Rankine cycle's four processes are represented on a pressure-enthalpy (P-H) diagram, illustrating the energy exchanges and state changes of the working fluid (water/steam) during the cycle. The cycle is a closed loop, meaning the working fluid is recycled and reused after each process.

While the Rankine cycle provides the theoretical framework for steam power plants, real-world power plants may include additional components like reheaters, superheaters, and feedwater heaters to improve efficiency and performance. The Rankine cycle is a fundamental concept in thermodynamics and serves as a basis for understanding the operation of various heat engine systems, including steam turbines used in power generation.

T-S Diagram of Rankine Cycle:



Parameters to increase the efficiency of Rankine Cycle:

To increase the efficiency of the Rankine cycle, which is the theoretical basis for many steam power plants, various parameters and strategies can be implemented. Improving the efficiency of the cycle leads to higher energy output for the same amount of fuel input, reducing operational costs and environmental impact. Here are some key parameters and strategies to increase the efficiency of the Rankine cycle:

1. Higher Boiler Pressure

2. Superheating

3. Reheating

4. Regeneration

5. Vacuum Improvement

6. Use of High-Temperature Materials

7. Minimizing Irreversibilities

8. Advanced Turbine Design

9. Optimized Cooling System

10. Use of Combined Cycles

By employing these parameters and strategies, thermal power plants can significantly increase the efficiency of the Rankine cycle and produce electricity in a more sustainable and cost-effective manner. However, it's essential to strike a balance between efficiency improvements and the practical constraints of the power plant's design, cost, and environmental considerations.

TYPES OF TURBINES

Turbines are devices that convert fluid (gas or liquid) energy into mechanical work, typically to generate electricity or perform other mechanical tasks. There are various types of turbines, each designed for specific applications and operating conditions. Some common types of turbines include:

1. Steam Turbine: Steam turbines are widely used in thermal power plants, where they use high-pressure steam to generate mechanical energy. They come in different configurations, such as impulse turbines and reaction turbines, and are used in both condensing and non-condensing setups.

2. Gas Turbine: Gas turbines, also known as combustion turbines, use compressed air mixed with fuel to produce high-velocity gases that drive the turbine blades. They are commonly used in gas-fired power plants, aviation engines, and industrial applications.

3. Hydro Turbine: Hydro turbines are used in hydroelectric power plants to convert the energy of falling or flowing water into mechanical work. Different types include Francis, Kaplan, and Pelton turbines, each suited for specific water flow conditions.

4. Wind Turbine: Wind turbines harness the kinetic energy of the wind to rotate blades, which then generate mechanical energy. This mechanical energy is converted into electrical energy using a generator, making wind turbines an essential component of wind power generation systems.

5. Gas Expander (Expansion Turbine): Gas expanders, or expansion turbines, are used in various industries, including oil and gas processing, where they expand pressurized gases to extract mechanical work and reduce the gas pressure.

6. Radial Turbine: Radial turbines are used in turbochargers, small gas turbines, and some industrial applications. They are known for their compact design and efficient operation at high rotational speeds.

7. Axial Turbine: Axial turbines are commonly used in aircraft engines, marine propulsion systems, and power generation applications. They provide a more streamlined flow of fluid along the turbine axis.

8. Mixed-Flow Turbine: Mixed-flow turbines combine characteristics of both axial and radial turbines. They are commonly used in automotive turbochargers and small power generation units.

9. Reaction Turbine: Reaction turbines convert pressure energy of the fluid into mechanical work by reacting with the moving blades. Examples include the Francis turbine used in hydroelectric power plants.

10. Impulse Turbine: Impulse turbines convert the kinetic energy of the fluid into mechanical work by impacting the moving blades. Examples include the Pelton turbine used in high-head hydroelectric power plants.

These are just a few examples of the many types of turbines used in various industries and applications. Each type of turbine has its advantages and limitations, making it suitable for specific conditions and requirements.

STEAM TURBINE

A steam turbine is a type of power turbine that harnesses the energy of high-pressure steam to generate mechanical work and subsequently convert it into electrical energy. It is widely used in thermal power plants, where steam is produced by heating water using a heat source such as a coal-fired boiler or a nuclear reactor.

The operation of a steam turbine can be divided into several key stages:

1. Steam Generation: Steam is generated by heating water in a boiler. The heat source can be generated by burning fossil fuels (coal, natural gas, or oil) or through a nuclear reaction. The high-pressure steam produced in the boiler is typically at temperatures and pressures well above the boiling point of water.

2. Steam Expansion: The high-pressure steam is directed into the steam turbine, where it expands and loses pressure. The steam flows through a series of stationary and rotating blades, known as stator and rotor blades, respectively. These blades are strategically designed to efficiently extract energy from the steam as it passes through.

3. Energy Conversion: As the high-pressure steam flows over the turbine blades, it imparts a force on them, causing the rotor to rotate. The rotor is connected to a shaft, and its rotational motion is transferred to a generator or alternator. The generator converts the mechanical energy of the rotating shaft into electrical energy.

4. Steam Exhaust: After passing through the turbine, the low-pressure and low-temperature steam is exhausted into a condenser, where it is condensed back into liquid water. The condenser typically uses cooling water to facilitate the condensation process. The condensed water is then pumped back into the boiler, and the cycle repeats.

Steam turbines can be classified based on their construction, steam flow path, and the number of stages. Some common types of steam turbines include:

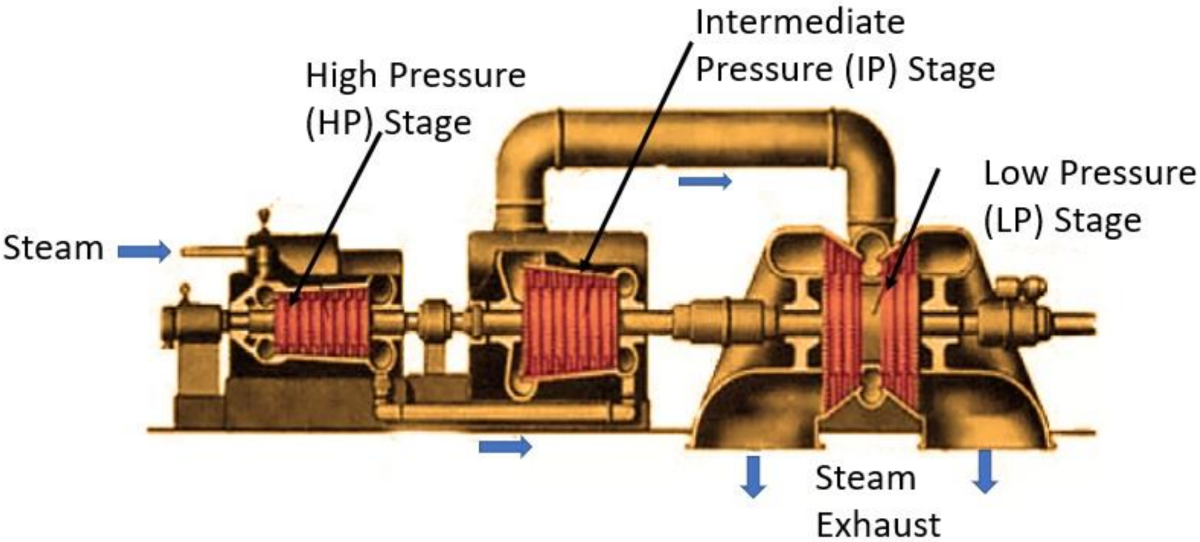
1. Impulse Turbines: In impulse turbines, the high-pressure steam expands through a series of nozzles, known as a nozzle diaphragm. The steam jets are directed onto a set of stationary blades, called buckets or nozzles, mounted on the rotor. The high-velocity steam jets cause the rotor to rotate.

2. Reaction Turbines: Reaction turbines have both fixed blades (stator) and moving blades (rotor). The high-pressure steam expands and passes through a series of moving and fixed blades, causing pressure drop and rotation of the rotor. The expansion of steam occurs both in the moving blades (where it exerts a force) and in the fixed blades (where it changes direction).

3. Combined-Cycle Turbines: These turbines are used in combined-cycle power plants, where the exhaust heat from a gas turbine is utilized to generate steam. The steam is then directed to a steam turbine for additional power generation. This combined-cycle configuration increases the overall efficiency of the power plant.

Steam turbines are known for their high efficiency and reliability. They are capable of producing large amounts of electrical power, ranging from a few megawatts to several hundred megawatts. The size and complexity of steam turbines can vary based on the power output requirements.

In summary, steam turbines play a crucial role in thermal power plants by converting the energy of high-pressure steam into mechanical work, which is further converted into electrical energy. They are essential components in the generation of electricity, providing a reliable and efficient means of power generation in various industrial applications.



<u>Parts of Steam Turbine</u>:

A steam turbine is a complex machine with several parts that work together to convert the energy of high-pressure steam into mechanical work. The main parts of a steam turbine include:

1. Rotor: The rotor is the central and rotating part of the steam turbine. It consists of a shaft with a series of blades attached to it. The high-pressure steam from the boiler enters the turbine and passes through these blades, causing the rotor to rotate.

2. Blades: Blades are attached to the rotor and come in various designs, such as impulse blades and reaction blades. Impulse blades change the direction of the steam flow and extract its kinetic energy, while reaction blades also react with the steam to extract energy.

3. Nozzles (Stator Blades): The nozzles are stationary blades located around the rotor. They direct the flow of steam onto the moving blades, converting its pressure energy into kinetic energy before it enters the rotor.

4. Casing: The casing surrounds the rotor and contains the steam flow. It is designed to be airtight to prevent steam leakage and direct the steam flow effectively towards the blades.

5. Diaphragms: Diaphragms are stationary partitions placed between the stages of the steam turbine. They serve to guide and control the steam flow as it moves from one set of rotating blades to the next.

6. Bearings: Bearings support the rotor and allow it to rotate smoothly. They reduce friction between the rotor and the casing, enabling efficient and reliable operation.

7. Lubrication System: Steam turbines require a lubrication system to reduce friction and wear on moving parts. Oil is supplied to the bearings and other critical parts to maintain proper functioning.

8. Governor: The governor is a control system that regulates the steam turbine's speed and output. It responds to changes in load demand and adjusts the steam flow accordingly to maintain the desired operating speed.

9. Extraction Ports: In some steam turbines, extraction ports are provided to tap steam at intermediate pressure levels for specific industrial processes or heating applications.

10. Condenser Connection: In steam power plants, a connection to the condenser is usually provided to receive the low-pressure exhaust steam for condensation and re-circulation to the boiler.

Blade and Stage Design:

Blade and stage design are critical aspects of steam turbine engineering, influencing the efficiency, performance, and reliability of the turbine. A steam turbine is typically composed of multiple stages, each consisting of rows of stationary nozzles (stator blades) and rows of rotating blades (rotor blades). The design of these blades and stages is tailored to extract the maximum energy from the steam and convert it into mechanical work. Here's an overview of blade and stage design in a steam turbine:

1. Blade Profiles:

- Impulse Blades: Impulse blades are designed to extract the kinetic energy of the steam. They have a symmetrical airfoil profile and change the direction of the steam flow. Impulse blades are commonly used in high-pressure stages of the turbine.

- Reaction Blades: Reaction blades, also known as moving blades or buckets, react with the steam as it passes through them. They have a more complex shape compared to impulse blades and convert both kinetic and pressure energy of the steam into mechanical work. Reaction blades are used in low-pressure stages of the turbine.

2. Stage Configuration:

- Impulse Stage: In an impulse stage, the steam is accelerated through nozzles, and all the pressure drop occurs in the stationary nozzles. The rotating blades do not contribute to pressure drop but only extract the kinetic energy of the steam. This type of stage is used in high-pressure sections of the turbine.

- Reaction Stage: In a reaction stage, the pressure drop occurs both in the stationary nozzles and the rotating blades. The steam pressure reduces progressively as it passes through both rows of blades. This design is commonly used in low-pressure sections of the turbine.

3. Blade Angle and Pitch:

- Blade Angle: The blade angle refers to the angle at which the steam flows relative to the blade. It is carefully designed to optimize the energy transfer between the steam and the blades, ensuring maximum efficiency.

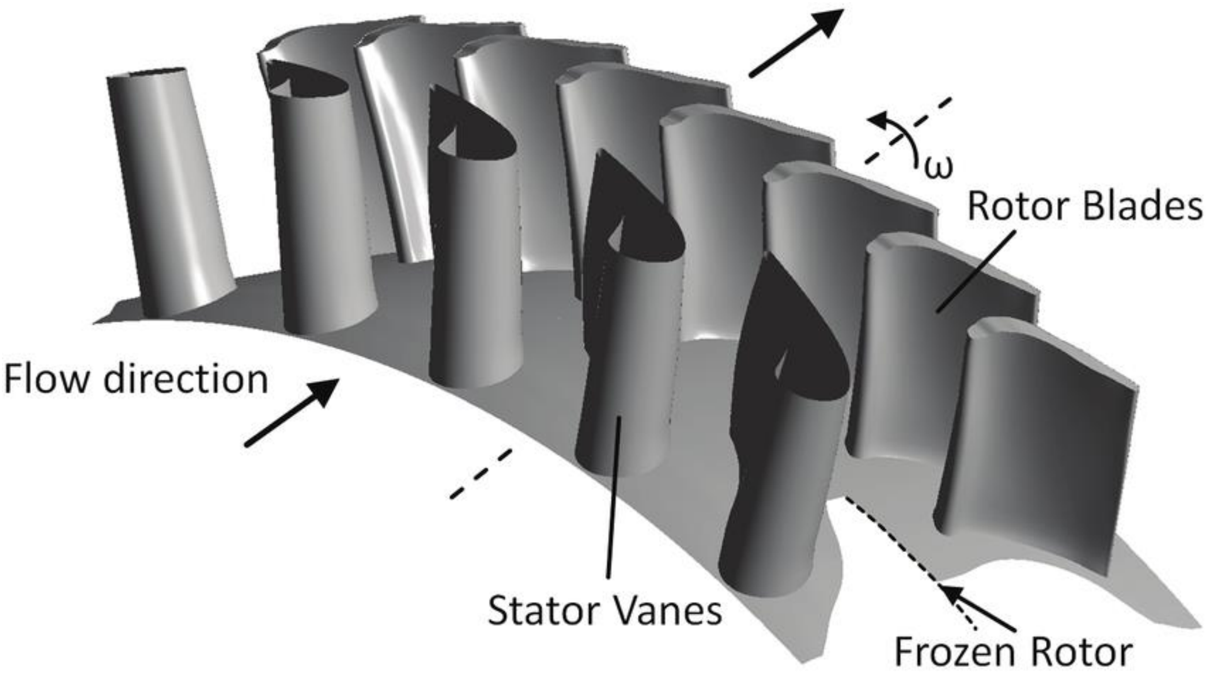
- Blade Pitch: The blade pitch is the distance between consecutive blades along the circumference of the rotor. It plays a crucial role in controlling the steam flow and ensuring uniform energy extraction across the blade row.

4. Camber: Camber refers to the curvature of the blade's airfoil profile. Proper camber design is essential for aerodynamic efficiency and reducing losses due to turbulence and separation of the steam flow.

5. Material and Cooling: The blades are typically made of high-strength materials capable of withstanding high temperatures and mechanical stresses. In high-temperature areas of the turbine, the blades may be air or steam-cooled to prevent thermal degradation.

6. Staging: The steam turbine is divided into multiple stages to optimize efficiency. Each stage extracts a portion of the steam's energy, leading to a more gradual pressure drop and improving overall turbine efficiency.

The blade and stage design in a steam turbine is a complex process involving aerodynamics, thermodynamics, material science, and structural engineering. Advancements in computational fluid dynamics (CFD) and finite element analysis (FEA) have enabled engineers to optimize blade and stage designs for improved turbine performance and efficiency.



Steam Supply and Exhaust Conditions:

In a steam turbine, the steam supply and exhaust conditions play a crucial role in determining the performance and efficiency of the turbine. The steam supply conditions refer to the state of the incoming high-pressure steam from the boiler, while the exhaust conditions pertain to the state of the low-pressure steam leaving the turbine and entering the condenser. Here are the key aspects of steam supply and exhaust conditions in a steam turbine:

1. Steam Supply Conditions:

- Pressure: The pressure of the steam at the turbine inlet is one of the essential parameters. Higher pressure steam contains more energy and allows for greater energy extraction in the turbine, resulting in higher efficiency.

- Temperature: The temperature of the steam is another critical factor. Higher temperature steam leads to higher thermal efficiency and allows for more work output in the turbine.

- Superheated Steam: Some steam turbines use superheated steam, which is steam at a temperature above its saturation point. Superheated steam ensures that the turbine operates without any moisture-related issues, enhancing turbine efficiency and prolonging blade life.

2. Steam Exhaust Conditions:

- Pressure: The pressure of the steam at the turbine exhaust is a crucial factor that determines the vacuum level in the condenser. Lower exhaust pressure leads to higher turbine efficiency by allowing more work extraction in the turbine.

- Temperature: The temperature of the steam at the turbine exhaust is an important consideration in condenser design and efficiency. Lower exhaust temperatures improve the condensation process and enhance overall turbine performance.

- Wetness Fraction: The wetness fraction of the exhaust steam refers to the amount of moisture present in the steam at the turbine outlet. Lower wetness fraction indicates more efficient steam expansion in the turbine.

Turbine Features:

The turbine feature of a steam turbine refers to the essential characteristics and design elements that make the steam turbine an efficient and effective device for converting high-pressure steam energy into mechanical work. Some of the key turbine features include:

1. Blade Design: The design of the turbine blades is crucial for efficient energy extraction from the steam. Impulse blades and reaction blades are carefully designed to optimize the conversion of kinetic and pressure energy of the steam into mechanical work.

2. Stage Configuration: Steam turbines are divided into multiple stages, each with rows of stationary nozzles (stator blades) and rotating blades (rotor blades). The combination of impulse and reaction stages allows for better energy extraction and increased turbine efficiency.

3. Casing and Casing Material: The casing surrounds the rotor and contains the steam flow. It is designed to be airtight and direct the steam flow effectively towards the blades. The casing material is chosen for its ability to withstand high pressures and temperatures.

4. Governor Control: Turbines are equipped with governor control systems that regulate the turbine speed and output based on the load demand. The governor ensures stable and efficient turbine operation under varying conditions.

5. Steam Path and Flow Control: The steam path within the turbine is carefully designed to minimize pressure losses and maximize energy extraction. The use of diaphragms and steam seals ensures proper flow control between stages.

6. Camber and Airfoil Design: The blade airfoil profile and camber are designed to optimize aerodynamic efficiency, reducing losses due to turbulence and separation of the steam flow.

7. Materials and Cooling: Turbine blades are typically made of high-strength materials capable of withstanding high temperatures and mechanical stresses. In high-temperature areas, the blades may be air or steam-cooled to prevent thermal degradation.

8. Extraction Ports: Some steam turbines are equipped with extraction ports to tap steam at intermediate pressure levels for specific industrial processes or heating applications.

9. Steam Inlet and Exhaust Arrangement: The steam inlet and exhaust arrangement are designed to ensure smooth flow and prevent steam losses during expansion and exhaust.

10. Rotor and Shaft Design: The rotor and shaft are designed to handle the mechanical stresses induced during turbine operation and maintain the desired rotational speed.

11. Condenser Connection: For steam power plants, a connection to the condenser is provided to receive the low-pressure exhaust steam for condensation and re-circulation to the boiler, increasing overall plant efficiency.

These turbine features are carefully engineered to optimize the performance, efficiency, and reliability of steam turbines, making them essential components in thermal power plants and various industrial applications where steam energy is converted into mechanical work.

Applications:

Steam turbines have a wide range of applications in various industries due to their efficiency, flexibility, and ability to convert thermal energy into mechanical work. Some of the primary areas of applications of steam turbines include:

1. Power Generation
2. Combined Heat and Power (CHP) Plants
3. Industrial Processes
4. Marine Propulsion
5. District Heating Systems
6. Geothermal Power Plants
7. Solar Thermal Power Plants
8. Desalination Plants
9. Waste-to-Energy Plants
10. Industrial Heat Recovery

<u>Product Range</u>:

1. Industrial Steam Turbines
2. Power Generation Steam Turbines
3. Cogeneration Steam Turbines
4. Geothermal Steam Turbines.
5. Solar Thermal Steam Turbines
6. Marine Steam Turbines
7. District Heating Steam Turbines
8. Steam Turbine-Generators
9. Industrial Steam Turbine-Compressor Sets
10. Steam Turbine Services and Aftermarket Solutions

<u>Parameter Range</u>:

The parameter range of a steam turbine can vary depending on the specific design, intended application, and technology used by different manufacturers. However, some common parameters that define the operating range of steam turbines include:

1. Steam Pressure
2. Steam Temperature
3. Steam Flow Rate
4. Exhaust Pressure
5. Turbine Speed
6. Power Output
7. Efficiency

8. Rotor Diameter

9. Steam Quality

10. Steam Turbine Type

GAS TURBINE

A gas turbine is a type of internal combustion engine that converts the chemical energy of a fuel (usually natural gas, diesel, or aviation fuel) into mechanical energy through the combustion process. It is widely used in various applications, including power generation, aviation, marine propulsion, and industrial processes. Gas turbines are known for their high power-to-weight ratio, efficiency, and reliability, making them a popular choice for a wide range of applications.

Here's a complete description of a gas turbine:

1. Components of a Gas Turbine:

- **Compressor:** The compressor is the first component in the gas turbine. It draws in and compresses atmospheric air to a higher pressure before entering the combustion chamber. Compression increases the air's temperature and energy content, preparing it for the combustion process.

- **Combustion Chamber:** The compressed air is mixed with fuel in the combustion chamber and ignited. The high-temperature combustion gases are produced, which expand rapidly, generating high-pressure and high-velocity exhaust gases.

- **Turbine:** The high-pressure and high-temperature exhaust gases flow through the turbine section, where they pass over rows of blades. The kinetic energy of the gases causes the turbine blades to rotate.

- **Shaft:** The turbine's rotating blades are connected to a shaft that extends from the turbine to the compressor. As the turbine rotates, it drives the compressor, completing the cycle.

- **Load:** In power generation applications, the mechanical energy from the gas turbine is used to drive an electrical generator to produce electricity. In aviation, the mechanical energy is used to propel the aircraft forward.

2. **Working Principle**:

The gas turbine operates on the Brayton cycle, which consists of four main stages: compression, combustion, expansion, and exhaust. The cycle begins with the compressor raising the air pressure, followed by the combustion process, where fuel is burned in the presence of compressed air to produce high-temperature exhaust gases. The expansion of these gases in the turbine section generates mechanical work. The exhaust gases are then expelled from the turbine to complete the cycle.

3. **Applications of Gas Turbines**:

- **Power Generation:** Gas turbines are widely used in electricity generation, either as standalone units or as part of combined cycle power plants. They are highly efficient and provide quick start-up times, making them suitable for meeting peak electricity demand.

- **Aviation:** Gas turbines, commonly known as jet engines, are the primary propulsion system for commercial and military aircraft. They offer high thrust-to-weight ratios and are capable of operating efficiently at high altitudes and speeds.

- **Marine Propulsion:** Gas turbines are used in marine vessels for propulsion due to their compact size, high power output, and rapid response capabilities.

- **Industrial Processes:** Gas turbines are utilized in various industrial applications, such as driving compressors, pumps, and generators.

- **Oil and Gas Industry:** Gas turbines are employed in the oil and gas sector for powering offshore platforms, LNG production, and pipeline compression.

4. **Advantages of Gas Turbines**:

- **High Power-to-Weight Ratio:** Gas turbines offer high power output relative to their weight, making them suitable for mobile applications like aviation and marine propulsion.

- **Quick Start-Up:** Gas turbines can achieve full power output relatively quickly compared to some other power generation technologies, enabling them to respond rapidly to changes in electricity demand.

- **Low Emissions:** Advanced gas turbines feature lower emissions of greenhouse gases and pollutants compared to older designs, making them more environmentally friendly.

- **Fuel Flexibility:** Gas turbines can run on various fuels, including natural gas, diesel, kerosene, and aviation fuel, providing fuel flexibility in different applications.

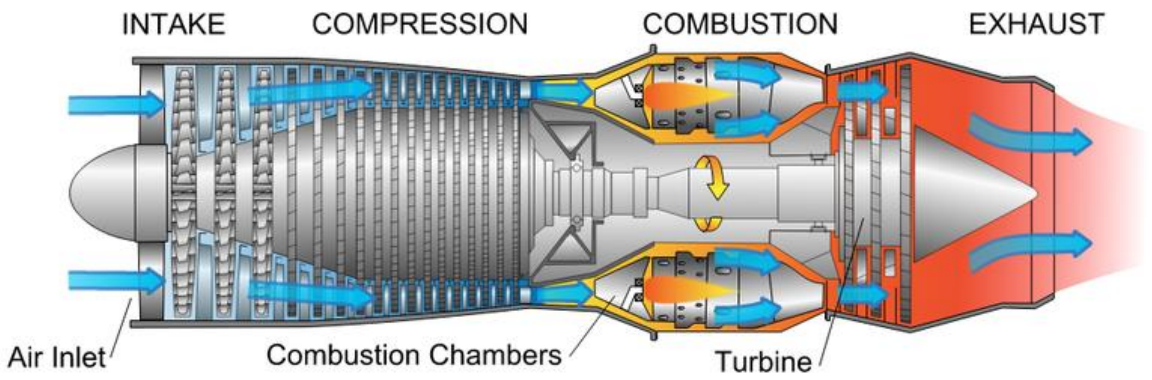
5. Limitations and Challenges:

- **Efficiency at Part Load:** Gas turbines may experience reduced efficiency at part load or low power demand conditions.

- **Maintenance:** Gas turbines require regular maintenance to ensure optimal performance and reliability.

- **High Capital Cost:** Gas turbines, especially those used in power generation, have relatively high capital costs.

Gas turbines continue to be an essential technology in various industries, with ongoing research and development efforts focused on improving efficiency, reducing emissions, and expanding their range of applications.



Turbine Features:

Gas turbines are complex and versatile machines with several key features that make them efficient, reliable, and well-suited for various applications. Some of the prominent gas turbine features include:

1. High Power-to-Weight Ratio: Gas turbines offer a high power output relative to their weight, making them ideal for applications where weight and space are critical factors, such as in aviation and marine propulsion.

2. Quick Start-Up and Rapid Response: Gas turbines can achieve full power output relatively quickly, enabling them to respond rapidly to changes in electricity demand or sudden acceleration requirements in aviation and marine applications.

3. Fuel Flexibility: Gas turbines can operate on a variety of fuels, including natural gas, diesel, kerosene, and aviation fuel, providing flexibility in fuel choices based on availability and cost.

4. High Efficiency: Modern gas turbines exhibit high thermal efficiency, which is the ratio of useful work output to the energy input in the form of fuel. Their efficiency can reach up to 60-65% in combined cycle power plants, contributing to reduced fuel consumption and lower emissions.

5. Low Emissions: Advanced gas turbines are designed to reduce emissions of greenhouse gases, nitrogen oxides (NOx), and other pollutants through technologies like dry low NOx (DLN) combustion systems and lean burn technologies.

6. Multiple Configurations: Gas turbines come in various configurations, including single-shaft and multi-shaft designs, open-cycle, and combined cycle arrangements, to cater to different applications and operational requirements.

7. High-Pressure Ratio Compressors: Gas turbine compressors are designed with high-pressure ratios to compress air efficiently before combustion, improving the overall cycle efficiency.

8. Advanced Materials and Cooling Systems: Gas turbine components are often made of advanced materials to withstand high temperatures and mechanical stresses. Cooling systems, such as film cooling and internal cooling, help maintain component integrity and prolong turbine life.

9. Combustion Systems: Gas turbines employ advanced combustion systems, like sequential combustion and annular combustors, to achieve stable combustion and improved fuel efficiency.

10. Aerodynamic Blade Designs: The turbine and compressor blades are carefully designed for optimal aerodynamics, reducing losses and improving energy extraction from the gas flow.

11. Advanced Control Systems: Gas turbines use sophisticated control systems and instrumentation to monitor and regulate various parameters, ensuring safe and efficient operation under different operating conditions.

12. Casing and Bearing Designs: The casing and bearing systems are designed to minimize air leakage and reduce friction, enhancing overall turbine efficiency.

13. Remote Monitoring and Diagnostics: Many modern gas turbines feature remote monitoring and diagnostics capabilities, allowing operators to detect potential issues and optimize performance through data analysis.

Gas turbines continue to evolve with ongoing research and development efforts aimed at improving efficiency, reducing emissions, enhancing operational flexibility, and expanding their range of applications in a rapidly changing energy landscape.

Product Range:

The product range of gas turbines typically includes:

1. Aero-Derivative Gas Turbines
2. Industrial Gas Turbines
3. Heavy-Duty Gas Turbines
4. Combined Cycle Gas Turbines
5. Open-Cycle Gas Turbines
6. Cogeneration Gas Turbines
7. Renewable Energy Gas Turbines
8. Offshore Gas Turbines
9. Mobile and Distributed Power Gas Turbines
10. Marine Gas Turbines

Parameter Range:

The parameter range of a gas turbine can vary depending on the specific design, intended application, and technology used by different manufacturers. However, some common parameters that define the operating range of gas turbines include:

1. Power Output
2. Efficiency

3. Compressor Pressure Ratio

4. Combustion Temperature

5. Inlet Air Temperature

6. Exhaust Gas Temperature

7. Turbine Inlet Temperature

8. Compressor and Turbine Speed

9. Fuel Flexibility

10. Startup Time

COMPARATIVE STUDY

STEAM TURBINE Vs GAS TURBINE

Steam turbines and gas turbines are both types of internal combustion engines used to convert energy into mechanical work. While they share some similarities, they also have distinct differences in their working principles, applications, and characteristics. Here's a comparison between steam turbines and gas turbines:

1. Working Principle:

- **Steam Turbine:** Steam turbines operate on the Rankine cycle, which involves the expansion of high-pressure and high-temperature steam. The steam enters the turbine and expands over stationary nozzles and rotating blades, causing the blades to rotate and generate mechanical work.

- **Gas Turbine:** Gas turbines operate on the Brayton cycle, which involves the compression of atmospheric air, combustion of fuel (natural gas, diesel, etc.) with the compressed air, and expansion of high-temperature exhaust gases through the turbine, generating mechanical work.

2. Energy Source:

- **Steam Turbine:** Steam turbines are typically driven by high-pressure steam produced in a boiler, which can be generated using various fuel sources, such as coal, natural gas, or nuclear energy.

- **Gas Turbine:** Gas turbines are driven by the combustion of gaseous or liquid fuels (natural gas, diesel, aviation fuel, etc.) mixed with compressed air.

3. Efficiency:

- **Steam Turbine:** Steam turbines can achieve high efficiencies, especially in combined cycle power plants, where waste heat from the gas turbine is used to produce steam for a steam turbine, increasing overall efficiency.

- **Gas Turbine:** Gas turbines also exhibit high efficiencies, particularly in combined cycle configurations. However, their efficiencies may reduce at part load conditions.

4. Application:

- Steam Turbine: Steam turbines are commonly used in thermal power plants for electricity generation, where they convert the thermal energy of steam into mechanical work to drive electrical generators. They are also used in industrial processes, district heating systems, and some marine applications.

- **Gas Turbine:** Gas turbines have a wide range of applications. They are extensively used in power generation, aviation (jet engines), marine propulsion, industrial processes, oil and gas, and other industries requiring mechanical drive applications.

5. Start-Up Time:

- **Steam Turbine:** Steam turbines typically require a longer start-up time as they need to heat the water to produce steam before operation.

- **Gas Turbine:** Gas turbines have a quicker start-up time since they do not require water heating. They can reach full power output relatively quickly.

6. Size and Weight:

- **Steam Turbine:** Steam turbines tend to be larger and heavier compared to gas turbines of similar power output.

- **Gas Turbine:** Gas turbines have a higher power-to-weight ratio and are more compact, making them suitable for mobile applications like aviation.

7. Environmental Impact:

- **Steam Turbine:** Steam turbines can be environmentally friendly when combined with modern emission control technologies, but they may produce more greenhouse gas emissions per unit of electricity generated compared to gas turbines.

- **Gas Turbine:** Gas turbines generally produce lower greenhouse gas emissions and have lower nitrogen oxide (NOx) emissions compared to steam turbines.

The choice between steam turbines and gas turbines depends on the specific application, power requirements, fuel availability, efficiency goals, and environmental considerations. Each type of turbine has its advantages and is well-suited for particular industries and operational conditions.

Aspect	Steam Turbine	Gas Turbine
Working Principle	Operates on Rankine cycle	Operates on Brayton cycle
Application	Thermal power plants, industrial processes	Power generation, aviation, marine, industry, oil & gas, etc.
Energy Source	High-pressure steam from a boiler	Gaseous or liquid fuels (natural gas, diesel, etc.) mixed with compressed air
Efficiency	High, especially in combined cycle plants	High, particularly in combined cycle configurations
Start-Up Time	Longer start-up time	Quicker start-up time
Size and Weight	Larger and heavier	Higher power-to-weight ratio, more compact
Environmental Impact	Can be environmentally friendly with emission controls	Generally lower greenhouse gas emissions and NOx emissions
Notable Features	Conversion of thermal energy into mechanical work	High power-to-weight ratio, suitable for mobile applications
Primary Application	Electricity generation and industrial processes	Power generation, aviation, marine propulsion, mechanical drive

<u>Advantages & Disadvantages of Steam Turbine</u>:

Advantages of Steam Turbine:

1. **Efficiency:** Steam turbines can achieve high thermodynamic efficiencies, especially in combined cycle power plants, where waste heat from the gas turbine is used to produce steam for the steam turbine. This makes them an efficient choice for electricity generation.

2. **Reliability:** Steam turbines are known for their reliability and robustness. They can operate continuously for extended periods with proper maintenance and are well-suited for continuous power generation applications.

3. **Fuel Flexibility:** Steam turbines can be fueled by various energy sources, such as coal, natural gas, nuclear energy, and biomass, providing fuel flexibility based on availability and cost.

4. **Long Operational Life:** With proper maintenance, steam turbines can have a long operational life, making them a durable and cost-effective choice for power generation.

5. **Versatility:** Steam turbines are used in a variety of applications, including electricity generation, industrial processes, district heating systems, and some marine propulsion.

6. **Environmental Control:** Modern steam power plants are equipped with emission control technologies that help reduce pollutants like sulfur dioxide (SO2), nitrogen oxides (NOx), and particulate matter, making them environmentally friendly.

****Disadvantages of Steam Turbine:****

1. **Slow Start-Up Time:** Steam turbines have a relatively slow start-up time compared to gas turbines. They require heating the water to produce steam before operation, which can take time.

2. **Large Size and Weight:** Steam turbines tend to be larger and heavier compared to gas turbines of similar power output. This makes them less suitable for mobile applications like aviation.

3. **Water Requirements:** Steam turbines require a constant supply of water for the production of steam, which may be a limiting factor in some regions with water scarcity.

4. **Thermal Cycling Issues:** Frequent startups and shutdowns can subject steam turbines to thermal cycling, which can cause thermal stresses and affect the turbine's longevity.

5. **Limited Efficiency at Part Load:** Steam turbines may experience reduced efficiency at part load or low power demand conditions, making them less suitable for fluctuating power demands.

6. **Capital Cost:** The initial capital cost of steam turbines can be relatively high, particularly for large-scale power plants, which may affect the overall project economics.

7. **Emissions During Start-Up:** During start-up, steam turbines may emit pollutants until the boiler and emission control systems reach their optimal operating conditions.

Overall, steam turbines are a proven and reliable technology for electricity generation and various industrial applications. While they have certain disadvantages, their advantages, especially in terms of efficiency and fuel flexibility, make them a vital component of the global energy landscape, particularly in power plants using different fuel sources.

Advantages & Disadvantages of Gas Turbine:

****Advantages of Gas Turbine:****

1. **High Efficiency:** Gas turbines offer high thermodynamic efficiencies, especially in combined cycle configurations. They can convert a significant portion of the fuel's energy into mechanical work.

2. **Quick Start-Up Time:** Gas turbines have a rapid start-up time, reaching full power output relatively quickly compared to steam turbines. This makes them suitable for applications requiring fast response to changing power demands.

3. **Fuel Flexibility:** Gas turbines can operate on various fuels, including natural gas, diesel, aviation fuel, and biofuels, providing flexibility based on fuel availability and cost.

4. **Compact Size and Weight:** Gas turbines have a higher power-to-weight ratio and are more compact compared to steam turbines of similar power output. This makes them well-suited for mobile applications, such as aviation and marine propulsion.

5. **Lower Emissions:** Gas turbines generally produce lower greenhouse gas emissions and have lower nitrogen oxide (NOx) emissions compared to steam turbines, particularly with the use of advanced emission control technologies.

6. **Low Water Consumption:** Unlike steam turbines, gas turbines do not require a continuous supply of water for steam generation, reducing water consumption and making them suitable for regions with water scarcity.

7. **Low Thermal Cycling Impact:** Gas turbines are less susceptible to thermal cycling issues compared to steam turbines, which enhances their durability and longevity.

8. **Adaptability:** Gas turbines can be used in a wide range of applications, including power generation, aviation, marine propulsion, industrial processes, and oil and gas industries.

Disadvantages of Gas Turbine:

1. **Lower Efficiency at Part Load:** Gas turbines may experience reduced efficiency at part load or low power demand conditions, making them less efficient in some operating regimes.

2. **Higher Capital Cost:** The initial capital cost of gas turbines can be relatively higher than steam turbines, especially for large-scale power generation applications.

3. **Less Suitable for Continuous Operation:** While gas turbines are reliable, they may not be as well-suited for continuous operation compared to steam turbines, which are known for their long operational life.

4. **Combustion Emissions:** Combustion in gas turbines produces carbon dioxide (CO2) and other emissions, contributing to environmental concerns, although advanced emission control technologies help reduce the impact.

5. **Fuel Price Volatility:** Gas turbine operations can be affected by fuel price fluctuations, especially if the chosen fuel is subject to significant price changes.

6. **Limited Start-Stop Frequency:** Frequent start-ups and shutdowns can impact the life of gas turbines, which is a consideration in applications with high start-stop frequency requirements.

Despite these disadvantages, gas turbines remain a widely used technology in various industries due to their high efficiency, rapid start-up, fuel flexibility, and relatively lower emissions compared to other combustion-based power generation methods. Advancements in technology and ongoing research continue to address some of the challenges associated with gas turbines, further improving their performance and environmental impact.

CONCLUSION

During the period of our internship, we were able to understand how a thermal power plant works and what are the parts of a thermal power plant. Amongst these parts a detailed knowledge on turbines and its manufacturing was given to us under the guidance of **Mr. ANUP KUMAR MAITY DY.MANAGER** sir. In the machining sector we were able to learn all the machining operations done to manufacture the parts of turbine such as rotor, blades etc. on machines like CNC lathe, vertical and horizontal lathe, vertical and horizontal milling machine, TIG welding etc. In the assembly and testing section we learnt how all the components are assembled and how the assembly is tested and inspected for misfunctions due to leakage, cracks or weld defects and machining error and after this the product is corrected and finally sent for the dispatch. We were able to gain knowledge from the other blocks of BHEL such as heat exchangers, pumps, foundry, heat treatment and electrical machines (Stator and generator) during our internship period.

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