# WINTER INTERNSHIP REPORT ON

# Thermal and Fluid Engineering in Refinery Operations: Insights from Guwahati Refinery

TRAINING PERIOD: 03.01.2025 - 30.01.2025


SUBMITTED BY:

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# PREFACE

Exposure to real-world industrial practices is integral to complement theoretical knowledge. Both workplace and in-plant training play crucial roles in the development of future engineers, serving as bridges between theoretical understanding and practical application. During our four weeks industrial training at Guwahati Refinery of Indian Oil Corporation, we gained invaluable insights into refining processes, maintenance work, and industrial accident mitigation. This experience emphasized the importance of putting theoretical concepts into action for success in the field of chemical engineering. Similarly, a 4-week internship with Indian Oil Corporation Limited in Guwahati provided us with a broader perspective on the engineering profession. Sponsored by the mechanical department at Guwahati Refinery, the internship allowed us to delve into the industrial application of mechanical engineering within refining processes. Both training experiences served as stepping stones, shaping us into proficient engineers and helping us carve out unique niches within the industry. The combination of theoretical knowledge and practical exposure is essential for the holistic development of engineering students.

# ACKNOWLEDGEMENT

The successful culmination of our project owes much to the invaluable guidance and unwavering support extended by numerous individuals. Throughout our entire internship, we were fortunate to receive assistance from various quarters, and it is with deep appreciation that we acknowledge the pivotal role played by these individuals in the completion of our project. Our heartfelt gratitude goes to Indian Oil Corporation Limited, specifically the Learning and Development Cell at Guwahati Refinery, for allowing us to partake in the Winter Internship program. Special thanks are extended to our mentor, Mr. Souvik Karmakar , Assistant Manager in Mechanical Planning (DCU) whose mentorship equipped us with essential information and imparted extensive knowledge in the realm of engineering applications.

# DECLARATION

I hereby declare that the Winter Industrial Training Report submitted by **Bishal Dutta**, a student of **Jorhat Engineering College**, in partial fulfillment of the requirements for the **B.Tech course**, is an authentic record of the work undertaken during the training.This report represents the candidate's original efforts under my supervision and has not been submitted elsewhere for any degree, certification, or other purposes prior to this submission.I extend my best wishes to the candidate for a successful career and a bright future.

Place- Noonmati, Guwahati
Date-30/01/ 2025

Mr. Souvik Karmakar
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(AMML)

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# ABSTRACT

This internship report, authored by **Bishal Dutta** during the period from **January 3, 2025, to January 30, 2025**, provides a detailed study of **thermal and fluid engineering applications in refinery operations**, with a focus on the Guwahati Refinery. The report highlights the critical role of thermal and fluid dynamics in the operation and efficiency of rotary equipment, such as pumps and compressors, and static equipment, including heat exchangers, furnaces, and boilers.

Through practical examples and case studies observed during the internship, the report delves into the principles of heat transfer, fluid flow, and energy optimization, offering real-world insights into their applications in refining processes. Additionally, it examines challenges like fouling, pressure drops, and thermal stresses, along with modern solutions and innovations, such as advanced materials and introduction of computational fluid dynamics (CFD) tools.

In conclusion, the report underscores the importance of understanding thermal and fluid systems for enhancing the efficiency, safety, and sustainability of refinery operations, making it a valuable resource for aspiring engineers and industry professionals alike.

# INTRODUCTION TO IOCL

Indian Oil Corporation Limited is an Indian multinational oil and gas company under the ownership of the Ministry of Petroleum and Natural Gas, Government of India. It is headquartered in New Delhi. It is a public sector undertaking whose operations are overseen by the Ministry of Petroleum and Natural Gas. Indian Oil is ranked 142nd on the Fortune Global 500 list of the world's biggest corporations as of 2022. It is the largest government- owned oil producer in the country both in terms of capacity and revenue. It has a consolidated refining capacity of 80.55MMTPA which it intends to increase to 107MMTPA by 2024-25.

India's highest-ranked Energy PSU in the Fortune-500 list of 2023 (Rank 94), IndianOil recorded Revenue from Operations of ₹9,34,953 Crores and a net profit of ₹8,242 Crores for the financial year 2022-23

The strength of Indian Oil springs from its experience of operating the largest number of refineries in India and adapting to a variety of refining processes along the way. The basket of technologies, that are in operation in Indian Oil refineries include Atmospheric/Vacuum Distillation; Distillate FCC/Residue FCC; Hydrocracking; Catalytic Reforming, Hydrogen Generation; Delayed Coking; Lube Processing Units; Visbreaking; Merox Treatment; Hydro desulphurisation of Kerosene Gasoil streams; Sulphur recovery; Dewaxing, Wax Hydro finishing; Coke Calcining, etc.

## INDIAN OIL REFINING - INSTALLED CAPACITY:

| REFINERIES | CAPACITY(MMTPA) |
|---|---|
| GUWAHATI | 1.2 |
| DIGBOI | .65 |
| BONGAIGAON | 2.70 |
| GUJRAT | 13.70 |
| PANIPAT | 15.00 |
| PRADIP | 15.00 |
| HALDIA | 8.00 |
| BARAUNI | 6.00 |
| MATHURA | 8.00 |
| TOTAL | 70.25 |
| CPCL, CHENNAI | 10.50 |
| GROUP TOTAL INCLUDING CPCL CHENNAI | 80.75 |


**Details of Group Refineries**

| REFINERY (LOCATION) | CAPACITY IN MMTPA (as on 31st March, 2021) |
|---|---|
| Digboi | 0.65 |
| Guwahati | 1.00 |
| Barauni | 6.00 |
| Gujarat (Koyali) | 13.70 |
| Haldia | 8.00 |
| Bongaigaon | 2.70* |
| Mathura | 8.00 |
| Panipat | 15.00 |
| Paradip | 15.00 |
| CPCL (Subsidiary) Refinery | |
| Manali, Chennai | 10.50 |
| Total | 80.55 |

*Capacity realisation after commissioning of OIL pipeline

**Details of Pipelines Network**

| S.NO. | PIPELINE | LENGTH (KM) | CAPACITY (MMTPA) |
|---|---|---|---|
| | Product Pipelines (as on March 31, 2021) | | |
| 1 | Koyali Ahmedabad Pipeline | 79 | 1.10 |
| 2 | Koyali Sanganer Pipeline with extension upto Panipat via JPNPL | 1644 | 5.00 |
| 3 | Koyali Dahej Pipeline | 197 | 2.60 |
| 4 | Koyali Ratlam Pipeline | 265 | 2.00 |
| 5 | Barauni Kanpur Pipeline and branch line to Motihari, Baitalpur and Amlekhgunj | 1227 | 3.50 |
| 6 | Haldia Mourigram Rajbandh Pipeline | 277 | 1.35 |
| 7 | Haldia Barauni Pipeline | 526 | 1.25 |
| 8 | Guwahati Siliguri Pipeline | 435 | 1.40 |
| 9 | Panipat Bhatinda Pipeline | 219 | 1.50 |
| 10 | Panipat Rewari Pipeline | 155 | 2.10 |
| 11 | Panipat Ambala Jalandhar Pipeline and branch line to Una | 495 | 3.50 |
| 12 | Panipat Delhi Pipeline | 189 | 3.00 |
| 13 | Panipat Bijwasan ATF line | 111 | |
| 14 | Mathura Delhi Pipeline | 147 | 3.70 |
| 15 | Mathura Tundla Pipeline | 56 | 1.20 |
| 16 | Mathura Bharatpur Pipeline | 21 | |
| 17 | Chennai Trichy Madurai Pipeline | 683 | 2.30 |
| 18 | Chennai Bengaluru Pipeline | 290 | 2.45 |
| 19 | Paradip Raipur Ranchi Pipeline | 1073 | 5.00 |
| 20 | Chennai Meenambakkam ATF Pipeline | 95 | 0.18 |
| 21 | Devangonthi Devanhalli Pipeline | 36 | 0.66 |
| 22 | Kolkata ATF Pipeline | 27 | 0.20 |
| Total (Product pipelines excluding LPG) | | 8247 | 43.99 |

**Details of Pipelines Network (Contd...)**

| S.NO. | PIPELINE | LENGTH (KM) | CAPACITY (MMTPA) |
|---|---|---|---|
| | LPG Pipelines | | |
| 1 | Panipat Jalandhar LPG Pipeline | 280 | 0.7 |
| 2 | Paradip Haldia Durgapur LPG Pipeline and extension to Banka | 873 | 1.27 |
| Total (LPG Pipelines) | | 1153 | 1.97 |
| | Crude Oil Pipelines | | |
| 1 | Salaya Mathura Pipeline | 2660 | 25 |
| 2 | Mundra Panipat Pipeline | 1194 | 8.4 |
| 3 | Paradip Haldia Barauni Pipelines | 1447 | 15.2 |
| Total (Crude Oil Pipelines) | | 5301 | 48.6 |
| Total Existing (Product + LPG + Crude Oil Pipelines) | | 14701 | 94.56 |
| | Gas Pipelines | | Capacity (MMSCMD) |
| 1 | Dadri Panipat Gas Pipeline | 141 | 9.5 |
| 2 | Ennore-Tuticorin-Bengaluru Gas Pipeline | 165 | 12.19 |
| Total Existing (Gas Pipelines) | | 306 | 21.69 |

Map not to scale

Fig: Refineries, Pipelines, R&D (as of march 31 2021)

# OVERVIEW OF GUWAHATI REFINERY

Nestled among the scenic landscapes near the Brahmaputra River in Guwahati, the Guwahati Refinery stands as India's inaugural Public Sector Refinery, integral to Indian Oil since its inception in 1962. Built with Rumanian technology available in the late 50s, the initial crude processing capacity of the Refinery was 0.75 Million Metric Tonnes Per Annum (MMTPA). The Refinery was designed to process a mix of OIL and ONGC crude in CDU, with secondary processing units being Delayed Coker Unit (DCU) of 0.33 MMTPA capacity and Kerosene Treating Unit (KTU) of 0.23 MMTPA capacity. Subsequently, capacity of the refinery was enhanced to 1.0 MMTPA in 1986. Noteworthy advancements include the commissioning of the INDMAX Unit in 2003, developed by IndianOil's R&D Centre to upgrade heavy ends to LPG, gasoline, and diesel. Adapting to evolving fuel specifications, Euro-III quality units such as the MS Isomerisation Unit, Naphtha Hydrotreater Unit, Naphtha Splitter Unit, and IndMax Gasoline Unit were added in 2010. Further innovations include the 2017 introduction of the INDAdept-G Unit for Heavy Gasoline treatment, complying with BS-IV MS norms. In 2024, the refinery's capacity expanded to 1.2 MMTPA, marking a significant stride in its commitment to delivering high-quality fuels while staying technologically relevant.


Fig: Guwahati refinery

## PRODUCTS OF GUWAHATI REFINERY:

1. Liquefied petroleum gas (LPG)
2. Motor Spirit (Petrol)
3. Ethanol Blended Motor Spirit (EBMS)
4. Aviation Turbine Fuel (ATF)
5. High-Speed Diesel (HSD)
6. Light Diesel Oil (LDO)
7. Superior Kerosene Oil (SKO)
8. Naphtha
9. Calcined / Green needle coke.

(It is the only refinery in India to produce green needle coke)

**Mode of Product Dispatch:**

1) Pipeline: GSPL for MS, SKO and HSD.

2) Tanker trucks for LPG, Naphtha, EBMS, and ATF.

## VARIOUS UNITS AND FUNCTIONS:

1. Delayed Coker Unit (DCU)
2. Crude Distillation Unit (CDU)
3. INDMax
4. INDAdept-G Unit
5. Hydrogen Generation Unit (HGU)
6. Sulphur Recovery Unit (SRU)
7. Effluent Treatment Plant (ETP)
8. Nitrogen Unit
9. Hydrotreater Unit (HDT)
10. Motor Spirit Quality unit (MSQ)
11. TPS(Thermal Power Station)
12. DEF Plant

# DELAYED COKER UNIT

The Delayed Coker Unit (DCU) is a critical component in petroleum refining, designed to process the heaviest fractions of crude oil through a thermal cracking process known as coking. This unit plays a crucial role in upgrading heavy feedstock into more valuable products, such as gasoline and diesel.

Delayed Cokers can convert even the heaviest residues to lighter distillates provides much needed flexibility to the refiners to process a wide variety of crude oil and therefore, is the most widely used process all over the world.

IndianOil and Engineers India Ltd. (EIL) is jointly licensing the Delayed Coker technology by synergizing individual technological strengths. IndianOil R&D has developed the capability to predict product yields, process conditions and product properties for Delayed Coking process based on a state-of-the-art pilot plant and in-house developed process simulator/calculations. EIL has experience in process design and engineering for both open art and licensed units. EIL has already licensed five grass roots Delayed Coker units and carried out one revamp. All the units have been operating successfully in line with the design.

**The main parts of DCU:**

**FURNACE:**

The furnace is a crucial component in the DCU responsible for preheating the heavy feedstock. It provides the high temperatures necessary to initiate the thermal cracking reactions within the coking drums. The preheating process in the furnace ensures that the feedstock reaches the optimal temperature for efficient cracking.

**FRACTIONATOR:**

The fractionator, also known as the distillation column, is a key part of the DCU that separates the cracked products into different fractions based on their boiling points. This separation is essential for recovering valuable liquid products such as gas oil from the cracked mixture. The fractionator plays a pivotal role in maximizing the yield of desirable products from the coking process.

**COKE DRUM:**

Coke drums are large vertical vessels where the actual thermal cracking or coking reactions take place. These drums receive the preheated feedstock and subject it to high temperatures and pressures, causing the heavy hydrocarbons to break down into lighter fractions. After the coking cycle, the drums contain a mixture of solid coke and cracked products, which is subsequently processed for further separation and handling.

**The process involves several steps, and here is an overview of the processes in a typical Delayed Coking Unit:**

The Delayed Coking Unit (DCU) in an oil refinery initiates with the preheating of heavy feedstock in a furnace, preparing it for the thermal cracking process. Subsequently, the feedstock is introduced into coking drums, where high temperatures facilitate the thermal cracking, breaking down heavy hydrocarbons into lighter fractions. The cracked products, a mixture of vapours and solid coke, undergo rapid quenching to halt further cracking reactions. A fractionation system then separates liquid products like gas oil from solid coke. The coke, once mechanically cut from the coking drums, is either stored or sold as a byproduct. Off-gases produced during coking are processed, and the unit may require decoking to maintain efficiency. Utilities such as steam and cooling water support operations, while a central control room monitors and manages the entire process. The DCU's role in converting heavy feedstock into valuable products like gasoline and diesel underscores its significance in the oil refining process.

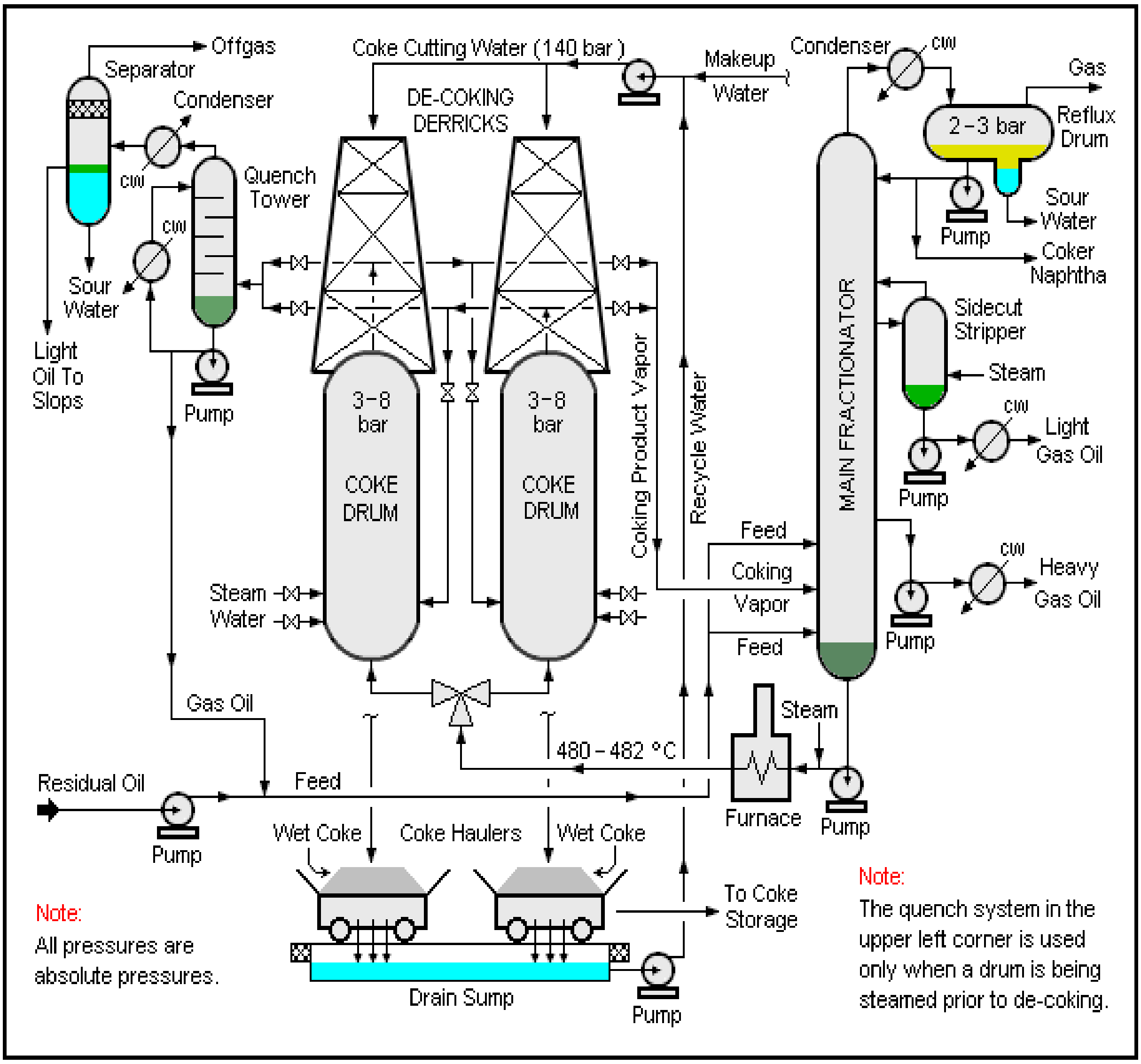



Fig: DCU Process Flow Diagram

**Products of Delayed Coking:**

- Delayed coker produces desirable liquid products (naphtha and gas oil) and byproducts coker gas and solid coke.

- Coker off-gas goes to the gas plant where C3 and C4 is recovered as LPG and the lighter end can be used as fuel gas in the refinery.

- Naphtha ex coker unit contains high olefin content and this stream is usually sent to hydrotreater for stabilisation.

- Light Coker Gas Oil (LCGO) is sent to diesel hydrotreater for production of diesel. Typical end point of this stream is around 370 °C.

- Heavy Coker Gas Oil (HCGO) is sent to FCC/ RFCC for production of valuable distillate products. Typical end point of this stream is around 538 °C.

Coke formed in Delayed Coker Unit can be classified into three different types-

- Sponge Coke
- Needle Coke
- Shot Coke

In conclusion, the Delayed Coker Unit is an integral part of modern refineries, playing a vital role in the conversion of heavy feedstock into valuable products. Understanding the operation and significance of the Delayed Coker Unit is essential for individuals involved in the petroleum refining industry, contributing to the overall knowledge and expertise in refinery operations.

# CRUDE DISTILLATION UNIT (CDU)

The Crude Distillation Unit (CDU) is a fundamental component in the oil refining process, designed to separate crude oil into various fractions based on their boiling points. As the initial step in refining, the CDU operates by heating the crude oil and then fractionating it into distinct products such as naphtha, kerosene, diesel, and heavy gas oil. This separation is achieved through a series of distillation columns, each catering to specific temperature ranges. The CDU plays a critical role in producing feedstocks for downstream refining processes, making it a key unit for obtaining valuable products from crude oil. It is the first processing unit in virtually all petroleum refineries. It separates the crude oil into different fractions based on their boiling points and chemical properties. These fractions are then further processed in other refining units to produce various petroleum products, such as gasoline, kerosene, diesel, and fuel oils. The CDU consists of two main stages: atmospheric distillation and vacuum distillation. In atmospheric distillation, the crude oil is heated and fed into a distillation column, where the lighter fractions rise to the top and the heavier fractions sink to the bottom. The fractions are collected at different levels of the column and sent to different units for further processing. The heaviest fraction, called the atmospheric residue, is then transferred to the vacuum distillation unit. In vacuum distillation, the atmospheric residue is heated and fed into another distillation column, where it is subjected to a lower pressure than the atmospheric pressure. This allows the separation of the heavier fractions that have high boiling points, such as lubricating oils, waxes, and asphalt. The fractions are collected at different levels of the column and sent to different units for further processing. The heaviest fraction, called the vacuum residue, is usually the final product of the CDU. The CDU is a critical unit in the petroleum refining process, as it determines the quality and quantity of the products that can be obtained from the crude oil. The CDU also affects the energy efficiency and environmental performance of the refinery, as it consumes a large amount of heat and produces many emissions. Therefore, the CDU is constantly optimized and improved to meet the changing market demands and environmental regulations.

The CDU produces several fractions of different boiling ranges and properties, such as:

(a) Light gases: methane, ethane, propane, and butane. These are used as fuel gas or feedstock for petrochemicals.

(b) Naphtha: a mixture of hydrocarbons with 5 to 12 carbon atoms. This is used as feedstock for gasoline production or petrochemicals.

(c) Kerosene: a mixture of hydrocarbons with 10 to 16 carbon atoms. This is used as jet fuel, heating oil, or feedstock for diesel production.

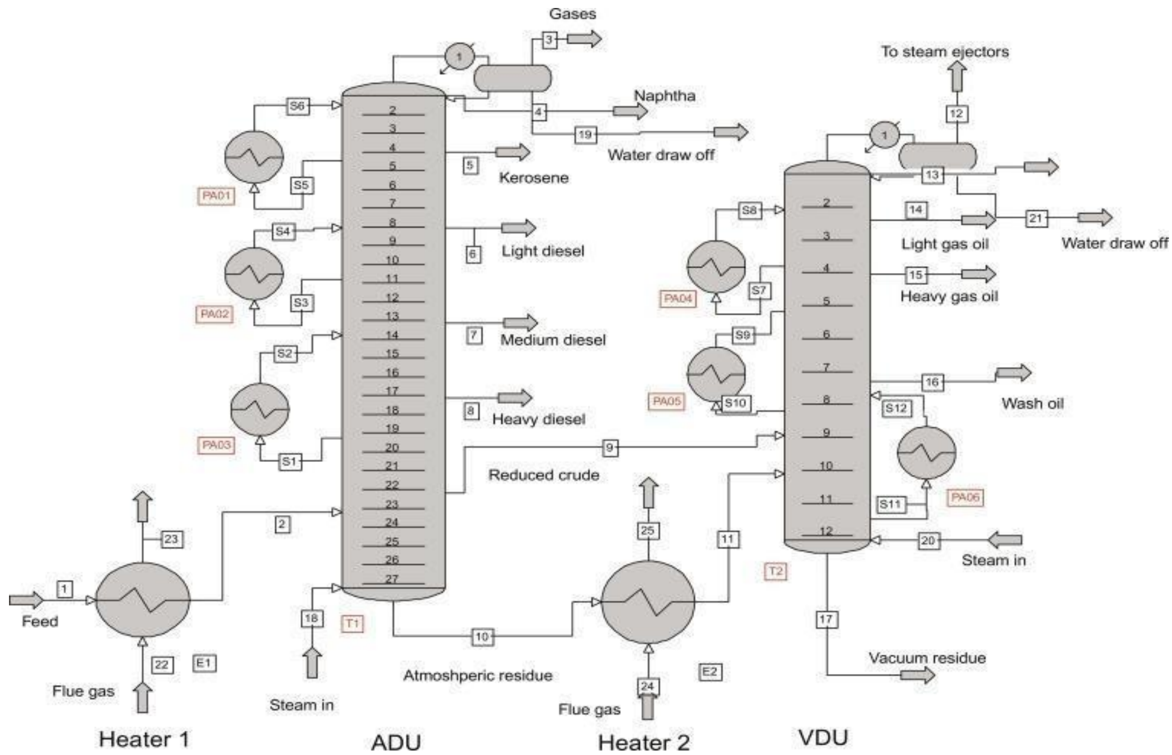
(d) Diesel: a mixture of hydrocarbons with 12 to 20 carbon atoms. This is used as fuel for diesel engines, heating oil, or feedstock for lubricating oils.

(e) Atmospheric gas oil: a mixture of hydrocarbons with 20 to 40 carbon atoms. This is used as feedstock for vacuum distillation, catalytic cracking, or hydrocracking.

(f) Vacuum gas oil: a mixture of hydrocarbons with 40 to 55 carbon atoms. This is used as feedstock for catalytic cracking, hydrocracking, or lubricating oils.

(g) Lubricating oil: a mixture of hydrocarbons with 55 to 90 carbon atoms. This is used as base oil for lubricants, waxes, or greases.

(h) Asphalt: a mixture of hydrocarbons with more than 90 carbon atoms. This is used as paving material, roofing material, or waterproofing agent.



# INDMAX GASOLINE UNIT

An INDMAX gasoline unit is a process unit that converts the heavy gasoline stream from the INDMAX fluid catalytic cracking (FCC) unit into high-octane gasoline that meets the BS-VI/Euro-VI quality standards. The INDMAX gasoline unit uses a proprietary technology developed by Indian Oil Corporation Ltd (IOCL) R&D Centre, called indeSelectG, which is based on adsorption. The indeSelectG technology selectively removes sulfur and olefins from the heavy gasoline stream by using a solid adsorbent material. The adsorbent material can be regenerated and reused, making the process more economical and environmentally friendly. The INDMAX gasoline unit also reduces the benzene and aromatics content of the gasoline, improving its performance and emissions.

The INDMAX gasoline unit typically consists of the following equipment:

A. A feed preheater that heats up the incoming heavy gasoline stream using hot streams from the unit or other sources.

B. An adsorption reactor that contacts the heavy gasoline stream with the adsorbent material in a fixed-bed configuration. The adsorption reactor removes sulfur and olefins from the heavy gasoline stream and produces a treated gasoline stream with high octane value. The adsorbent material is periodically regenerated by purging it with hydrogen or nitrogen.


**Fig: INDMAX unit**

C. A product cooler that cools down the treated gasoline stream by exchanging heat with a cooling medium, such as water or air. The product cooler reduces the temperature and pressure of the treated gasoline stream and sends it to the downstream units or storage tanks.

D. A regeneration system that provides the necessary heat and gas for regenerating the adsorbent material. The regeneration system consists of a heater, a blower, and a vent gas recovery unit. The heater provides the heat for desorbing the sulfur and olefins from the adsorbent material. The blower provides gas for purging the adsorbent material. The vent gas recovery unit recovers the valuable hydrocarbons from the vent gas and recycles them to the unit or other units.

An INDMAX gasoline unit is important for meeting the quality and performance standards of gasoline and other petroleum products, especially for low-sulfur and high-octane specifications. An INDMAX gasoline unit is usually designed and operated based on the feedstock characteristics, product specifications, and process economic

# HYDROGEN GENERATION UNIT

The hydrogen generation unit in a refinery is a bustling hub, transforming raw materials into the lifeblood of various processes. The chosen hydrocarbon, prepped and partnered with hydrogen, enters a high-pressure reactor where a catalyst facilitates a dance of transformation. Sulfur, nitrogen, and other impurities tango with hydrogen, forming removable byproducts. In the separator, the purified product emerges, while the hydrogen gas, a true recycling champion, rejoins the starting line for another round. This intricate process, tailored for specific needs, ensures not only cleaner fuels but also smoother refinery operations and a more sustainable future.

Hydrogen production has become a priority in current refinery operations and when planning to prepare low sulphur gasoline and diesel. It also supplies Hydrogen to Hydro treating Unit (to meet out the cetane specific in diesel fuels) and MSQU Unit (to meet the octane and aromatic specification of gasoline fuels).

The unit was licensed by Technip, Benelux and has a capacity of 10000 TPA. It uses the technology Steam Reforming and PSA (Pressure Swing Adsorption). It was commissioned on 6 October 2002.

## PROCESS FEATURES

- Feed preparations: Removal of Sulphur and Chlorides and saturation of olefins. Absorption of HCl and H2S by Na-Aluminate and ZnO bed.
- Pre-reforming section: Conversion of Naphtha to CO, CO2, H2, and CH4.
- Reforming section: Conversion of CH4 to CO, CO2 and H2.
- HT and LT Shift conversion section: Conversion of CO and H2O to CO2 and H2.
- PSA units: Purification of H2 from CO, CO2, CH4 in exiting reformer HT-LT downstream gases.

BASIC DESCRIPTION OF THE PROCESS

MAIN SECTION OF HGU:

- Feed treatment section
- Pre-reformer
- Reformer
- Shift reaction
- Pressure Swing Adsorption (PSA) operation

# SULPHUR RECOVERY UNIT

Sulphur is a by-product produced in various refineries processing high Sulphur crude crude. Sulphur is produced from the Sulphur rich fuel gas to reduce the emission level of Sulphur in the atmosphere along with flue gases from the furnaces.

H2S removed in the HDT, DCU and INDMAX [process is sent to the sulphur recovery unit (SRU) as acid gas. SRU recovers H2S as elemental sulphur through the Claus reaction**.**

Reactions occur in the two stages: Thermal stage (MCC) and 3 catalytic reaction stage. The former consists of a high-performance burner, mixing chamber and heat removing boiler, while the latter has two to three reactor stages. The sulphur recovery rate of the Claus process is about 95 to 97%.

The tail gas that contains unrecovered sulphur is feed to the tail gas treating unit (TGT). The recovered sulphur is stored in the sulphur pit and shipped as a product after undergoing a degassing process to remove H2S.The Claus process is an equilibrium process, and a modified version of it with direct oxidation catalysts stored in the final stage is called SUPERCLAUS
.Since this improved process does not depend on Claus equilibrium, it can attain a 99% recovery ratio without TGT.

## SRU COMPONENTS:

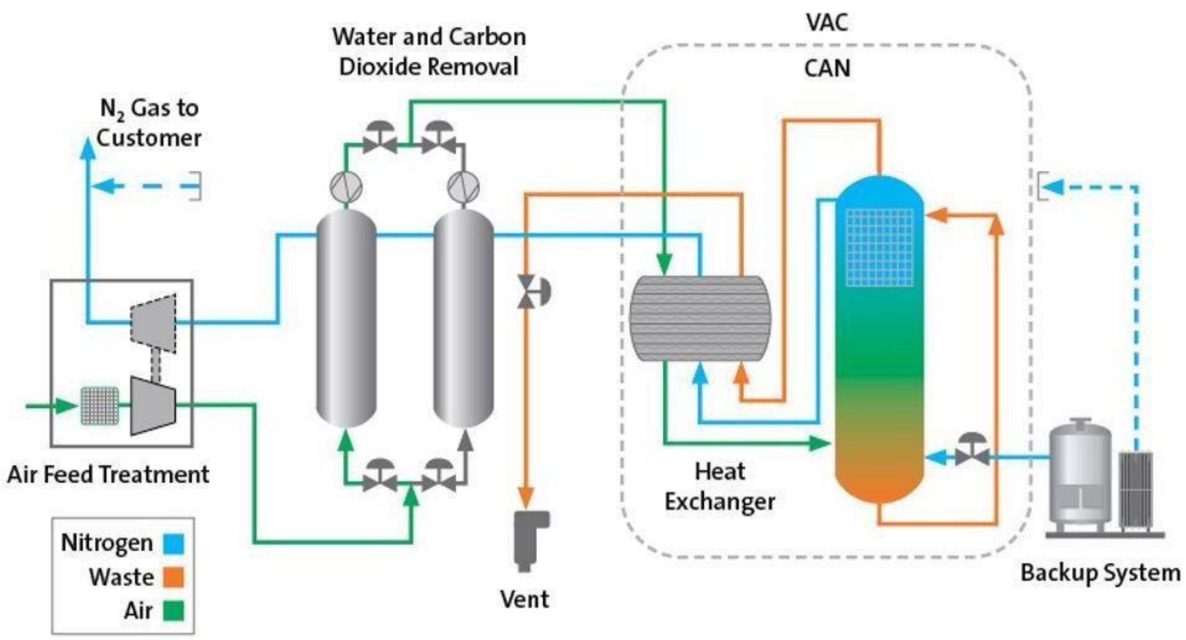
- CLAUS train based on combustion of acid gas coming from ARU (mine regeneration unit) and SWS (sour water stripping unit).
- In tail gas coming from SRU and sweep gas coming from Sulphur pit are fed to thermal incinerator to oxidise the residual H2S.
- The Flue gas leaving incinerator is discharged to atmosphere via a stack.

## BRIEF DESCRIPTION:

The feed consisting of sour gas and acid gas is mixed and is sent to main combustion chamber (MCC). In MCC, burners are design to provide complete mixing of air and feed gas for oxidation of all hydrocarbons, residual sulphur compounds and ammonia and a nominal fuel gas. Then, it passes through a series of catalytic convertors where the SO 2 and H2S react to give elemental sulphur in presence of catalyst (activated Al oxide/ Ti oxide). After each reactor bed, the mixture is passed through a heat exchanger to decrease the temperature as the reaction is exothermic and gives better yield at lower temperature. Part of sulphur vapours that converts to liquid is sent to steam jacketed vessel and the remaining gases are sent back to the reactors for further reactions. This step is done 2 times and after coming out of the 3rd bed and being sent to exchanger for cooling, the whole mixture is sent to steam jacketed vessel. From the vessel, the gaseous phase is sent to incinerator for combustion of sulphur and is sent into stack. The liquid sulphur is sent to underground steam jacketed vessels for storage. If there some vapours in the underground vessel, then it is sent to incinerator.

# NITROGEN UNIT

A nitrogen unit in a refinery is a process unit that produces nitrogen gas, which is used as an inert gas for various applications, such as blanketing, purging, cooling, and catalyst regeneration. Nitrogen gas can prevent the ignition of flammable liquids and gases, protect the equipment and catalysts from oxidation and corrosion, and reduce the emissions of pollutants. Nitrogen gas can be produced from different sources, such as air, natural gas, or refinery off- gases. Depending on the source and the process, different technologies and equipment are used for nitrogen production, such as air separation, pressure swing adsorption, membrane separation, or cryogenic distillation.




A typical nitrogen unit in a refinery consists of the following equipment:

- A feed preheater that heats up the incoming feedstock stream using hot streams from the unit or other sources.
- A nitrogen generator that separates nitrogen from the feedstock stream using one of the technologies mentioned above. The nitrogen generator can produce nitrogen gas with purity up to 99.999% and pressure up to 200 bar.
- A product cooler that cools down the nitrogen gas by exchanging heat with a cooling medium, such as water or air. The product cooler reduces the temperature and pressure of the nitrogen gas and sends it to the downstream units or storage tanks.

- A compressor that increases the pressure of the nitrogen gas to the desired level for storage or transportation.
- A storage tank that stores the nitrogen gas under pressure or as a liquid at low temperature.
- A pipeline or a truck that transports the nitrogen gas to the end-users or other units.

A nitrogen unit in a refinery is important for meeting the safety and operational standards of various refining processes, especially for low-oxygen and high-inertness specifications. A nitrogen unit in a refinery is usually designed and operated based on the feedstock characteristics, product specifications, and process economics.

# HYDROTRATER UNIT (HDT)

The heart of an oil refinery, the hydrotreater unit, acts as a purification station for various intermediate streams. Its primary mission is to Removing sulphur, the villain behind air pollution and equipment corrosion. But it doesn't stop there. It also takes nitrogen, unwanted aromatics, and even stabilizes olefins.

Normal capacity of the hydrotreater is 0.6 MMTPA of fresh feed. However, the unit is designed for the throughput of 0.66 MMTPA of fresh feed (a cushion of 10% on design capacity is kept). The unit will be operated in two blocked out modes: kerosene and diesel. Occasionally, the unit will operate in a blocked-out mode to produce ATF.

The HDT unit reduces the sulphur content of diesel by treating it with hydrogen at high temperature and pressure over catalyst to convert the bound sulphur in the diesel to $H_2S$. The unit is also able to achieve 48.5 cetane no. during diesel operation (EOR) and 21mm smoke point during kerosene operation (EOR).The unit also have the flexibility to process straight run kerosene-1 alone to produce aviation turbine fuel (ATF) if it is required.

## PROCESSING STEPS INVOLVED:

- Pumping of feed to desired pressure.
- Mixing recycle gas with feed.
- Heating of feed and recycle gas mix to desired temperature.
- Contacting the feed and recycle gas mixture with catalyst.
- Cooling of the reactor effluent.
- Separating liquid and vapour from reactor effluent.
- Recycling the separated gases to reactors inlet.
- Stripping the liquid reactor effluents to remove lower boiling fractions as wild naphtha.
- Cooling and polishing of product before sending to storage.

Catalyst selected are oxides of Ni or Co and Mo, impregnated on alumina base. Catalyst selection depends on type of feed stock, desired product properties and process design conditions. The economical combination of these factors determine the best overall-catalyst system.

Most products of crude and vacuum distillation in refineries contain a significant amount of sulfur that must be removed prior to further processing or use. Hydrotreating or hydrodesulfurization refers to a set of operations that remove sulfur and other impurities. During hydrotreating, crude oil cuts are selectively reacted with hydrogen in the presence of a catalyst at relatively high temperatures and moderate pressures. The process converts undesirable aromatics, olefins, nitrogen, metals, and organosulfur compounds into stabilized products. Some hydrotreated cuts may require additional processing to meet final product specifications.

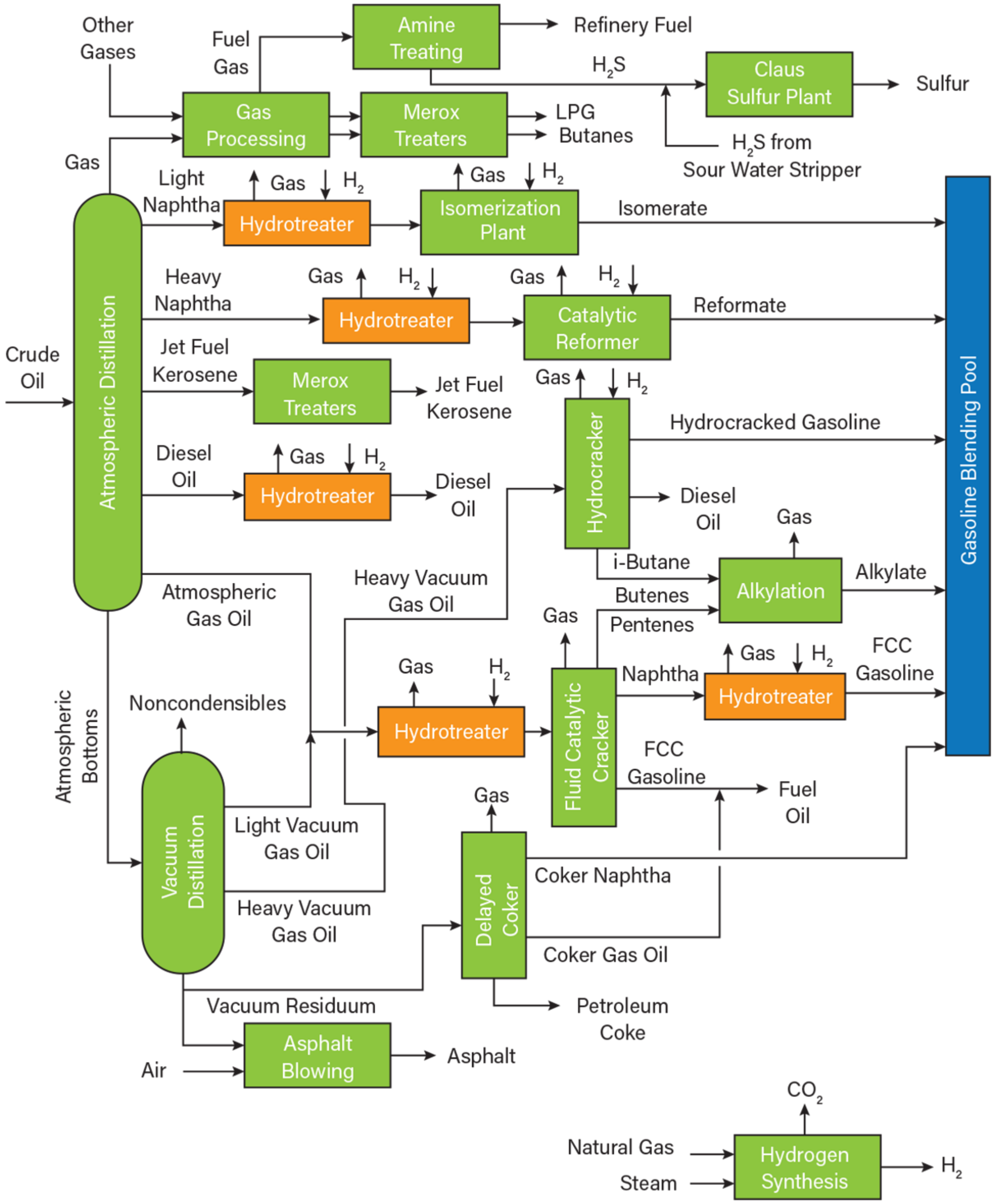



Fig: This general process flow diagram of a petroleum refinery includes several hydrotreating units.

# MOTOR SPIRIT QUALITY UNIT

## Process Objective :

The Stabilised Naphtha from Naphtha stabilising Unit is sent here to obtain Petrol.

## Process Description:

MSQU has four sections -NSU, RSU, NHDT and Isomerisation (ISOM). The main function of this unit is to reduce benzene percentage and improve RON of light Naphtha fraction and make it suitable for blending in the BS-II MS Pool.

## NSU (Naphtha Splitter Unit):

Stabilised Raw Naphtha in AVU is received in MSQU fuel tanks. Feed Naphtha from the fuel tank is produced along with Coker Naphtha and Heavy Naphtha. they are sent to CRU feed tanks Liquid Naphtha is sent as NHDT feed.

## RSU (Reformate Splitter Unit) :

Reformate received from CRU in the reformate splitter unit, where it is split into light reformate and heavy reformate. Light Reformate is treated as ISOM feed while heavy reformate is moved to the MS pool

## NHDT (New Hydro-Treater Unit):

Light Naphtha is received in NSU is processed in Naphtha Hydrotreater Unit (NHDT) in the presence of H2 HDT reactor to remove impurities like sulphur, nitrogen, oxygen compounds, etc,. through hydrotreatment to make the Naphtha product suitable for ISOM reactor.

## ISOM (Isomerisation Unit) :

Hydrotreated light Naphtha and NHDT along with light reformate combined together continues the feed to LSOM section. In this section the feed is dried in the dryer and processed along with H2 in the benzene saturation sector. The Naphtha processed through the ISOM section with reduced benzene level and enhance RON is routed to MS pool.

# Thermal Power Station

A thermal power plant is a facility where heat energy is converted into electrical energy through the process of power generation. This type of plant primarily relies on fossil fuels such as coal, natural gas, or oil, or alternative sources like biomass or nuclear energy, to produce steam by heating water. The high-pressure steam drives a turbine connected to an electric generator, converting mechanical energy into electricity.

Thermal power plants are widely used for their ability to generate large-scale electricity and meet industrial and domestic energy demands. However, they also contribute to environmental concerns, including greenhouse gas emissions and resource depletion, emphasizing the need for sustainable and efficient energy production methods.

## Here are the key components of a Thermal Power Plant :

1. Boiler:
    - The boiler is where water is heated to produce high-pressure steam.
    - Fossil fuels like coal, oil, or natural gas are burned in a combustion chamber to generate heat.
    - In modern systems, advanced designs such as supercritical boilers enhance efficiency.

2. Turbine:
    - The high-pressure steam is directed onto turbine blades, causing them to spin.
    - This rotational energy is essential for generating electricity.

3. Generator:
    - The turbine is mechanically coupled to a generator.
    - The spinning turbine rotates a magnet within a coil, producing electricity via electromagnetic induction.

4. Condenser:
    - After driving the turbine, the steam is condensed back into water using cooling systems, such as water or air-cooled condensers.
    - This water is then recirculated to the boiler.

5. Cooling Tower:
    - Used to dissipate excess heat into the atmosphere and maintain the temperature balance of the plant.

6. Chimney and Pollution Control Devices:
    - Flue gases from the combustion process are released through a chimney.
    - Modern plants incorporate pollution control technologies like electrostatic precipitators and scrubbers to minimize environmental impact.

Brief Description about the key components of TPS :

- **BOILERS**: A boiler is a key component in power plants, industrial processes, and heating systems,designed to generate steam or hot water by transferring heat to water. In thermal power plants, boilers

  are used to produce high-pressure steam that drives turbines to generate electricity. Boilers can use various fuels, including coal, natural gas, oil, biomass, or even nuclear energy, to provide the required heat. They are classified based on their design and operation, such as fire-tube boilers, where hot gases pass through tubes surrounded by water, and watertube boilers, where water flows through tubes heated by external combustion gases. Advanced boilers, like supercritical and ultra-supercritical types, operate at very high temperatures and pressures to enhance efficiency and reduce emissions.

In Guwahati Refinery ,There are five boilers which are being used and these are numbered

as: Boiler – 3 (This is a Romanian tech boiler which is being used since 1962)

Boiler - 4 (This is also a Romanian tech boiler which is being used since 1962)

Boiler – 5 (This is a boiler which is being used since 1992)

Boiler – 6 (This Boiler was introduced in in 2004)

Boiler – 7(This Boiler was introduced in in 2004)

The boilers with number 3,4,5 are induced as well as forced draught while the boilers that are numbered as 6,7 are only Forced Draught.

The type of boiler that are being used are Water Tube Boilers as it requires low maintenance and are not does not require regular checking.

Fig : Boiler

- **STEAM TURBINE**: A steam turbine is a mechanical device that converts the thermal energy of high-pressure steam into mechanical energy by rotating its blades. This rotation drives a connected generator to produce electricity. Steam turbines are a key component of thermal power plants,known for their efficiency and ability to handle large-scale power generation.

They come in two main types: **impulse turbines**, where steam jets strike blades causing movement, and **reaction turbines**, where the blades themselves act as nozzles, utilizing both pressure and velocity changes. Modern steam turbines often have multiple stages, including reheating and condensing stages, to optimize energy extraction and efficiency. Designed to operate under extreme conditions, turbines are built using high-strength alloys to withstand high temperatures and pressures, ensuring durability and performance.

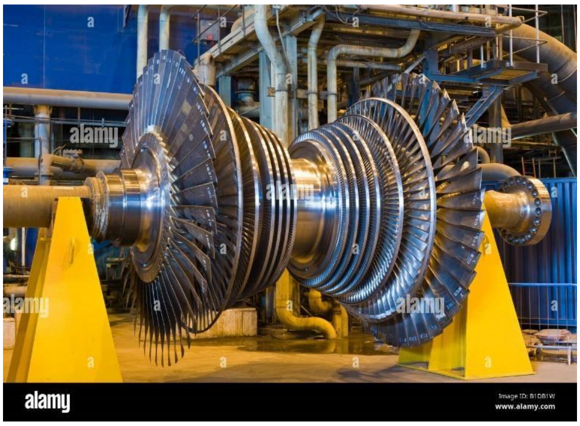


Fig : Steam Turbine

- **GENERATOR**: A generator in a thermal power plant is the equipment responsible for converting mechanical energy from the steam turbine into electrical energy. It operates on the principle of electromagnetic induction, where the rotation of a magnet (rotor) within a stationary coil (stator) generates an alternating current (AC).

The generator is mechanically coupled to the turbine, ensuring synchronized operation. To manage the heat generated during operation, cooling systems like air, hydrogen, or water cooling are used. Generators in thermal plants are designed for high efficiency and reliability, making them capable of producing large-scale electricity to meet industrial and domestic energy demands.

- **CONDENSER :** A condenser in a thermal power plant is a heat-exchange device that converts the exhaust steam from the turbine back into liquid water. This process creates a vacuum in the turbine, enhancing efficiency by maximizing energy extraction from the steam. Condensers also enable the reuse of water in the boiler, conserving resources and maintaining a continuous cycle.

There are two main types of condensers: water-cooled, which use nearby water bodies as a cooling medium, and air-cooled, which use ambient air for heat dissipation. By efficiently managing heat and water, the condenser plays a crucial role in improving the overall performance and sustainability of the power plant.

- **COOLING TOWERS**: A cooling tower is a vital component in a thermal power plant that helps dissipate excess heat generated during the power production process. It works by cooling the water used in the condenser, where steam from the turbine is condensed back into water. The cooling tower uses air to lower the temperature of the hot water before recirculating it to the system.

There are two main types: natural draft cooling towers, which rely on the natural airflow created by the chimney effect, and mechanical draft cooling towers, which use fans to force air circulation.

By efficiently managing heat rejection, cooling towers enhance plant performance, conserve water, and reduce thermal pollution in nearby water bodies.

Fig : Cooling Tower

# BASIC SAFETY IN REFINERIES

According to the regulations of the plant administration, every employee & visitor in the plant has to adhere to the 11-point General Safety Rules, as mentioned below:

- Safety Shoe
- Safety Helmet
- Spark Arrestor (in the exhaust of vehicles)
- Photography Prohibited
- Speed Limit in plant is 20 kmph
- Smoking Banned
- Incendiary Items (matchbox, lighter, etc.) Banned
- Use of VCD VCR Prohibited
- Use of Radio Devices Banned
- Use Fire Safety Equipment like Extinguishers-DCP, Foam,CO2.
- Use of Hydrant Water for other purposes is banned.

Apart from the above-mentioned rules, several other things must also be kept in mind. In case of an accident or hazard, there are MCP (Manual Call Point) at regular intervals, which must be activated once a danger is seen. If the danger Is very serious in nature, then the people are required to assemble in the Assembly Points provided for the purpose, so that they may be safely escorted out.

## THE FIRE TRIANGLE:

For a fire to occur, three components must be present: fuel, an oxidizer (often oxygen), and a source of ignition, as depicted in Figure. If any side of the fire triangle is removed, a fire will not form . If a flammable material is stored in the presence of oxygen but no ignition source is present, a fire cannot occur. Similarly, if a fuel is heated under an inert gas, a fire will not have oxygen and will not burn. Last, it is simple to see that a fire will not occur if there is no fuel. Regardless of the size of a system, without the three components of the fire triangle, a fire will not take place.

While the absence of any side of the fire triangle prevents ignition, the presence of all three components of the fire triangle does not necessarily ensure that a fire will occur. Many factors relating to the three fire triangle components dictate whether a fire will occur, including the amount of each component present in the fire triangle. For example, a reduction in the oxygen concentration past a certain point will extinguish liquid flammable fires. The concentration of oxygen in the air is an important factor in the existence of a fire.

## PERSONAL PROTECTION EQUIPMENT:

- Hand Gloves
- Hard Helmet
- Goggles
- Breathing Apparatus
- Ear Plugs
- Scaffolding
- Safety Net
- Safety Belt

# Thermal and Fluid Dynamics in Refineries

**Thermal Dynamics**
Thermal dynamics involves energy transfer through conduction, convection, and radiation. In refineries, it ensures efficient heat exchange in equipment like heat exchangers and furnaces, optimizing energy recovery, reducing losses, and preventing thermal stresses.

**Fluid Dynamics**
Fluid dynamics studies the motion of liquids and gases, focusing on flow rate, pressure drop, and flow regimes. It ensures smooth fluid transport, efficient heat transfer, and proper air-fuel mixing in refinery systems, enhancing operational stability.

**Application in Heat Exchangers**
Heat exchangers rely on thermal dynamics for effective heat transfer and fluid dynamics for balanced flow, ensuring energy efficiency and preventing fouling.

**Application in Furnaces**
Furnaces use thermal dynamics for uniform heat distribution and fluid dynamics for air-fuel mixing, enabling complete combustion and reducing energy losses.

**Application in Rotary Systems**
Pumps and compressors depend on fluid dynamics for smooth operation, managing flow rates, and preventing issues like cavitation and overheating, ensuring reliability and efficiency.

# Fundamentals of Thermal and Fluid Engineering

Thermal and fluid engineering is a branch of mechanical engineering that focuses on the principles of heat transfer and fluid flow. These principles form the backbone of designing and optimizing systems like heat exchangers, furnaces, pumps, and compressors in refineries. By understanding energy transfer and fluid behavior, engineers ensure efficient and reliable operations, minimizing energy losses and improving performance.

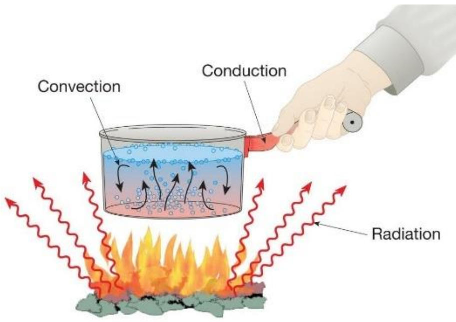
## Principles of Heat Transfer

Heat transfer is the movement of thermal energy from one medium to another due to a temperature difference. There are three primary modes:

1. **Conduction**
   Conduction involves heat transfer within a solid or between contacting surfaces. In refinery operations, conduction occurs in heat exchanger tubes, furnace walls, and other solid materials, facilitating efficient energy transfer.

$$\dot{Q} = \frac{kA\Delta T}{\Delta x}$$

$\dot{Q}$= heat transfer (J/hr), A = cross-sectional area ($m^2$), k=thermal conductivity (J/m-hr-°C), $\Delta T$ = change in temperature (°C), $\Delta x$ = thickness (m)




2. **Convection**
   Convection governs heat exchange between a solid surface and a fluid. In refineries, convection occurs during cooling or heating processes in heat exchangers and furnaces.
   **Types:**
   - **Natural Convection:** Fluid motion driven by temperature-induced density differences.
   - **Forced Convection:** Fluid motion caused by external forces like pumps or fans.

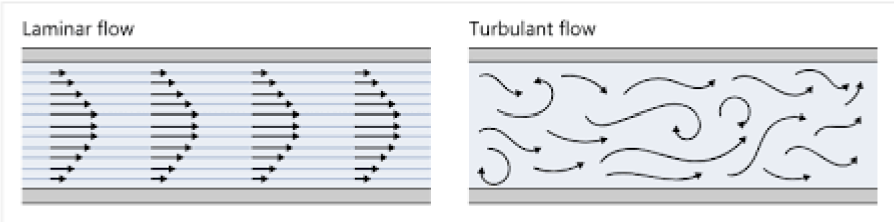
3. **Radiation**
   Radiation transfers heat through electromagnetic waves, requiring no medium. In furnaces, radiation ensures uniform heating of surfaces and materials.

## Principles of Fluid Dynamics

Fluid dynamics focuses on the behavior of liquids and gases in motion. In refinery operations, understanding fluid flow is critical for the efficient transport of hydrocarbons, gases, and steam.

1. **Laminar vs. Turbulent Flow**

   - **Laminar Flow:** Smooth and orderly flow, typically occurring at low velocities.
   - **Turbulent Flow:** Chaotic and irregular flow, common at higher velocities, where mixing is more effective.
   - **Relevance:** Turbulent flow is preferred in heat exchangers for improved heat transfer, while laminar flow minimizes pressure drops in pipelines.




### Pressure Drops

Pressure drops occur as fluids flow through pipelines, valves, or equipment due to friction and obstructions. Proper design ensures minimal energy losses and consistent flow rates.

**Formula:**

$$\Delta p = f\left(\frac{L}{D}\right)\left(\frac{\rho}{gc}\right)\left(\frac{v^2}{2}\right)$$

***Where***

*$\Delta p$ = Pressure Drop ($lb_f/ft^2$)*

$f$ = Friction factor (dimensionless)

$L$ = Length of pipe (ft)

$D$ = Internal diameter of Pipe (ft)

$\rho$ = Fluid density at mean temperature ($lb_m/ft^3$)

$V$ = Average velocity (fps)

$g_c$ = Units conversion factor (32.2 ft * $lb_m/lb_f$ * $s^2$)

### Flow Rate Calculations

Accurate flow rate calculations ensure efficient operation of pumps, compressors, and other equipment.

Formula **Q=A.V**

Where:

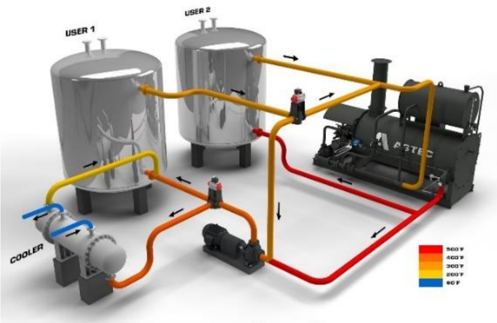
- Q: Volumetric flow rate
- A: Cross-sectional area

- V: Flow velocity

## Importance in Refinery Operations

The principles of heat transfer and fluid dynamics are indispensable in refinery operations**:**

- Heat Transfer: Ensures optimal energy recovery and minimizes thermal losses in equipment like heat exchangers and furnaces.
- Fluid Dynamics: Facilitates efficient fluid transport, reduces energy consumption, and ensures process stability in rotary systems and pipelines.
- Proper understanding of these principles allows for improved equipment performance, energy optimization, and operational safety.



Temperature Control Loop

# Applications in Refinery Equipment

## HEAT EXCHANGER

A heat exchanger is a device that facilitates the process of heat exchange between two fluids that are at different temperatures. Heat exchangers are used in many engineering applications, such as refrigeration, heating and air conditioning systems, power plants, chemical processing systems, food processing systems, automobile radiators, and waste heat recovery units. Air preheaters, economizers, evaporators, superheaters, condensers, and cooling towers used in a power plant are a few examples of heat exchangers.

**Types of Heat Exchangers:**

Heat exchangers are available in various designs, depending on the design characteristics. The following are some of the more popular variations used in the industry:

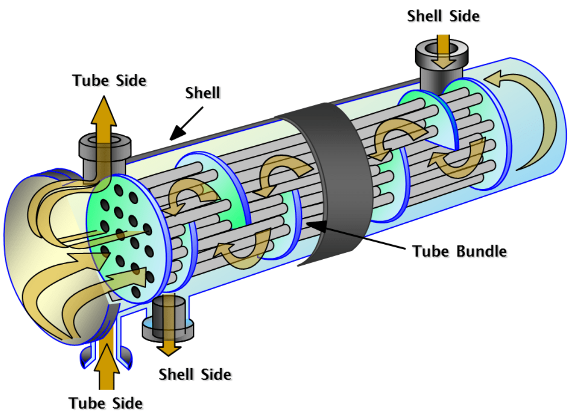
- Shell and tube heat exchanger
- Double pipe heat exchanger
- Plate heat exchanger

`Based on flow of fluid, there are three types of Heat Exchanger,

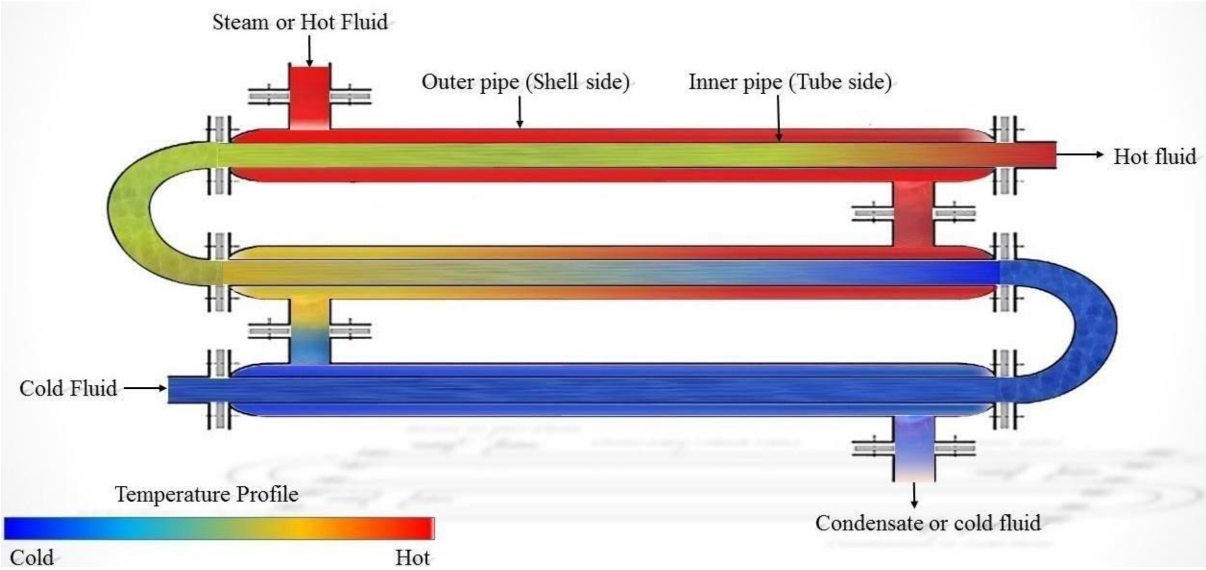
- Parallel Flow
- Counter Flow
- Cross Flow

## SHELL AND TUBE HEAT EXCHANGER

A single tube or a sequence of parallel tubes is encased within a sealed, cylindrical pressure vessel in a shell and tube heat exchanger. One fluid travels through the smaller tube(s), while the other flows around its/their outsides and between them within the sealed shell. Finned tubes, single- or two-phase heat transfer, counter current flow, co-current flow, or crossflow arrangements, and single, two, or multiple pass configurations are some of the other design features available for this type of heat exchanger.



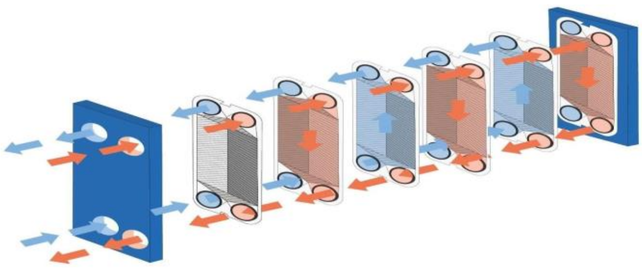
# DOUBLE TUBE HEAT EXCHANGER




Heat exchangers with two or more concentric, cylindrical pipes or tubes are known as double pipe heat exchangers (one larger tube and one or smaller tube). One fluid goes through the smaller tube(s) while the other fluid flows around the smaller tube(s) within the bigger tube, according to the shell and tube heat exchanger's design. Because the fluids remain separated and flow via their channels throughout the heat transfer process, the design requirements of a double pipe heat exchanger contain characteristics from the recuperative and indirect contact types.

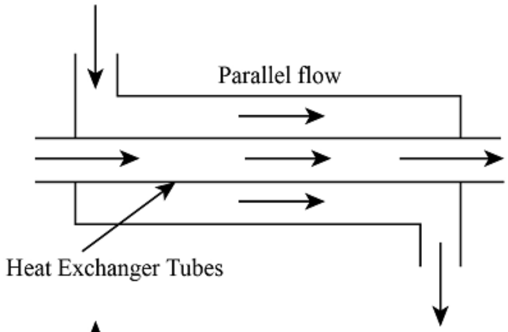
# PLATE HEAT EXCHANGER

Plate heat exchangers are made up of several thin, corrugated plates that have been grouped. Each pair of plates produces a channel for one fluid to flow through, and the pairs are stacked and connected (by bolting, brazing, or welding) to create a second passage for the other fluid to flow through. There are some modifications to the typical plate design, such as plate-fin or pillow plate heat exchanger. Fins or spacers between plates in plate-fin exchangers allow for different flow configurations and more than two fluid streams to pass through the device.

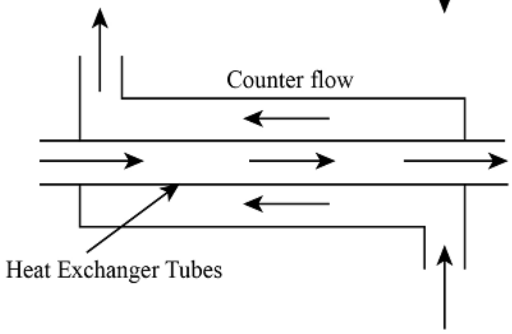


## Based on flow of fluid

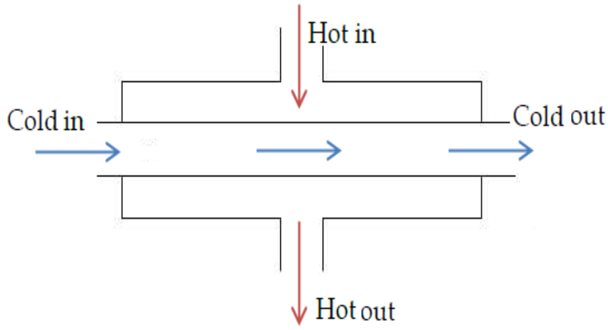
- PARALLEL FLOW: A parallel flow heat exchanger is a type of heat exchanger in which both the hot and cold fluid streams flow in the same direction, parallel to each other.




- COUNTER FLOW : A Counter flow heat exchanger is a type of heat exchanger in which both the hot and cold fluid streams flow in the opposite direction.




- CROSS FLOW: In a cross-flow heat exchanger, hot and cold fluids flow perpendicular to each other.



# FURNACE

A furnace is a piece of equipment that provides direct electric or fired heat for industrial processes that require temperatures that exceed 752 °F (400 °C). Many industrial processes require heating for the preparation of materials for production or the completion of an application. In all cases, the dependability and durability of electric and fired industrial furnaces provide the necessary temperature control and reliability to complete a manufacturing process or operation.

The two general types of industrial furnaces are *electrical and fired*. Electrical industrial furnaces are either arc or high-frequency induction. The arc type is used for refining, while high-frequency induction is used for melting metals. Fired furnaces rely on the combustion of a fuel source to heat raw materials directly or indirectly or to sinter finished parts.

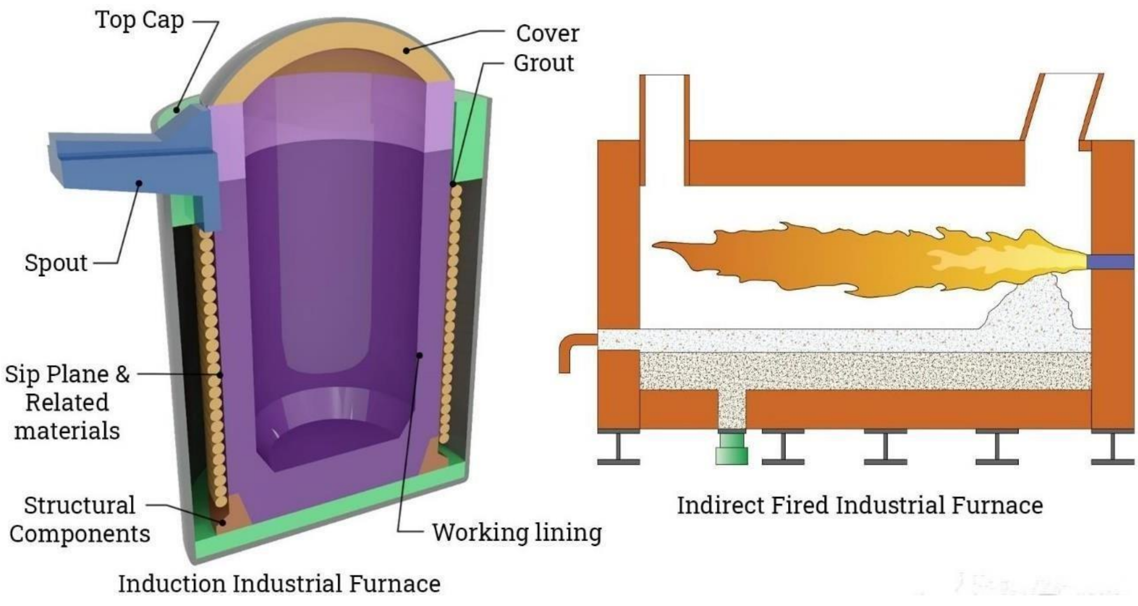



Fig: Electrical and Fired Industrial Furnace

The construction of furnaces varies depending on the fuel source and type of furnace, with wide variation between electric and fueled furnaces. All furnaces are built of materials capable of withstanding extraordinary levels of heat without failing or breakage. Some factors considered during furnace design are process temperature, height of the furnace, outer diameter (OD), length, and desired pressure range.

Different furnaces function differently and burn different types of fuel. For many years, furnaces were powered by wood or coal; this required constant refueling for continuous heat.

Modern furnaces have moved on to fuels that are supplied automatically.

## How a Furnace is Fueled?

The critical element in the operation of an efficient and economical furnace is its fuel. Though coal and wood were used for many years, they polluted the environment, required constant feeding, and made it difficult to keep a steady temperature. Modern furnaces have fuel fed directly into the furnace at a controlled rate, using electricity to maintain even temperature.

Fuel-fired furnaces are the most widely used. The nature of the fuel determines the design of the furnace but is not relevant to modern furnaces. As with any type of heat-operated device, the supply of oxygen is important to the furnace's efficient operation.

Electric furnaces are efficient and environmentally sound because they do not release flue gasses. Unfortunately, they are expensive to operate. Electric furnaces can use either induction or resistance heating.

First, resistance heating is the most expensive type of electric furnace. These furnaces use a circulating fan to maintain temperature uniformity. Resistors can be made of various materials. The load to be heated may also serve as a resistor.

Induction heating is used for heating a localized area of a workpiece. With induction heating, electricity passes through a coil that surrounds the load. The type of load determines the frequency of this current. The coils are water-cooled to prevent them from overheating.

## Furnace Burner Types

The fuel is supplied to the burners where, predictably, it is burnt. Most furnaces have more than one burner that can be mounted in different sections of the furnace depending on its design. The burner has an oxidizer to change the chemical energy into thermal energy. The type of fuel used in a furnace is determined by the burners, which mix the fuel and air and ignite them. Burners must be stable, cost effective, reliable, and energy efficient, and they must have proper flame dimensions.

The components of the burner include the nozzle, mixing tube, downstream connection, and air fuel ratio control. The fuel and air are mixed to produce the best quality flame; forced air is required for the mixing process.

Burners produce six types of flames: A, C, E, F, G, and H.

- Type A – Type A is a conventional flame that burns forward and is shaped like a feather. It is used in all-purpose furnaces.
- Type C – Type C is ball-shaped with swirl and has a hot reverse flow. It is used in cubicle-shaped furnaces.
- Type E – Type E has a very high swirl with some recirculation. Convex types are used to avoid flame impingement, while concave types focus on hot spots. Both types increase direct radiation.
- Type F – Type F has no swirl or recirculation and is long and luminous. Due to its

luminous radiation, it is used in long furnaces.

- Type G – Type G is also long and luminous without swirl. It supplies uniform coverage for long furnaces.
- Type H – Type H has high velocity and low swirl with high circulation. It is fast-mixing and used to force flow around the backs of furnaces.

## Heat Transfer in Furnaces

Heat transfer in a furnace takes place in three ways: radiation, convection, and conduction.

- Radiation in Furnaces:
  In a furnace, the initial heat source, the burners, are located in a chamber with tubes on four sides. Radiation occurs when the burners are ignited and radiate heat to the fluid inside the tubes.

- Convection in Furnaces:
  Convection requires the flow of a gas or liquid to carry heat. In a furnace, there are tubes located above the furnace that catch heat as it leaves the heating chamber before it exits through the stack. This process helps maintain the efficiency of the furnace by preventing wasted heat.

- Conduction in Furnaces:
  Conduction is the transferring of heat through a solid surface. Heat conduction happens in a furnace when heat is transferred to the tubes, which act as the surface that transfer heat.

In conclusion,

- A furnace is a direct-fired device used to provide heat for industrial processes that require heat in excess of 752 °F (400 °C).
- Through the combustion of fuels and gasses, raw materials and products are heated by direct or indirect contact.
- The wide selection of furnaces have different methods of performing their functions and use different fuels.
- Regardless of the differences in operation, all furnaces serve the primary purpose of providing heat.
- Industrial uses of furnaces tend to center around the annealing, melting, tempering, and carburizing of metals.

# PUMP

Pumps are mechanical devices that use energy to move fluids from one point to another. The main application of pumps is to move fluids, such as gasses, oils, and water. An impeller or propeller is a part of a pump that helps move fluids through the device.

A well-known example of the pump is the water pump., A water pump is a device that moves water from one place to another. It works by using mechanical energy to create a pressure difference, which causes the water to flow. Water pumps can be used for a variety of purposes, including irrigation, water supply, and drainage. Some water pumps are powered by electricity, while others use gasoline or diesel engines.

A pump moves fluid by creating a pressure difference between the inlet and outlet of the device. The movement of the piston, impeller, or other mechanisms in the pump creates this pressure difference and drives the fluid through the pump. Different types of pumps use different mechanisms to create the pressure difference and move the fluid, such as the movement of a piston, the spinning of an impeller, or the rotation of blades in an axial flow pump.

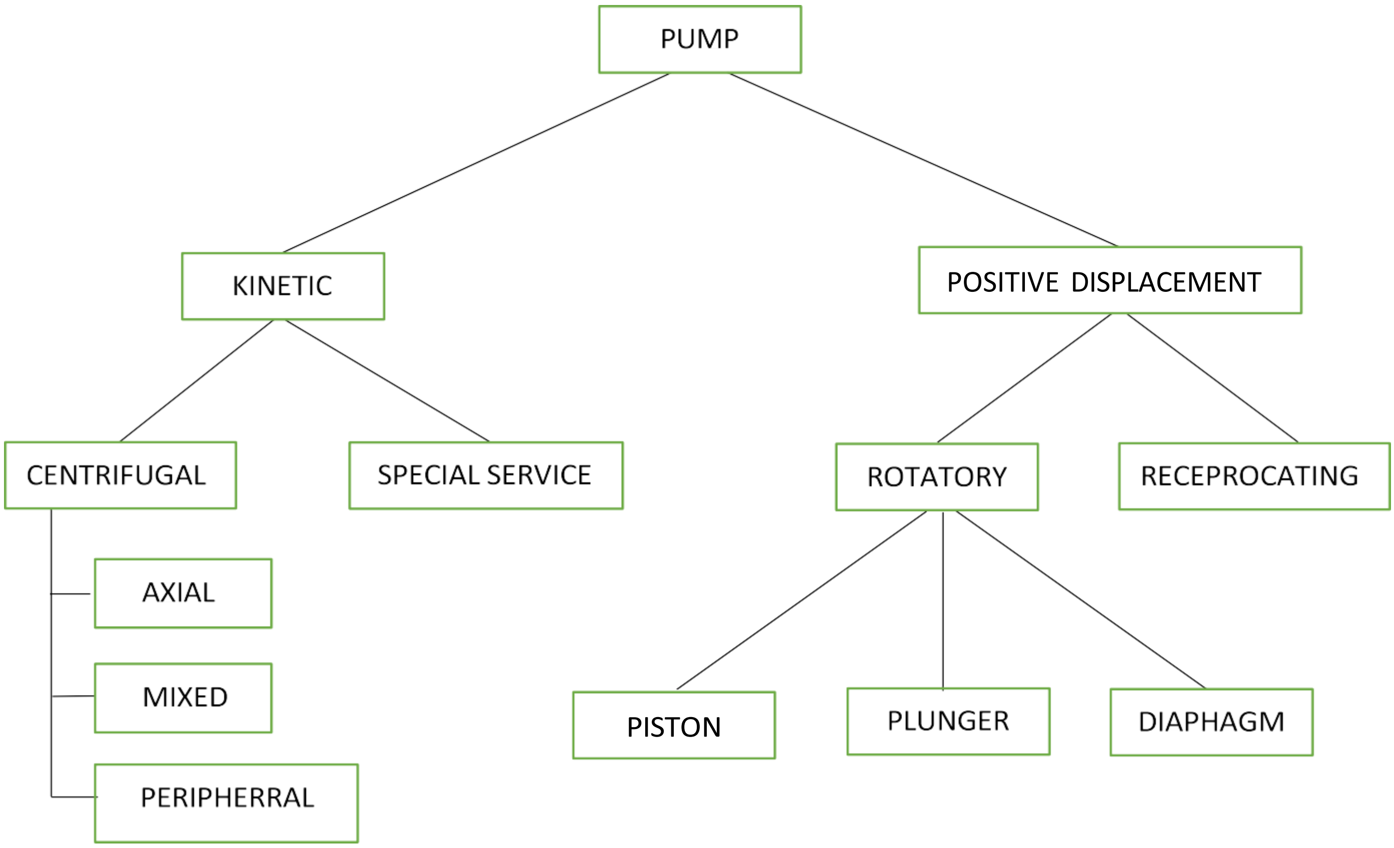
Pumps are used to move fluids from one point to another. This can include moving water for irrigation, pumping oil or gas for transportation or industrial processes, moving air in vacuum cleaners, and many other applications. Pumps are essential in many industries and are used in a wide range of applications.

The basic operating principle of a pump is that it uses energy to move fluids from one point to another. All pumps contain a moving component. The moving component (impeller, vane, piston) displaces air, decreasing the pressure and creating a partial vacuum. Air or fluid then moves into this area of low pressure. This is similar to sucking on a straw.

# CLASSIFICATION OF PUMPS

Pumps can be classified into two main types: kinetic and positive displacement. ‘dynamic pumps' use the kinetic energy of the moving fluid to move the fluid through the pump and Positive-displacement pumps use a mechanism to trap and release a fixed volume of fluid.

The efficiency of a pump refers to the amount of mechanical work required to move a particular volume of fluid. High-efficiency pumps require less energy and are, therefore, more cost- effective and environmentally friendly. Different types of pumps have varying levels of efficiency, and it is crucial to consider this factor when selecting a pump for a specific application.

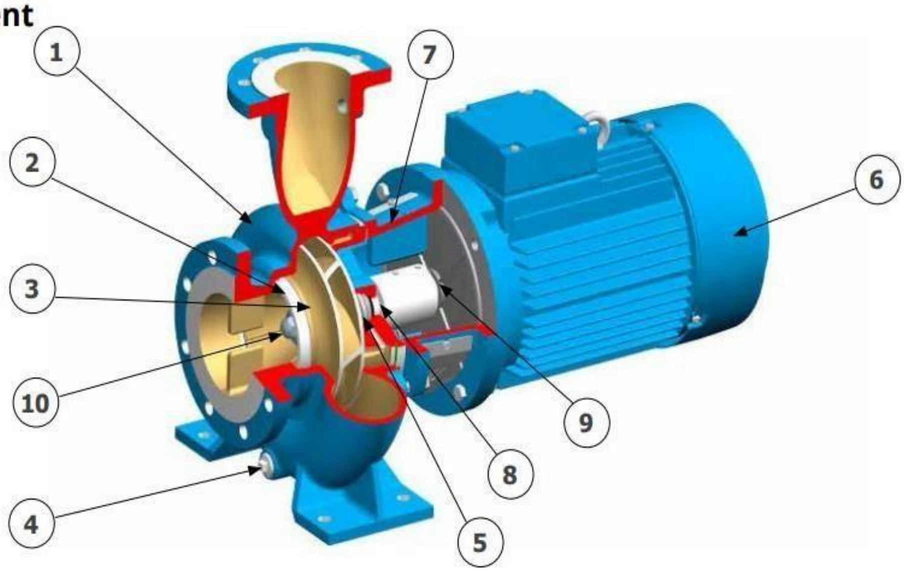


# BASIC PARTS OF PUMPS

1. The Casing – this is the outer shell or housing that encases the pump.
2. Fluid Displacement Device – The two main ways of moving fluid are centrifugal and positive displacement. In centrifugal pumps, impellers are the rotating discs with fins or vanes attached. They spin rapidly accelerating the fluid outwards to the discharge port. Positive displacement pumps use different types of pistons, gears, lobes or screws to pump fluids
3. Bearings – A mechanical support that allows continuous rotation of the impeller, reduces rotational friction, and supports the loads in other pump assemblies.
4. The Hub – the central part of a wheel attached to the bearing assembly. It is the source of power for impeller rotation in centrifugal pumps.
5. The Seal – protects the bearing assembly from excess grease loss and contamination. Seals also keep fluids inside the pump from leaking while allowing the shaft to spin or reciprocate depending upon the pump.

**General Arrangement**

| Parts | |
|---|---|
| # | Description |
| 1 | Volute Casing |
| 2 | Wear Ring |
| 3 | Impeller |
| 4 | Screw Plug |
| 5 | Mechanical Seal |
| 6 | IEC Standard Motor |
| 7 | Adapter |
| 8 | Slinger |
| 9 | Shaft |
| 10 | Impeller Nut |



# KINETIC PUMP

Kinetic pumps are designed to move liquids smoothly and quietly, whether it's water in your home, oil in a factory, or even the blood in your body. Picture them as reliable, silent assistants always ready to keep the fluids flowing seamlessly.

Kinetic pumps are available in diverse forms and dimensions, with each type customized for particular applications and sectors. Let's classify these pumps into various categories and examine their distinct features.

## CENTRIFUGAL PUMPS

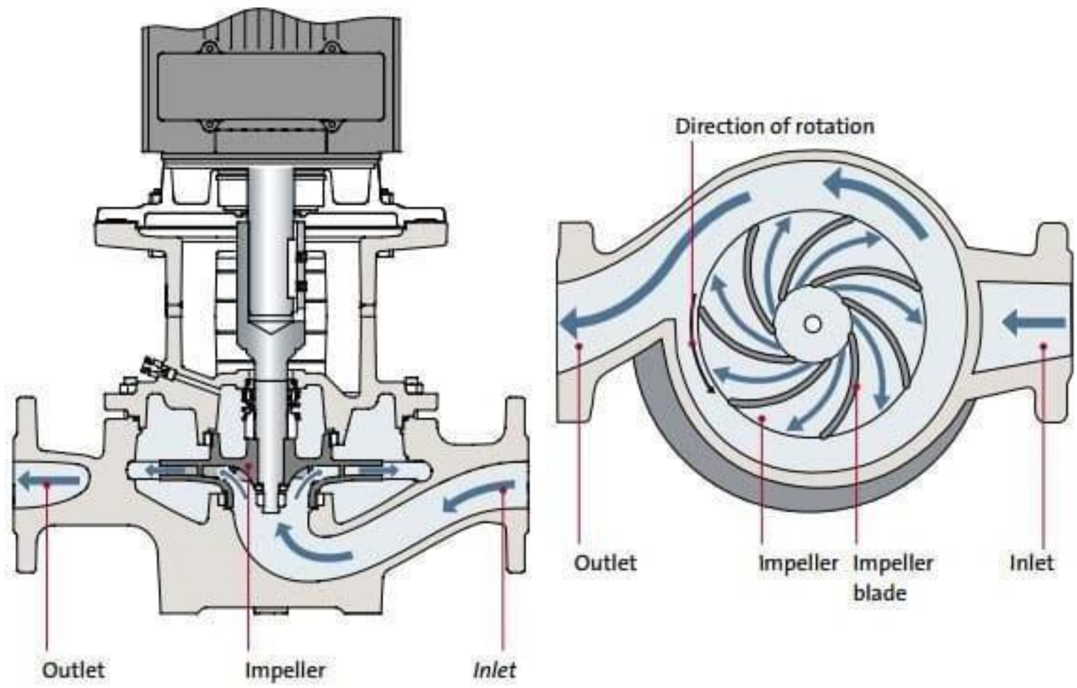
A centrifugal pump is a mechanical device that moves fluid by transferring rotational energy from one or more driven rotors, called impellers.

Characteristics:

- Used in industries like farming, factories, and city water supply.
- Works by spinning an impeller to create force.
- Best for moving lots of liquid with not much pressure.
- Often used for water and thin

fluids. Working Principle:

Centrifugal pumps operate by transferring rotational energy from one or more driven rotors, called impellers. The impellers act to increase the speed and pressure of the fluid and direct it to the pump outlet.



## AXIAL FLOW PUMPS

An axial flow pump is a type of centrifugal pump in which the fluid enters and exits the pump in a parallel direction to the impeller. It has a suction parallel to the impeller. An axial flow pump doesn’t change the flow direction of the fluid. It has an impeller inside the pipe. This pump has three to four blades that are installed on the impeller.

Characteristics:

- Often used to move lots of water or liquids.
- They have a design that keeps the flow smooth.
- Great for things like preventing floods, watering crops, and managing wastewater.
- Works well when there isn't much vertical distance but needs lots of liquid to flow.

Working Principle:

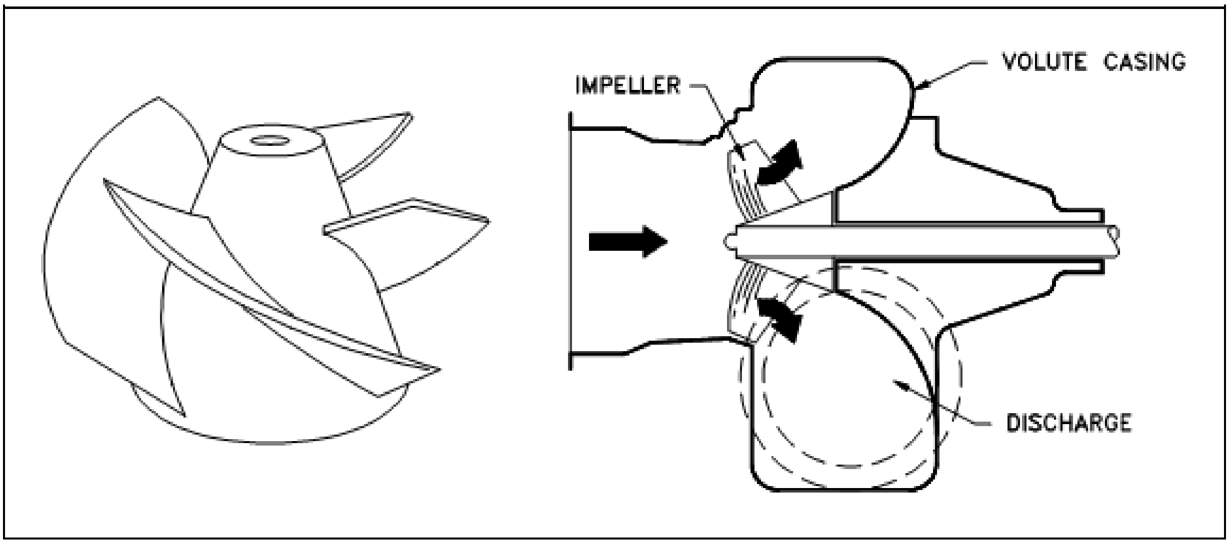
It works on the same principle as a ceiling fan. Axial pump is also a type of Kinetic pump that uses fluid momentum and velocity to generate the pump pressure used for higher flow rate.The blades of the impeller which is permanently fixed on the shaft exert a force on the fluid and increase its angular moment. Pressure and absolute speed increase as a result. Consequently, energy is being transferred to the fluid.

## MIXED FLOW PUMPS

A mixed flow pump is a specialty pump that exhibits characteristics of both radial flow centrifugal pumps and axial flow pumps. As the name suggests, the impeller imparts velocity to the fluid both radially and axially. However, the dominant flow remains in the radial direction.

Characteristics:

- Combines features of centrifugal and axial flow pumps for a good mix of flow and pressure.
- Works well when you need moderate pressure and flow.
- Used in places like sewage treatment, farm irrigation, and cooling systems.




Working Principle:

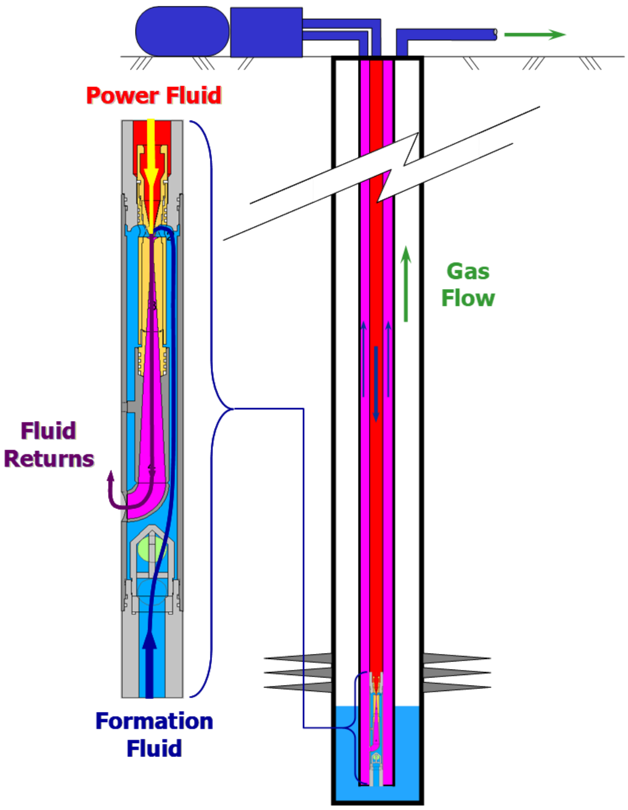
The working principle of mixed flow pumps involves the rotating impeller imparting momentum on the fluid by accelerating it radially and axially. The fluid enters the suction nozzle of the pump and flows into the impeller eye. As the impeller rotates, the angled blades push the fluid outwards radially via centrifugal action. At the same time, the angled blades also provide an axial thrust to the fluid generating flow parallel to the impeller shaft. So the fluid velocity gets a radial as well as axial component.

# JET PUMPS

Jet pumps, also known as ejector pumps, are devices capable of handling and transporting all forms of motive fluid including gas, steam, or liquid. They can be considered mixers or circulators since the intake combines multiple fluid sources.

Characteristics:

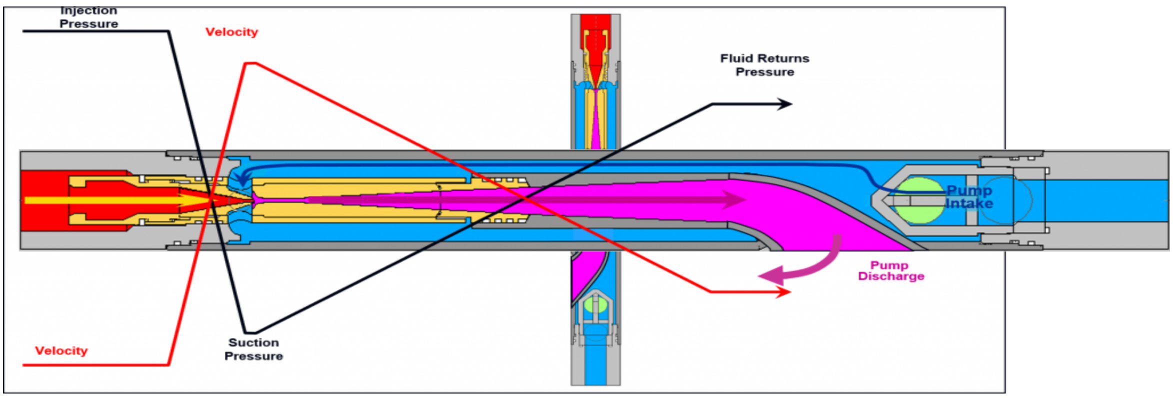
- Use a high-speed fluid jet to draw in fluids.
- Commonly used to pump groundwater.
- Compact and efficient, ideal for home well systems.




Working Principle:

A jet pump is a pump that operates on the principle of a high-pressure fluid jet and the venturi effect.

The basic principle of a jet involves injecting power fluid (pressurized water or oil) down the power fluid flow path at a design rate and pressure. Once the fluid reaches the jet pump, the flow path area is decreased through a sized nozzle, increasing the velocity of the fluid creating a venturi effect. The differential pressure created from the venturi effect draws reservoir fluid into the jet pump. The power fluid and reservoir fluids commingle and the pressure increases as the velocity drops through the flow path of increased area. The pressure increase is sufficient to lift the commingled fluids to surface.



## POSITIVE DISPLACEMENT PUMP

A positive displacement pump operates by drawing in a fluid, filling a cavity and then displacing the same volume of fluid, delivering a constant amount of liquid for each cycle that the pump makes regardless of the discharge pressure or head. Positive displacement pumps differ from centrifugal pumps in that the volume of the chamber changes, driving the fluid. When the plunger draws back the volume increases, creating a vacuum and the cylinder fills. Pushing on the plunger has the opposite effect and forces the fluid out. The mechanical devices that move the fluid in a positive displacement pump can be a plunger, piston, diaphragm, gears or intermeshing lobes. PD Pumps are the designed for use where there are solids or abrasive material suspended in the fluid. High velocities within a centrifugal pump will wear out the impeller and casing rapidly if they pump anything but low viscosity clear fluids. Positive displacement pumps run at lower internal speeds and should be a more economical option for viscous or abrasive liquids.

PD Pumps are the best choice if:

- The smallest available centrifugal pump needs to operate at a flow less than 50% of the best efficiency flow.
- The fluid is high viscosity.
- You need to produce higher heads or pressures at a more economical price.
- You require a near-constant flow that makes it possible to match the flow to the process requirements.
- For metering applications.

## ROTARY PUMP

Because of their design, Rotary pumps can produce more fluid than reciprocating pumps of the same weight, and they are self-priming. The pump classifications under Rotary pumps are Gear, Lobe, Peristaltic and Screw or Moving Vane. Rotary pumps are capable of pumping more fluid than reciprocating pumps of the same weight. Unlike the centrifugal pump, the rotary pump is a positive-displacement pump meaning that for each revolution of the pump, a fixed volume of fluid is moved regardless of the resistance against which the pump is pushing.

## RECIPROCATING PUMP

Reciprocating pumps use a crankshaft connecting rod mechanism the same way it works on the engine in a car. It converts the crankshaft's rotary movement into a straight or linear movement of the piston. There are three moving parts including the inlet valve, the plunger or piston and the outlet or discharge valve. As the piston retracts, ambient air pressure forces the fluid in through an inlet check valve to fill the vacuum left by the piston. As the piston reverses the cycle, pressure closes the inlet check valve, and the outlet check valve opens discharging the fluid. The volume of fluid remains constant with each revolution of the crank, but pump configuration determines pressure and system flow. Pump shaft speeds are relatively low, requiring speed reduction from the motor or driver to the pump shaft.

## DIAPHRAGM PUMP

Diaphragm Pumps also, called Membrane Pumps, Diaphragm Pumps use a flexible membrane to create low and high pressure by flexing in and out of a chamber. Check valves direct the flow of liquid in and out of the chamber with each reciprocating cycle of the diaphragm. These pumps work well pumping high viscosity fluids such as sludges and slurries containing solid materials. They can reach discharge pressures up to 1,200 bars.

## PISTON AND PLUNGER PUMP

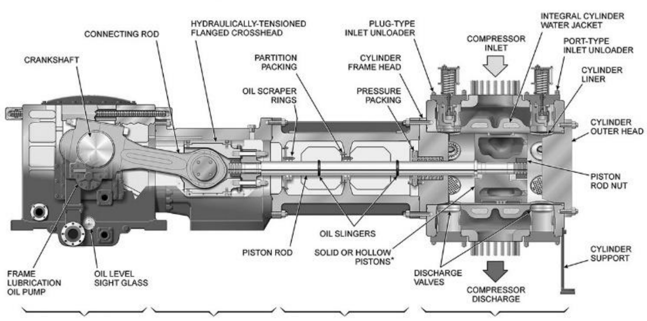
Piston and Plunger Pumps Both Piston and Plunger Pumps work with the linear motion displacing fluid inside of a cylinder. The difference is that the seal on the piston moves with the piston contacting the cylinder wall to create a seal. The plunger on a Plunger pump passes through a stationary seal and will generate higher pressure than piston pumps. There are two types of piston pumps, Lift and Force. In a lift pump, it takes three strokes to complete the cycle. The first stroke or upstroke of the piston draws water, through a valve, into the lower part of the cylinder. With the second or downstroke, water passes through valves in the piston, filling the upper portion of the cylinder. On the third or upstroke, water discharges from the top part of the cylinder via a spout. Force pumps need only an upstroke to fill the cylinder and a down stroke to force the fluid out.

## 4. Compressors

Compressors are used in Guwahati Refinery for gas handling and pressurization in units like **Hydrogen Generation (HGU)** and **Sulfur Recovery (SRU)**. The refinery employs **large reciprocating compressors** to meet operational demands.

- **Gas Compression Principles:**
  Compressors increase gas pressure by reducing its volume. In reciprocating compressors, pistons compress gas in a controlled chamber.
- **Applications:**
  - **Hydrogen Generation Units:** Compressors supply high-pressure hydrogen for hydroprocessing and desulfurization.
  - **Sulfur Recovery Units:** Handling gases for sulfur extraction and conversion processes.
- **Challenges:**
  Compressors require precise temperature control to avoid overheating, as well as robust maintenance practices to ensure reliability under high-pressure conditions.

Reciprocating Process Compressor Components



## 5. Boilers

The Guwahati Refinery operates **five large water-tube boilers** to generate steam for various processes:

- **Two Romanian Boilers:** Older designs still functional due to consistent maintenance.
- **One 30-Year-Old Boiler:** A reliable backup system for critical processes.
- **Two Modern Boilers (Installed in 2004):** Equipped with advanced monitoring systems for better efficiency.
- **Working Principles:**
  - Boilers transfer heat from burning fuel to water flowing through tubes, generating steam.
  - Steam is used for heating, driving turbines, and hydrogen generation.

- **Boiler Mountings and Accessories:**
  Each boiler is equipped with essential safety and monitoring devices, including:
  - **Pressure Gauges:** Monitor internal steam pressure.
  - **Water Level Indicators:** Prevent low-water conditions.
  - **Safety Valves:** Release excess pressure to avoid explosions.

- **Thermal Efficiency:**
  Efficiency is maintained through regular cleaning, insulation, and heat recovery systems to minimize losses.

## 6. Turbines

The refinery uses **three steam turbines** to generate power for critical operations:

- **Two Turbines (8 MW Each):** Power units with moderate energy requirements.
- **One Turbine (15 MW):** Supplies energy to high-demand units.
- **Applications:**
  - Turbines utilize excess steam from boilers to produce electricity, ensuring energy independence for the refinery.
  - Provide power backup during external grid fluctuations.

# MECHANICAL WORKSHOP

A mechanical workshop is a facility equipped with tools, machinery, and equipment for manufacturing, repairing, and maintaining mechanical components and systems. It serves as a practical environment for operations such as machining, welding, assembling, and testing. Commonly found in industries, educational institutions, and research centers, these workshops support activities like fabricating machine parts, overhauling engines, and performing maintenance tasks. Equipped with tools like lathes, milling machines, drills, grinders, and CNC machines, a mechanical workshop plays a crucial role in developing engineering solutions, fostering hands-on learning, and ensuring the functionality of mechanical systems.

Different Machines Used In workshop:

- Lathe Machine:
- Function: Used for shaping and machining cylindrical parts. It rotates the workpiece while a cutting tool is fed into it to remove material, producing parts like shafts, rods, and pulleys.
- Applications: Turning, facing, threading, and boring operations.

- Milling Machine:
- Function: Uses a rotating cutter to remove material from a workpiece, which is usually held stationary. It can perform a wide variety of operations, such as cutting, drilling, and shaping.
- Applications: Producing flat surfaces, grooves, slots, and intricate shapes.

- Drilling Machine:
- Function: Primarily used for drilling holes in a workpiece. It can also be used for tapping threads and reaming.
- Applications: Drilling holes of various sizes and depths, tapping, and countersinking.

- Grinding Machine:
- Function: Uses an abrasive wheel to remove small amounts of material, providing a smooth finish or sharpening tools.
- Applications: Surface grinding, cylindrical grinding, and tool sharpening.

- CNC Machine (Computer Numerical Control):
- Function: A computer-controlled machine tool that automates machining tasks such as milling, turning, and drilling with high precision.
- Applications: Complex and intricate parts with high accuracy and repeatability.

- Welding Machine:
- Function: Joins metal pieces by melting them together, often with a filler material, to form a solid bond.
- Applications: Welding components of various sizes and materials, including steel, aluminum, and stainless steel.

  In Refinery mainly oxy-acetylene welding is being used.

- Slotting Machine :

  A slotting machine is a vertical tool used for machining slots, grooves, and keyways in a workpiece. It operates by moving a single-point cutting tool vertically in a reciprocating motion while the workpiece remains stationary or moves slowly on a table. The cutting action occurs during the downward stroke, and the upward stroke is idle, preparing for the next cut.

- Counter Ball Machine : A counter boring machine is a specialized tool designed for enlarging the upper part of a drilled hole to create a recess or flat-bottomed area that allows for the head of a bolt, screw, or fastener to sit flush with or below the surface of the material. This machine ensures precision in counterboring operations, enhancing the functionality and appearance of mechanical assemblies.

- EDT Crank : An EDT crank (Electrically Discharge Textured crankshaft) is a type of crankshaft that has undergone surface texturing through electrical discharge machining (EDM). This process involves creating micro-textures or dimples on the crankshaft surface to improve lubrication retention, reduce friction, and enhance durability.

  EDT crankshafts are particularly beneficial in high-performance and modern engines, where precision and efficiency are critical. The texturing helps optimize oil film behaviour, ensuring better wear resistance and smoother operation under varying loads and temperatures.

# CONCLUSION

In retrospect, the winter training period at the IOCL-Guwahati Refinery has been an exceptionally gratifying experience for us. This immersive opportunity not only allowed us to become integral members of the refinery but also provided a unique platform to bridge the gap between theoretical knowledge and practical application. During this period, we had the privilege of visiting various units, gaining valuable insights into the entire refinery infrastructure. Although the duration was limited, the exposure to different facets of the refinery, including furnaces, pumps, distillation columns, heat exchangers, and various other equipment, proved to be immensely beneficial for our understanding as mechanical engineering students. The hands-on experience not only enhanced our practical skills but also strengthened the theoretical foundations of our academic pursuits. This tenure was not only memorable and interesting but also served as a crucial building block for our future endeavors in the dynamic field of mechanical engineering.

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