# REPORT ON INDUSTRIAL TRAINING

At Numaligarh Refinery Limited

(Session – 2022)

PERIOD OF TRAINING

($27^{TH}$ June To $12^{th}$ July)

SUBMITTED BY

SIDDHANT DEY

B.Tech $5^{TH}$ SEMESTER

DEPARTMENT OF MECHANICAL ENGINEERING

TEZPUR UNIVERSITY

NAPAAM, TEZPUR.

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# CERTIFICATE

This is to certify that Mr. Siddhant Dey of B.Tech 5th Semester, Mechanical Engineering Department of Tezpur University, Assam have successfully completed summer industrial training at Numaligarh Refinery Limited (NRL).

Mr Sangam Panchanan
(Officer, T&D)

Mr. Asish Boruah
(Chief Manager, T&D)

# ACKNOWLEDGEMENT

This work carries with it kind support, inspiration and guidance by various people at various levels, to whom we are grateful and sincerely indebted.

Firstly, I would like to thank **NUMALIGARH REFINERY LIMITED, NUMALIGARH** for giving us an opportunity to do our internship in their esteemed organization.

We would like to take the opportunity for learning to thanks and express our heartfelt **to Mr Asish Baruah (Chief Manger, T&D) and Mr. Sangam Panchanan (Officer, T&D).** We are highly indebted to them for their guidance and constant supervision as well as for providing necessary information regarding the project. We are really grateful to our mentor **Mr. Monjit Borah** for his constant guidance throughout the project.

We are also very much thankful to **Mr. Harchan Singh Bedi (Senior Manager, Mechanical Maintenance), Mr. Palash Kalita (Officer, Mechanical Maintenance), Mr. Hifjur Ahmed (Officer, Mechanical Maintenance) and Mr. Suman Sarma (Officer, Mechanical Maintenance)** for their guidance and constant supervision as well as their kind co-operation and encouragement which helped us in completion of this project throughout the training period.

# INTRODUCTION TO NUMALIGARH REFINERY LIMITED

The **Numaligarh Refinery**, located at Morangi, Golaghat district, Assam in India, is a refinery which is a joint venture between Oil India which is under the ownership of Ministry of Petroleum and Natural Gas of the government of India and Assam Oil, Ministry of Mineral and Petroleum, government of Assam and Engineers India. It opened in 1999.

The Numaligarh Refinery Limited was dedicated to the nation by the erstwhile Hon'ble Prime Minister Shri A. B. Vajpayee on 9th July, 1999. NRL has been able to display creditable performance since commencement of commercial production in October, 2000. With its concern, commitment and contribution to socio-economic development of the state combined with a track record of continuous growth, NRL has been conferred the status of Mini Ratna PSU.

As of 2014, it had a capacity of 3 million metric tonnes per year. In January 2019, the Cabinet Committee on Economic Affairs approved plans to increase the refinery's capacity to 9 million metric tonnes per year.

Product range includes LPG Naphtha, Motor Spirit (MS), Aviation Turbine Fuel (ATF), Superior Kerosene Oil (SKO), High Speed Diesel (HSD), Raw Petroleum Coke (RPC), Calcined Petroleum Coke (CPC), Sulphur & Petroleum wax.

## *CONTRIBUTON TO SOCIETY*

• Employment, education and skill development.

• Infrastructure and health care facility in nearby areas. (Hospital under NRL in Kanaighat)

• Sports and art development.

## *VISION 2030 AND EXPANSION PROJECT*

• NRL is a key driver in Northeast hydrocarbon vision 2030.

• NRL is undergoing a major expansion project for 3MMTPA to 9 MMTPA, the additional quantity of crude oil is planned to be imported through Paradip Port in Odisha. For this pipeline will be installed cross country. Rs.28,026Cr project.

• This project will be helpful for other NE refineries.

## *NEW PROJECT*

• Ethanol from Bamboo. Products- ethanol, acetic acid, furfural.

• Bamboo because, it is one of the major non-food biomass resources available in NE.

• Availability in NE- 66 million ton and requirement is 0.5 million ton per year.

# ASSAM CRUDE

Crude oil was discovered in Assam in late 19th century. Digboi is known as the Oil City of Assam where the first oil well in Asia was drilled. Presently it accounts for almost 15% of the total crude of India. Physio-Chemical characteristic of Assam Crude Oil is as follows:

| Sl. No | Characteristic | Result |
|---|---|---|
| 1 | Density at 15.6 °C, gm/ml<br>Specific density at 15.6 °C<br>API gravity at 15.6 °C | 0.8735<br>0.8739<br>30.3 |
| 2 | Pour point,°C | +24 |
| 3 | Kinematic viscosity, cst at 40 °C<br>Kinematic viscosity, cst at 50 °C | 7.46<br>45.2 |
| 4 | Vapour pressure at 37.8 °C<br>Vapour pressure at 50 °C | 3.0<br>5.0 |
| 5 | Water content , %vol (D&S) | 2.05 |
| 6 | B.S & W, %vol | 2.30 |
| 7 | Salt content, ppm | 8.7 |
| 8 | Sediment by entrance, %wt | 0.245 |
| 9 | Sulphur content, %wt | 0.25 |
| 10 | Wax content, %wt | 9.8 |
| 11 | Carbon residue, %wt | 1.45 |
| 12 | Ash content, ppm | 8.1 |
| 13 | Asphaltenes, %wt | 0.20 |

| Sl.No | Characteristic | Result |
|---|---|---|
| 15 | Inorganic acidity, mg KOH/gm | Nil |
| 16 | Nitrogen, ppm | 1028 |
| 17 | TAN, mg KOH/gm | 0.161 |
| 18 | RCH, %wt | 1.21 |
| 19 | ASTM distillation | 58 |
| 20 | Characteristic factor, K (VOP) | 11.62 |
| 21 | Trace metals, ppm<br>Magnesium<br>Sodium<br>Potassium<br>Iron<br>Copper<br>Nickel<br>Vanadium<br>Cadmium | <br>0.4<br>19<br>2.4<br>3.8<br>0.25<br>0.3<br><0.1<br>5.6 |

# FIRE & SAFETY

## *INTRODUCTION*

Fire is a rapid, self-sustaining oxidation process accompanied by the evolution of heat and light of varying intensity. Fire results from the combination of fuel, heat and oxygen. When fuel is heated to a certain critical temperature called the 'Ignition Temperature', it will ignite and continue to burn as long as there is fuel, proper temperature and supply of oxygen (air). This is typically represented by Fire Triangle. Combustion processes are exothermic and rate of heat release is rapid enough to sustain continuous reaction. Uninhibited combustion chain reaction is essential for the fire to continue. Fighting a fire is actually the process of breaking up the chain reaction. This could be achieved by taking out heat - cooling, taking out fuel – starvation or by taking out oxygen - smothering. Breaking up the chain reaction by chemical flame repression will extinguish the fire. An oil Refinery handles highly inflammable liquid and gas at high temperature and pressure. Many of these substances will ignite spontaneously on contact with air. Therefore protection against fire is almost important in the refinery. Many of the refinery fires are caused due to non-compliance of established procedure and recognized practices

Figure 1 Boiler Suit

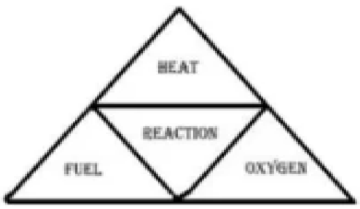

Figure 2 Fire triangle

Figure 3 Safety gloves

Figure 4 Safety helmet

# *THE FIRE TRIANGLE*

For extinguishing fire, removal of any of these components is essential. Removal of heat is called Cooling, limitation of O2 is called Smothering and removal of fuel is called Starvation. One more method of fire extinguishing is chemical interference which interrupts the chain reaction of fire. Keeping in view the serious consequences due to fire in any area of refinery installation, "Fire Protection" is the key objective. Care should be taken to prevent the occurrence of fire rather than extinguishing it after it occurs.




The occurrence of fire can be prevented if we don't allow formation of fire triangle by eliminating at least one of its sides.

## DIFFERENT FIRE FIGHTING AGENTS

- Water
- Steam
- Foam
- Dry chemical powder
- CO2
- Sand and Blanketing

## SOURCES OF IGNITION

- Electrical equipments: sparks from motor, lamps, electrical defects etc.
- Friction: hot bearings, misaligned or broken machine parts.
- Open flames: cutting and welding torches, gas & oil burners.
- Smoking or matches: smoking booths, areas where combustibles are stored.
- Spontaneous ignition: Pyrophoric iron is the main source. Hot oil leakage etc. also plays as an important source.
- Hot surfaces: Contact of combustible material with hot surfaces, heated lines acts as an source too.
- Lighting: Bad weather such as thunder storm, cloud burst etc. are also an important source of ignition.

## *SAFETY, HEALTH AND ENVIRONMENT POLICY (S, H&E)*

The Safety, Health and Environment policy was approved by the board of directors on 28.08.01. Its function is to establish and maintain good standards for safety of the people, the processes & the assets. It complies with all rules and regulations on safety, occupational health & environmental protections. It plans, designs, operate sand maintains all facilities, processes & procedures to secure sustained safety, health & environmental protection. It remains trained, equipped and ready for effective and prompt response in case of accidents and emergencies.

## *POTENTIAL REFINERY HAZARD FIRE & EXPLOSION*

- Because of highly inflammable nature of crude oil & various petroleum products, fire is a major hazard in a petroleum refinery.
- The occurrence of fire can be prevented if we don't allow formation of fire triangle by eliminating at least one of its sides.

The sources of ignition can be controlled to some extent by proper guarding & a number of other means such as

- Matches, lighters, mobile phones or any other spark producing item should never be taken inside the refinery complex.
- All hot work should be carried out under fully authorized "Hot Work" permit & all specific conditions should be met.
- Smoking is strictly prohibited in all areas of refinery except in authorized smoking booth.

# CRUDE DISTILLATION UNIT

***OBJECTIVE*:** To distil the raw crude into various fractions depending on boiling point ranges.

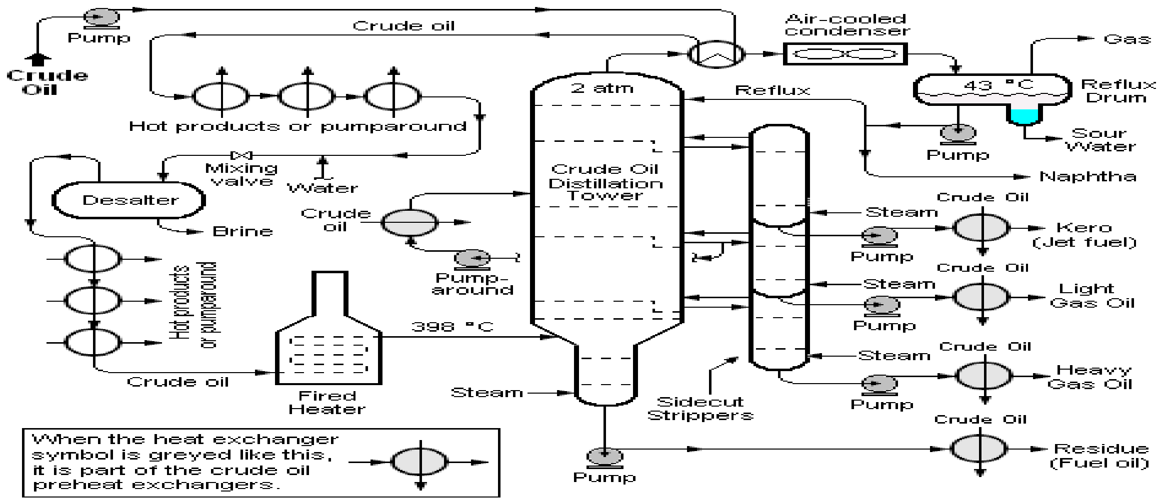
***CAPACITY*:** 0.75 MMTPA to 1.15 MMTPA

***FEED*:** Raw crude

***PRODUCT* :** LPG, Light Naphtha, Reformate Naphtha, Heavy Naphtha, Stabilised Gasoline, Kero I, Kero II, Gas Oil, Reduced Crude Oil.

## INTRODUCTION

The crude distillation unit is the mother unit of the refinery. It has a Licensor capacity of IMMTPA. It is the first unit which receives the crude for processing. This unit consists of a series of heat exchangers as preheaters followed by a desalter. From the desalter, the crude enters the pre-topping column where ammonia, steam and Ahuralan are injected. The vapour goes to stabiliser while the liquid flows to the main fractionating column through an Atmospheric furnace. In the main fractionating column different fractions of petroleum are obtained on the basis of their boiling points.

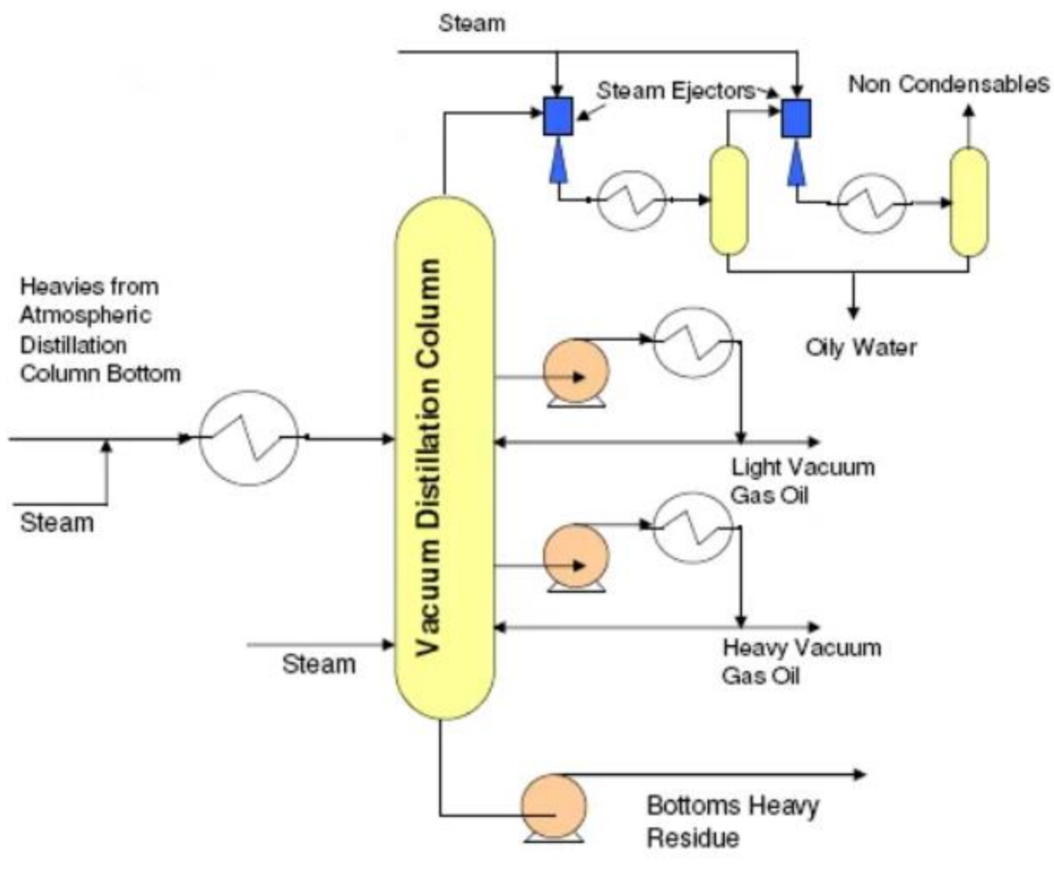


# VACUUM DISTILLATION UNIT

## *Process Description*

Hot reduce crude oil from the atmospheric column at 364 °C is mixed with slope recycle heated and Vaporized Vacuum Furnace and introduced into the flash zone of the Vacuum Column. The liquid portion of the feed drops into the bottom section of the column and is withdrawn as vacuum residue. The bottom temperature is kept at 350 °C to reduce the possible cracking during holdup in the column. The quenching is achieved by returning a quench stream to the lower at a temperature of 254 °C after the heat exchange between vacuum residue and crude. The vaporized portion rises up the tower and is fractionated into the five side stream products. Slope distillate cut is withdrawn as the first side draw product along with the recycle which is pumped back to the inlet of the vacuum furnace through the slope distillate and the recycle pumps. The slope cut is mixed with Vacuum residue which helps to achieve the quality of the HCU (Hydrocracker Unit) feed. The vapours rising from the wash zone passes through the demister bed to ensure the removal of entrained asphaltenes. The hydrocarbon vapour is condensed in the HVGO ( High Vacuum Gas Oil), LVGO (low Vacuum Gas Oil) and Vacuum diesel sections by circulating refluxes. HVGO internal reflux and circulating reflux are withdrawn as the second side stream from the vacuum column. HVGO internal reflux is pumped back into the vacuum column, while the crude in the exchangers are preheated by the circulating refluxes. The third stream drawn is the MVGO (Medium Vacuum Gas Oil) circulating reflux. MVGO internal reflux is returned to the MVGO section through the MVGO and IR pumps. The fourth side stream withdrawn from the vacuum column is the LVGO internal reflux and the circulating reflux, where the internal reflux is returned to the top of the LVGO section through the LVGO and IR pumps. Vacuum diesel product and the circulating reflux is the fifth side stream withdrawn from the vacuum column. Vacuum diesel circulating reflux is returned to the vacuum column. Vacuum diesel product then joins the gas oil product coming from the gas oil air cooler and further gets cooled in the gas oil trim cooler before being sent to the offsite storage.

LVGO, MVGO and HVGO products are withdrawn through separate pumps from the vacuum column. LVGO product is pumped by LVGO product pumps to the vacuum product cooling section. MVGO product is pumped by MVG product pumps to exchange heat with crude oil in heat exchangers. Hot MVGO product is also used to heat desalting water in exchangers before being routed into the vacuum product cooling system. Similarly HVGO product is pumped by the HVGO product pumps and the process is similar to the pumping of the MVGO product. Slope distillate and recycle is withdrawn from the vacuum column to slope distillate drum. In order to prevent the cracking of hydrocarbons, the slope distillate drum is provided to minimize the residence time of the product. Vacuum Residue is withdrawn from the Vacuum Column bottom by Vacuum Residue Pump. Vacuum is maintained by the two-stage ejector system with surface condensers, vacuum column overhead vapour flows to the pre-condensers where steam and condensable are condensed out. The discharge from the first stage goes to the inter condenser and the no condensed vapour are sent to the second stage. The discharge of the second stage goes to the after condenser and the non-condensable are routed to up stream, and the condensate is routed to the hot well, where oil and sour water interphase separate.



# DELAYED COKING UNIT

*OBJECTIVE*: To recover LPG and other useful fractions from Reduced Crude Oil and to produce coke.

*CAPACITY*: 0.44 MMTPA

*FEED*: Reduced Crude Oil

*PRODUCT*: LPG, Coker Gasoline, Coker Kerosene, Coker Gas Oil, Coker Furnace Oil, Reduced Fuel Oil and Petroleum Coke.

## *THEORY OF COKING*

During Processing of Crude Oil in the Crude Distillation Unit, Hydrocarbon fractions of different boiling ranges are separated out. These fractions are LPG, Gasoline, Kerosene separated out. These fractions are LPG, Gasoline, Kerosene, Gas Oil and Reduced Crude, obtained from the fractionating column of Distillation Unit. The heavier hydrocarbon fraction, obtained as Reduced Crude Oil (also called long residue) at the bottom of the fractionating column is of less value. It is therefore, required to subject the heavier hydrocarbon (Reduced Crude) to still higher temperature (around 495 °C) to crack the heavier ends for producing the lighter ends. At this temperature the larger hydrocarbon molecules of high boiling ranges are thermally decomposed to smaller low boiling molecules thereby producing lower boiling light and middle distillates such as Gas, Gasoline, Kerosene, Gas Oil and at the same time, some of the molecules which are reactive, combine with one another giving even larger molecules than those present in the original stock forming Residual Fuel Oil and petroleum coke. The phenomenon or the process under which the above changes in the molecular structure of the hydrocarbons take place, is known as Thermal Cracking or more precisely Coking. The coking process therefore involves two types of reactions.

- Primary Reaction
- Secondary Reaction

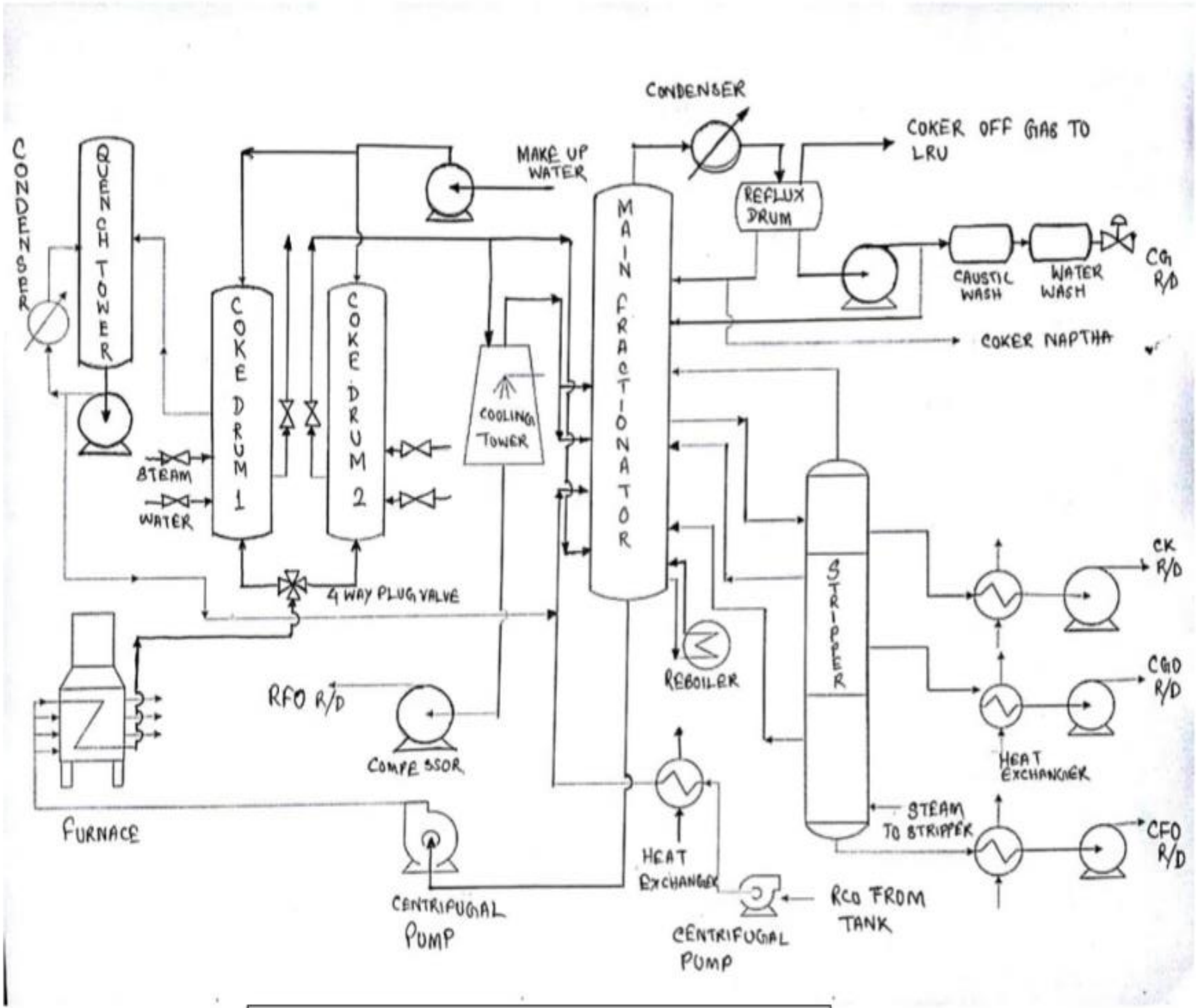



FIG-4 : FLOW DIAGRAM OF DELAYED COKING UNIT

# HYDROGEN UNIT (HGU)

*OBJECTIVE*: Supply hydrogen to hydrotreating unit and ISOSIV unit.

*CAPACITY*: 10000TPA

*FEED*: Straight Run Naphtha

## *INTRODUCTION*

The hydrogen unit consists of Desulfurization, Pre-reforming, Reforming and process gas cooling and High temperature / Low temperature shift conversion sections to increase the hydrogen content of the process gas. Purification is done with a PSA Unit. The feedstock to the Hydrogen unit is LRU off gas and Naphtha feed. (LRU off gases are not used because it does not suit this unit). The hydrogen generation is based on steam reforming technology of KTI using a mixture of LN (SRN)and off gases ex-LPG reformer unit (LRU) as primary feed. For achieving the required feed flexibility a pre-reforming step is applied upstream the reforming using Kvaerner's technology. For the purification of low hydrogen after the shift conversion, pressure swing adsorption (PSA) process applied to produce the high purity hydrogen product.

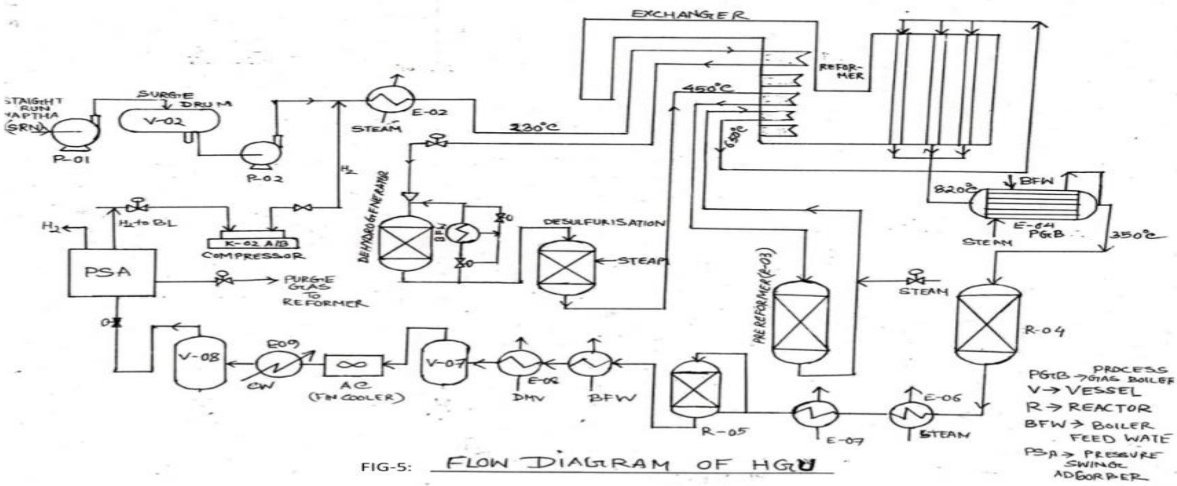



FIG-5: FLOW DIAGRAM OF HGU

# HYDROGEN CRACKING UNIT (HCU)

*OBJECTIVE*: Objective of hydrocracking unit is to produce middle distillate fuel of superior quality.

*CAPACITY*: 0.6 MMTPA

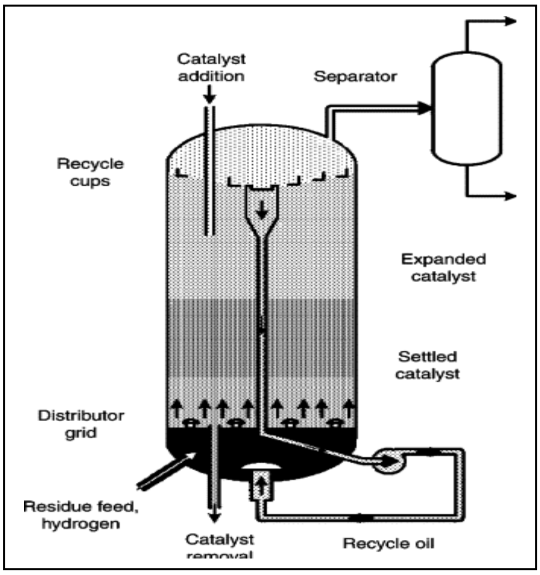
*FEED*: Diesel feed (SRK II, SRGO, CK-I, CGO)

*PRODUCT:*

- LPG
- Stabilize light naphtha
- Heavy naphtha
- Kerosene (ATF)
- HSD

*INTRODUCTION*

Two stage hydrocracking unit is being constructed in Numaligarh in Assam. Feed to the unit consists of Vacuum gas oil from VDU, coker distillate from delayed coker unit (DCU) and Hydrogen. Feed rate = 1.45mm metric tons/year Objective of hydrocracking unit is to produce middle distillate fuel of superior quality. Bi-product from this unit are: -




1. Unconverted oil bleed
2. Turbine condensate
3. Sour water from sour water strippers
4. Reaction section recycle gas bleed

# SULFUR RECOVERY UNIT

***OBJECTIVE*:** For cleaner environment.

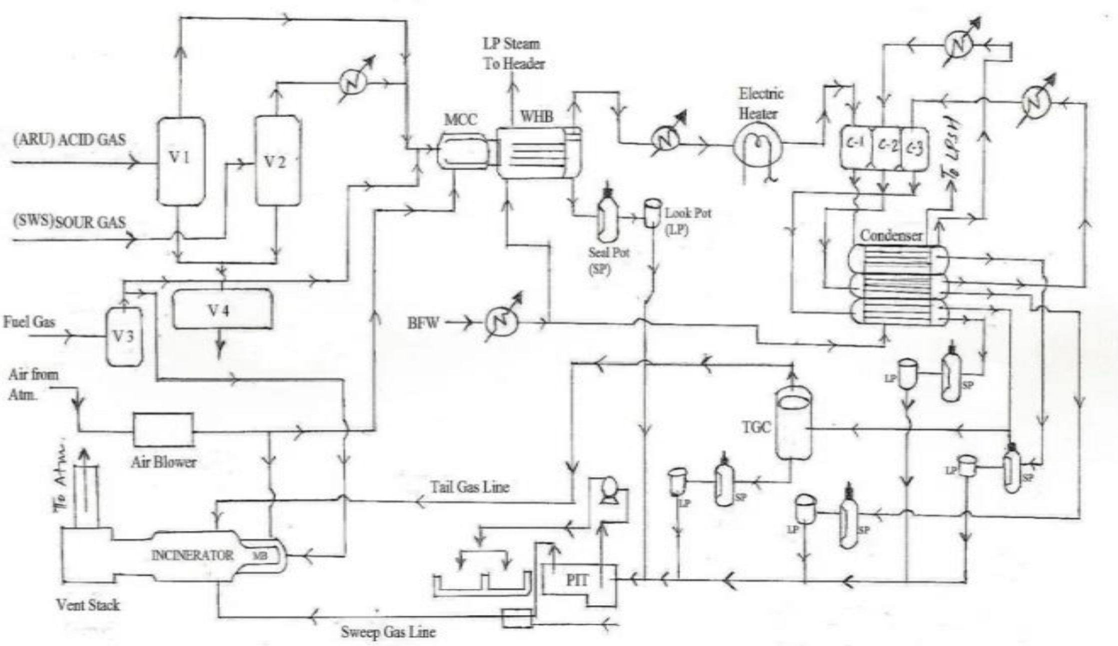
***CAPACITY*:** 5 MT/Day of sulphur.

***FEED*:** Off gases from DCU & HDT (via ATU)

***PRODUCTS*:** Elemental sulphur.

## *PROCESS DESCRIPTION*

The process design of SRU is based on 3 stage modified Claus process. This process consists of one thermal stage (Main combustion chamber) and 3 catalytic stages (Catalytic converter). 96 %( min) sulphur recovery is achievable from this configuration. Acid gas from Amine Regeneration Unit (ARU) and sour gas from Sour Water Stripper (SWS) are fed to SRU. In SRU, H2S present in feed gas is converted to elemental Sulphur.




NOMENCLATURE: V 1, 2, 4 - Surge vessels; ARU - Amine Recovery Unit; SWS - Sour Water Stripper; MCC - Main Combustion Chamber; WHB - Waste Heat Boiler; C 1, 2, 3 - Converters; LP Steam - Low Pressure Steam; LPSH - Low Pressure Steam Header; MB - Main Blower, BFW - Boiler Feed Water. TGC - Tail Gas Coalescer; V 3 - Knock Out Drum

# PUMPS

Pumps can be broadly listed under two categories:

- Non-positive displacement (dynamic) pumps
- Positive displacement pumps.

## 1) *Dynamic (nonpositive displacement) pumps.*

- This type is generally used for: low-pressure, high-volume flow applications. In these pumps the fluid is pressurized by the rotation of the propeller and the fluid pressure is proportional to the rotor speed. These pumps cannot withstand high pressures and generally used for low-pressure and high-volume flow applications. The important advantages of nonpositive displacement pumps are lower initial cost, less operating maintenance because of less moving parts, simplicity of operation, higher reliability, and suitability with wide range of fluid etc.
- These pumps are primarily used for transporting fluids and find little use in the hydraulic or fluid power industries.
- The two most common types of dynamic pumps are :-
    i. the centrifugal pump
    ii. the axial flow propeller pumps

## 2) *Positive displacement pumps.*

- This type is universally used for fluid power systems.
- A positive displacement pump ejects a fixed amount of fluid into the hydraulic system per revolution of pump shaft rotation.
- Such a pump can overcome the pressure resulting from the mechanical loads on the system as well as the resistance to flow due to friction. These are two features that are desired of fluid power pumps.

- These pumps have the following advantages over nonpositive displacement pumps:
    i. High-pressure capability (up to 12,000 psi)
    ii. Small, compact size
    iii. High volumetric efficiency
    iv. small changes in efficiency throughout the design pressure range
    v. Great flexibility of performance (can operate over a wide range of pressure requirements and speed ranges).

# CENTRIFUGAL PUMP

A centrifugal pump is a mechanical device designed to move a fluid by means of the transfer of rotational energy from one or more driven rotors, called impellers. Fluid enters the rapidly rotating impeller along its axis and is cast out by centrifugal force along its circumference through the impeller's vane tips. The action of the impeller increases the fluid's velocity and pressure and also directs it towards the pump outlet. The pump casing is specially designed to constrict the fluid from the pump inlet, direct it into the impeller and then slow and control the fluid before discharge.

The impeller is the key component of a centrifugal pump. It consists of a series of curved vanes. These are normally sandwiched between two discs (an enclosed impeller).

*Figure 1. Impeller Types (l to r): Open, Semi-Enclosed (or Semi-Open), Enclosed.*

Fluid enters the impeller at its axis (the 'eye') and exits along the circumference between the vanes. The impeller, on the opposite side to the eye, is connected through a drive shaft to a motor and rotated at high speed (typically 500-5000rpm). The rotational motion of the impeller accelerates the fluid out through the impeller vanes into the pump casing.

There are two basic designs of pump casing: volute and diffuser. The purpose in both designs is to translate the fluid flow into a controlled discharge at pressure.

In a volute casing, the impeller is offset, effectively creating a curved funnel with an increasing cross-sectional area towards the pump outlet. This design causes the fluid pressure to increase towards the outlet.

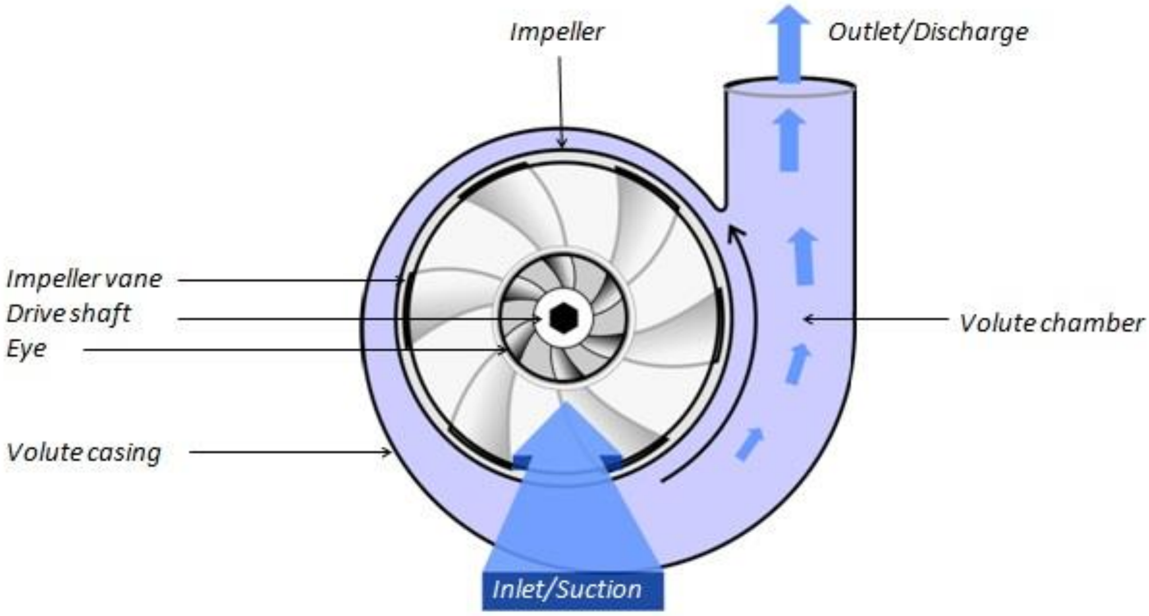



*Figure 2. Volute case design*

Most pumps are equipped with ball bearings. Typical construction consists of single rows of deep-grooved ball bearing of ample size to withstand axial and radial loads. The bearing housing may be of the rotating type, so that the entire rotating element can be removed from the pump without disturbing the alignment or exposing the bearings to water or dirt. The bearing housing may be positioned by means of dowel pins in the lower portion of the casing and securely clamped by covers split on the same plane as the pump casing. Then the entire bearing can be removed from the shaft without damage by using the sleeve nut as a puller. However, single ball bearings are an exception. Most pumps today are provided with double ball bearings.

## MECHANICAL SEAL USED IN CENTRIFUGAL PUMPS

Mechanical seals are critical components in centrifugal pump systems. These devices preserve the integrity of the pump systems by preventing fluid leaks and keeping contaminants out. Mechanical seal systems are used on various seal designs to detect leakage, control the seal environment and lubricate secondary seals.

Depending on the pump type and the process variables, there are various mechanical seal types to choose from. Each seal variant has its unique design and characteristics which make it suitable for a specific application.

Mechanical seal failure has an effect on many different parts of a pump, including the pump shaft.

1. *SLEEVE / SHAFT WEAR*
   When mechanical seals fail, they tend to spin on the shaft, or shaft sleeve. Grooves are worn into the metal and require that the shaft or sleeve be replaced. Once they're worn, they shouldn't be re-used.

2. *GOUGING, DENTING, SCRATCHING OF SHAFT*
   In the case of a catastrophic failure and shattered seal faces, bits of tungsten, or silica carbide can gouge, dent, or scratch the shaft or the sleeve. Sliding a new seal over the damaged shaft surface will ruin the new O-ring on the seal, setting the seal up to fail from the start.

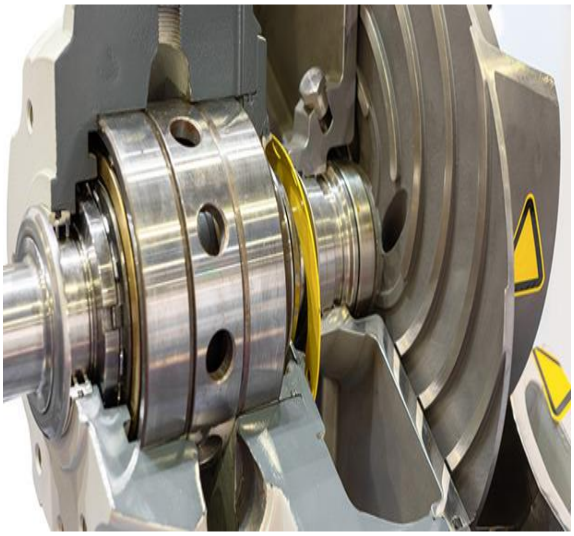
3. *CORROSION OF SEAL SHAFT*
   Over the course of a long term seal failure, where the seal is leaking or dripping small amounts of fluid, the shaft can become corroded and weaken.

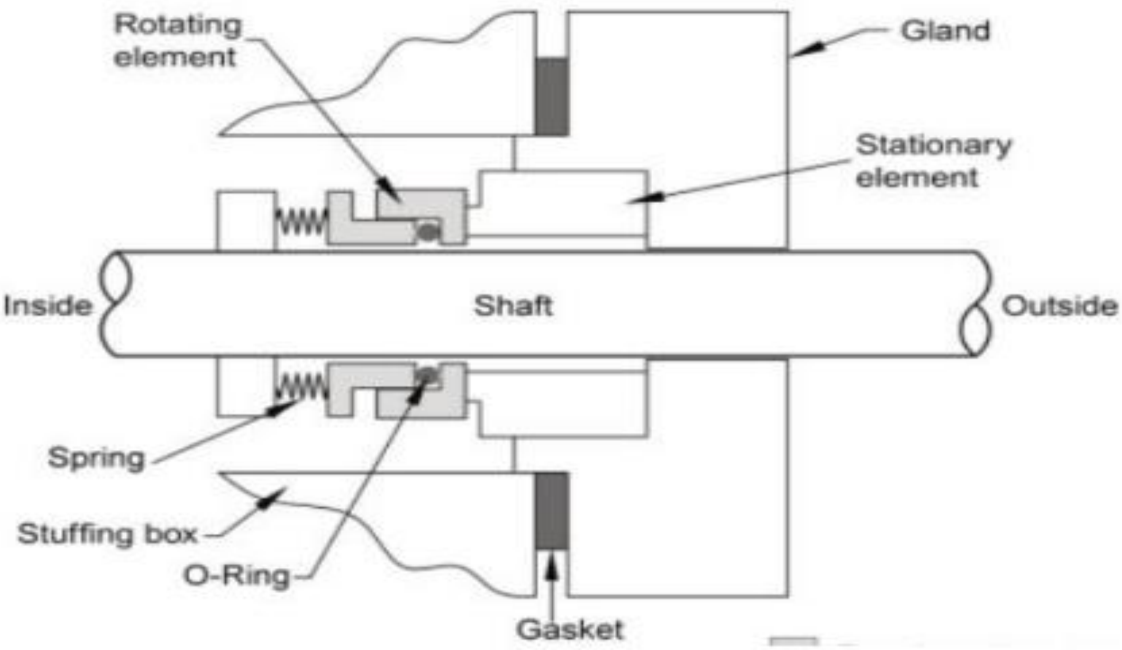
4. *FLASHING OR ETCHING*
   Flashing or etching occurs most often in situations where the fluid is very hot, or in a boiler feed application.

5. *FRETTING*

   Fretting is wear caused by movement of the mechanical seal. If the seal faces are damaged, or the seal is improperly installed, a great deal of movement will occur, causing fretting on the shaft.

If a mechanical seal has failed and damaged the pump shaft, it's best to just replace it. Continuing to use a damaged shaft or sleeve will cause more issues down the road, and will most certainly become a more costly repair.





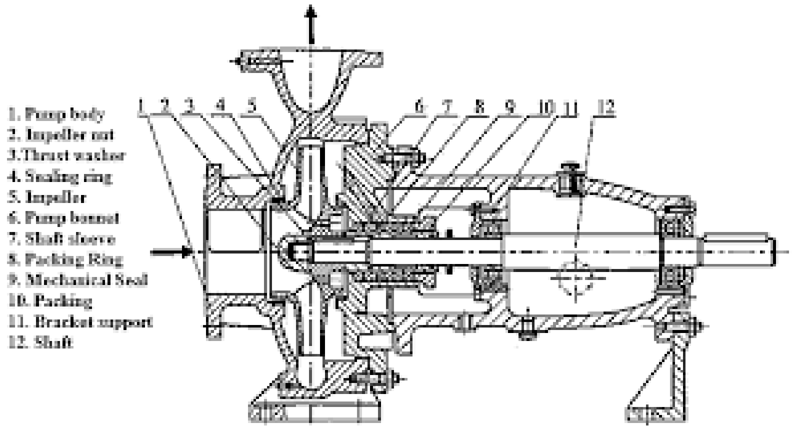
# *CAVITATION IN CENTRIFUGAL PUMPS*

Cavitation also called “Heart attack in pumps” occurs in centrifugal pumps when the Nett Positive Suction Head Available (NPSHa) is lower than the Nett Positive Suction Head Required (NPSHr) causing the formation and accumulation of bubbles around the impeller eye that then collapse resulting in a series of mini implosions and significant damage to both the impeller and the casing. If your pump sounds as though it is pumping marbles, then you probably have a cavitation problem (or marbles have got into your system). Other problems associated with cavitation are excessive vibration that will lead to premature failure of seals and bearings, higher power consumption and decreased flow and pressure.

Cavitation is a common problem but damage to impellers can be largely avoided with correct pump sizing, well designed pipework and routine maintenance of filters and strainers.

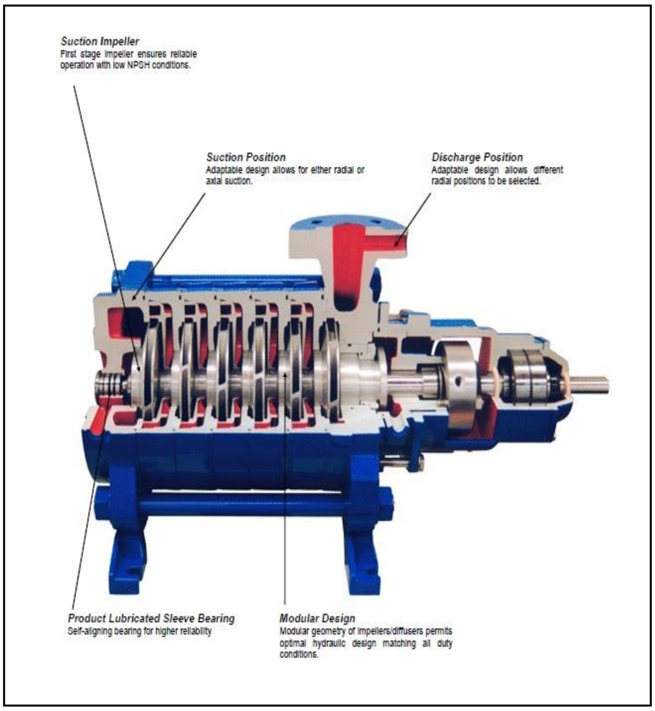
*Figure 2. Cavitation damage to an impeller*

# SINGLE STAGE CENTRIFUGAL PUMP




A single-stage centrifugal pump consists of one impeller rotating on a shaft within a pump casing which is designed to produce fluid flow when driven by a motor. It is one of the simplest designs of pumps available and many variations in design exist to satisfy the duty requirements of applications. It with a simple structure, stable performance, high speed, small volume, light weight, high efficiency, large flow, easy to operate and repair and so on. Single-stage centrifugal pumps are be classified as horizontal single-stage pumps, vertical single-stage pumps, single-stage single-suction centrifugal pumps, single-stage double-suction pumps.

# MULTI STAGE CENTRIFUGAL PUMP

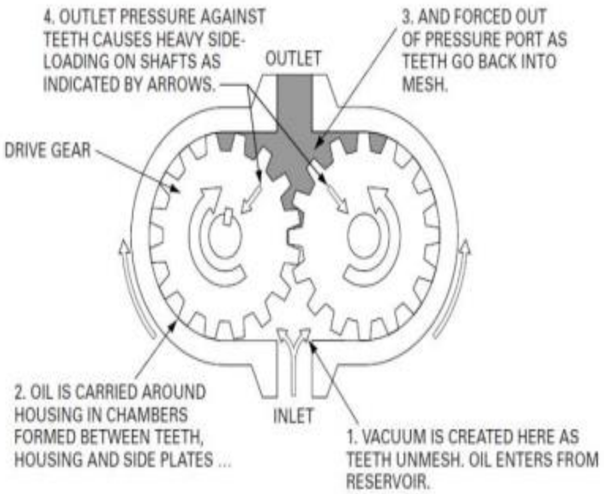



Multistage pump also is a kind of centrifugal pump which consists of the pull rod. The output water pressure of the pump can be very large. These pump types depend on the rotation of the impeller to obtain the centrifugal force. When the gas density reaches the working range of the mechanical vacuum pump, and it is drawn out. Then gradually obtaining a high vacuum. Multistage pump is by the pump chamber volume changes to achieve suction, compression and exhaust. Therefore, it is a centrifugal pump which can change the cubage.

# OTHER TYPES OF PUMPS

## 1. External Gear Pump

An external gear pump utilizes two identical gears meshed side by side, where one gear (driving) is driven by a motor, and it – in turn – drives the other gear (driven) driving gear driving the idle (driven) gear. Each gear is supported by a shaft with bearings on both sides of the gear. Fluid trapped between the gear teeth is transported from the inlet to outlet ports, with the gear mesh acting as a seal between the ports. In the external gear pumps the two gears mesh with each other in a close fitting housing. As the gears rotate, fluid fills the space between corresponding gear teeth and is carried from the inlet side to the outlet around the external circumference of the gears. Where the teeth mesh together, fluid cannot pass and so it is ejected through the outlet.



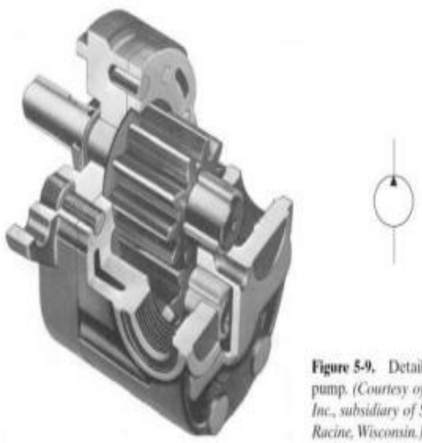
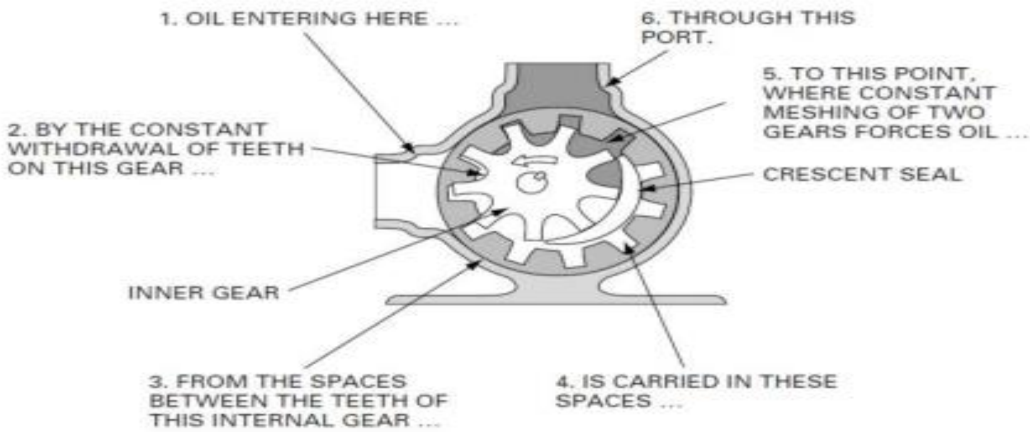



**Figure 5-9.** Detailed features of an external gear pump. *(Courtesy of Webster Electric Company, Inc., subsidiary of STA-RITE Industries, Inc., Racine, Wisconsin.)*

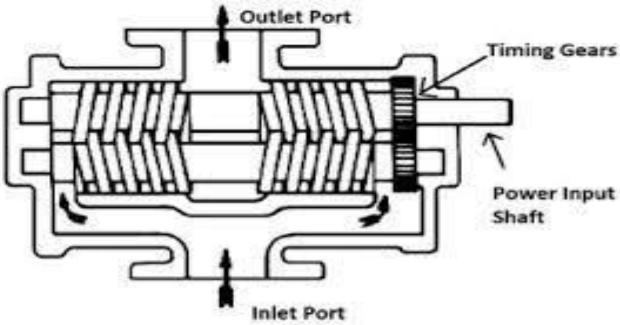
## 2. Internal Gear Pump

An internal gear pump utilizes two meshing gears with the outer (ring) gear typically driving the inner (idler) gear. Fluids trapped between the gears are transmitted from the inlet to the outlet port due to the rotation of the meshing gears, with the gear mesh typically acting as a seal between the ports. An internal gear pump will often use a crescent component to assist in the internal sealing of the gears.



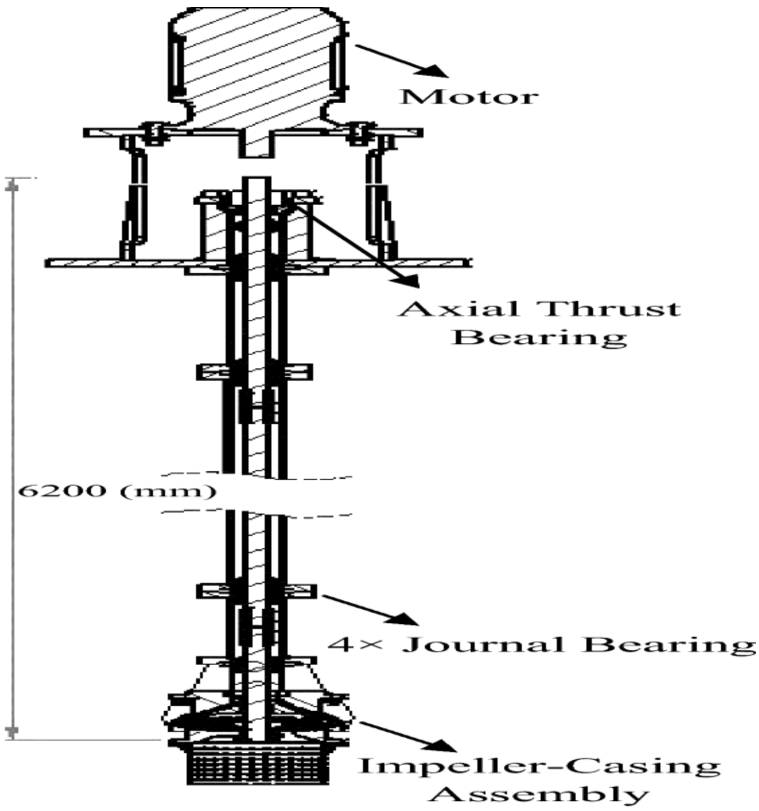

## 3. Screw Pump

A screw pump, also known as a water screw, is a positive-displacement (PD) pump that use one or several screws to move fluid solids or liquids along the screw(s) axis. In its simplest form, a single screw rotates in a cylindrical cavity, thereby moving the material along the screw's spindle. This ancient construction is still used in many low-tech applications, such as irrigation systems and in agricultural machinery for transporting grain and other solids.



## 4. Vertically Suspended Pump

Vertical pumps are designed similar to conventional pumps. Vertical pumps move liquids in the vertical direction upwards through a pipe known as the discharge pipe. The vertically suspended pumps have similarities to their horizontal counterparts. A casing called a volute contains an impeller mounted perpendicularly on an upright (vertical) rotating shaft. The electric drive motor uses its mechanical energy to turn the pump impeller with blades, and imparts kinetic energy to the liquid as it begins to rotate. These pumps can be single stage or multistage with several in-line stages mounted in series.



# <u>CASE STUDY – 1</u>

*Pump No.*: - 01-PA-020A

*Problem*: - Bearing problem

*Dimensions*: -

- *While Dismantling*
  - Radial runout: - 0.04
  - Radial play: - 0.15
  - Axial float: - 0.04
- *While Assembling*
  - Radial runout: - 0.01
  - Radial play: - 0.02
  - Axial float: - 0.02

*Observations*: -

- *In pump*: -

  i. Fretting was observed on the bearings.
  ii. Two studs of the casing were found broken.
  iii. The jacket was chocked due to deposit of dirt.
  iv. The O-ring is damaged.
  v. The bearing jacket is damaged.

- *In the mechanical seal*: -

  i. Minor scoring observed on the seal faces and bellow.
  ii. Throttle bush and screw found missing.

- Number of impeller vanes = 5

- *Bearing number*
    i. 7311 :- 2 nos.
    ii. NU311E :- 1 nos.

- Bare shaft runout = 0.03 (at impeller post )

- *Suction wearing* :-

    i. Impeller wearing, OD = 124.50 / 124.52
    ii. Casing wearing, ID = 125.40

    Clearance = 0.88

- *Discharge wearing* :-

    i. Impeller wearing, OD = 144.40 / 144.42
    ii. Casing wearing, ID = 145.02

    Clearance = 0.60

- *NDE*
    i. Side housing labyrinth, ID = 45.40
    ii. Shaft body labyrinth portion, OD = 45.00

    Clearance = 0.40

- *DE*
    i. Side housing labyrinth, ID = 45.66
    ii. Shaft body labyrinth portion, OD = 45.00

    Clearance = 0.66

- Throttle bush, ID = 51.18
  Sleeve bush, OD = 50.80

    Clearance = 0.38

*Items required for the job* :-

i. Bearing (7311) :- 2 nos.
ii. Bearing (NU311E) :- 1 nos.
iii. Throttle bush screws :- 2 nos.
iv. Studs :- 16 nos.
v. All seal packing :- 1 nos.
vi. Impeller locknut packing :- 1 nos.
vii. Sleeve packing :- 1 nos.
viii. Jacket O-ring :- 1 nos.
ix. Insert :- 1 nos.
x. Insert mounting :- 1 nos.
xi. Bearing locknut washer :- 1 nos.

*Actions taken* :-

i. Casing bolts given for machining
ii. New labyrinth , DE = 45.40

The entire pump is then reassembled and checked for leaks in the hydrotest with prescribed pressure.

# CASE STUDY – 2

*Pump No.:* - 03-PA-28

*Problem*: - Mechanical seal leakage.

*Dimensions*: -

- *While Dismantling*
  - Radial runout: - 0.07
  - Radial play: - 0.04
  - Axial float: - 0.01
- *While Assembling*
  - Radial runout: - 0.03
  - Radial play: - 0.02
  - Axial float: - 0.01

*Observations*: -

i. Dirt found in casing.
ii. Seal packing damaged.
iii. Crack observed on the inner periphery.
iv. Locknut and sleeve packing found flattened.
v. Gland gasket found flattened.
vi. Compression Unit seal face holding pin damaged.

- *Bearing number*

i. 7307 :- 2 nos.
ii. NU307EC :- 1 nos.

- *Suction wearing* :-

    i. Impeller wearing, OD (s) = 109.30 / 109.32
    ii. Casing wearing, ID = 110.04 / 110.00

    Clearance = 0.68

- *Discharge wearing :-*

    i. Impeller wearing, OD (d) = 109.52 / 109.50
    ii. Back plate wearing, ID = 110.20

    Clearance = 0.70

- *NDE*
    i. Side housing labyrinth, ID = 35.60
    ii. Shaft body labyrinth portion, OD = 35.00

    Clearance = 0.60

*Items required for the job :-*

i. Bearing (7307) :- 2 nos.
ii. Bearing (NU307EC) :- 1 nos.
iii. Impeller locknut packing :- 1 nos.
iv. Sleeve packing :- 1 nos.
v. Bearing housing O-ring :- 1 nos.
vi. All seal packing :- 1 nos.
vii. Oil seal (45x32x8) :- 2 nos.
viii. Casing gasket :- 2 nos.
ix. Seal face mating ring & seal ring :- 1 set.

*Actions taken*: -

The new mechanical seal had a slight oval instead of a round face which is because of manufacturing defect. The defect is confirmed using light bend testing machine.

The defect is rectified using the SpeedFam hand lap plate (400 mm) diameter plain which uses Silicon Carbide (SiC) as the abrasive.

The entire pump is then reassembled and checked for leaks in the hydrotest with prescribed pressure.

# CONCLUSION

I have been blessed with the best opportunity to do my summer training at Numaligarh Refinery Limited for the month of July. I got to explore the different units, see the various products with different properties of each product, their separation process, production processes, etc.

I am grateful to Numaligarh Refinery Limited for giving us this wonderful opportunity. I feel that I got the maximum out of this experience. Also, learnt the way of work in an organization, the importance of being punctual, the important of maximum commitment and the importance of team spirit. The main objective of the industrial training is to provide an opportunity to undergraduates to identify, observe and practice how engineering is applicable in the real industry. It is not only to get experience on technical practices but also to observe management practices and to interact with fellow workers. Last but not the least, I gained lots of knowledge and experience needed to be successful in a great engineering adventure.