“PROCESS DESIGN OF PETROLEUM REFINERY FOR PROCESSING 400,000 BARRELS OF CRUDE OIL PER DAY”

A Dissertation Submitted in Partial Fulfillment of the Requirement of the Award of the Degree of

BACHELOR OF TECHNOLOGY in CHEMICAL ENGINEERING

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CERTIFICATE

This is to certify that the work is being presented in the major project entitled, "*PROCESS DESIGN OF PETROLEUM REFINERY FOR PROCESSING 400,000 BARRELS OF CRUDE OIL PER DAY*". In partial fulfillment of the requirements for the award of degree of Bachelor on Technology in Chemical Engineering submitted in school of Chemical Engineering of Galgotias University, Greater Noida, is an authentic record of my work carried out under the supervision of Mr. Gagnesh

This is to certify that the above statement made by the candidates is correct and true to the best of my knowledge.

Mr. Gagnesh

(Professor)

ACKNOWLEDGEMENT

The completion of this undertaking could not have been possible without the assistance and participation of so many people. I take the opportunity to express my deep sense of gratitude and indebtedness to my esteemed supervisor **Prof. Gagnesh Sharma**, who helped enormously andalways inspired me by her indispensable guidance and encouragement during the whole long dissertation work. Her meticulous and valuable views, Constructive criticism, and tireless review of themanuscript have immensely helped me to improve the work, I am extremely thankful to her for her dedicated academics.

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The whole credit of my achievements goes to my parents who are always there for me in difficulties. It is their unshakable faith in me that always helped me to proceed further. Words fall insufficient to express my indebtedness to my friends for their constant support and encouragement I wish to extend a warm thank to all those who could not find a separate name but have helped directly or indirectly.

Date:

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PREFACE

The field of theory, provides only the fundamental stone for the guidance of practice but practice examines the element of truth lying in the theory therefore stand coordination between theories and practice is very essential to make a B. Tech project perfect.

Each & every activity is started for the accomplishment of goals & for this purpose realistic approach is required. A project is a systematic and scientific study of a problem with application of experimental skill and concepts.

I was assigned a project on "PROCESS DESIGN OF PETROLEUM REFINERY FOR PROCESSING 400,000 BARRELS OF CRUDE OIL PER DAY" in the field of "OIL AND GAS INDUSTRY"

Secondary is to share the practical knowledge and real experience in world of oil and gas industry. I hope the report will be special interest to the students who are on look for such real life situation beyond their class room study.

Chapter 1 includes a brief introduction of refinery and CDU and an overview of Indian oil industry and types of crude oil.

In, Chapter 2, we gave a literature review which also includes some of the environmental challenges.

Chapter 3 includes of material balance, energy balance, design of equipment.

Chapter 4, is about result and discussion in which experimental results obtained is included.

Chapter 5 includes concluded discussions by the experimental data. Also it includes scope of the refinery in the future.

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LIST OF SYMBOLS

SG_{oil}	Specific gravity of the crude oil
API	American petroleum institute
Bbl	Barrel
ρ	Density
D_s	Shell inside diameter
u_t	Tube-side velocity
A_o	Heat transfer area
D_s	Baffle spacing
Re	Tube-side heat transfer coefficient
RWM	Raw material
I.B.P	Initial boiling point
F.B.P	Final boiling point
Q	The heat liberated
LPG	Liquid petroleum gas
ΔT	temperature difference
N_{Tubes}	Number of tubes
L.N	Light naphtha
H.N	Heavy naphtha
Gal	Gallon
Re	Reynolds number
j_h	Heat transfer factor

CHAPTER 1

1. INTRODUCTION

Oil refining assumes a big process in our lives. Most transportation motors are managed with the aid of delicate gadgets, as an instance, gas, diesel, avionics turbine kerosene(ATK) and fuel oil. The continuing cost ascent of uncooked petroleum from $50 to $a hundred and fifty per bbl within the path of the maximum latest 2 years has inspired the refining commercial enterprise in 3 special ways: First is an expanded quest for gas gadgets from non-fossil sources, for example, biodiesel and alcohols from vegetable assets, 2d is the development of higher strategies to system tar sand, coal gasification and mix of energizes via Fischer–Tropsch (toes) innovation and 0.33 is the commencement of lengthy haul intends to search for inexhaustible electricity resources. Anyways, uncooked petroleum costs are as but a modest hotspot for transportation energizes and petrochemicals. Alternatively, stricter condition pointers have raised the fee of creating smooth powers. This spurred the search for developing clean energizes through non-everyday techniques, for instance, via surrounding desulphurization by means of fluid oxidants. Olefin alkylation and Fischer–Tropsch are different potential techniques for handing over clean energizes. New innovation and higher plan of treatment facility tools are additionally being created to be able to supply best and less cost fills.

1.1. PROBLEM STATEMENT

A distinguished u . S . Like India is one of the top oil ingesting nations within the international and consequently considered one of the largest crude oil importer inside the world. The u . S . A . Has eighteen refineries which has been under foremost demanding situations in terms of gold standard operations and dealing with environmental challenges due to the fact that modern-day technologies aren't implemented in those refineries.

These eventualities remain severe issues that want pressing interest. These refineries is nothing in comparison with the amount of crude oil we consume and what is obtainable in other countries like the America with over 2 hundred refineries in complete operations. Consequently, the need to enhance our processing potential and being self-reliant in refining and probably decreasing the overall price whilst redefining the environmental norms.

1.2. CRUDE DISTILLATION UNIT

1.2.1. Scope

Crude distillation unit (CDU) is at the front-finish of the treatment facility, otherwise called besting unit, or then again environmental refining unit. It gets high stream rates thus its size and working expense are the absolute biggest in the treatment facility. Numerous unrefined refining units are intended to deal with an assortment of unrefined petroleum types. In many treatment facilities, this procedure is completed in two phases. The oil is first warmed to the most extreme temperature admissible for the rough being prepared and for the activity being drilled and afterward took care of to a fractionating tower which works at marginally above environmental pressure. It yields a few distillate items and a bottoms item. This pinnacle is normally called the climatic pinnacle. Truth be told, modern refining sections don't give entirely sharp partitions. There are a few causal factors, for example, introductory estimations utilizing unrefined petroleum tests accept that all materials at a specific breaking point goes to some item, flawed partitions bring about light closures and overwhelming finishes "tails" in neighboring items and nearness of tails convolute the meaning of "cut point".

1.2.2. Processes in Crude Distillation Units

Crude units are the principal units that procedure oil in any processing plant. The goal is to separate the blend into a few parts like naphtha, lamp oil, diesel and gas oil. Raw petroleum is siphoned from capability to be warmed by using change in opposition to warm overhead and object aspect streams inside the Crude Unit. At a preheat temperature of around 200–250◦F water is infused into the rough to interrupt up salt this is typically present. The blend enters a desalter drum almost always containing an electrostatic precipitator. The salt water contained in the unrefined is remoted by techniques for this electrostatic precipitation. A chunk of the water stage from the drum is sent to a sourwater stripper to be cleaned before removal to the smooth water sewer. The unrefined petroleum leaves the desalter drum and enters a flood drum. A portion of the light closures additionally, any entrained water are flashed off in this drum and recommended straightforwardly to the refining tower streak quarter (they do not undergo to the radiator). The unrefined refining sponsor siphon takes pull from this drum and conveys the desalted unrefined sub-contemporary control to the terminated radiator via the relaxation of the warmth exchange educate. On leaving heat exchanger train, the unrefined petroleum is warmed in a terminated radiator to a temperature so that it will crumble the distillate items inside the rough pinnacle. The warmed unrefined enters the fractionation tower in a decrease region called the Flash area.'

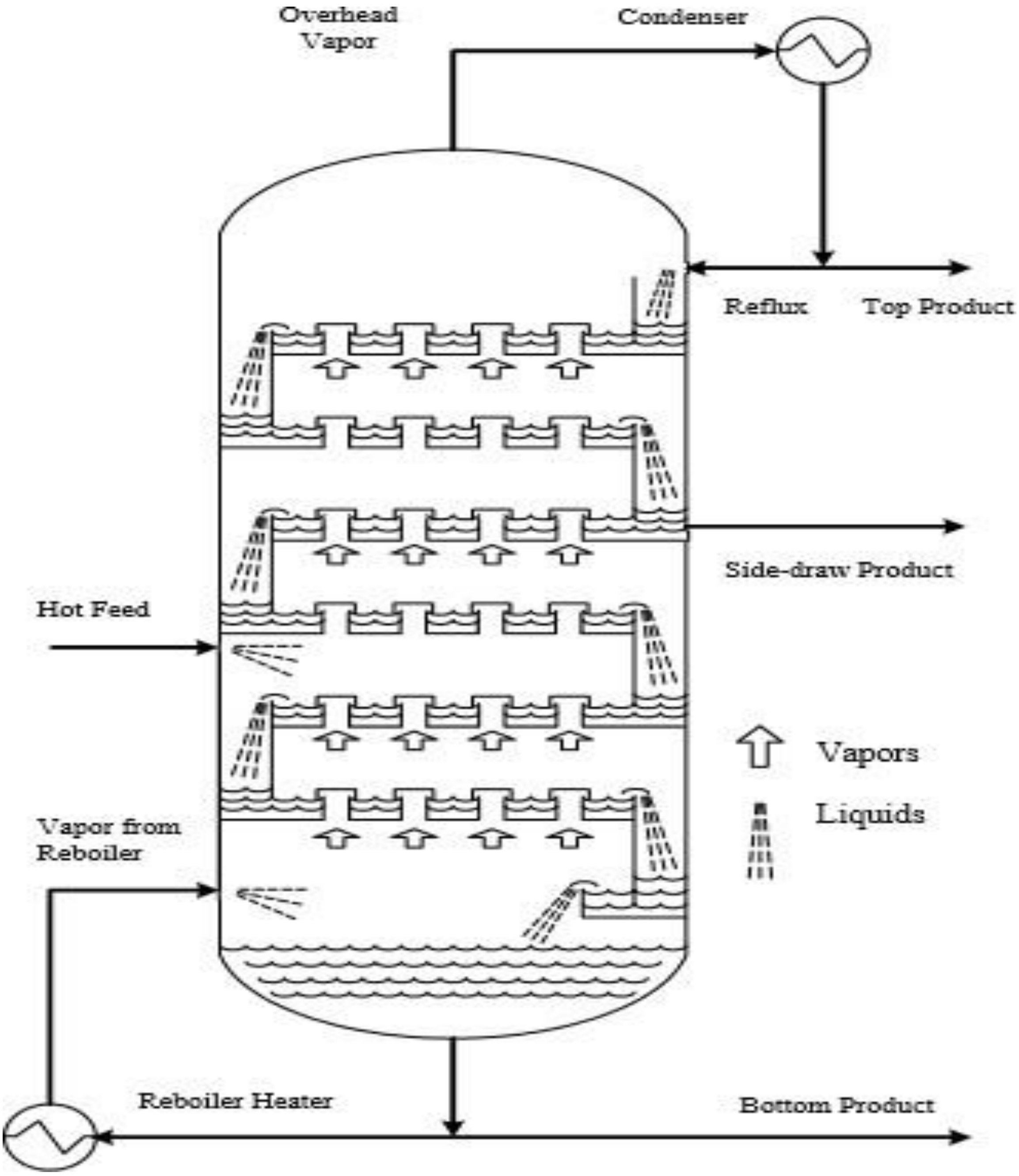


Figure1:- Distillation Tower

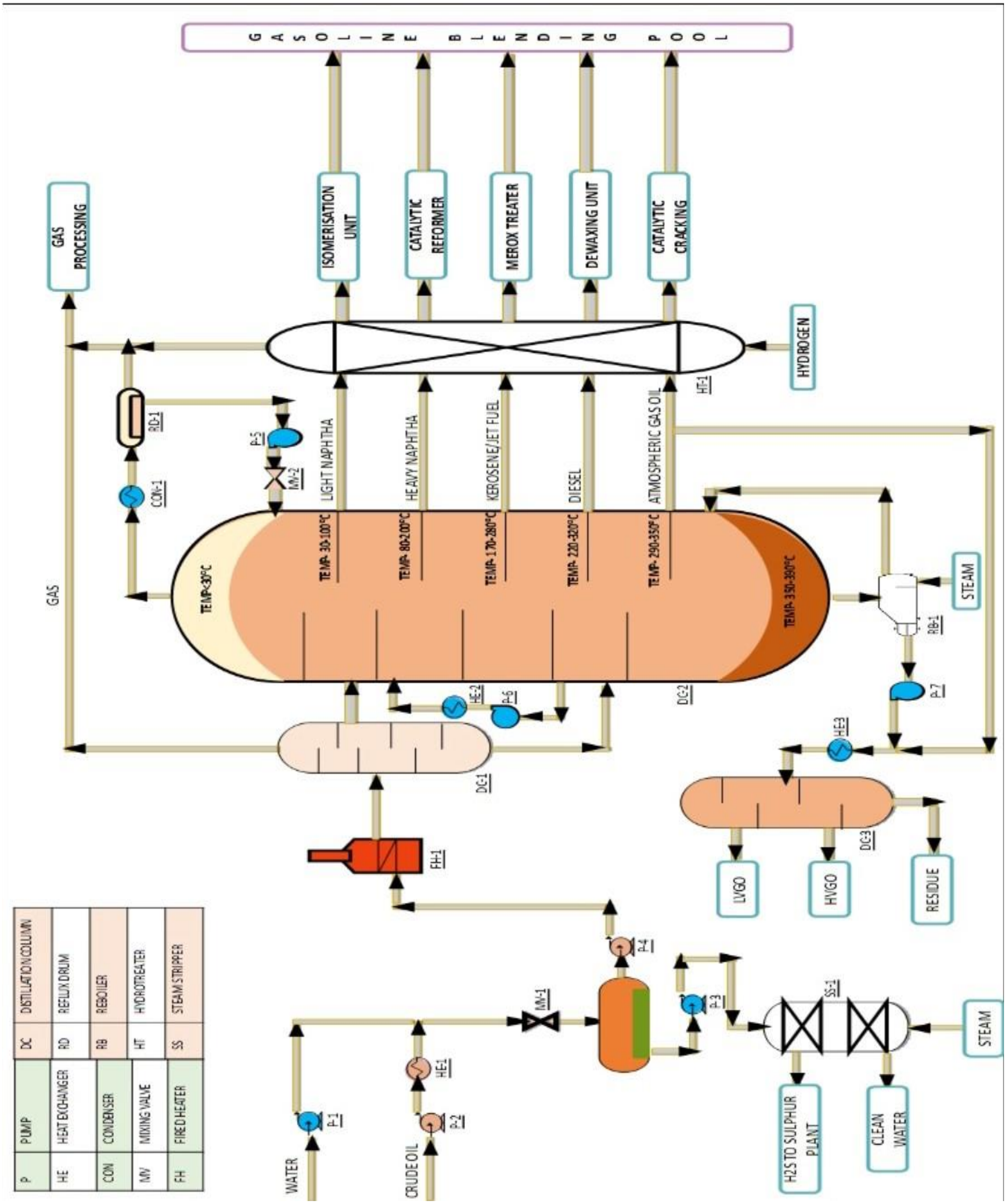


Figure 2:- Process Flow Diagram of Petroleum Refinery

Fraction	Approx. °C	Boling Range ^{o}F	Next Destination	Ultimate Product(s)
LPG	-40 to 0	-40 to 31	Sweetener	Propane fuel
Light Naphtha	39 to 85	80 to 185	Hydrotreater	Gasoline
Heavy Naphtha	85 to 200	185 to 390	Cat. Reformer	Gasoline, Aromatic
Kerosene	170 to 270	340 to 515	Hydrotreater	Jet fuel, No. 1 diesel
Gas Oil	180 to 340	350 to 650	Hydrotreater	Heating Oil, No. 2 diesel
Vacuum Gas Oil	340 to 566	650 to 1050	FCC Hydrotreater Lube plant Hydrocracker	Fuel oil, FCC feed, Lube basestock, Gasoline, jet, diesel

Table 1:- Destination for Straight-Run Distillates

i. **Refinery gas**- Made up of methane and ethane. This stream remains a gas and is used as fuel for the refinery.
ii. **Light ends** - Stream containing primarily propane and butane.
iii. **Light straight run naphtha**- Sold as a feedstock for petrochemicals, mixed straightforwardly into fuel or redesigned through isomerization..
iv. **Heavy naphtha**- Mostly overhauled through the reformer however some of the time mixed straightforwardly into fuel
v. **Kerosene**- jet fuel or blended into diesel
vi. **Atmospheric gas oil**- Used to make diesel or converted to gasoline through upgrading in the FCC
vii. **Atmospheric bottoms**- Contains all of the hydrocarbons that do not vaporize in the atmospheric distillation tower.

CHAPTER 2

2. LITERATURE REVIEW

During the study of process design for petroleum and petrochemicals refinery the research paper written by M. N. Idris (Ph.D.),on "*Design and Development of 15,000 Barrel per day (BPD) Capacity of Modular Crude Oil Refinery Plant(2018)"* which discusses the latest development in the field of oil industry and This report covers the fabric and energy balances across the important gadgets, the initial and detail design of the primary gadget, HAZOP research, environmental protection, as well as economic and profitability evaluation of the plant. The predicted products consist of; kerosene, gasoline, diesel, heavy fuel oil (HGO), and lengthy product residue (LPR). It's miles a modular refinery because of its small processing potential in comparison to the traditional refinery.

However, "Multisite Refinery and Petrochemical network design: most appropriate Integration and Coordination" written with the aid of okay. Al-Qahtani and A. Elkamel discusses the layout of top-quality integration and coordination of a refinery and petrochemical network
To meet given chemical products call for. The remedy facility and petrochemical frameworks have been displayed as a blended quantity issue in with the intention of restricting the annualized price over a given time skyline a number of the processing plants and augmenting the additional estimation of the petrochemical organize. The principle spotlight of the paper is the development of a process for concurrent exam of technique arrange incorporation internal a multisite processing plant and petrochemical framework. This technique offers proper arranging over the oil refining and petrochemical industry and accomplishes a super advent system by means of allowing fitting change offs between the remedy facility and the downstream petrochemical markets. The proposed approach not just devises the combination arrange in the treatment facilities and integrates the petrochemical business, yet additionally gives processing plant extension necessities, creation levels, and mixing levels.

The paper written on "*Eco-efficiency analysis of desalination by precipitation integrated with reverse osmosis for zero liquid discharge in oil refineries"* by Av. Prof. Lineu Prestes explains the advantages and efficiency of ZLD system in petroleum refinery. Also, it has been demonstrated that the proposed situations were financially ideal. By methods for an eco-productivity examination, monetary, enthusiastic and ecological ramifications named to benefits on creating of concoction precipitation strategies for a high RO desalting recuperation in ZLD activities for fluid effluents of oil processing plants. It has likewise been discovered that some level of intercession may prompt an improvement of all eco-productivity pointers, however at some degree of mediation, probably a portion of the eco-effectiveness markers may turn out to be less great.

In the paper "*Dynamic scheduling of maintenance tasks in the petroleum industry: A reinforcement approach"* cited by N. Aissani explains the Maintenance of such extraordinarily automatized is crucial, no longer handiest to preserve production efficiency but also to insure minimum protection stages. Protection mission scheduling is difficult considering that some obligations are already recognized because they should be executed repeatedly, and different obligations need to be identified dynamically. "*The petroleum industry in oil-importing developing countries"* by F. Ghadar present an analytical study between various developing country including India, Argentina and Korea explaining the further development of crude oil processing units and technology.

The optimization of petrochemical and petroleum refinery were studied to investigate the possible opportunity to further increase the Pleasant of the very last product. In "*Optimization of separation of oil from oil-in-water emulsion by demulsification using different demulsifiers"*cited by V.K Rajak Investigated characterization of oil-in-water emulsion and eventually separation of oil from emulsion using specific chemical dimulsifiers. The effect of settling time, pH, temperature, and demulsifier dosage on oil separation efficiency has been studied. It turned into observed that as time, temperature, and chemical dosage increased oil separation efficiency multiplied. Droplet size distribution of emulsions illustrated that the demulsifier should lead to the breakup of crude oil-in-water emulsions by way of flocculation and coalescence. Extra than ninety eight% oil separations were discovered with some demulsifiers underneath premiere operating situations.

"Petroleum Refining Design and Applications Handbook" by A. Kayode Coker gives The maximum updated and complete coverage of the maximum enormous and latest modifications to petroleum refining, offering the brand new to the engineer, scientist, or pupil. It clearly explains the organic chemistry involved in the process. The refining process and consumption of optimum utility is explained in a lucid manner. Whereas, "*Petroleum refineryprocess economics"* discusses the major OPEX and CAPEX process. It includes the estimation for cash flow, payback period and depreciation period for the analysis of the overall economic.

CHAPTER 3

3.1 REFINING PROCESSES

3.1.1 Physical Separation Processes

i. Crude Distillation
Unrefined oils are first desalted and in a while acquainted with steam with an environmental refining section. The barometrical buildup is then acquainted with a vacuum refining tower running at around 50 mmHg, in which heavier items are acquired.

ii. Solvent Deasphalting
This is the primary bodily manner in which carbon is brushed off from giant oil element, as an instance, vacuum buildup. Propane in fluid shape (at slight weight) is typically used to collapse the entire oil, leaving asphal-tene to inspire. The deasphalted oil (DAO) has low sulfur and metallic substance since those are evacuated with asphaltene. This oil is additionally referred to as "vibrant stock" and is applied as feedstock for lube oil plant. The DAO can likewise be sent to splitting units to build light oil creation.

iii. Solvent Extraction
On this procedure, lube oil stock is handled via a dissolvable, as an example, N-methyl pyrrolidone (NMP), which can cut up the aromatic segments in a unmarried degree (extricate) and the remainder of the oil in some other phase(raffinate). The dissolvable is expelled from the two ranges and the raffinate is dewaxed.

iv. Solvent Dewaxing
The raffinate is damaged up in a dissolvable (methyl ethyl ketone, MEK) and the arrangement is little by little chilled, all through which high atomic weight paraffin (wax) is solidified, and the rest of the association is sifted. The extractedand dewaxed coming approximately oil is known as "lube oil". In a few reducing part treatment facilities expulsion of aromatics and waxes is completed by reactant paperwork in "all hydrogenation method".

3.1.2 Chemical Catalytic Conversion Processes

i. Catalytic Reforming
In this method an exceptional impetus (platinum metallic upheld on silica or silica base alumina) is applied to rebuild naphtha component (C6–C10) into aromatics and isoparaffins. The created naphtha reformate has an loads higher octane number than the feed. This reformate is utilized in fuel definition and as a feedstock for fragrant introduction (benzene–toluene–xylene, BTX).

ii. Hydrotreating
This is one of the massive methods for the cleaning of oil portions from pollutions, as an instance, sulfur, nitrogen, oxy-mixes, chloro-mixes, aromatics, waxes and metals utilizing hydrogen. The impetus is selected to fit the extent of hydrotreating and type of pollutants. Impetuses, as an example, cobalt and molybdenum oxides on alumina grid, are normally applied.

iii. Catalytic Hydrocracking
For better sub-atomic weight portions, for example, atmospheric residues (AR) and vacuum fuel oils (VGOs), breaking in the sight of hydrogen is needed to get mild objects. For this situation a double capacity impetus is utilized. It is made from a zeolite impetus for the breaking capability and unusual earth metals bolstered on alumina for the hydrogenation paintings. The fundamental objects are lamp oil, fly gasoline, diesel and gas oil.

iv. Catalytic Cracking
Fluid catalytic cracking (FCC) is the fundamental player for the creation of gas. The impetus for this situation is a zeolite base for the splitting capability. The precept feed to FCC is VGO and the object is fuel, but a few gas oil and processing plant gases are additionally created.

v. Alkylation
Alkylation is the manner wherein isobutane responds with olefins, as an example, butylene (C4) to create a gas run alkylate. The impetus for this case is both sulphuric corrosive or hydrofluoric corrosive. The hydrocarbons and corrosive respond in fluid level. Isobutane and olefins are collected essentially from FCC and deferred coker.

vi. Isomerization
Isomerization of mild naphtha is the process where low octane variety hydrocarbons (C4, C5, C6) are changed to a stretched item with a similar carbon number. This procedure creates excessive octane variety gadgets. One fundamental favorable position of this technique is to isolate hexane (C6) previously.

3.1.3 Thermal Chemical Conversion Processes

i. Delayed Coking
This method relies upon on the warm splitting of vacuum buildup thru carbon dismissal framing coke and lighter gadgets, as an example, gases, fuel and fuel oils. 3 forms of coke may be created: wipe, shot and needle. The vacuum buildup is warmed in a heater and flashed into big drums where coke is saved at the dividers of those drums, and the the rest of the items are isolated by means of refining.

ii. Flexicoking

In this heat technique, most of the people of the coke is gasified into fuel gasoline utilising steam and air. The ingesting of coke through air will deliver the warmth required to warm splitting. The gadgets are gases, gasoline and gasoline oils with nearly no coke.

iii. Visbreaking

That is a gentle warm splitting system used to interrupt the high thickness and pour purposes of vacuum buildup to the extent which can be utilized in in addition downstream processes. For this case, the buildup is either broken within the heater loop (curl visbreaking) or absorbed a reactor for multiple moments (soaker visbreaker). The objects are gases, fuel, gas oil and the unconverted buildup.

Element	Percent range
Carbon	83 to 85%
hydrogen	10 to 14%
nitrogen	0.1 to 2%
oxygen	0.05 to 1.5%
sulfur	0.05 to 6.0%
metals	<0.1%

Table2:- chemical elements of petroleum

Hydrocarbon	Average	Range
alkanes(paraffins)	13%	15 to 60%
naphthenes	49%	30 to 60%
aromatics	15%	3 to 30%
asphaltics	6%	Remainder

Table3- the percentage of hydrocarbons in petroleum

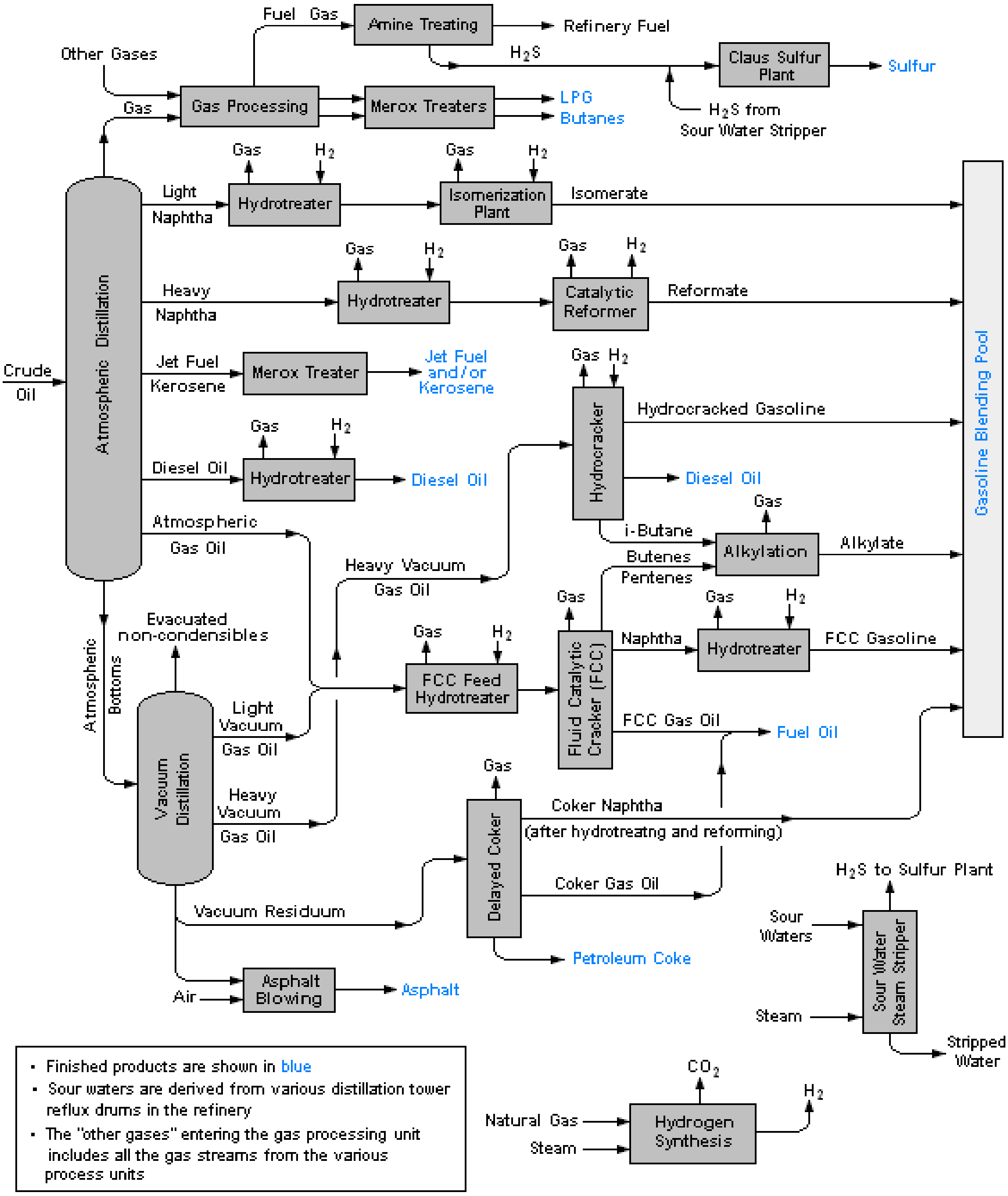


Figure 3:- Detailed PFD of a refinery including ADU and VDU units

3.2 API GRAVITY

API stands for the yankee Petroleum Institute, which is the principal united states of america trade courting for the oil and gaseous petrol industry. The API speaks to around 400 organizations within the oil enterprise and assists with setting principles for creation, refinement, and dissemination of oil based totally items. They additionally suggest for the enterprise. One of the most considerable norms that the API has set is the approach applied for estimating the thickness of oil. This popular is referred to as the API gravity.Precise gravity is a proportion of the thickness of one substance to the thickness of a reference substance, usually water. The API gravity is just the usual express gravity used by the oil business, which thinks about the thickness of oil to that of water through a be counted intended to assure consistency in estimation. Less thick oil or "light oil" is applicable over step by step thick oil because it carries greater noteworthy quantities of hydrocarbons that can be changed over to fuel. Oil is much less thick that water and in 1916, the U.S. Government organized the Baumé scale as the usual measure for any fluid much less thick than water. This, frequently, applies to oil. The really worth utilized in this scale become 141.Five (see computation beneath), but resulting checking out confirmed that,due to mistake, the real really worth have to be one hundred forty. The legislature changed the size to 140 to address the difficulty, but the usage of 141.5 had gotten so dug in the oil enterprise that the API selected to make the API gravity scale using the vintage estimation of 141.Five.API gravity is decided utilising the particular gravity of oil, that's simply the share of its thickness to that of water (thickness of the oil/thickness of water).

Precise gravity forAPI calculations is continually decided at 60 levels Fahrenheit. API gravity is located as follows:

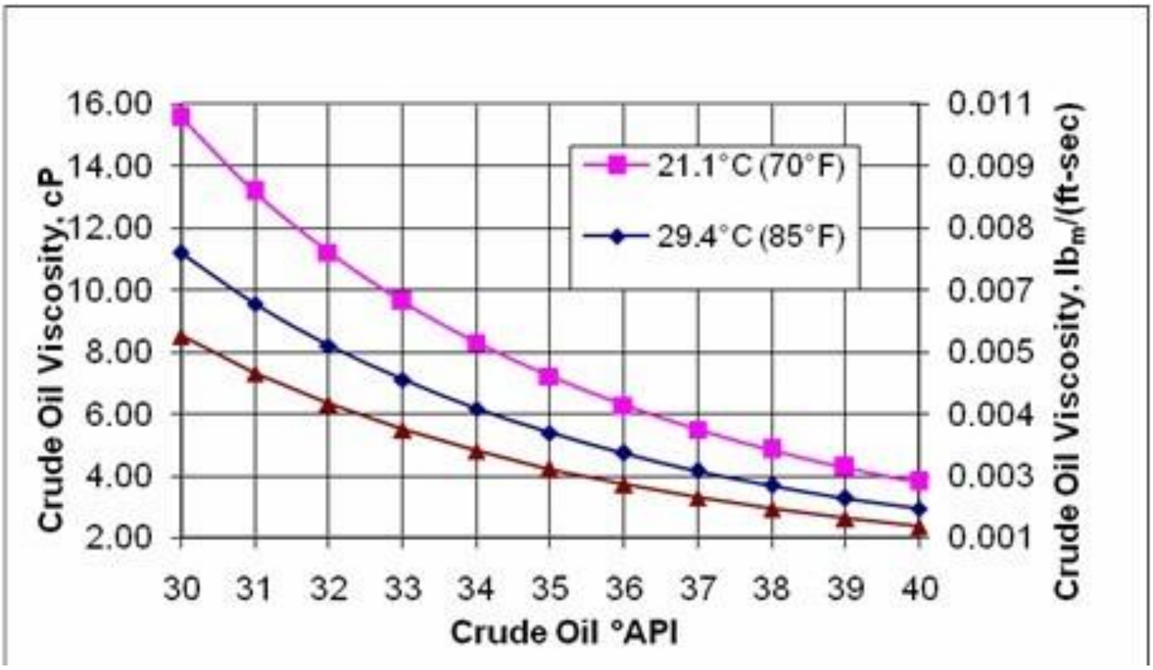
API gravity = (141.5/Specific Gravity) – 131.5

The API gravity is used to categorise oils as mild, medium, heavy, or greater heavy. As The “weight” of oil is the most important determinant of its market fee, API gravity is quite critical. The API values for every “weight” are as follows:

Light – API > 31.1
Medium – API between 22.3 and 31.1
Heavy – API < 22.3
Extra Heavy – API < 10.0

3.3 VISCOSITY

The viscosity of oil is a share of its protection from inner move and method that its greasing up traits, within the oil business it's far everyday to cite viscosity both in centistokes (which is the unit for kinematic thickness), and seconds Saybolt all inclusive, seconds Saybolt furol, or seconds Redwood. Those units had been related and such connections may be discovered in maximum statistics books. Inside the research facility, test statistics on viscosities is usually determined at temperatures of one hundred◦F, one hundred thirty◦F, or 210◦F. As a result of gasoline oils temperatures of 122◦F and 210◦F are applied.



Graph 1:- Variation of Crude oil viscosity with API & temperature

3.4 TYPE OF CRUDE OIL

The oil and gasoline enterprise in India goes returned to 1889 when the number one oil shops within the country were discovered close to the city of Digboi in the province of Assam. The flammable gas industry in India started out at some point of the Sixties with the revelation of gasoline fields in Assam and Gujarat. As on 31 March 2018, India had evaluated unrefined petroleum shops of 594.49 million tons (MT) and flammable gasoline stores of 1339.Fifty seven billion cubic meters (BCM). India imports eighty two% of its oil needs and intends to bring that down to 67% by 2022 by using supplanting it with neighborhood investigation, sustainable energy source and indigenous ethanol gas. India became the 1/3 top net uncooked petroleum (counting uncooked petroleum gadgets) shipper of 205.Three Mt in 2018.

3.4.1 Arab Light crude

Middle Easterner Light is a medium-gravity, high-sulfur raw petroleum delivered by Saudi Arabia. It is the significant fare grade for Saudi Arabia and a worldwide unrefined benchmark. Middle Easterner Light is for the most part created from the too mammoth Ghawar field, however it additionally contains volumes from different fields. Bedouin Light is showcased in the entirety of the significant refining places including Europe, Asia, and North America. Bedouin Light is evaluated utilizing local equations dependent on benchmarks in every one of the districts.

Quality:

API: 33.0

Sulfur: 1.77%

3.4.2 Bonny Light crude

Bonny Light is a light-sweet raw petroleum grade delivered in Nigeria. It is a significant benchmark rough for all West African unrefined creation.

Bonny Light has especially great gas yields, which has made it a well known rough for US purifiers, especially on the US East Coast.

Quality:

API: 34.5
Sulfur: 0.14%

3.4.3 Bombay High

Raw petroleum created from Bombay High is viewed as of generally excellent quality when contrasted with crudes delivered in center east. Bombay High rough has over 60% paraffinic content while light Arabian unrefined has just 25% paraffin. Bombay High raw petroleum is Waxy in nature and has a excessive pour factor (30°C), The wax found in it to a great extent comprises of strong n-alkanes.

3.5PLANT LOCATION- GUJARAT

The factors are as follows:

1. Law and order situation,
2. Availability of infrastructure facilities,
3. Good industrial relations,
4. Availability of skilled workforce,
5. Social infrastructure,
6. Investor friendly attitude,
7. Nearness to market,
8. Nearness to raw-materials' source,
9. Closeness to strong ventures and benefits, and
10. Must meet safety requirements.

Gujarat kingdom has the longest sea coast of 1214 km in India. Different essential ports in Gujarat are the Port of Navlakhi, Port of Magdalla, Port Pipavav, Bedi Port, Port of Porbandar, Port of Veraval and the privately owned Mundra Port. The country additionally has Ro-Ro ferry service. This allows petroleum industry toeasily import crude oil from western countries.

Gujarat state policy and taxation is also a very reasonable for petroleum industry.
Gujarat has a huge network of industries and specially chemical and petrochemical industry. Availability of petrochemical industry near the refinery is a great advantage because the products of the refinery can be easily transported to the desired petrochemical industry. Thus Gujarat as a state is favorable for the upcoming Petroleum industry in India.

3.6 ENVIRONMENTAL CHALLENGES

Oil has numerous utilization, and the ecological effect of the oil business is correspondingly broad and sweeping. Unrefined petroleum and gaseous petrol are essential vitality and crude material sources that empower various parts of present day every day Existence and the world economy.. Their supply has grown quickly over the last a hundred and fifty years to satisfy the demands of unexpectedly growing human populace, creativity, and consumerism. Extensive amounts of toxic and non-harmful waste are produced all through the extraction, refinement, and transportation levels of oil and gas. A few industry through-merchandise, together with risky natural compounds, nitrogen & sulfur compounds, and spilled oil can pollute air, water, and soil at stages which can be harmful to existence where improperly managed. Weather warming, ocean acidification, and sea stage upward thrust are worldwide adjustments improved by the industry's emissions of greenhouse gases like methane and micro-particulate aerosols like black carbon.

Refineries are typically considered a first-rate supply of pollutants in areas in which they're located and are regulated via some of environmental laws associated with air, land and water. Some of the policies that affect the refining enterprise consist of the easy Air Act, the clean Water Act, the safe drinking Water Act, CERCLA (i.E. Superfund: complete Environmental reaction, compensation, and liability Act), Emergency planning and network proper-to-recognize (EPCRA), OSHA (Occupational protection & fitness management), TSCA (poisonous materials manipulate Act), Oil pollutants Act and Spill Prevention control and Countermeasure Plans. Here is a breakdown of the air, water, and soil hazards posed by means of refineries:

- **Air pollution hazards**
- **Water pollution hazards**
- **Soil pollution hazards**

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3.6.2 ZERO LIQUID DISCHARGE

Zero fluid discharge(ZLD) is a designing way to deal with water treatment where all water is recuperated and contaminants are decreased to strong waste. While many water treatment forms endeavor to augment recuperation of freshwater and limit squander, ZLD is the most requesting objective since the expense and difficulties of recuperation increment as the wastewater gets progressively thought. Saltiness, scaling mixes, and organics all expansion in focus, which includes costs related with dealing with these increments. ZLD is accomplished by hanging together water treatment innovation that can regard wastewater as the contaminants are concentrated.

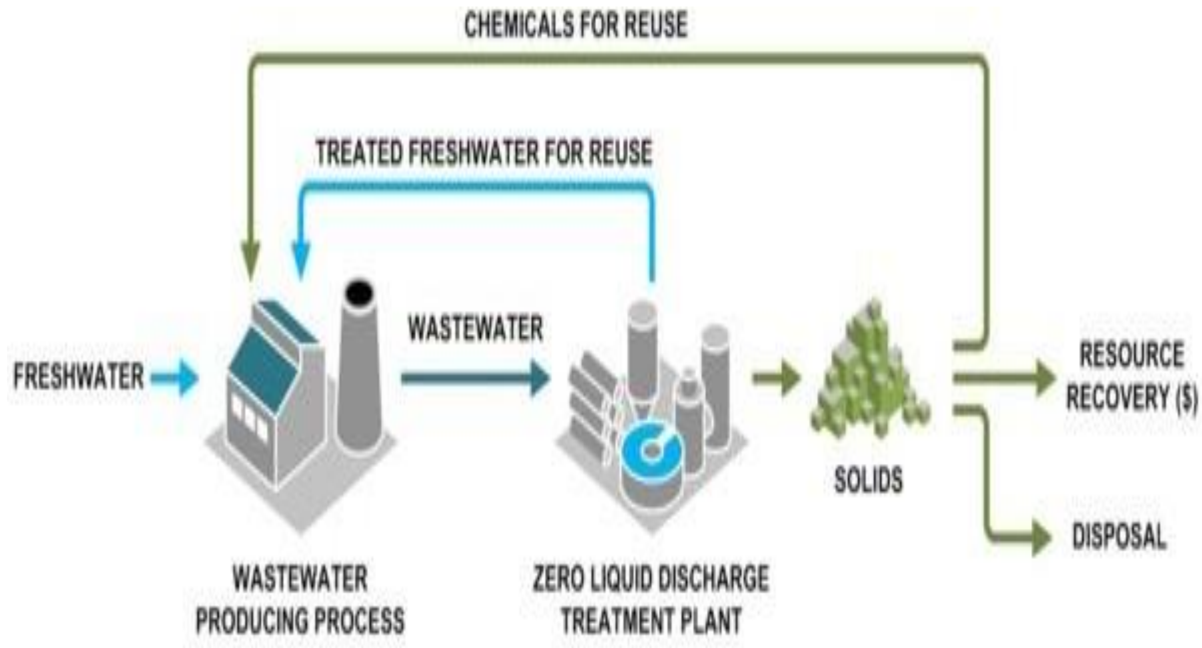


Figure 4:- Zero Liquid Discharge System

In spite of the variable wellsprings of a wastewater stream, a ZLD framework is by and large included by two stages

1. **Pre-Concentration;** Pre-concentrating the salt water is normally accomplished with layer saline solution concentrators or electrodialysis (ED). These advancements concentrate the stream to a high saltiness and can recuperate up to 60–80% of the water.
2. **Evaporation/Crystallization;** The subsequent stage with warm procedures or vanishing, dissipates all the extra water, gather it, and drives it for reuse. The waste that is deserted at that point goes to a crystallizer which heats up all the water until all the contaminations take shape and are sifted through as a strong.

There are various advantages to focusing on zero fluid release for a mechanical procedure

- Lowered waste volumes decline the expense related with squander the executives.
- Recycle water nearby, bringing down water obtaining expenses and hazard. Reusing nearby can likewise bring about less treatment needs, as opposed to rewarding to satisfy severe ecological release guidelines.
- Reduce trucks related with off-site squander water removal, and their related ozone harming substance effect and network street episode hazard.
- Improved natural execution, and administrative hazard profile for future allowing.
- Some procedures may recuperate significant assets, for instance ammonium sulfate manure or sodium chloride salt for ice liquefying.

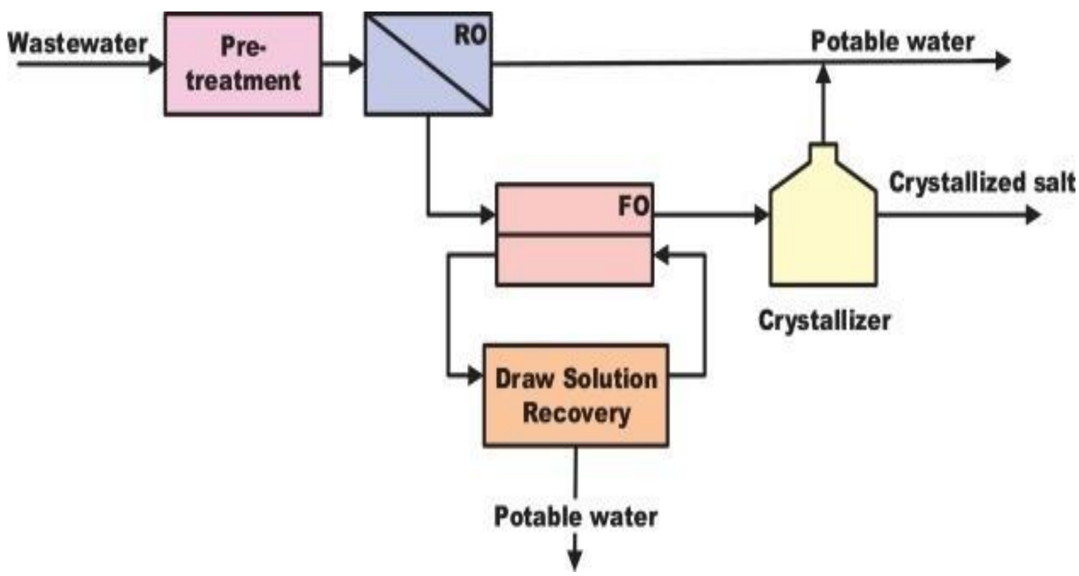


Figure 5:- Zero Liquid Discharge two stage recovery system

3.7 PROCESSING UNITS AND EQUIPMENT

Chemical Engineering has evolved from chemical technology and became an impartial department of knowledge. Chemical Engineering is predicated on arithmetic, physics, chemistry and bodily chemistry. The unit operations are very critical part inside the chemical industries.

3.7.1 TRADITIONAL CLASSIFICATION OF PROCESSES

i. Mechanical processes

ii. Hydro dynamical processes

iii. Heat transport processes

iv. Mass-transport processes

v. Chemical processes

vi. Biochemical and biological processes

3.7.2 ESSENTIAL PROCESSES BASED ON DIFFERENT PHYSICAL PRINCIPLES:

1) Transport Processes

i. Momentum transport – utilized in hydrodynamics and liquid stream.

ii. Energy transport – utilized in depiction of warmth move and warmth exchangers.

iii. Mass transport – utilized in dispersion partition forms.

2) Transformation Processes

i. Segment change: it's miles used in warmness trade followed through boiling or condensation and in mass change such as distillation, drying.

ii. Chemical response: it's far utilized in description of chemical reactors.

3.7.3 EXAMPLES OF UNIT OPERATIONS:

i. Fluid transportation, filtration settling, fluidization, mixing: they involve hydro mechanical processes

ii. Heat exchange, evaporation: they involve energy (heat) transport

iii. Extraction, absorption, drying, and distillation, membranes: they involve mass transport.

iv. Reactors, bioreactors: they involve chemical reaction

The refinery is for this reason a very complex technical facility and its productiveness can be ensured best through strict and constant manage of all of the issue components, to assure product quality, operational protection and surroundings protection, theses aims are attained by size, manage and supervision strategies, which can be now of critical significance in all petroleum and petrochemical complexes. In this connection, the type of chemical engineering unit operations has been used and the following could be examined successively:

i. Gadget for isolating the additives of a combination, either by means of mass transfer between phases (gasoline- liquid or liquid-liquid) or via bodily separation of multi-segment systems together with fuel-liquid, liquid- liquid, gas-strong, and liquid-solid combos.

ii. System for achieving warmth transfers, inclusive of furnaces and warmth exchangers.

iii. System known as reactors wherein chemical reactions take location.

iv. Gadget used to perform the mechanical operations of fluid shipping (pumps, compressors, or blending).

3.8 MATERIAL BALANCE

3.8.1 INTRODUCTION

Fabric adjusts are widespread preliminary step when structuring every other system or breaking down a modern-day one. They may be pretty regularly essential to each other estimation in the arrangement of procedure designing issues. Cloth adjusts are simply using the regulation of protection of mass, which expresses that mass can nor be made nor obliterated. In this manner, you can not, for instance, imply a contribution to a reactor of 1 ton of naphtha and a yield of two tons of fuel or gases or whatever else. One ton of all out material data will just supply one ton of all out yield, for instance

All out mass of records = absolute mass of yield

A fabric equalization is a representing material. On this way, material adjusts are regularly contrasted with the adjusting of contemporary information. They're utilized in enterprise to compute mass movement paces of diverse streams getting into or leaving compound or bodily approaches. The overall stability Equation think propane is part of both the statistics and yield surges of a constant manner unit seemed beneath, those move paces of the statistics and yield are predicted and visible as diverse. In the event that there are no spills and the estimations are right, at that point different possibilities that could constitute this difference are that propane is both being produced, gobbled, or accumulated within the unit.

A balance (or stock) on a material in a device (a single procedure unit, a collection of units, or a whole technique) can be written in the following popular way:

. Input	+ generation	− output	− consumption	= accumulation
(Enter Through System)	(produced within system)	(leave through system)	(consumed within system)	(buildup within system)

This wellknown equalization circumstance might be composed for any cloth that enters or leaves any method framework; it thoroughly may be applied to absolutely the mass of this fabric or to any sub-atomic or nuclear species associated with the method. The general equalization situation is probably disentangled by way of the cutting-edge system. As an instance, by using definition, the collection term for constant state consistent procedure is zero. On this manner the above situation becomes:

Input + generation = output + consumption

For bodily process, since there may be no substance reaction, the age and utilization phrases gets 0, and the parity circumstance for consistent kingdom bodily procedure may be basically dwindled to:

Input = Output

3.8.2 MASS FEEDBACK (RECYCLE)

Mass adjusts can be accomplished throughout frameworks which have cyclic streams. In these frameworks yield streams are looked after cross into the contribution of a unit, often for extra reprocessing. Such frameworks are basic in pounding circuits, in which substances are squashed at that factor sieved to simply allow a particular length of molecule out of the circuit and the larger debris are come returned to the processor. Anyways, reuse streams are in no manner, shape or form constrained to strong mechanics activities; they're applied in fluid and fuel streams, too. One such model is in cooling towers, in which water is siphoned thru a top frequently, with only a little quantity of water drawn off at every go (to forestall solids broaden) till it has either dissipated or left with the drawn off water.

The usage of the reuse helps in increasing in trendy transformation of statistics objects, that's treasured for low per-pass trade paperwork, (as an example, the Haber technique).

3.8.3 COMMERCIAL USE

In mechanical system flowers, utilising the manner that the mass coming into and leaving any a part of a system plant need to alter, records approval and compromise calculations might be applied to address estimated streams, gave that enough excess of stream estimations exist to allow factual compromise and rejection of recognizably incorrect estimations. Since all genuine estimated values contain inborn blunder, the accommodated estimations give a superior premise than the deliberate qualities accomplish for monetary announcing, streamlining, and administrative revealing. Programming bundles exist to make this industrially doable consistently.

3.8.4 BASIC CALCULATIONS

The basic calculation for design the units of refinery is 400000 barl/day

400000 * 159 *1 kg

= 63600000 kg/day

The specific gravity of the crude oil from table of specific temperature 15.7 ℃ is 0.8418

$SGoil = \rho oil \rho H2o$

ρoil = SGoil × qH2O = 0.8418 × 1000 kg/m3

ρoil = 841.8 kg/m3

$Voil = moil / \rho oil$ = 63600000kg/day / 841.8 kg/m3

$Voil$= 7555.2 m3/day

API GRAVITY
=141.5/0.8418 -131.5
=36.592

3.8.5 The Material Balance on The Stripper Towers:

The calculations of the inputs and the outputs percent and refluxes about the strippers are performed as following

3.8.5.1 material balance about stripper of heavy naphtha (H.N):

Percentage reflux in top tower is consistent (6%)

- The enter quantity for strippers towers (H.N) and steam

$= (mass\ of\ H.N\ total) / (total\ percent\% - percent\ reflux) \times 100$

$=(2266560\ Kg/day)/(100 - 6) \times 100$

$= 2411234.043\ Kg/day$

- The percent of reflux at the top of the column (H.N) and steam

= (H.N) Input to strippers– (input without reflux)

$=2411234.043\ Kg/day - 2266560\ Kg/day$

$= 144674.0426\ Kg/day$

$The\ amount\ by\ gallon\ unit\ (gal)$:

$= 144674.0426\ Kg/day \times 1\ liter/1\ Kg \times 1\ gal/3.785412\ liter$

$= 38218.83658\ gal/day$

- The amount steam injected to stripper will be stander for (H.N)

  Amount steam = $0.2268\ Kg/gal$

  The amount steam = (H.N) reflux percent ×steam amount

  $= 38218.83658\ gal/day \times 0.2268\ Kg/gal$

  $= 8668.032136\ Kg/day$

- Total of reflux Amount from steam and (H.N)

  = Amount steam + (H.N) reflux at the top column

  $=8668.032136\ Kg/day + 144674.0426\ Kg/day$

  $= 153342.0747\ Kg/day$

- The product bottom of (H.N)stripper

  = input of (H.N)stripper + amount of steam –reflux amount of steam and (H.N)

  $= 2411234.043 + 8668.032136 - 153342.0747$

  $= 2266560\ Kg/day$

3.8.5.2 the material Balances About The Stripper Of Kerosene (ker):

The percent of reflux at the top of the tower is consistent (4%)

- The input amount to Kerosene stripper tower
  $= (total\ mass\ of\ kerosene)/(total\ percent\% - reflux\ percent\ ) \times 100$
  $=(2077680\ Kg/day) / (100 - 4) \times 100 = 2164250\ Kg/day$

- The Percent of reflux at the top of the column (Ker) and steam
  = Input to strippers(Ker) – (input without reflux)
  $= 2164250\ Kg/day - 2077680\ Kg/day = 86570\ Kg/day$

- $The\ amount\ by\ gallon\ unit\ (gal) = 86570\ Kg/day \times 1\ liter/1Kg \times 1gal/3.785412\ liter$
  $= 22869.37327\ gal/day$
- The amount steam injected to stripper will be stander for kerosene:
  $amount\ steam = 0.13608\ Kg\ /gal$
  So the amount steam water necessary to strip = Percent reflux (Ker) × amount steam
  $= 22869.37327\ Kg\ /gal \times 0.13608\ kg/gal$
  $= 3112.064314\ Kg\ steam\ /day$
- total reflux Amount from steam and kerosene = amount steam water + reflux kerosene
  $= 3112.064314\ kgsteam/day + 86570\ Kg/day$
  $= 89682.06431\ kg/day$
- The product bottom stripper(Kerosene)
  =Input stripper (Ker) + column steam water – amount reflux steam and kerosene
  $= 2164250\ Kg/day + 3112.064314\ Kgsteam/day - 89682.06431\ kg/day$
  $= 2077680\ Kg/day$

3.8.5.3 <u>Material -Balance about the Stripper of Diesel (diel).</u>

The Percent reflux in top tower is constant (2%)

- The input amount to diesel stripper tower (die) and steam

$= (mass\ of\ diesel\ total)/(total\ percent\% - percent\ reflul) \times 100$

$=(4533120\ kg/day)/(100 - 2) \times 100 = 4625632.653\ kg/day$

- The Percent of reflux at the top of column (die) and steam

= Input to stripper (diesel) and steam – input without reflux

$= 4625632.653\ kg/day - 4533120\ kg/day$

$= 92512.65306\ kg/day$

- *The amount by gallon unit* (*gal*)

$= 92512.65306\ kg\ /day \times 1\ liter/1kg \times 1\ gal/3.785412\ liter$

$= 24439.25603\ gal/day$

- The amount steam injected to stripper will be stander for diesel:

$amount\ steam = 0.02265\ kg/gal$

So amount steam water = percent reflux (diesel) × amount steam

$=24439.25603\ gal/day \times 0.02265\ kg/gal$

$= 553.5491492\ kgsteam/day$

- total reflux Amount from steam and diesel = amount steam water + reflux top

$= 553.5491492 + 92512.65306$

$= 93066.20221\ kg/day$

- The product bottom column diesel

= Input stripper (diesel) + amount steam water – amount reflux Steam and (diesel)

$= 4625632.653 + 553.5491492 - 93066.20221$

$= 4533120\ kg/day$

3.9 ENERGY BALANCE

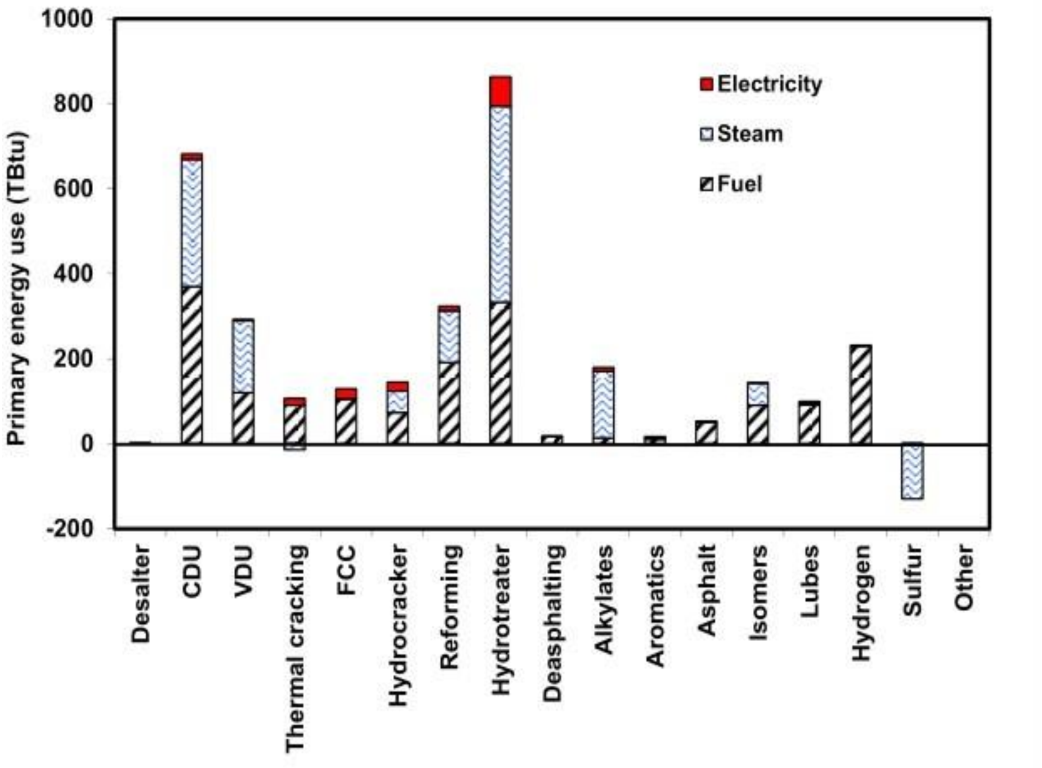
When the mass transfer balance derived with the aid of making use of the law of conservation of mass, which states that the full generation of mass is 0, also there's one greater important conservation law which gives a further equation that is the conservation of strength.

3.9.1 TYPES OF ENERGY`

For writing an energy balance the types of energy gained or lost are:-

1. Kinetic energy for a moving system.
2. Potential energy.
3. Heat Energy
4. Work done on the system.

Summation of all the energy above is the total energy.



Graph 2:- the primary energy consumption of the different processes

3.9.2 CALCULATION OF ENERGY BALANCE

The energy balance for all units which use 8 heat exchangers

Unit	Inlet temperature°C	Outlet temperature °C	specific heat *KJ*/Kg°C
Crude Oil	26.67	-	2.55
Heavy naphtha	141.67	82.22	2.007
Kerosene	180.56	40	2.14
Cold Diesel A ,B	171.11	81.11	2.30
Heavy naphtha pumproulid A ,B	175.56	97.78	2.007
Cold Residue A,B	254.44	161.11	2.39
Hot Diesel	252.22	182.22	2.30
Diesel pumproulid A,B	270.56	195.56	2.30
Hot Residue	356.11	254.44	2.39

Table 5:- initial and final temperature for oil products and their specific heat

1) Heavy Naphtha heat exchanger

The temperature of crude oil equal 26.67

The temperature of heavy naphtha that inlet to the heat exchanger = 141.67

the temperature of heavy naphtha that outlet from the heat exchanger =82.22

And by using the total energy equation **Q = mcΔTWhere:**

m: the mass of product

c: specific heat for product

ΔT: temperature difference

$(\mathbf{m_{H.N}*cp_{H.N}*\Delta T_{H.N}) = (m_{oil}*cp_{Oil}*\Delta T_{Oil})}$

(5701476*2.007*(141.67-82.22))= (29733489.6*2.55*ΔT)

ΔT = 680278165.6 / 75820398.48

ΔT=8.97

$T_{Oil\ out}=T_{Oil\ int}+8.97$

$T_{Oil\ out}=35.64$

2) Kerosene heat exchanger

The temperature of kerosene that inlet to the heat exchanger =180.56

The temperature ofkerosene that outlet from the heat exchanger = 40

The temperature of crude oil which inlet to the second heat exchanger = 35.64

$(m_{ke}*cp_{ke}*\Delta T)=(m_{Oil}*cp_{oil}*\Delta T)$

(2077680*2.14*(180.56-40))-(29733489.6*2.55*ΔT)

ΔT= 624962819.7 / 75820398.48

$\Delta T=8.243$

$T_{Oil\ out}$ $=T_{Oil\ int}+8.243$

$=35.64+8.243$

$T_{Oil\ out}=43.88$

3) Cold diesel (A) heat exchanger

The temperature of cold diesel that inlet to the heat exchanger = 171.11

The temperature of cold diesel that outlet from the heat exchanger =81.11

The temperature of crude oil inlet to the heat exchanger = 43.88

$(m_{co\ Die}*cp_{co\ Die}*\Delta T) = (m_{Oil}*cp_{Oil}*\Delta T_{Oil})$

$(4533120*2.30*(171.11-81.11)) = (29733489.6*2.55*\Delta T)$

$\Delta T = 938355840 / 75820398.48$

Δ = 12.38

$T_{Oil\ out}=T_{Oil\ in}+12.38$

$=43.88+12.38$

$T_{Oil\ out}=56.26$

4) Cold diesel (B) heat exchanger

$Q_{Die}=m_{Oil}*cp_{oil}*\Delta$

$=29733489.6*2.55*\Delta T$

$\Delta T = 12.38$

$T_{Oil\ out}$ =$T_{oil\ in}$+12.38

=56.26+12.38

$T_{Oil\ out}$=68.64

5) Heavy Naphtha pumproulid (A) heat exchanger

The temperature of Heavy Naphtha inlet to the heat exchanger = 175.56

The temperature of Heavy Naphtha outlet from the heat exchanger = 97.78

The temperature of crude oil inlet to the heat exchanger = 68.64

$m_{H.N}$*$cp_{H.N}$*Δ⍰= m_{Oil}*cp_{Oil}*Δ⍰

5701476*2.007*(175.56-97.78)=29733489.6*2.55*Δ⍰

ΔT = 890025832.2 / 75820398.48

Δ⍰ = 11.74

$T_{Oil\ out}$= $T_{oil\ in}$+11.74

$T_{Oil\ out}$ =80.38

6) Heavy Naphtha pumproulid heat (B) exchanger

$Q_{H.N}$=m_{Oil} *cp_{Oil}*Δ⍰

890025832.2=29733489.6*2.55*Δ⍰

Δ⍰ = 11.74

$T_{Oil\ out}$ =80.38+11.74

=92.12

7) Cold residue (A) heat exchanger

The temperature of cold residue inlet to the heat exchanger = 254.44

The temperature of cold residue outlet from the heat exchange=161.11

The temperature of crude oil inlet to the heat exchanger = 92.12

$m_{C.Re} * cp_{C.Re} * \Delta T = m_{Oil} * cp_{Oil} * \Delta T$

$22612713.6 * 2.39 * (254.44 - 161.11) = 29733489.6 * 2.55 * \Delta T$

$\Delta T = 5043962499 / 75820398.48$

$\Delta T = 66.53$

$T_{oil\ out} = 92.12 + 66.53$

$T_{oil\ out} = 158.65$

8) Cold residue (B) heat exchanger

$Q_{C.Re} = m_{Oil} * cp_{Oil} * \Delta T$

$5043962499 = 29733489.6 * 2.55 * \Delta T$

$\Delta T = 66.53$

$T_{oil\ out} = 158.65 + 66.53$

$T_{oil\ out} = 225.18$

9) Hot Diesel heat exchanger

The temperature of hot diesel inlet to the heat exchanger = 252.22

The temperature of hot diesel outlet from the heat exchanger = 182.22

The temperature of the crude oil inlet to the heat exchanger = 225.18

$m_{H.De} * cp_{H.De} * \Delta T = m_{Oil} * cp_{Oil} * \Delta T$

$4533120 * 2.30 * (252.22-182.22) = 29733489.6 * 2.55 * \Delta T$

$\Delta T = 729832320 / 75820398.48$

$\Delta T = 9.63$

$T_{Oil\ out} = 225.18+9.63$

$T_{Oil\ out} = 234.81$

10) Diesel pumparoulid (A) heat exchanger

The temperature of diesel pumparoulid inlet to the heat exchanger=270.56

The temperature of diesel pumparoulid outlet from the heat exchanger = 195.56

The temperature of diesel pumparoulid inlet the toheat exchanger = 234.81

$m_{De.P} * cp_{De.P} * \Delta T = m_{Oil} * cp_{Oil} * \Delta T$ $4533120 * 2.30 * (270.56-195.56) = 29733489.6 * 2.55 * \Delta T$

$\Delta T = 781963200 / 75820398.48$

$\Delta T = 10.3$

$T_{Oil\ out} = 234.81+10.3$

$T_{Oil\ out} = 245.12$

11) Diesel pumparoulid (B) heat exchanger

$Q_{De.p}=m_{Oil}*cp_{Oil}*\Delta T$

$781963200=29733489*2.55*\Delta T$

$\Delta T = 10.3$

$T_{Oil\ out}=245.12+10.3$

$T_{Oil\ out}=255.4$

12) Hot Residue heat exchanger

The temperature of hot residue inlet to the heat exchanger = 356.11

The temperature of hot residue outlet from the heat exchanger = 54.44

The temperature of crude oil inlet to the heat exchanger = 255.4

$m_{H.De}*cp_{H.De}*\Delta T=m_{Oil}*cp_{Oil}*\Delta T$

$22612713.6*2.39*(356.11-254.44) = 29733489.6*2.55*\Delta T$

$\Delta T = 5494692674 / 75820398.48$

$\Delta T = 72.47$

$T_{Oil\ out} =255.4+72.47$

$T_{Oil\ out} =327.79$ this is the final temperature of crude oil

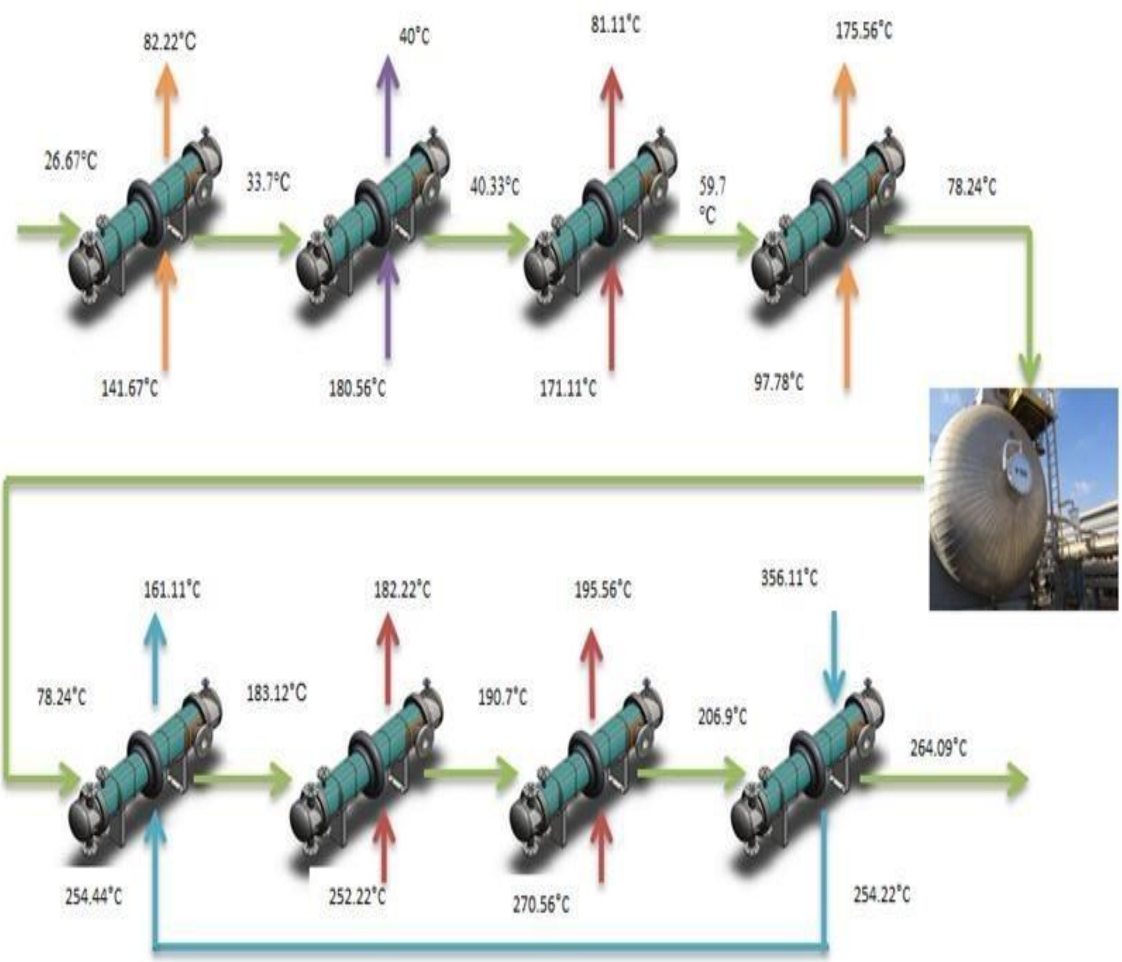


Figure 6:- shows increase temperature crude oil inside heat exchanger

Line	Product
	Oil
(orange line)	Heavy naphtha
(purple line)	Kerosene
(red line)	Diesel
(blue line)	Radium

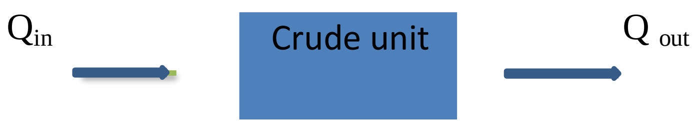
Heat Exchanger	**temperature of out oil (KJ)**
E1	35.64
E2	43.88
E3A	56.26
E3B	68.64
E4A	80.38
E4B	92.12
E5A	158.65
E5B	225.18
E6	234.81
E7A	245.12
E7B	255.4
E8	327.79

Table 6- the overall energy balance

Qin	**Qout**
680278165.6	680108974.4
624962819.7	624760083.5
938355840	938656533.2
890025832.2	890131478.2
5043962499	5044331111
72983232	729771335.4
78196320	781935769.5
5494692674	5494628457
$1.382*10^{10}$	**$1.382*10^{10}$**

$$Q_{in} = Q_{out}$$

$$1.382*10^{10} = 1.382*10^{10}$$



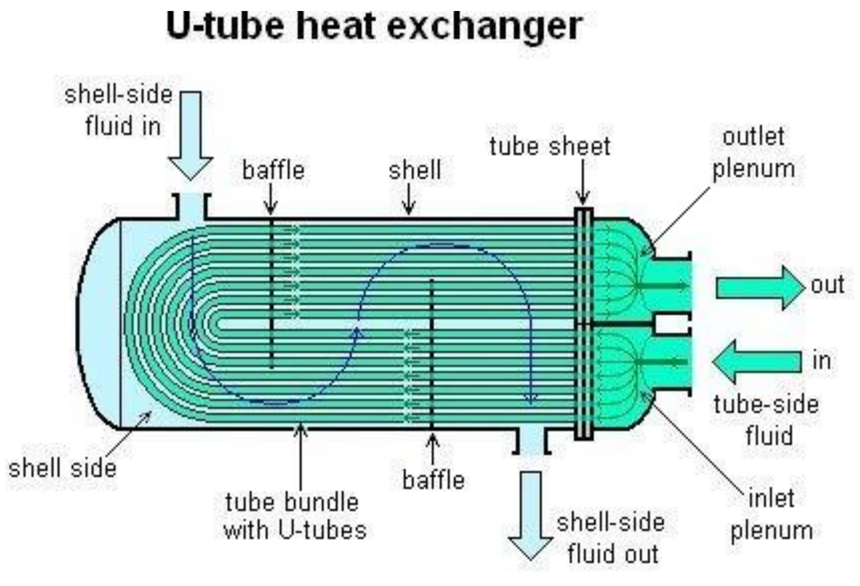
3.10 DESIGN OF HEAT EXCHANGER

A shell and cylinder heat exchanger is a class of heat exchanger designs. It's miles the most broadly recognized kind of warmth exchanger in petroleum treatment facilities and other huge concoction paperwork, and is suitable for better-strain programs. As its call shows, this kind of warm temperature exchanger contains of a shell (an vast weight vessel) with a heap of cylinders internal it. One liquid is going thru the cylinders, and every other liquid streams over the cylinders (thru the shell) to transport warmness between the 2 beverages. The association of cylinders is known as a cylinder %, and is probably constructed from a few kinds of cylinders: plain, longitudinally finned, and so on.

3.10.1 SHELL AND TUBE HEAT EXCHANGER DESIGN

There may be severe minor departure from the shell and cylinder shape. Often, the elements of the deals are related to plenums (here and there known as water bins) thru gaps in tube sheets. The cylinders might be immediately or bowed looking like a U, called U-tubes.

In atomic pressure vegetation referred to as pressurized water reactors, huge warmth exchangers known as steam generators are -level, shell-and-cylinder warmness exchangers which usually have U- tubes. They're utilized to bubble water reused from a surface condenser into steam to pressure a turbine to create energy. Maximum shell-and-cylinder warmth exchangers are both 1, 2, or four bypass systems on the cylinder side. This alludes to the occasions the liquid inside the cylinders is going through the liquid in the shell.



3.10.2 SELECTION OF TUBE MATERIAL

To have the option to transport warmth properly, the cylinder material need to have wonderful warm conductivity. Considering that warmness is moved from a hot to a pandemic side via the cylinders, there's a temperature contrast thru the width of the cylinders. In light of the inclination of the cylinder cloth to thermally extend diversely at one of a kind temperatures, heat burdens take place at some stage in interest. These necessities call for careful choice of stable, thermally-conductive, intake secure, high-quality tube substances, frequently metals, such as aluminum, copper composite, hardened metallic, carbon metallic, non-ferrous copper amalgam, Inconel, nickel.

Poor choice of cylinder fabric could result in a hole thru a cylinder among the shell and cylinder aspects causing liquid go-sullying and conceivably lack of weight.

3.10.3 APPLICATION AND USES

The sincere plan of a shell and cylinder warmness exchanger makes it an excellent cooling solution for a wide collection of utilizations. One of the maximum widely diagnosed packages is the cooling of stress pushed liquid and oil in automobiles, transmissions and water pushed pressure packs. With the privilege selection of substances they can likewise be applied to chill or warm temperature one of a kind mediums, for instance, pool water or fee air. One of the extensive points of interest of utilizing a shell and cylinder heat exchanger is that they may be often easy to assist, in particular with fashions in which a gliding tube institution (where the cylinder plates aren't welded to the outside shell) is on the market.

3.10.4 CONSTRUCTION DETAILS

The chief styles of shell and cylinder exchanger are seemed in Figures to the same old classification utilized for shell and cylinder exchanger is given beneath:

1. Shell
2. Shell cover
3. Floating-head cover
4. Floating-tube plate
5. Clamp ring
6. Fixed-tube sheet (tube plate)
7. Channel (end-box or header)
8. Channel cover
9. Branch (nozzle)
10. Tie rod and spacer
11. Cross baffle or tube-support plate
12. Impingement baffles
13. Longitudinal baffle
14. Support bracket
15. Floating-head support
16. Weir
17. Split ring
18. Tube
19. Tube bundle
20. Pass partition
21. Floating-head gland (packed gland)
22. Floating-head gland ring
23. Vent connection
24. Drain connection
25. Test connection
26. Expansion bellows
27. Lifting ring

3.10.5 STEPS FOR DESIGN OF HEAT EXCHANGER

Design a shell-and-tube exchanger for the following steps.

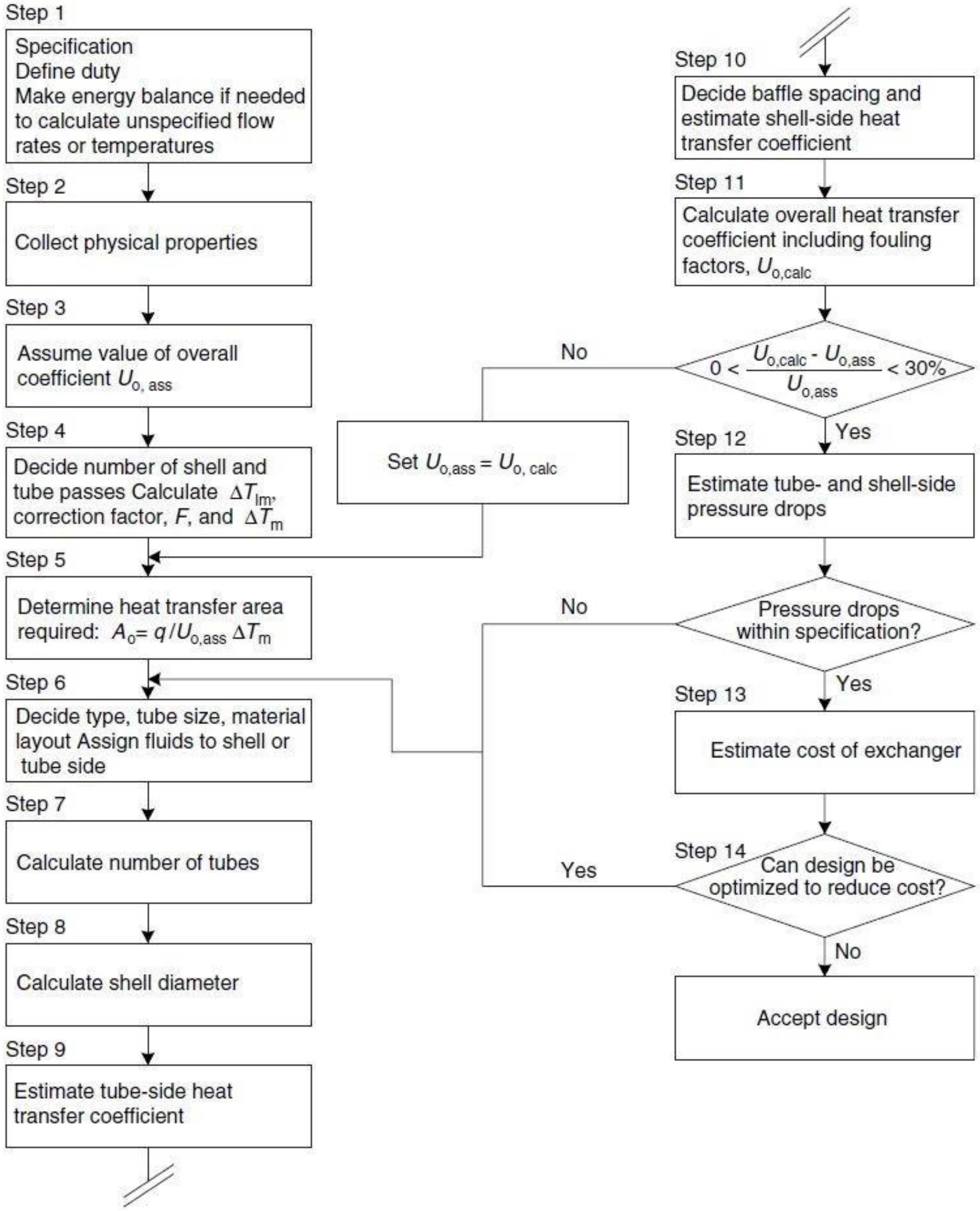
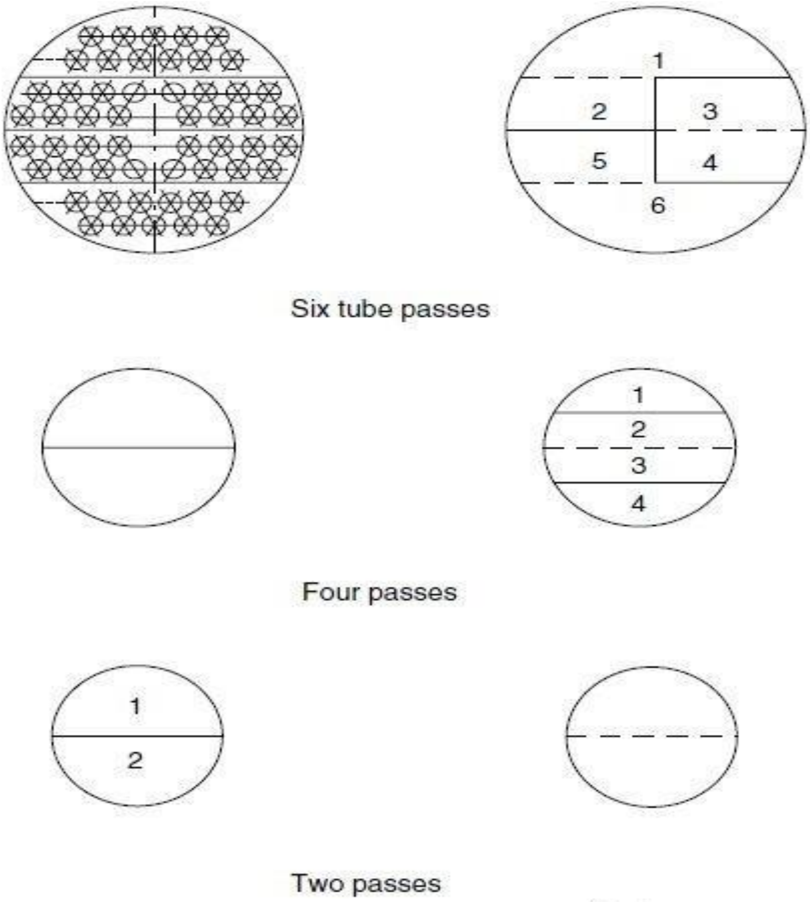
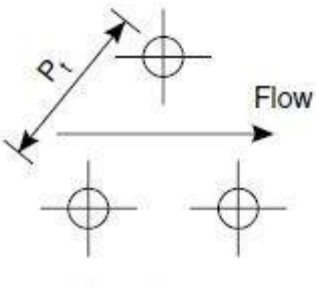


Figure 10:- Design procedures for shell-and-tube heat exchangers

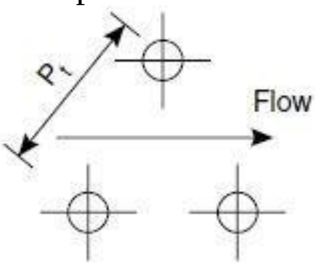
3.10.6 SHAPE PARTS OF THE HEAT EXCHANGER





Triangular

1) Tube passes and tube arrangements.



Triangular

2) Types of baffle used in shell and tube heat exchangers.

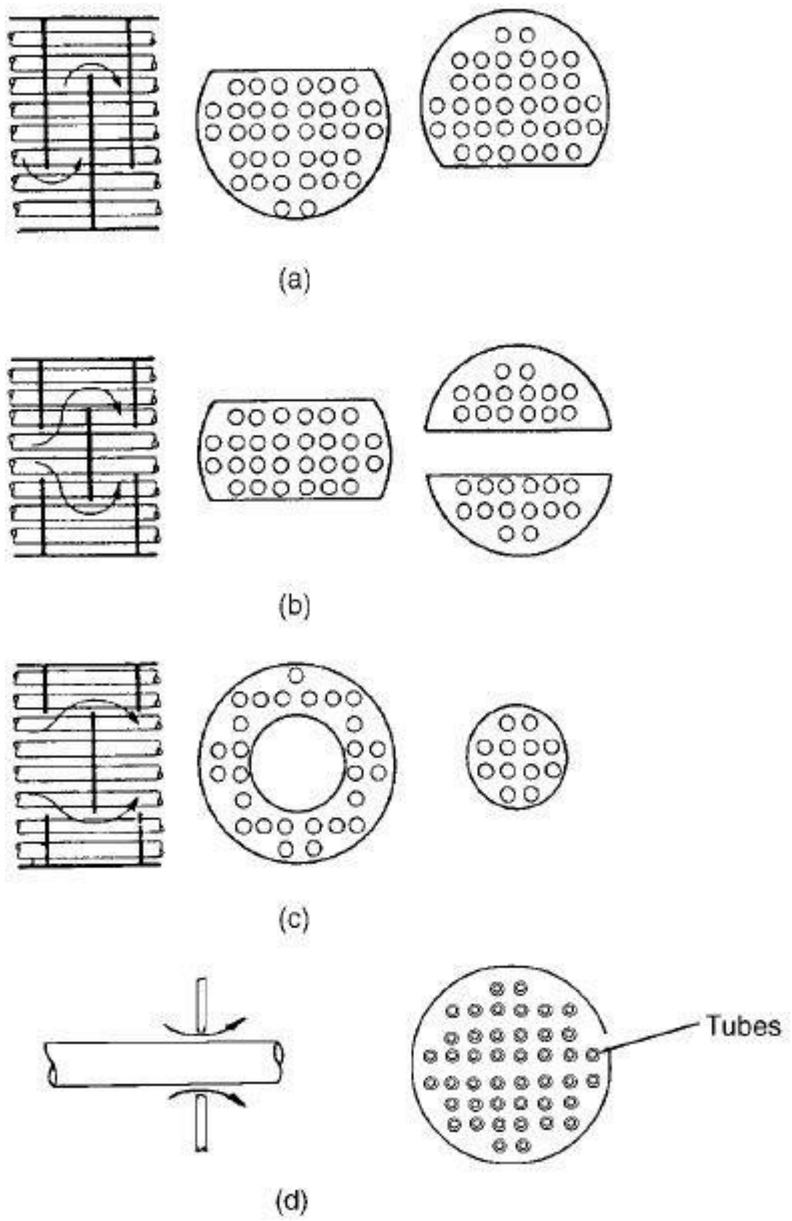


Figure 11:- (a) Segmental (b)Segmental and strip (c) Disc and doughnut (d)Orifice

3.11 DISTILLATION COLUMN DESIGN

3.11.1 DEFINITION

Refining is a unit interest that's utilized to isolate the fluid blends into its constituent species based totally on distinction in breaking points of each individual species (or Relative Volatility).

3.11.2 TYPES OF DISTILLATION

Refining is remoted into two precept kinds primarily based on event of substance response. 1.Distillation (now not inclusive of Chemical response; physical Distillation)

2. Reactive Distillation (regarding Chemical response)

The established order that is essential to realize the method of refining is the fundamentals of Thermodynamics and Chemical Kinetics. Basically, the profundity information on the accompanying zones is crucial:

1. Segment Equilibrium
2. Chemical Equilibrium (It is not required for non-responsive refining)

At Bachelor's stage, just the comprehension of NON-REACTIVE DISTILLATION is important.

3.11.3 NON-REACTIVE DISTILLATION AND ITS CLASSIFICATION

Non-Reactive Distillation or just Distillation is additionally characterized based on:

1.Number of Components in the Feed Mixture

a. Binary Distillation

b. Multicomponent Distillation

2.Type of Column utilized for Distillation

a. Tray Column Distillation

b. Packed Column Distillation

3.Mode of Operation

Differential Distillation

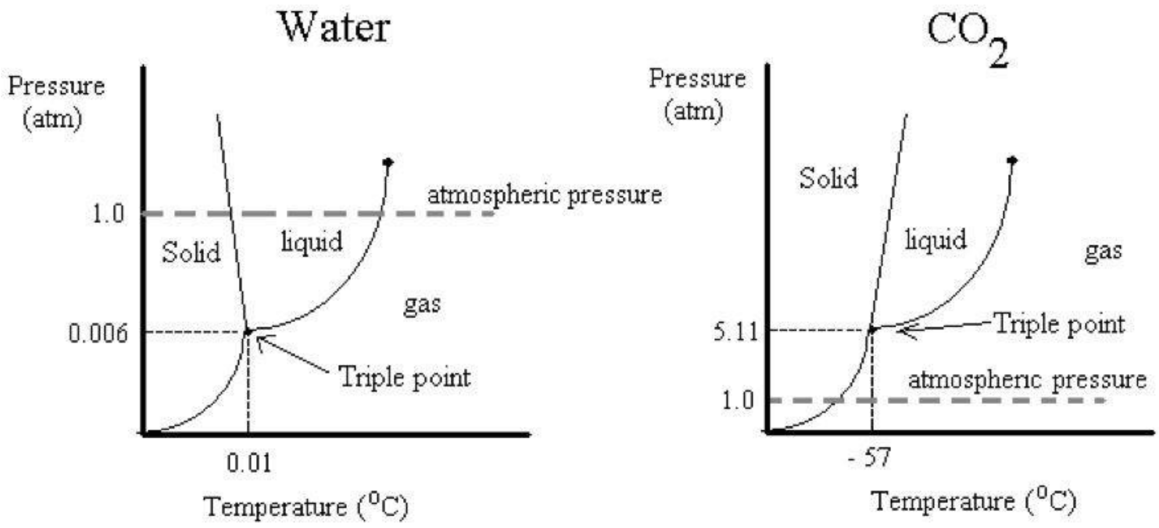
c. Flash or Equilibrium Distillation

d. Rectification

4.Phase of Feed

a. Liquid Feed Distillation

b. Cryogenic Distillation (for example Division of Air)



3.11.4 MATHEMATICAL MODELING OF THE DISTILLATION

The motivation behind the consistent state displaying is to show up at plan conditions so that the section can be structured and its number of plate or stages required can be found for indicated item quality details.

Figure shows a section containing what might be compared to N hypothetical stages; an aggregate condenser in which the overhead fume leaving the top stage is completely dense to an air pocket point fluid distillate and a fluid reflux that is come back to the top stage; an incomplete reboiler in which fluid from the base stage is halfway disintegrated to give a fluid bottoms item and fume bubble up that is come back to the base stage; and an middle feed stage. By methods for different, countercurrent stages organized in a two segment course with reflux and bubble up, a sharp detachment between the two feed parts is conceivable except if an azeotrope exists, in which case one of the two items will approach the azeotropic piece.The steady state modeling of the distillation column is based on the Figure shown below:

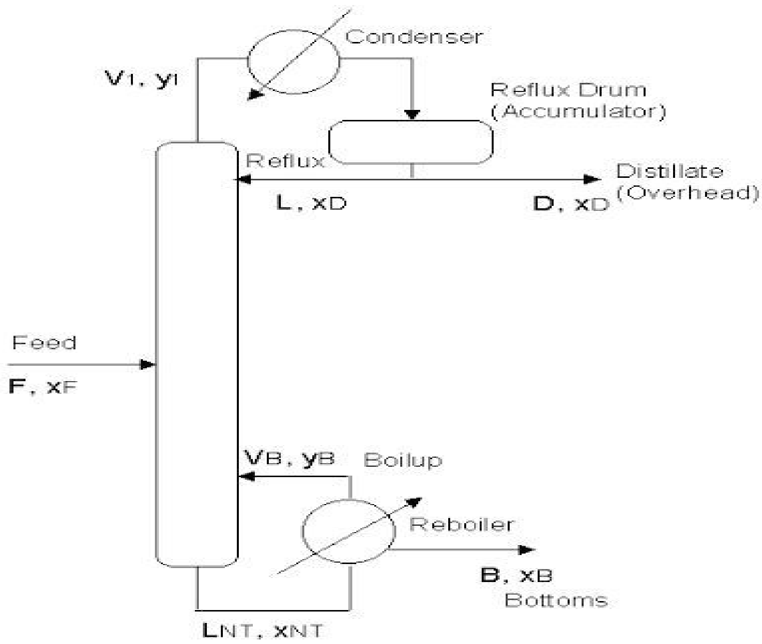


Figure 12:- Steady State modeling of Distillation Column

Component Mole Balance on Overall Process:

As referenced, refining segments are planned utilizing VLE information for the blends to be

- Overall Material Balance :

  $$L_{in} + V_{in} - L_{out} - V_{out} = 0$$

- Material Balance of the Components

  $$L_{in} \cdot x_{i,in} + V_{in} \cdot y_{i,in} - L_{out} \cdot x_{i,out} - V_{out} \cdot y_{i,out} = 0$$

- Equilibrium

  $$P \cdot y_i = \gamma_i \cdot x_i \cdot P_i^{vap}$$

- Mole Fraction Summation

  $$\sum y_i = 1$$

- Heat Balance

  $$L_{in} \cdot H^L_{i,in} + V_{in} \cdot H^V_{i,in} - L_{out} \cdot H^L_{i,out} - V_{out} \cdot H^V_{i,out} = 0$$

isolated. The fume fluid balance attributes (demonstrated by the state of the balance bend) of the blend will decide the quantity of stages, and thus the quantity of plate, required for the partition. This is represented plainly by applying the McCabe-Thiele strategy to plan a double section.

3.11.5 McCABE-THIELE DESIGN METHOD

This strategy utilizes the balance bend outline to decide the quantity of hypothetical stages (plate) required to accomplish an ideal level of detachment. It is a disentangled strategy for examination utilizing a few presumptions, yet in any case a helpful apparatus for the comprehension of refining activity. Snap right here for more information on the examination of this method. The VLE information need to be on hand at the running weight of the segment. Statistics required are the feed condition (temperature, piece), distillate and base systems; and the reflux share, which, as we visible previous, is characterized as the proportion of reflux fluid over the distillate object. This is appeared within the determine underneath.

For instance, a segment is to be supposed for the detachment of a parallel combo. The feed has a convergence of xF (mole department) of the extra unpredictable segment, and a distillate having a grouping of xD of the greater unstable component and a bottoms having a centralization of xB is needed. In its substance, the method consists of the plotting on the harmony define three straight lines: the redressing section working line (ROL), the feed line (in any other case called the q-line) and the stripping location working line (SOL).

Each such a lines is going via the focuses talking to the mole parts of the more unpredictable section inside the distillate, bottoms and feed (xD, xB and xF) one at a time. Those strains communicate to the relationship among the focuses within the fume level (y) and the fluid degree (x). The quantity of hypothetical degrees required for a given detachment is then the amount of triangles that can be drawn between these working lines and the concord bend. The preserve going triangle at the graph speaks to the reboiler.

To accumulate the amount of hypothetical plate making use of the McCabe-Thiele approach, we can applied the "parts-whole courting": exam is first completed by using dividing the phase into three segments: redressing, feed and stripping regions as regarded in left discern below. These segments are then spoken to on the stability bend for the parallel combination being cited and re-consolidated to make a total shape, as regarded in the perfect discern;

Inside the best case, the McCabe-Thiele technique to decide the number of theoretical degrees follows the stairs beneath:

1) evaluation of the Rectifying section, and decide the ROL the use of xD and R 2)analysis of the Feed phase, and decide the feed circumstance (q)

3) determination of the feed line (q-line) the usage of xF and q

4) discover the intersection factor among ROL and q-line

5)evaluation of the Stripping section, and decide the SOL the usage of (four) and xB

NOTE:

1) when R is unknown (however alternatively particular as a multiple of the minimal charge), we are able to first determine the q-line.

2) stop bulletUsually the SOL is the ultimate line to draw, after each ROL and q-line are drawn. Fixing the ROL and the q-line robotically fixes the SOL

On the completed design (equilibrium diagram): The number of triangles drawn = Number of theoretical trays + 1 Reboiler (last triangle).

Distillation Design: Eight Practical Steps

1. Define product specification(s)

2. Choose an operating pressure

3. Choose appropriate VLE data

4. Calculate the number of theoretical trays

5. Select a tray efficiency

6. Select appropriate tower internals

7. Perform tower sizing and tray hydraulics

8. Select a process control scheme

3.12 ECONOMIC STUDY

An attainability study is an exam of ways correctly an venture can be finished, representing factors that influence it, for example, financial, innovative, lawful and booking factors. Assignment supervisors use opportunity research to determine capability positive and bad results of an assignment before contributing a whole lot of time and coins into it. An achievability examine expects to impartially and objectively reveal the qualities and shortcomings of a present day enterprise or proposed adventure, openings and dangers present in the earth, the property required to deliver thru, and sooner or later the possibilities for progress. In its least complicated phrases, the two measures to skip judgment on achievability are value required and incentive to be done. An all round planned attainability take a look at need to provide a verifiable basis of the enterprise or task, a depiction of the object or administration, bookkeeping motives, subtleties of the tasks and the executives, advertising exam and preparations, budgetary statistics, lawful necessities and responsibility commitments. For the maximum element, practicality considers move earlier than specialized flip of activities and task utilization. An achievability observe assesses the venture's ability for progress; finally, noticed objectivity is a massive thing within the validity of the exam for capacity monetary specialists and loaning foundations. It have to on this way be directed with a goal, impartial manner to address provide statistics whereupon selections can be based. A opportunity look at tests the feasibility of a concept, a mission or maybe every other commercial enterprise. The goal of an attainability have a look at is to put accentuation on potential issues that could appear if a assignment is well known and determine whether or not, after every single huge factor are thought of, the venture have to be favorite. Attainability concentrates likewise allow a business to deal with where and how it will work, ability obstructions, contention and the subsidizing expected to get the business going.

3.12.1 PLANT COST

It is regularly essential to appraise the price of a chunk of plant while no cost facts are available for the unique length of operational limit covered. Notable consequences can be gotten by means of utilizing the logarithmic courting known as the six-tenths-component rule, if the new bit of plant is like certainly one of any other limit with regards to which price information are accessible. As in line with this well-known, if the cost of a given unit at one restrict is known, the cost of a comparable unit with X times the limit of the first is around (X) m times the cost of the underlying unit.

$$\text{Cost of plant B} = \text{cost of plant A}\ \{(\text{capacity of plant B}) / (\text{capacity of plant A})\}^{m}$$

$$m = \frac{\text{current year} - \text{original year}}{100}$$

On this challenge there a comparison the charges of the jamnagar refinery that have ability of 12,00,000 barrel in keeping with day with a plant have capability 400.000 barrel per day, which recover the order of fuel stations, The price of plant B need to be converting from the authentic 12 months (2008) to provide 12 months (2020) relying at the fee index to gain the constant fee. And the price of plant A= Rs 270,000 million, m= zero.12

Cost of Plant B= $27*10^{9}\ (400{,}000/1{,}200{,}000)^{0.12}$ = Rs $23.665*10^{9}$ (240,000 million)

3.12.2 COST INDEX

Most cost information which are accessible for sure fire use in a primer or pre-plan gauge depend on conditions previously. Considering that prices ought exchange impressively with time due to changes in economic situations, some approach to be utilized for clean cost information pertinent at a past date to fees which are illustrative of situations sometime in the not too distant future; this should be possible by the utilization of cost files. A cost file is just a file an incentivefor a given point in time demonstrating the expense around then comparative with a specific base time. On the off chance that the expense previously is known, the comparable expense right now can be controlled by duplicating the first expense by the proportion of the current file an incentive to the list esteem material when the first expense was acquired. Cost files can be utilized to give a general gauge, however no file can consider all elements, for example,exceptional innovative progressions or nearby conditions. The basic files grant genuinely exact appraisals if the timespan included is under 10 years.

$$\text{present cost} = \text{original cost} * \frac{(\text{index value at present time})}{(\text{index value at time original cost was obtained})}$$

Cost index at present time (2020) = (1090)

Cost index at original time (2008) = (800)

$$\text{Present cost (2020)} = 24*10^{9} * \frac{(1090)}{(800)}$$

$$\text{Fixed cost} = \text{Present cost} = 32.7*10^{9}$$

Assume the variable cost equal 60% of fixed cost

$$\text{Variable cost} = 0.6 * \text{fixed cost} = 19*10^{9}$$

$$\text{Total cost} = \text{fixed cost} + \text{Variable cost} = 50.3*10^{9}$$

3.12.3 THE COST OF PRODUCTS AND RAW MATERIAL

The subsequent desk suggests the charge of the goods and the go with the flow charge for each product via cubic meter consistent with day, statistics taken from mass stability and the rate for the 12 months 2020, expect the products costs identical 50 Rs/m3

Products	**Price Rs/ m^3**	**m^3/Day**
LPG	50	528.864
Light naphtha	50	5704.176
Heavy naphtha	50	2266.56
Kerosene	50	2077.68
Diesel	50	4533.12
Residue	50	22612.7136

Table 7:- The flow rate of products and their prices.

The cost of the products = (the flow rate for the product1* its price + product2 *its price ….)

Assume the working house for the units is 7200 hr/year, which equal 300 day/year

The cost of the products/ day = [(528.864*50) + (5704.176*50) + (2266.56*50)
+ (2077.68*50) + (4533.12*50) + (22612.7136*50)]*300

$$= 56.5*10^9 \text{ Rs/year}$$

The next table shows the flow rate for raw materials and their Cost, assume the price of the raw material equal 20 Rs/m^3

Raw material	**Rs/ m^3**	**Flow rate m^3/day**
Crude oil	20	37776

Table 8:- The flow rate of the raw material and their prices.

The cost of the RWM = (the flow rate for the RWM 1* its price + RWM 2 *its price...)

The cost of RWM /year = [(37776*10)] * 300 = $11.3*10^9$ Rs/year

3.12.4. DEPRECIATION

Depreciation is a bookkeeping technique for assigning the expense of an unmistakable resource over its valuable life. Organizations devalue long haul resources For both fee and bookkeeping purposes. For rate purposes, agencies can deduct the price of the unmistakable sources they purchase as prices of doing commercial enterprise; in any case, organizations must deteriorate these advantages as per IRS leads about

Assume 30 years depreciation period and the installation has no salvage value

$$\text{Depreciation} = \frac{\text{total cost (C)}}{\text{life period (n)}}$$

Depreciation= $50.3*10^9$ / 30 = $17.3*10^8$ Rs/year

3.12.5 COST OF THE OPERATION

The cost of pastime is the commercial enterprise technique actualized in severa businesses to boom a tremendous marketplace. Price of activity is the value procured in finishing one pastime. It is probably a trade of contributions to the yields or work charges and so on. In the event that the expense of activity is low, at that point it is anything but difficult to keep up cost authority and addition the market with upper hand.

Operating cost = Raw material (**RM**) + utilities (**util**) + operation labor + others

RM + DEP = 90% from production cost

$$\text{Production cost} = \frac{\text{RM + DEP}}{0.9}$$

$$\text{Production Cost} = (11.3*10^9 + 17*10^8) / 0.9 = 14.4*10^9 \text{ Rs/year}$$

Util + Labor = 0.1 * production cost

$$\text{Util + Labor} = 0.1 *14.4 \ast 10^9 = 14.4 \ast 10^8 \text{ Rs/year}$$

$$\text{Operating cost} =14.4 \ast 10^9 + 14.4 \ast 10^8 = 1.59*10^8 \text{ Rs/year}$$

3.12.6 CASH FLOW

Cash float is the internet degree of cash and cash reciprocals stepping into and out of a commercial enterprise. Effective profits indicates that an organization’s fluid sources are expanding, empowering it to settle responsibilities, reinvest in its commercial enterprise, go back coins to traders, pay fees and supply a cradle in opposition to destiny budgetary difficulties. Poor earnings indicate that an corporation's fluid assets are diminishing. Net income is identified from usual gain, which incorporates debt claims and various things for which installment has not virtually been gotten. Earnings is utilized to assess the nature of an organization's salary, that is, the means by which fluid it is, which can demonstrate whether the organization is situated to stay dissolvable.

Cash Flow are frequently changed into measures that give data for example on an organization's worth and circumstance:

i. To decide a venture's pace of return or worth. The hour of incomes into and out of undertakings are utilized as contributions to budgetary models, for example, interior pace of go back and net present worth.

ii. To decide issues with a business' liquidity. Being gainful doesn't really mean being fluid. An organization can fizzle as a result of a deficiency of money even while productive.

iii. As an elective proportion of a business' benefits when it is accepted that gathering bookkeeping ideas don't speak to financial real factors. For example, an organization might be notionally beneficial however creating minimal operational money (as might be the situation for an organization that trades its items instead of selling for money). In such a case, the organization might be inferring extra working money by giving offers or raising extra obligation fund.

iv. Cash stream can be utilized to assess the 'nature' of pay created by accumulation bookkeeping. At the point when total compensation is made out of enormous non-money things it is viewed as low quality.

v. To assess the dangers inside a money related item, e.g., coordinating money prerequisites, assessing default hazard, re-venture necessities, and so on.

Cash flow = Net profit

Years 1-30	**Prices Rs/year**
Income	$56.5*10^9$
Operating	$-15.9*10^9$
Depreciation	$-17*10^8$
The net profit	$=38.8*10^9$

Table 10:- Cash flow inculcating the OPEX and CAPEX

$$\text{Cash flow} = 38.8*10^9 \text{Rs/year}$$

3.12.7 PAY- BACK PERIOD

Payback period is the time wherein the underlying money surge of a venture is relied upon to be recouped from the money inflows produced by the speculation. It is one of the least difficult speculation examination methods.

Formula

$$\text{pay} - \text{back period} = \frac{\text{Total cost}}{\text{cash flow}}$$

$$\text{pay} - \text{back period} = \frac{50.3 * 10^9}{3.88 * 108}$$

$$= 1.297\ year$$

Advantages of Payback Period are:

1. Payback period is lucid to calculate.
2. It could be a measure of threat inherent in a assignment. Since incomes that happen later in a project's lifestyles are viewed as increasingly more unsure, restitution duration gives a signal of ways certain the project money inflows are.
3. For companies confronting liquidity issues, it gives a first rate positioning of duties that might go back cash early.

Disadvantages of Payback Period are:

1. Payback period doesn't consider the time estimation of cash which is a genuine disadvantage since it can prompt wrong choices.
2. It doesn't consider, the incomes that happen after the recompense time frame.

CHAPTER 4

1. RESULT AND DISCUSSION

This review project presents the importance of heat exchanger, crude distillation unit, and Distillation column in oil refineries. Petroleum refineries are the continuous process industry. The extraction of oil and different by-product is a completely complex and continuous chain system, which requires the maximum dependable and efficient system. So it is apparent that the warmth exchangers and distillation devices are beneficial tools inside the industries. After the above dialogue, it is simple to mention that the shell & tube kind heat exchangers were given first-rate admire among all the instructions of warmth exchangers due to their virtues like relatively large ratios of warmth switch place to extent and weight and plenty of greater. Moreover properly designed in addition to described strategies are to be had for its designing and evaluation. After several materialbalance and energy balances on this equipment we have the following economic analysis.

Following are the outcomes;

1. It is vital to bear in mind the significance of getting oil refinery producing devices in India.
2. New and stepped forward generation were considered inside the development of this system design like 0 Liquid Discharge.
3. The classification of the crude oil is an important aspect for the unit layout
4. The fabric stability for this unit become four hundred,000 barrel of oil consistent with day
5. The overall electricity stability for the warmth exchangers 1, 2.....8 and ZLD machine was 1.382*1010KJ.
6. The cost of refinery was Rs 5030,00,00,000 or Rs 50.3*109

CHAPTER 5

2. CONCLUSION

This projects gives an in-depth explanation to the process design of a petroleum refinery not just with Indian standards but with the international standards. Most of the Indian refinery lacks the advance technologies in terms of equipment and designing. This projects gives an overview of the latest advancement and development in the field of Petroleum Engineering. Current industry faces lot of Environmental challenges whether it is in terms of Air pollution, Water pollution or soil pollution. With this project we have incorporated recent techniques like Zero Liquid Discharge, which is not only an energy efficient process for wastewater treatment but with the help of Zero Liquid Discharge system the water can be reused in the industry and thus saving a lot of operational cost.

It is crucial to recollect the importance of having oil refinery producing units in India. Factors like type of crude or location of the plant plays a pivotal role in deciding the distillation and refining units. For example, we have used Bombay High crude oil, which certainly has good API gravity and sulphur content but it contains a lot of wax which ultimately becomes a problem for the industry. Thus, to manage the amount of wax we have installed a dewaxing unit in the refinery. This projects takes in account that every element that is produced in the refinery is either sold as a raw material to other chemical industries or it is reused in the industry itself. Therefore making it cost efficient in long run.

The material balance for the unit was 400,000 barrel per day with an optimum rate of production considering the demand in country like India. The overall energy balance for all the equipment and Zero liquid Discharge system came out to be $1.382*10^{10}$KJ. Therefore, considering the material balance, energy balance and current economic industry the cost of refinery was calculated to be Rs 5030,00,00,000 or Rs $50.3*10^{9}$. In which the depreciation was considered for next 30 years. The refinery has a payback period of 1.2 years with continuous rate of production.

Hence, the process design for refining 400,000 barrel of oil per day in a petroleum refinery is completed with the consideration of various factors and optimization techniques.

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