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METHODS OF DESALTING CRUDE OIL

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بِسْمِ اللهِ الرَّحْمنِ الرَّحِيمِ

((قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا ۖ إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ))

صدق الله العظيم

سورة البقرة

الآية(32)

الاهداء

اهدي تخرجي ونجاحي الئ امهات الشهداء اولا
انا اليوم اكملت دراستي بفضل تضحياتهم
ودمائهم الزكيه هم ضحو في ارواحهم من اجل
الوطن ونحن نعاهدهم بالاخلاص في عملنا اثناء
سيرتنا المهنيه

شكر وتقدير

الئ الذين مهدو لنا طريق لعلم والمعرفه..
الى جميع اساتذتنا الافاضل .. ونخص بالشكر والتقدير د.حنون حسن لتفضله بالاشراف على بحثنا هذا لما بذله من جهود ورعايه علميه وتوجيهات ونصائح قيمه اذ كانت بمثابة وسام شرف لنا نعتز بها عاملينن بها لمن يقصدنا بالعون والمساعده واثرها واضح في عملنا.

Abstract

reason for desalination of crude oil is to remove water and salt from the oil, which can interfere with the characterization of its physicochemical properties and affect the price of the oil . The salt content of crude oil is reduced by washing crude oil containing residual salt water with wash water of lower salinity than the water present in the crude oil and allowing the resulting mixture to settle into a layer of crude oil of reduced salt water content and a layer of saline water.

Water droplets in crude oil can be difficult to separate due to the presence of emulsifiers and the viscosity of the oil . Desalination processes, such as using demulsifiers and ultrasound, can promote the coalescence of water droplets and facilitate their removal from the oil . Desalination also helps to improve the quality of the oil by reducing the content of sulfur compounds, which can increase the polarity of the oil and lead to the formation of emulsions . Overall, desalination of crude oil is important for reducing equipment wear and tear, lowering costs, and maintaining environmental integrit.

CHAPTER ONE

INTRODUCTION

Introduction

Throughout the history of petroleum refining, various treatment methods have been used to remove non-hydrocarbons, impurities, and other constituents that can adversely affect the properties of finished products or reduce the efficiency of the conversion process. Quite often these treatment processes use a variety and combination of processes to achieve the required crude oil grade. In order to do these, the crude may undergo desalting, drying hydro-desulfurizing, solvent refining sweating, solvent extraction, and solvent dewaxing.
Fine water droplets are dispersed in the crude continuous phase i.e. crude is surrounded by stabilized film of asphaltenes and iron sulfites. This stabilized film prevents water droplets from merging together and settling down. The droplets act as an appropriate medium for dissolving the salts.
Dissolved salts can affect the crude refining quite significantly, foul heat exchanger and refinery equipment. Also, at high temperature, mineral chlorides decompose to form HCl which is highly corrosive in the presence of water, and is believed to be the main cause of the overhead corrosion in crude fractionator Furthermore the most bothering salts are calcium chloride, magnesium chloride and sodium chloride is relatively stable and less decomposable.
Crude dehydration alone is not practically sufficient to remove water droplets and consequently salts from crude, since some water of high salinity will be remnant.
Desalting of crude oil is a treatment process made to remove salts from crude.

1.1Crude oil desalting processes

In a typical desalting unit, water is added and mixed to wash the salts in the emulsion and dilutes its salinity. An amine is added to the wash water or to the crude oil prior to processing in the desalter. The amine maximizes the yield of wash water removed from the desalter and substantially improves the removal of acid generating corrosive element.
The addition of the amine upstream of the desalter results in the removal of a significant amount of corrosive chlorides from the crude oil before it is passed through the fractionating unit and other refinery. he avoidance of adding metals to assist in removing other metals from the crude system aids in the reduction or elimination of downstream fouling and petroleum catalyst poisoning.

1.2 Removal of calcium (Decalcinization)

A calcium-containing hydro carbonaceous material is treated with an aqueous mixture, comprising acetate ion and an alkaline material and having a pH in the range of 3.0 to 5.0, in order to extract at least a portion of the calcium from the hydro-carbonaceous material into the aqueous phase. Acetic acid is a suitable source of acetate ion. Ammonium hydroxide, sodium hydroxide, and potassium hydroxide are example of alkaline materials.

3. Importance of process control

1. External disturbances

One of the most common objectives of a controller in chemical plant is to suppress the influence of external disturbances. The disturbances; which denote the effect of the surrounding on the processes are usually out of the reach of human operator. The control mechanism is needed to make the proper changes on the process on the process to cancel the negative impact of the disturbances.

2. Process stability

If a process variable as temperature, pressure, concentrations, flow rate return to their initial values by the time progress after disturbed by external factors; this is called self regulation and needs no external interventions for stabilization. If the process variable does not return to the initial value after disturbed by external influences, it is called as unstable process. This requires a control to stabilize the system behavior

3. Performance Optimization

Control is necessary for the processes of desalting crude oil and refinery operation. The main objectives of applying Control on processes are: maintaining safety (operation conditions to be within allowable limits), production specifications (final products to be in the right amounts), compliance with environment regulations (federal and state laws may specify temperature, chemicals concentrations and flow rates of effluent coming out from a plant to be within certain limits), Operational condition (some equipments have constrains to be adhered with through its operation in a plant) and economic consideration (plant operation must conform with the market conditions: availability of raw materials, demand of products and utilization of energy, capital and human labor).

CHAPTER TWO

▪ BRIEF HISTORY

▪ LITERATURE REVIEW

Brief history

Early 20th Century: The desalination of crude oil began in the early 1900s as the demand for petroleum products increased. Initially, simple gravity settling tanks were used to allow water and salt to separate from crude oil. This method was inefficient and required long settling times.

1940s-1950s: During World War II, the need for desalinated crude oil increased significantly. This led to the development of more advanced desalination techniques. Electrostatic coalescence, which used electric fields to separate water and salt from crude oil, was introduced during this period.

1960s-1970s: Membrane filtration gained popularity as a desalination method during the 1960s and 1970s. The development of synthetic membranes with specific pore sizes allowed for more efficient separation of water and salt from crude oil.

1980s-1990s: Chemical treatments, such as the use of demulsifiers and desalting agents, became widely adopted in the 1980s and 1990s. These chemicals helped break down emulsions formed between water and oil, facilitating their separation.

2000s-present: In recent years, there has been a focus on improving the efficiency and sustainability of crude oil desalination methods. Advanced technologies, such as nanofiltration and reverse osmosis, have been introduced to enhance the desalination process.

Additionally, research and development efforts have been directed towards reducing the environmental impact of desalination by optimizing energy consumption and minimizing waste generation.

Overall, the history of crude oil desalination is marked by continuous advancements in technology and a growing emphasis on sustainability. These developments have significantly improved the efficiency and effectiveness of desalination methods, ensuring a steady supply of purified crude oil for various industries.

Literature review

2.1. Electrostatic enhancement of coalescence of water droplets in Oil

highlighting particularly the mechanisms proposed for droplet-droplet and droplet-interface coalescence under the influence of an applied electrostatic field, as well as various factors influencing the electrocoalescence phenomenon. Generally, the coalescence behaviour can be described in three stages: droplets approaching each other, the process of film thinning/drainage, and film rupture leading to droplet-droplet coalescence. Other possible mechanisms, such as droplet chain formation, dipole-dipole coalescence, electrophoresis, dielectrophoresis and random collisions, are also presented. Experimental work and mathematical modelling of the coalescence process are both reviewed, including various models, such as molecular dynamic simulation, random collision/coalescence modelling, and linear condensation polymerisation kinetics. The type of electric field, such as alternating, direct and pulsed direct current, plays a significant role, depending on the design and set-up of the system. The concept of an optimum frequency is also discussed here, relating to the electrode design and coating. Other factors, such as the average droplet size and the residence time of the liquid mixture exposed to the electric field, are highlighted relating to coalescence efficiency. The characteristics of the emulsion system itself determine the practicality of employing a high electric field to break the emulsion. Emulsions with high aqueous phase content tend to short-circuit the electrodes and collapse the electric field. Type and concentration of surface-active components have been shown to impart stability and rheological property changes to the interfacial film, thus making the coalescence mechanism more complicated. More investigations, both experimental and by computer simulation, should be carried out to study the electrocoalescence phenomenon and to contribute to the design and operation of new electrocoalescers.

2.2. Highly Efficient Dehydration and Desalting of Crude Oil from Mature Fields in the Middle East

Mature crude oil fields are often prone to high water cuts and high content of fines. The large population of small water droplets and fines forms very stable crude oil emulsions that are difficult to break using conventional treaters. The high water cut creates a high-viscosity crude oil emulsion, often leading to a need for higher operating temperatures, high demulsifier dosage, and frequent production upsets.

The high water cut also causes arcing between electrodes. Typically, older crude oil dehydration and desalting treaters use AC-type electrostatic technology, which is less effective in treating crude oils with high water cuts. The use of AC/DC-type electrostatic technology provides a two-pronged approach—bulk water is removed in a weaker AC field, and the remaining smaller water droplets are removed in a stronger DC field. Further improvements to the AC/DC treaters include use of composite electrodes, modulated electrostatic fields, and improved fluid distribution inside the treaters.

AC/DC treaters provide an attractive opportunity for retrofitting existing AC treaters in mature fields and make the treaters more suitable for dehydrating the crude oil emulsions from these fields. Recent upgrading of a large number of older electrostatic treaters and desalters in the Middle East provided the operators with several benefits in the form of higher production, ability to operate the facility at a lower temperature, lower wash water consumption, and improved overall performance.

This paper describes a new enhanced electrostatic dehydration technology that provides improved efficiency in treating high-water-cut crude oil emulsions in mature fields and efficient test methods to optimize use of production chemicals and selection of electrostatic technologies. Several case studies from the Middle East are included.

2.3. Compositions and methods of removing contaminants in refinery desalting

It has been discovered that contaminants such as metals and/or amines can be transferred from a hydrocarbon phase to a water phase in an emulsion breaking process by using a composition that contains water-soluble C5-C12 polyhydroxy carboxylic acids, ammonium salts thereof, alkali metal salts thereof, and mixtures of all of these. The composition may also optionally include a mineral acid to reduce the pH of the desalter wash water. The method permits transfer of metals and/or amines into the aqueous phase with little or no hydrocarbon phase under-carry into the aqueous phase. Resolving the emulsion into the hydrocarbon phase and the aqueous phase occurs in a refinery desalting process using electrostatic coalescence. The composition is particularly useful in treating crude oil emulsions, and in removing calcium and other metals therefrom. The polyhydroxy carboxylic acid additionally inhibits metal corrosion of metal pipe or other equipment used in a crude unit.

4. Crude oil desalination and dehydration equipment and applications thereo

The invention relates to the technical field of desalination and dehydration of crude oil, and particularly provides crude oil desalination and dehydration equipment and a crude oil desalination and dehydration method. The crude oil desalination and dehydration equipment comprises a crude oil tank and an electric desalination tank, wherein the crude oil tank is connected to the electric desalination tank through a pipeline, the pipeline is provided with a heat exchanger, the electric desalination tank uses a vertical electrode plate structure, and the distance between electrode plates is 100-200 mm. According to the present invention, with the crude oil desalination and dehydration method, the dehydration effect on the refinery crude oil, especially the inferior oil, can be improved, and the problems of high desalination current, high energy consumption and serious emulsification of crude oil can be solved.

5. Crude oil desalting system

The present invention relates to a crude oil desalting system which applies high voltages supplied from an electric transformer to a high-voltage cable and enables a desalter to remove impurities such as moisture and/or salt from the crude oil in the desalter. The crude oil desalting system comprises: a high-voltage side bushing equipped with a jack plug for ensuring ease of attachment/detachment of the high-voltage cable; desalting side bushing for ensuring the durability of the high-voltage cable and preventing the outflow of the crude oil in the deslater; and a connection pipe for electrical connection of the high-voltage cable from the electric transformer to the desalter such that the high-voltage cable is in an electrically insulated state.

6. Improved desalter operation

A petroleum desalting process in which the role played by the oil/bulk-resolved-water interface in the dehydration of the stabilized emulsion which forms in the desalter is recognized. The desalting process is improved by introducing the demulsifier and chemical high voltage electrodes. Water droplets in the mixture coalesce and settle towards the bottom of the vessel. A stabilized emulsion layer formed from the oil and the water with additives into the water phase and/or injecting chemical additives directly in the vicinity of the water/oil interface. This improved methodology that makes the rapid and effective delivery of chemical demulsifiers to the rag layer and/or oil/bulk-resolved-water interface possible. In operation, the desalting is carried out by mixing a crude oil to be desalted with water and passing the mixture of oil and water to the desalter vessel. The mixture enters the desalting vessel in the form of an emulsified mixture which is then separated by application of an electric field between emulsion-stabilizing solids from the oil forms above the interface between the denser water layer and the supernatant oil layer. A chemical demulsifier is added to the water layer in the region of the stabilized emulsion layer and/or directly into the emulsion layer itself. The separated water is removed as effluent through a water outlet at the bottom of the vessel and desalted oil is removed from the oil layer through an oil outlet at the top of the vessel.

7. Heavy polluted oil processing device and method thereof

The invention relates to a heavy polluted oil processing device and a method thereof. The method comprises the following steps: heating the heavy polluted oil to be processed to 50-90DEG C, mixing with a de-emulsifier, and inputting to the light phase inlet of a centrifugation extraction separator; heating cycle water in a storing apparatus to 50-90DEG C, and inputting the heated cycle water to the heavy phase inlet of the centrifugation extraction separator; mixing and separating the heavy polluted oil and the cycle water in the centrifugation extraction separator; and respectively outputting the removed polluted oil and sewage from the light phase outlet and the heavy phase outlet of the centrifugation extraction separator, wherein the removed polluted oil and the sewage can be recycled. In the invention, the content of water in the heavy polluted oil is decreased to below 5%, the salt content is decreased to below 35mg/L, and the pollution source and the processing loss are reduced. The method and the device have the advantages of strong adaptability, short oil-water separation time, good dehydration and desalination effect, and low operation cost.

8. Electrostatic coalescence system with independent AC and DC hydrophilic electrodes

An improved electrostatic coalescence system is provided in which independent AC and DC hydrophilic electrodes are employed to provide more complete dehydration of an oil emulsion. The AC field is produced between an AC electrode array and the water-oil interface wherein the AC electrode array is positioned parallel to the interface which acts as a grounded electrode. The emulsion is introduced into the AC field in an evenly distributed manner at the interface. The AC field promotes drop-drop and drop-interface coalescence of the water phase in the entering emulsion. The continuous oil phase passes upward through the perforated AC electrode array and enters a strong DC field produced between closely spaced DC electrodes in which small dispersed droplets of water entrained in the continuous phase are removed primarily by collection at hydrophilic DC electrodes. Large droplets of water collected by the electrodes migrate downward through the AC electrode array to the interface. All phase separation mechanisms are utilized to accomplish more complete phase separation.

9. Energy-saving seawater desalination device

The invention discloses an energy-saving seawater desalination device which comprises a raw water tank, a microfiltration device, a nanofiltration salt separation device and a nanofiltration desalination device, and the nanofiltration desalination device being connected with the monovalent brine output side of the nanofiltration salt separation device and used for desalination treatment; a nanofiltration concentration device, connected with the concentrated water output side of the nanofiltration desalination device through a second water outlet pipe, and the concentrated water output side ofthe nanofiltration concentration device being connected with a high-salt water tank through a water drainage pipe; an RO desalination device, used for carrying out concentration desalination treatmenton the desalinated primary desalinated water; and a desalination water tank, the water inlet end of the desalination water tank being connected with the water production side of the RO desalination device. According to the device, the salt in the seawater can be desalted and treated step by step through gradient permeation, and the salt in the seawater is subjected to salt separation, concentration and resource utilization.

10. Estimation of Salinity of Salty Crude Oil Using Arrhenius-type Asymptotic Exponential Function and Vandermonde Matrix

Production of wet crude due to increase in oil-water contact in many oil fields has been a growing field problem and it has affected the quality of crudes. In almost all cases, the salt is found dissolved in the water that is dispersed in the crude oil and its separation is not an easy task because desalting is considered a critical operation due to the importance of meeting the specifications of the acceptable quantities of salt and water in the treated oil. For these reasons, measurements of salt and water content in crude oils are very important in all oil industry operations including crude oil production, processing, transportation and refining. In this paper, an attempt has been made to formulate a simple-to-use method which is easier than existing approaches, less complicated and with fewer computations for accurate and rapid estimation of crude oil salinity as a function of brine quantity that remains in the oil, its salinity (in vol% of sodium chloride concentration) and temperature using an Arrhenius-type asymptotic exponential function and Vandermonde matrix. The proposed method predicts the Salinity of Salty Crude Oil for temperatures up to 373 K and sodium chloride concentrations up to 250,000 ppm (25% by volume). Estimations from the proposed correlation are found to be in excellent agreement with the reported data in the literature with average absolute deviation being 0.3%. The proposed method is superior owing to its accuracy and clear numerical background based on Vandermonde matrix, wherein the relevant coefficients can be retuned quickly for various cases. The tool developed in this study can be of immense practical value for the engineers to have a quick check on the salt content in the crude oil at various conditions without opting for any experimental measurements. In particular, petroleum and field engineers would find the approach to be user-friendly with transparent calculations involving no complex expressions.

2.11. Analysis of particulate matter in anthropized areas characterized by the presence of crude oil pre-treatment plants: The case study of the Agri Valley (Southern Italy)

Atmospheric particulate matter (PM) is a significant worldwide environmental issue due to several adverse impacts on human health (Franck et al., 2011; Pope and Dockery, 2006; Pope et al., 2002), visibility (Yuan et al., 2006), ecosystems (Yatkin and Bayram, 2007; Rajamani and Yadav, 2006), global climate and atmospheric chemistry (Gugamsetty et al., 2012; IPCC, 2007). It is widely recognized that PM concentrations are highly variable in space and time due to many factors such as type, quantity and location of emission sources (both local and long-range transport related), background concentrations, chemical transformations, meteorological conditions, geographical and topographical characteristics of the considered area. All this makes the PM atmospheric dynamics very complex; therefore, an integrated approach combining an innovative statistical methodology with forecast models and remote sensing observations is necessary for understanding the origin of particles and characterizing the involved atmospheric processes. This approach is especially required in anthropized areas characterized by considerable contributions of local anthropogenic sources as well as those related to long-range transport and where the lack of data on PM chemical composition makes the identification of the PM sources, the nature of possible exceedances of limit and/or guidelines values and the dynamics in which PM is involved is rather difficult. Multivariate statistical techniques such as Cluster Analysis (CA) and Principal Component Analysis (PCA) are widely used to analyze PM data and obtain information on PM sources (e.g., Belis et al., 2013; Duan et al., 2012; Deshmukh et al., 2011; Senaratne et al., 2005) however, they are not able to gain insight into the complex and non-stationary nature of the PM time variability. Thus, different advanced techniques have to be applied. Among these techniques, the Singular Spectral Analysis (SSA) is particularly fruitful since it allows to decompose the original data into statistically significant non-linear trends and oscillations permitting the identification of temporal structures, like cycles, scaling, or also anomalies with respect to some background behavior (Kandlikar, 2007). Despite SSA application in several research fields such as climatology (e.g., Ghil et al., 2002), oceanography (e.g., Vianna and Menezes, 2006), seismology (e.g., Telesca et al., 2012), this technique is rarely used in air quality studies. In fact, at our knowledge, only He and Lu (2012) applied the SSA to air quality data to obtain indication about the major contributors to air pollution at a typical traffic intersection of Hong Kong.

The present study enters this context and analyzes PM_{10}, $PM_{2.5}$ and PM_1 (i.e., aerosol particles with aerodynamic diameter less than 10, 2.5 and 1 μm, respectively) data simultaneously measured in Agri Valley (Southern Italy) using a statistical approach based on the SSA along with model outcomes and satellite observations. Moreover, synthetic indices describing PM pollution were used to evaluate the degree of possible effects on human health as a function of particle dimension. The Agri Valley houses the largest on-shore European reservoir and the biggest existing crude oil pre-treatment plant located in an anthropized area. Moreover, due to its peculiar emission features and its position in the Center of the Mediterranean area, it represents a ―natural laboratory‖ where strategies for air quality monitoring can be developed and successively applied in areas open to local contamination phenomena and where the long-range transport contribution is not negligible.

12. Dewatering of crude oil emulsions 4. Emulsion resolution by the application of an electric field

The effect of the application of an a.c. electric field on the structure of a water-in-crude oil emulsion has been investigated both experimentally and using a molecular dynamics simulation. In both cases, long chains of droplets are seen to grow between the electrodes as a function of time. This results from an induced dipole on the water droplets in the presence of an external electric field, similar to that seen in electrorheological fluids. In the presence of a rigid interfacial film, resulting from adsorbed crude oil components such as asphaltenes, no coalescence of the drops was apparent. Simulations were also carried out to study the coalescence of water droplets in our emulsion, typical of those in which the asphaltene film was disrupted by the presence of added demulsifier. Coalescence was observed in the microscopic analysis. The results show that the solid interfacial film is a key factor for the prevention of coalescence between droplets in the electric field.

13. Safe Processing of High Acid Crudes

Economic pressures on the refining industry are forcing many refiners to look at lower priced high acid crudes to improve margins. These crudes may be discounted because they are perceived to cause increased corrosion or fouling problems, or simply because they are new or unknown to the market. If these problems are not properly managed or understood, the benefits of lower price may be consumed by higher processing costs or by the deterioration of the assets caused by corrosion. To safely process these high acid crudes, a comprehensive multi-discipline service has been implemented to identify, assess and mitigate the corrosion, fouling and processing risks associated with these crudes. This service covers all the aspects that are necessary to optimize the economics of processing corrosive crudes, such as materials selection, corrosion inhibition, process control, corrosion monitoring, inspection, and scheduling. In addition to managing the potential corrosion problems, it also addresses key issues such as crude oil selection strategy, the true value and cost of processing the crudes, an evaluation of the refinery's blending capabilities, the compatibility of various crudes, the quality of products, etc. This paper provides an overview of the strategic issues associated with processing high acid crudes and several case histories describing the benefits gained from using this approach.

CHAPTER THREE

- **THE PURPOSE OF DESALINATION OF CRUDE OIL**

- **CRUDE OIL DESALINATION METHODS**

The purpose of desalination of crude oil

The primary purpose of desalination of crude oil is to remove salt and other impurities from the oil before it undergoes further refining processes. Here are the main reasons why desalination is important:

1. Equipment Protection: Salt and impurities present in crude oil can cause corrosion and damage to equipment such as pipelines, pumps, and refining units. Desalination helps protect these valuable assets by removing the corrosive elements.

2. Refinery Efficiency: Salt and impurities can interfere with the refining process, leading to operational issues and reduced efficiency. Desalination ensures that the crude oil entering the refining units is of higher quality, allowing for smoother operations and improved yield of refined products.

3. Product Quality: Desalination helps produce higher-quality refined products. Salt can negatively impact the quality and performance of fuels, lubricants, and other petroleum products. By removing salt and impurities, desalination improves the final product's specifications and performance characteristics.

4. Environmental Considerations: Discharging salt-laden water into the environment can harm ecosystems and aquatic life. Desalination reduces the salt content in the wastewater generated during the refining process, making it safer for disposal or treatment.

Overall, desalination plays a crucial role in ensuring the integrity of equipment, optimizing refinery operations, improving product quality, and minimizing environmental impacts associated with crude oil refining.

Crude oil desalination methods

There are several methods used for crude oil desalination. Here are some of the most common techniques:

3.1.Gravity Settling

This is one of the simplest and oldest methods of desalination. Crude oil is allowed to sit in large settling tanks, where water and salt separate from the oil due to differences in density. The separated water and salt are then removed.

3.2. Chemical desalting methods

In chemical desalting, water and chemical surfactant (demulsifier) are added to the crude and heated so that salts and other impurities dissolve in or attach to the present water. The mixture is then held in a tank where they settle into two distinct phases.

3.3 Filtration method

A third and less-common process involves filtering heated crude using diatomaceous earth. In this method, the feedstock crude oil is heated to between 150 and 350 F to reduce its viscosity and surface tension for easier mixing and separation of its water content. The temperature is limited by the vapor pressure of the crude oil feedstock.

The three methods of desalting may involve the addition of other chemicals to improve the separation efficiency. Ammonia is often used to reduce corrosion. Caustic soda or acid may be added to adjust the pH of the water wash.

Waste water and contaminants are discharged from the bottom of the setting tank to the waste water treatment facility. The desalted crude is continuously drawn from the top of the settling tanks and sent to the crude distillation (fractionating) tower. In desalting process; control is necessary to avoid any problems that can make the desalting process failed.

3.4. Electrical desalting method

Electrical desalting is the application of high-voltage electrostatic charges to concentrate suspended water globules in the bottom of the settling tank. Surfactants are added only when the crude has a large amount of suspended solids.

Based on the salt containing situation of crude oil, before entering tank, crude oil exchanges heat (Figure 1) and then is filled with water. With proper strength mixing, the salts in crude oil are dissolved in water. Water exists in crude oil in emulsified state. By the polarization of high-tension electric field, the middle and small water droplets in the crude oil emulsion are accumulated to form large water droplets based on density difference between oil and water.

Water droplets settle down in the crude oil, and the salts are dissolved in water to be removed together with water.

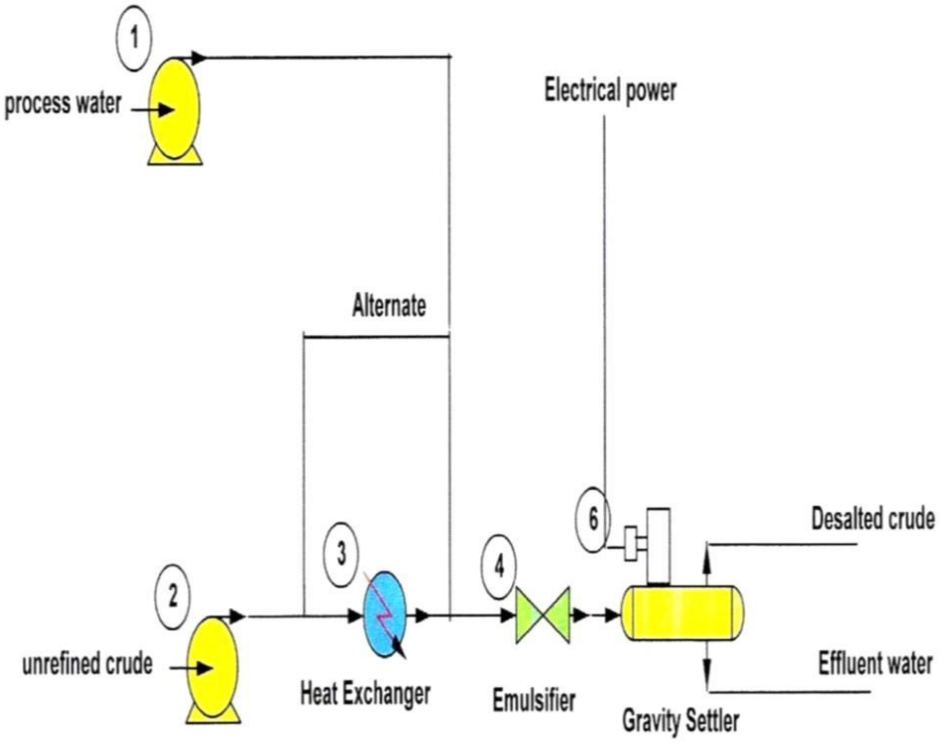

Figure 1: Electrical Desalting Process

Heating

The most pronounced effect is the reduction of oil viscosity. In addition, other advantages are contributed to heat. These are:
a. An increase in the difference in specific gravity between oil and water.
b. An increase in the droplet size as demonstrated by its molecular movement which enhances coalescence.
c. Heat will help destabilization of the emulsifying film.
On the other hand, heat has some disadvantages such as:
a. Loss of valuable hydrocarbons
b. Consumption of fuels for heaters
c. Heating equipment is costly
d. Gases liberated during heating will add additional problems in handling and represents a safety hazards
Field heaters are of two types:
- • Direct, in which the crude oil is passed through a coil exposed to the hot gases used as a fuel.
- • Indirect, in which water is used as a transfer medium for heat from hot flue gases to the oil to be heated and immersed in the water. Both methods are illustrated as shown in Figure 3. Examples of some industrial field heaters are: line heaters, wash tanks, gun-barrel treaters

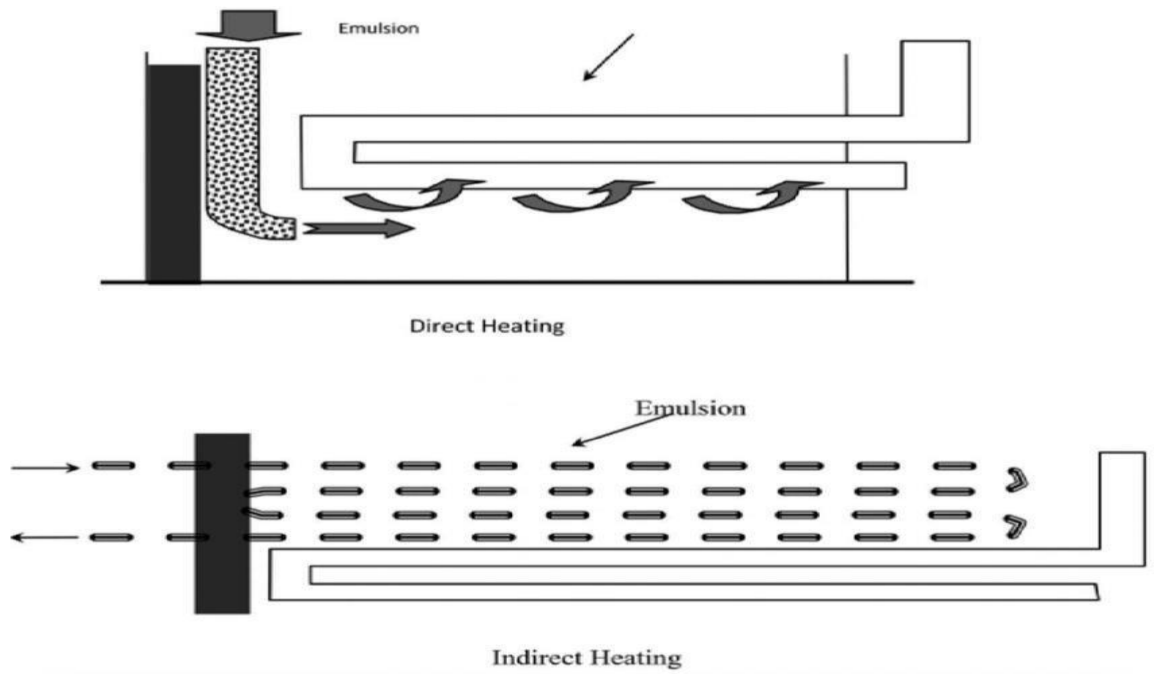

figure 2: direct and indirect heating

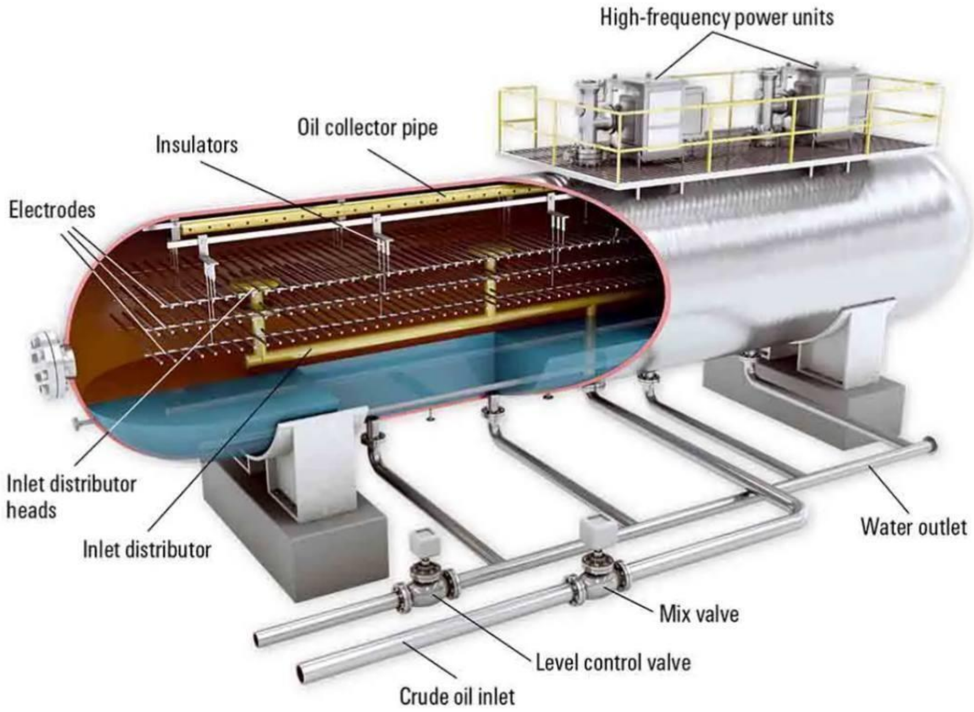

figure 3: Electric Desalter Components

Components of electric desalter are as follows:

1 High-Frequency Power Unit: This power transforming unit mounted on top of the desalter creates a high-frequency voltage in the Water-Oil mixture for Waterdrop coalescence.
2 Oil collector Pipe: After separation of Oil and Water. A separate layer of Oil forms on top of the emulsion which collected by Oil collector pipe. It is installed in the topmost part inside the desalter.
3-Insulators: These are components of desalter which insulate electrodes from other parts of desalters.
4 Electrodes: Power transmitted from Transformer are distributed through Electrodes in Oil-water mixture.
5 Inlet distributor: This is the main header pipe connected to the Inlet distributor heads.
6 Inlet distributor heads: these are branches from the inlet distributor header which distribute oil-water emulsion into the desalter tank.
7 Crude oil inlet: This is the piping system that allows crude to enter in the Inlet distributor header.
8 Mix Valve: This valve connected to crude oil inlet piping allowing or isolating crude flow into the desalter. This is also a common valve for freshwater inlet line chemical injection systems. In short, This valve allows the creation of a mixture of Crude oil, water, and demulsifying agent.
9 Water Outlet: This is the drainage of the desalter vessel which allows water to exit from the desalter system.
10 Level control valve: This is a valve connected to a water outlet piping system that controls the level of water inside the desalter vessel.
11 Desalter Feed Pump: Pumps sucking crude oil from preheating train and pumping to desalter.

Types of Desalter

According to the processing of crude oil and water mixture for cleaning and desalting, there are two types of the desalter present:

1 **Single-stage Desalter**: This type of desalting unit has a single vessel to process the crude oil-water mixture for removing oleophobic impurities from crude oil. In single-stage desalter water, the intake ratio is about 5%-7%.

2 **Two-Stage Desalter**: Field desalting requires water in some required percentage to efficiently process the cleaning of crude oil. But in places where freshwater has some scarcity, two-stage desalters are used.
In this desalting method, an Oil-water mixture enters 1st desalting with the mixing of emulsifying agents only. With the application of high voltage current in the mixture of 1st stage, some amount of staggered saline water accumulates and transferred to 2nd stage desalting vessel which 3%-4% wash water is mixed into the emulsion for further processing and desalting method.

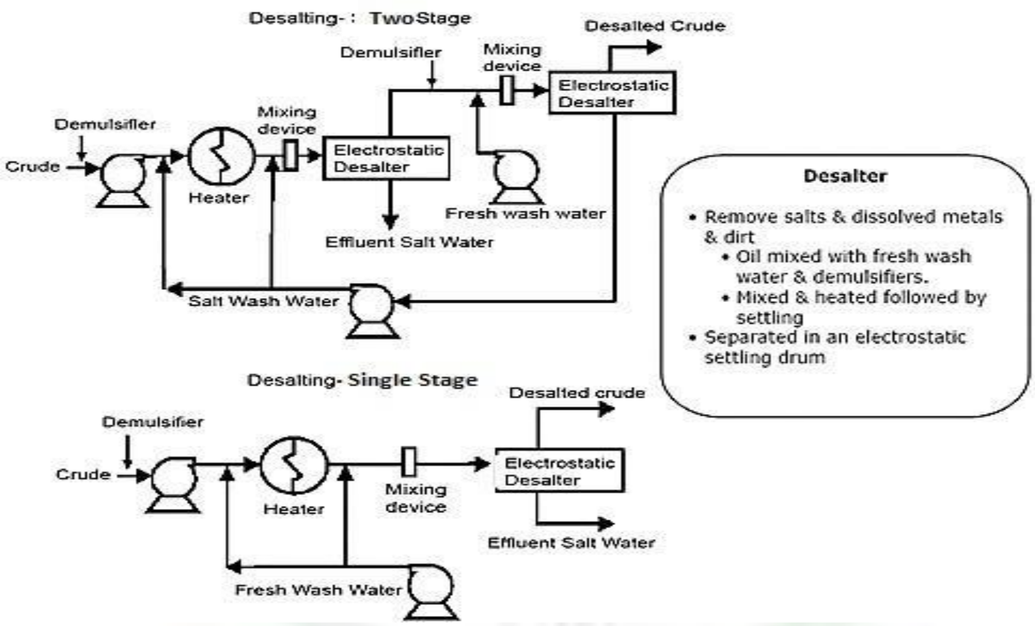

Figure 4:desaliting single stage and two stage

Optimum Transportation Method for Development of Extra Heavy Crude Oil

One of the big issues for the development of extra heavy crude oil is transportation from the well head to the refinery or shipping facility. Conventionally, dilution is applied to reduce density and viscosity and diluted heavy oil is transported through pipelines. However, if diluent is not available at low cost or in substantial quantities, such oil fields are not developed from an economic point of view.

Therefore, alternative methods, such as heated pipelines and partial upgrading technology to reduce the density and/or viscosity are expected as economic transportation methods rather than simple dilution. However, these methods also have advantages and disadvantages; heated pipelines may result in higher operating costs due to high electricity costs or higher capital costs in remote areas. Partial upgrading technology is also developed by several companies, but no matter what thermal technology is used for heavy oil conversion, the cracked products obtained may be unstable and they are not acceptable to the refineries. In this study, the economic evaluation of the transportation methods for extra heavy crude oil is addressed. Capital costs and operating costs for the dilution method, heated pipeline and partial upgrading are compared with respect to several factors, such as distance from the well to the refining facility or diluent cost.

Technical evaluation of partially-upgraded heavy oil is also addressed. Compatibility with other crudes, desalting operation, refinery fouling and hydrotreating were examined to address refinery processing of partially-upgraded heavy oil. JGC is operating a 5 bpd upgrading facility at Western Canada. Its operating experiences are applied for the economic and technical evaluations.

Systematic Approach to Controlling Fouling and Corrosion in Crude Unit Overheads and Hydrotreater Reactor Effluents

Fouling and related corrosion problems in crude distillation and naphtha hydrotreating units are often the symptoms of more fundamental problems. Some of these underlying problems are: the varying quality of the incoming crude, operating upsets in the desalters, inadequate procedures for draining the storage tanks, and the inappropriate use of process chemicals. The consequences of these problems can be higher corrosion rates, heat exchanger fouling, effluent water problems, increased energy consumption, and deactivation of catalysts in residue processing units. This paper describes a systematic approach to identifying the root causes and the solutions of corrosion and fouling in the crude distillation unit overhead and hydrotreater reactor effluent systems. This method has proven its effectiveness and efficiency to resolve complex and often puzzling problems, by combining multiple resources and skills needed to identify the cause of the problem and implement the solutions. Examples of recent case histories from several refineries illustrate the method.

CRUDE OIL DESALTING USING HYDROCYCLONES

Crude oil contains varying amounts of inorganic salts (NaCl, $CaCl_2$, $MgCl_2$, and so on). The presence of such salts presents difficulties during crude oil processing such as corrosion, plugging and fouling of equipment, and poisoning the catalysts in processing units. In order to mitigate the effects resulting from the presence of salts, it is advantageous to reduce the salt concentration to the range of 3–5 mg L^{-1}. The desalting process works by washing the crude with clean water and then removing the water to leave dry, low salt crude oil (Liu et al., 2003).
Electrical desalter is typical methods of crude-oil desalting. But operational complex and high operating cost are great disadvantages to electrical desalter. Many research institute developed the studying of non-electrical desalting and gained many achievements recently, including centrifuge method, filtration method, magnetic handling method, microwave radiation method and so on (Wang and Cui, 1997, Majumdar et al., 2002, Tirmizi et al., 1996, Law et al., 1997, Tanaka, 2004, Al-Otaibi et al., 2003, Popp and Dinulescu, 1997, Mohammed et al., 1994, Bai and Wang, 2006a, Bai and Wang, 2006b). But those techniques were less used in industrial production because of the complex of the equipment and low reliability.

Hydrocyclones are used in various industries to separate two components of different densities with the aid of the strong centrifugal force created by the swirling flow. The fluid is injected tangentially at the top of the hydrocyclone and cause centrifugal forces to accelerate particles towards the walls. As the fluid passes through the hydrocyclone in a spiral fashion, large or dense particles are forced against the wall and migrate downwards to the underflow. Figure 1 illustrates the fluid motion through a hydrocyclone. Fine or low density particles are swept into a second inner spiral which moves upward to the overflow.

Then a new process of crude desalting that is based on hydrocyclone technology is designed. Preliminary industrial experiments have been carried out to prove the feasibility of desalting using hydrocyclone. About 5–8 vol% of fresh water (or recycled sour water after stripping) is injected into the crude oil as fine droplets through a mixing valve to dissolve salts. We demonstrated here that salt was being removed successfully in the wash water through hydrocyclones.

THEORETICAL AND EXPERIMENTAL INVESTIGATION OF DESALTING AND DEHYDRATION OF CRUDE OIL BY ASSISTANCE OF ULTRASONIC IRRADIATION

Salts and water are removed from crude oil in day-to-day operation for four reasons: corrosion, scale accumulation, lowering of activity of catalysts and plugging or fouling in pipelines . In crude oil processing or refining, the desalting techniques for removal of dissolved salts, mainly NaCl, comprise the intentional mixing of the incoming crude with a fresh ―wash water‖ to extract the water soluble salts and hydrophilic solid that are formed [5]. An emulsion is then produced in which water droplets are dispersed in oil phase. The water emulsified droplets containing soluble salts in crude oil are stabilized by interfacial barriers (e.g. asphaltenes, resins and waxes), which are not easily separable to two phase of water and crude oil .

Desalting/dehydration units are installed to avoid transporting high viscosity liquids, ‗‗water-in-oil‖ (w/o) emulsions, which require more pumping energy . In order to minimize the production problems related with crude oil emulsions and environmental concerns, petroleum operators need to prevent their formation or to break them . The main objective of a desalting plant is to break the films surrounding the small water droplets, coalescing droplets to form larger drops, and allowing water drops to settle out during or after coalescing .

The commonly used electrostatic method for breaking emulsion has drawbacks such as a high operation and energy cost (applying a high electric field of 1–10 kV/cm) or contamination of treated crude oil. In emulsions with high aqueous-phase, water droplets surrounded by a rigid interfacial film will attain a chain-like configuration under the influence of a low electric field. Increasing the field strength will cause the droplets to bridge the gap between the electrodes . The chains of aqueous droplets connecting the electrodes will create short-circuits and ultimately will lead to collapse of the electric field applied in the desalting device [. Also, Binks] concluded that w/o droplets decrease in size solubilizing more oil with increasing the salt concentration. At low and high salt concentrations, the monolayer constrained to lie at the flat interface has a preferred tendency to curve and increase the tension. Therefore, for heavier crude oil which contains more salt concentration, the commonly used electrostatic method is an undesirable and non-efficient method.

The present work demonstrates that breaking the w/o emulsion can be carried out with an easier, cleaner and more efficient method using ultrasonic irradiation. Devices for the irradiation are easy to install into common equipment. In addition, irradiation conditions are adjustable to satisfy the objectives of the study .

The effect of ultrasonic waves had been studied on suspended particle , droplet and bubbles . Recent studies, have investigated this effect on the oil emulsions separation acceleration. Yu et al. carried out an experimental study on the crude oil dehydration in a reverberation-wave resonator chamber in which the radiated sound waves get a total reflection at the bottom of chamber and then spread at the opposite direction of the radiated wave. Guoxiang Ye et al. presented a more efficient resonator chamber by using the known acoustic field of standing wave in which, unlike the reverberation field, the acoustic path length must be equal to odd times of the ultrasonic half wavelength and accordingly all of the reflection waves have the same frequency and amplitude as the radiation ones. Therefore they could demonstrate that the desalting and dewatering results in the ultrasonic standing wave field were better than those in the ultrasonic reverberation field . Since the acoustic chamber designed by Guoxiang Ye et al. was based on applicability at atmospheric pressure, the used different temperatures were below the boiling point of crude oil (below 80 °C) and thus are not practically acceptable for refinery. Furthermore, the operating results at optimum temperature can't be estimated via extrapolation of the results of their experiments, because the behavior of ultrasonic waves in the emulsions (such as velocity, attenuation) varies strongly with temperature Therefore, their results only indicate that, the ultrasonic irradiation in the standing-wave field is a desirable method for w/o emulsion separation.

In this study, the optimum irradiation temperature (as an operating parameter) is obtained, by evaluating different ultrasonic irradiation temperatures in a novel standing-wave resonator reactor, and then applied for ultrasonically assisted desalting and dehydration of crude oil. Moreover, the effect of other main parameters including ultrasonic irradiation parameters, namely irradiation input power and irradiation time, and also the operating parameter of injected water on the removal efficiencies of salt and water have been investigated.

APPLICATION OF ULTRASOUND ON CRUDE OIL PRETREATMENT

As a current preliminary step of refinery treatment, crude oil is normally desalted to remove species such as chloride which deactivate the refinery catalysts and cause further corrosion of overhead distillation columns . In this process, water is deliberately mixed into the oil to dissolve hydrophilic materials. Usually, emulsions are formed of water-in-oil (w/o). In the case of emulsions, when two droplets approach each other, the interfaces are separated by a thin film of oil [5]. The emulsions must subsequently be broken down to recover the ―clean‖ crude oil. Some of the oil fields have already got into the stage of secondary or tertiary oil recovery. The crude oil recovered in this way tends to become ropier and heavier, containing more salts. It may be hard to desalt those oils with conventional methods by electric desalting and dewatering processes. Blackout of the desalting device and current collapse of the electric field usually happened. The oil pretreatment is discontinuous and unsteady. The need of demulsification and the impetus of developing new methods for effective treatment of oil have become more acute .The stability of w/o emulsion was decreased in the presence of ultrasonic irradiation. This was due to the impulse of ultrasonic field. The motion of solid, liquid or bubble particle in an acoustic field had been studied by many researchers in the past, such as Zhao et al. Pangu and Feke and Yutaka et al. . The suspended particles would respond to the acoustic resonant if there was a non-zero acoustic contrasted between the dispersed phase and the suspending fluid. In those methods, a one-dimensional sound field was used to organize the particles into thin parallel bands separated by half of the acoustic wavelength spacing. The particles were separated from their suspending fluid by two methods. Firstly, barriers were placed closely between the bands of particles. Particle-free and particle-rich streams were produced in the acoustic field. It would be transported into separate exit streams Secondly, the particles were also transported to the opposite direction of the flowing fluid by using slowly moving pseudo-standing-waves . It was shown that tiny water drops in the crude oil could be driven and aggregated into bigger ones in a suitable ultrasonic standing-wave field. Therefore, the water drops would settle down easily.

The original emulsion of water in the crude oil is very stable and difficult to be broken Many researchers were concerned on the dewatering process of the crude oil by ultrasound in oil fields. Seldom of them applied ultrasound on the desalting step of the crude oil, especially in refinery In this paper, ultrasound was applied in demulsification of the man-made crude oil emulsion to desalt. A method moving suspended drops to the nodes of an ultrasonic standing-wave field was given . It was efficient to separate water from oil emulsion with ultrasonic. The main purpose of this paper was to demonstrate the method for separating water from oil and to investigate the influences of ultrasonic standing-wave resonator to desalting process.

APPLYING ULTRASONIC FIELDS TO SEPARATE WATER CONTAINED IN MEDIUM-GRAVITY CRUDE OIL EMULSIONS AND DETERMINING CRUDE OIL ADHESION COEFFICIENTS

Crude oils, as they are produced, are complex mixed fluids, associated with salt-water often in the form of persistent emulsions that are difficult to breakdown. Some of these water-in-oil emulsions are actually developed during crude oil handling at the surface as it passes through pipework and valves and its pressure and temperature changes. In addition to becoming bound up in emulsions, some of the produced water becomes fixed in other components that natively exist in crude oil, such as waxes, resins, asphaltenes, and solids .

During crude-oil production, its association with water is both undesired and costly, particularly during midstream transportation and storage in pipelines, terminal tanks, and ships . Water-free crude oil is a requirement for efficient pipeline flow and refining processes. The water and salt contents of crude oil need to be minimized before it can be efficiently refined. Breaking water-in-oil emulsions are often required to achieve sufficiently low water contents in crude oil sold to refineries; that means reducing the water cuts of crude oils to less than 0.5% weight percent Breaking down water-in-oil emulsions in crude oil can be difficult, requiring complex treatments for large scale processing plants. A broad range of novel technologies and their applications, introduced in recent years, plays a substantial role in improving standards of living and access to energy and resources, such as CO2 emission , energy resources , enhanced oil recovery , iron corrosion , bioresources

Demulsifying crude oils can be achieved in laboratory and field scales , by various processes, which in addition to dosing them with chemical demulsifiers, include treatments involving: centrifuges , filtration through membranes , and microwave irradiation . These demulsification procedures demonstrate high efficiency when applied to light crude oils. However, as crude oils become denser with longer-chain hydrocarbon molecules making them more viscous, these demulsification processes become less efficient and often require the addition of chemical demulsifiers to be effective.

Various methods have been proposed and tested in the past two decades to exploit ultrasound to enhance water-in-oil demulsification , and oil in produced water emulsification , some of which have been patented . More recently, some ultrasound methods have been scaled up for field-scale processing plant applications . Specifically, for demulsification operations, two ultrasound effects have been identified as influencing the separation of water from oil. These are the production of standing waves and cavitation , Cavitation depends on how ultrasound treatments are applied and can either enhance droplet formation in fluids involving liquid phases that are immiscible or indeed stimulate emulsification . Cavitation in powerful ultrasound treatments can cause larger drops to disperse into smaller droplets by micro-jet activity fracturing the drops leading to emulsification . On the other hand, in certain conditions and fluid types, cavitation can stimulate the coagulation of drops instead of their fragmentation , thereby enhancing water and crude oil separation . The bulk viscosity of the emulsified oil-in-water fluids and the emulsion droplet size play a role in the efficiency of ultrasonic wave fields in separating oil and water .

Ultrasound has been successfully used in demulsification mixtures of water with natural plant oils and hydrocarbon-based solvents as well as crude oil . Several advantages of ultrasonic methods have been reported by researchers. One of the advantages of ultrasonic methods is the reduction of the emulsification time and the formation of smaller droplets compared with that generated by the conventional method . The beneficial effects of ultrasonic waves on crude oil viscosity were previously recognized by Abramov et al. . They showed that a viscosity reduction of 16% could be obtained by the application of the ultrasonic waves implemented by a downhole tool in the wellbore . An ultrasonic method for enhanced oil recovery has also been proposed . An average 3-fold productivity increase was accomplished for a production well employing a chemical treatment technology linked with the ultrasonic technique

Applying ultrasonic fields represents a relatively new technology for achieving the dewatering and desalination of crude oil. Experimental analysis reveals that the segregation of water from medium-gravity crude oils can be effectively achieved by applying ultrasonic fields . This enables ultrasonic techniques to potentially replace conventional desalting and dehydration equipment typically used in crude oil processing. Moreover, it has the potential to substitute for electrostatic treatments which work less well with medium-gravity and heavy-gravity crude oils. Ultrasonic crude oil treatment systems are shown to be potentially better alternatives than relying on chemical demulsifiers to break water-in-oil emulsions in crude oils. They could achieve a substantial reduction or, in some cases, total avoidance in the use of such chemicals in the water separation processing of crude oils. This would lead to the added benefit of reducing environmental pollution due to the generation and processing of wastewater from conventional oil dewatering and desalting units. Therefore, the practice of using chemical demulsifiers in crude oil processing is prevalent around the world, leading to high costs in procuring chemicals and potentially adverse environmental impacts as some of the chemicals used are potential water and soil pollutants . Based on the ultrasonic pilot-plant studies, ultrasonic fields also offer the potential to be used to continuously separate water droplets in crude oil pipelines. Chemical demulsifiers are popular because they are easily applied at a reasonable cost . However, applying ultrasonic methods typically increases the production cost and these methods must be improved to provide lower costs to be accepted as a replacement for chemical demulsifiers.—

The amount of energy delivered during the deployment of ultrasound, with water as the dispersed media can be adjusted to tune the effectiveness of oil-water separation and avoid causing emulsions to form emulsification. Nevertheless, published studies have primarily focused on applying ultrasound frequencies of 35 kHz. Demulsification efficiency has been shown to increase as irradiation time increases, but published studies question how significant this effect is in practice . High temperatures, which may accompany long irradiation times have been shown to diminish the water separation effects of ultrasonic treatments . Ultrasonic power has also been identified as a critical variable; below certain power thresholds, ultrasonic waves can enhance demulsification, whereas above those thresholds emulsification can actually increase
The hydraulic residence time (HRT) of fluid into an ultrasound coalescence chamber needs to be carefully controlled to achieve maximum water separation benefits The optimum HRT is likely to be influenced by the initial water concentration in the crude oil and the temperature of the production fluids entering the ultrasound chamber. In some cases, there is a requirement to accompany ultrasound treatment with a minimal demulsifier dosage to optimize separation. The stability of the emulsion is also influenced by the presence of surfactants and biosurfactants in fluid production streams from enhanced oil recovery projects . As well as assisting in dewatering and desalting water-in-oil emulsions, ultrasonic treatments have also been shown to enhance oxidative desulfurization efficiency by some 10% at ultrasonic conditions of 100 W and 70 kHz .
Unfortunately, most existing research is dedicated to investigating the effects of ultrasonic waves on oil-water separation as an *assisted* technique for industrial applications. The objective of this work is to evaluate the potential for the ultrasound method to *replace* conventional desalting and dehydration equipment.
In this experimental work, the ultrasonic field was tested to evaluate its demulsification performance when applied to three types of medium-gravity (25° to 30°API). These crude oils were used as the basis for forming synthetic emulsions (water-in-oil) with various water concentrations: The tests conducted on these fluid mixtures with synthetic emulsions included 1) varying the ultrasonic irradiation time (between 1 and 5 min), 2) varying the initial water concentrations in the crude oil samples (10%, 15%, 20%, and 25%), and 3) varying the ultrasonic field intensity
(0.25 w/cm^3, 0.5 w/cm^3, 0.75 w/cm^3 and 1 w/cm^3).
Three distinct crude oil (codes 010, 020 and 030) qualities are used in this study: crude oil 010 (25°API), crude oil 020 (28°API), and crude oil 030 (30°API). The crude oil samples were injected with fresh water and chemical emulsifiers: 75 ppm for 010 oil and 50 ppm for the 020 and 030 samples. These combinations were subjected to five minutes of high-speed electric mixing to produce homogeneous emulsified fluid samples. The samples

were each then irradiated for 1, 2, and 5 min. The effectiveness in separating the water from the crude oil in each sample was evaluated by establishing the differences between the initial and final contents of the water. Additionally, the adhesion coefficient function (β) was measured, for each of the three samples of crude oil tested in terms of ultrasonic field intensity and the initial water concentration of crude oil.

METHODS FOR GENERATING ULTRASONIC WAVES:

1 PIEZOELECTRIC VIBRATORS

The interaction of mechanical pressure and electrical force in an environment is called the piezoelectric effect. For example, some crystals produce electrical force due to mechanical pressure, and, conversely, the created potential difference between opposite sides of such crystal causes compression and expansion. Sustaining such compression and expansion over time causes oscillation and the creation of ultrasonic waves. These materials are referred to as piezoelectric and typically exist in macrocrystalline forms. The piezoelectric effect is present only in crystals that do not have symmetrical structures. Quartz crystals often exist in piezoelectric forms and were used to create ultrasonic waves for the first time. Although many natural crystalline materials display piezoelectric properties, in the industry the crystals that are commonly used to generate sustained ultrasonic waves are made of artificially produced ceramics. Some of the materials used industrially are crystalline mixtures of lead zirconate and lead titanate which are highly piezoelectric. These materials act as a useful means for converting electrical energy into mechanical energy (as ultrasonic waveforms), and vice versa, are referred to as transducers

2 MAGNETOSTRICTION

Ferromagnetic materials, under the influence of the magnetic field involving small magnetic dipoles, become spontaneously aligned with their influencing dipoles. The shape and size of these materials change in these fields and can be made to oscillate according to the frequency of imposed alternating currents, leading to the production of ultrasonic waves. The intensity of the ultrasonic waves generated via the magnetostriction method is low. This method is more practical for generating ultrasonic waves in the laboratory

3-ULTRASONIC WAVES IN EMULSION SYSTEMS

As shown in FIGURE 5 , oil droplets tend to be dispersed in water-in-oil emulsions. The effectiveness of the breakdown of such emulsions and ultimate separation of water and oil components depends on several factors. The ultrasonic force on the emulsion system causes the separation of droplets from the fluid due to the difference in density and the velocity of sound passing through the two fluid components.

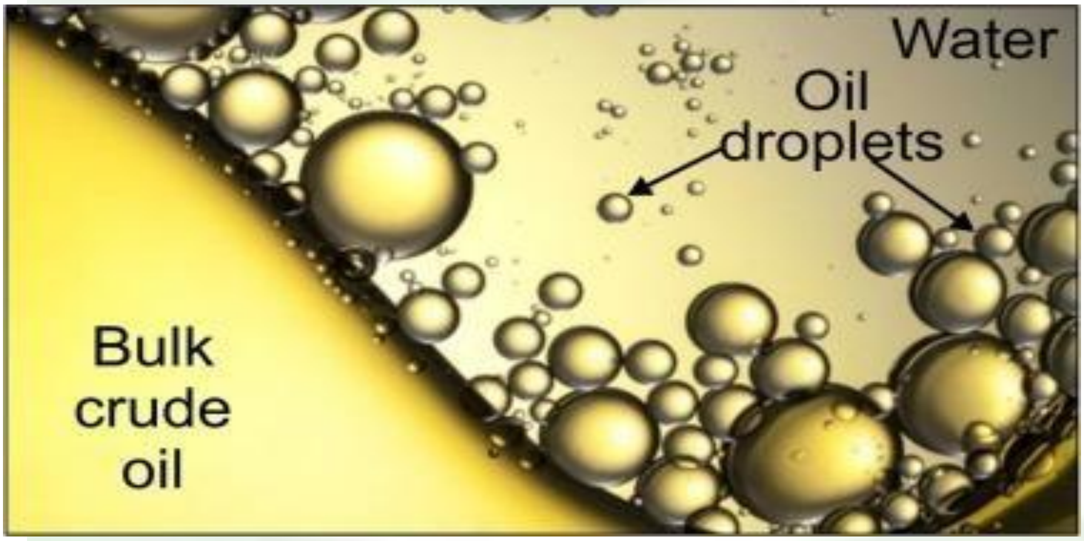

Figure 5: image of water in oil emulsion in oil. Breaking such emulsion to effectively remove water from crude oil

Oil-in-water and water-in-oil emulsions formation and demulsification

In the petroleum industry oil and water emulsions are frequent, not only in oilfield operations but also during the transportation and refining processes. Once depicting emulsion formation and stabilization, it is essential to analyse how it is possible to reverse the process, demulsifying the emulsion. Depending on operating conditions and fluid components, crude oils can form stable emulsions with water. In fact, some of the oil's compounds can act as natural surfactants, decreasing the interfacial tension between fluids, promoting emulsification (https://www.sciencedirect.com/topics/earth-and-planetary-sciences/emulsification). (https://www.sciencedirect.com/topics/earth-and-planetary-sciences/emulsification) Several studies have been developed to analyse how the emulsification (https://www.sciencedirect.com/topics/earth-and-planetary-sciences/emulsification) process occurs and how to demulsify

them. However, the literature does not offer a systematic review of both methods.
The current work is a critical review to highlight the energy input needed to promote the formation of an emulsion and the type of emulsifying agents necessary to enable the appearance of oil-in-water or water-in-oil emulsion. Secondly, this work also aims to review the state of the art of demulsification techniques applied in the oil industry. The result offers a robust background on this matter, discussing the demulsification methods, enabling a decision support perspective since it emphasizes their advantages and disadvantages.

The Safe Processing of High Naphthenic Acid Content Crude Oils - Refinery Experience and Mitigation Studies.

The economics of processing opportunity crudes is often so attractive that more and more refineries are updating their strategy for purchasing these difficult crudes. The experience gained from treating over 50 high acid crude units over the last 20 years is used to manage the risks of processing new opportunity crudes. When developing a strategy for processing opportunity crudes, you must consider the total impact on the refinery- both positive and negative. This paper shows an effective way to analyze opportunity crudes for potential negative impacts on the process. Risk managing techniques for corrosivity studies, desalter emulsion stability, fouling prediction and stability issues are reported. Listed are laboratory and field evaluations utilising on-line monitoring systems, corrosion probes and corrosion coupons. Proper monitoring strategy is critical to successfully managing the risk of processing opportunity crudes. Finally, the use of high temperature corrosion inhibitors was successfully evaluated as a means to mitigate naphthenic acid corrosion.

Performance Appraisals of Gas/Oil Separation Plants.

Produced crude oil is typically processed at wet crude handling facility (WCHF) or a gas oil separation plant (GOSP). Most of the crude is commingled with water and produced in the form of emulsions that are separated at the GOSP using demulsifiers. In general, the emulsions at the inlet of Saudi Aramco GOSPs are tight and no free water is observed in the feed stream. In spite of the tightness of the emulsions, the demulsifier costs per barrel of produced oil in Saudi Aramco are one of the lowest in the world.

This paper describes the performance appraisal of several Saudi Aramco GOSPs. It also discusses the evaluation of these facilities and the efforts undertaken to reduce and optimize the costs of oil-water separation. The most important effort was the characterization of emulsions from various fields. It shows the relative tightness of emulsions and the associated causes of tightness. It has become a diagnostic tool in the quest to understand the causes and treatment of emulsions. The inlet emulsions were characterized by conducting field tests at each of the GOSPs using fresh emulsion samples. The factors associated with the tightness of emulsions include the amount of fine solids such as asphaltenes and scales in the crude, watercuts, temperature, brine chemistry, and shear. Another aspect of oil-water separation investigated was the effect of processing equipment and vessel retrofitting. These included the conversion of two-phase (gas-liquid) separators into three phase (gas-oil-water) separators, installation of coalescer packs, demulsifier injection strategies and use of online analyzers. An innovative approach to optimizing oil-water separation is described. The paper provides invaluable operational experience and many _lessons learned‘ are applicable to other crude oil treating facilities.

The Impact of Oil Field Chemicals on Refinery Corrosion Problems.

Chemical additives play an important role in oil production. Chemicals are used to enhance oil production, control corrosion, prevent wax or paraffin deposition, enhance the flow characteristics of the crude oils, aid in water separation, etc. However, oil field chemicals are often suspected of causing diverse problems in refining operations, including corrosion, fouling, desalting upsets, and loss of catalyst activity. One recent example is the appearance of "rogue chlorides" in certain crudes, which has led to severe corrosion problems in crude distillation units and naphtha hydrotreaters. This paper presents a review of the nature and function of chemical additives that are commonly used in oil production, and discusses examples of the type of problems encountered in refining that are caused by some of these chemicals. A clear understanding of the impact of oil field chemicals on refinery operations is critical to both refiners and producers, to avoid these problems and prevent the erosion of value of the crude. Better communications between producers and refiners is a first step to resolve these problems

Economic Feasibility of Crude Desalting With Multistage Agitated Extractors.

Desalting of crude oil for processing is related to environment protection and corrosion problems. Spherical, vertical and horizontal desaltors and electrodehydrators have been used for desalting of crudes, with a considerable processing cost. The crude oil contains fine globules of brine that remain in the oil. Natural surfactants are absorbed on the surfaces of these globules. These surfactants are emulsifiers that form strong hydrophobic films which can be broken up by mechanical agitation and counter-current flow of the crude oil and water. Crude oil desalting is particularly difficult when the oil contains large amount of resins and asphaltenes, which gives stable emulsion and persists gravity separation. However, counter-current liquid extraction columns make gravity separation much easier. Agitated extraction columns require smaller vessel size, operate at lower temperature, can handle viscos crude, operate counter-currently with high mass transfer rate, high efficiency, and large throughput with reduced operational cost. The process is much feasible and desirable with substantial reductions in the quantity of fresh water and thermal energy.

It is strongly recommended that the concerned parties start experimentation on these columns in parties start experimentation on these columns in order to establish the operating range for an efficient alternative to the existing desalting technology.

Handling, Treatment and Transportation of Fluids Tailor-Made for Faja Crudes.

The extensive development of the Orinoco Belt has been supported by the concourse of various worldwide companies with different philosophies. Thus, Exxon-Mobil, Conoco, Phillips, Texaco, Totalfina, Veba Oel, Statoil and PDVSA are participating in the Orinoco Belt development and their participation has been determinant in the operation and design criteria for each of the particular project.

To face the challenge of developing this huge field, with more than 1,2 MMM Bls OOIP, of a crude with extreme characteristics such as 7-9°API gravity and dead crude viscosity between 20,000 and 100,000 cst, as well as the foamy oil and topography effects, it has been necessary to implement the following:

- Conventional Technologies, such as gas separators, electrostatic dehydration and desalter, heater treater, etc.
- Advanced Technologies, such as multiphase pumping and measurement.

• New developments jointly with the suppliers, such as high volume capacity Progressive Cavity Pumps (PCP).

This paper summarizes and compares the different technologies and methodologies utilized by various companies currently involved in the Orinoco Belt such as Petrozuata, Sincor, Ameriven and Cerro Negro, for handling, measuring, treating and transporting crude, water and gas which were tailor-made for the Orinoco Belt crude.

Crude Oil Process Enhancement and Water Conservation Through Industrial Revolution Initiatives.

One of the primary functions of Saudi Aramco Gas-Oil Separation Plants (also known as GOSPs) is to separate emulsified water from the crude. The water is typically highly concentrated with salt, so crude desalting is required to meet the standard quality specifications. GOSPs are typically designed with standard Proportional-Integral-Derivative (PID) controllers to control demulsifier and wash water flow for injection into wet crude. Demulsifier and wash water injection rates are normally left to operator judgement. The challenge with manual adjustment of flowrate is the high risk of overdosing or underdosing as there are several variables that impact the required demulsifier and wash water rates. Overdosing will result in wastage of demulsifier and wash water and higher operating expenditures. Underdosing may lead to operational upsets and potentially off-spec crude production.
To overcome this challenge, innovative schemes (Smart Demulsifier Control & Wash Water Ratio Control) have been developed in-house. Smart Demulsifier Control optimizes the separation efficiency (or percentage of total produced water separated) of an upstream High Pressure Production Trap (HPPT or 3-Phase Separator) based on a dynamic target by adjusting the demulsifier injection rate and concentration in the wet crude. Simultaneously, wash water ratio control ensures that an adequate wash water rate is injected to satisfy salt-in-crude specifications. These control schemes eliminate the need for operators to determine the required dosage rate, thereby avoiding both overdosing and underdosing of demulsifier and wash water.
The Smart Demulsifier Control (SDC) scheme controls demulsifier injection using two control layers. The first layer controls the Concentration of the Demulsifier in the Wet Crude so that demulsifier flow is automatically adjusted based on the Production Rate to achieve the set point concentration determined by the second layer of control. The second layer adjusts the demulsifier concentration to control the Separation Efficiency of the HPPT, or the amount of water separated in the HPPT vs. the Dehydrator, to achieve the Target

Separation Efficiency Set Point determined by a site specific process model. In case of a dehydrator upset, another PID controller with more aggressive tuning will override the HPPT Separation PID Controller to set the required demulsifier concentration to mitigate the upset.
Wash water ratio control scheme controls the flow of wash water to ensure that the salt-in-crude specification is met. A site specific target ratio is determined through a salt mass balance.
These innovative controls have reduced desalting train upsets by 78% as the process related upsets are practically eliminated. This is achieved while optimizing the demulsifier dosage where 20-40% of demulsifier dosage reduction was realized, especially during the winter season. Moreover, savings of 20% wash water have been achieved throughout the utilization of these self-calculated and smart controls that were developed in-house with minimal costs.

CHAPTER FOUR

CRUDE OIL DESALTER:

IMPORTANCE

ADVANTAGE

WORKING PRINCIPLE

If crude oil is left untreated before processing, salt present in crude oil can cause many types of operating failure and maintenance problems. Crude oil Desalter is an important part of the refinery that helps to clean crude oil in its initial processing stage. Before processing crude oil in the heater and stating its separation process in Crude or Vacuum column every oil refinery needs to process crude oil through desalter.

you will learn:

1 What is desalter and why it is important.
2 Working principle of Desalter and Its transformer.
3 Process scheme of desalter
4 Type of desalter and its component
5 Frequently used desalter related terms and
6 Variable that affect the efficiency of desalter in crude processing

Why Desalter is important?

The main purpose of desalter is to remove undesirable impurities from crude oil before processing it for distillation. The most concerning points for removing impurities from crude oil are as follows:

- Inorganic impurities like chlorides of sodium, calcium, and magnesium can be decomposed in the Heating unit and Hydrogen Chloride will be formed which can get condensate to Hydrochloric Acid.
- This formation of hydrochloric acid may cause corrosion to other equipment and piping systems resulting in less life span than expected.
- By-products of Salts present in crude oil can cause plugging of the heat exchanger, column trays, coils of heat, and also they can cause corrosion to any surface they contact.
- Sand or Mud present in crude oil can damage Pumps and piping systems and will require more maintenance

Advantage of Desalter in oil production

The basic benefits of desalter for crude oil are as follows:

• Cleaning of crude increases flowability in pipes, Pumps, Heat exchangers, etc.
• Less plugging and choking of equipment and piping system.
• No formation of scale in the Heat exchanger and heating unit
• Less corrosion in the Heat exchangers, distillation towers, Piping systems, etc.
• Less maintenance for pumps because of removal of mud, sand, and other impurities.
• Saving of oil from waste crude.

Desalter working principle

Crude oil received after transportation includes many types of salt traps in small droplets of water staggered all locations of the volume. These droplets are so small that self-extraction and settling are not possible. In general, there are 03 types of oleophobic Impurities found in crude oil:

• Salt: Mainly chlorides and Sulphates of Sodium (Na), Potassium (K), Calcium (Ca), and Magnesium (Mg).
• Sediments: Such as silt, sands, Mud, Iron oxide, and Sulphides.
• Water: Present as soluble, emulsified, and finely dispersed form.

Apart from above mention impurities crude oil also have some Oleophilic impurities but Desalter basics work to clear those 03 types of impurities for crude oil cleaning. The basic principle to wash the salt from crude oil is called Desalting. This Desalting process is done in two steps:

1. 1st Step is to dilute the dispersed water-soluble salt content with fresh water
2. 2nd Step is to remove diluted dispersed brine from crude oil.

For the First Stage of desalting, The crude oil is heated up to 120°C to 140°C then freshwater is added in crude oil in the amount of 4%-8% (Vo/Vo) with demulsifying chemicals or Effluent.

Desalter effluent composition is consists of many things such as:

- brine washing water used for removing salt, sand and
- Mud washing water jet used at periodic intervals, connate water produced from the reservoir with crude oil.

After adding Wash water to Crude oil a proper mixing is done that collects all small droplets of staggered brine into bigger drops.

In the Second Stage, Water or brine collected is drained out effluent system, and Cleaned Desalted oil is processed to preheat train for further processing. caused by some of these chemicals. A clear understanding of the impact of oil field chemicals on refinery operations is critical to both refiners and producers, to avoid these problems and prevent the erosion of value of the crude. Better communications between producers and refiners is a first step to resolve these problems

Stages of crude oil desalination methods

Crude oil desalination typically involves several stages to effectively remove salt and impurities. While the specific stages may vary depending on the desalination method used, here are the general steps involved:

1. Pre-treatment: This stage involves the removal of large particles, solids, and debris from the crude oil. It may include processes such as filtration, settling, or centrifugation to separate the solid impurities from the oil.

2. Desalting: The desalting stage focuses on removing dissolved salts from the crude oil. Various methods can be employed, such as electrostatic coalescers, chemical demulsification, or desalting by heat and water washing. These methods aim to break down the emulsions and separate the water and salt from the oil.

3. Separation: After desalting, the crude oil is typically subjected to separation processes to remove any remaining water, salt, or other impurities. This can involve techniques like gravity settling, centrifugation, or filtration to separate the different components based on their density or size.

4. Post-treatment: Once the crude oil has undergone desalination and separation, it may undergo further treatment to improve its quality. This can include additional filtration, heating, or chemical treatment to remove any remaining impurities or contaminants.

It's important to note that these stages are not always sequential and can vary depending on the specific desalination method used. Additionally, some desalination methods may combine multiple stages into a single process. The goal of all these stages is to ensure the crude oil is desalinated and purified to meet the desired specifications for further processing or transportation.

CHAPTER FIVE

CONCLUSION

Conclusion

Choosing the most efficient way to desalinate crude oil depends on several factors, including the specific characteristics of the crude oil, the desired level of desalination, and the available resources and infrastructure. Here are a few considerations to help you make an informed decision:

1. Reverse Osmosis (RO): RO is a widely used desalination method that utilizes a semi-permeable membrane to separate salt and water from the crude oil. It is generally more energy-efficient than other methods but may not be suitable for all types of crude oil.

2. Electrostatic Coalescers: This method uses an electric field to coalesce water droplets in the crude oil, making it easier to separate them. Electrostatic coalescers are effective for removing water but may not be as efficient in removing salt.

3. Centrifugation: Centrifuges use centrifugal force to separate water and salt from the crude oil. This method is effective for removing larger water droplets but may not be as efficient for salt removal.

4. Chemical Demulsification: Chemical demulsifiers can be added to the crude oil to break down emulsions and facilitate the separation of water and salt. This method is often used in combination with other desalination techniques.

5. Energy Requirements: Consider the energy requirements of each desalination method. Some methods, like RO, may require more energy than others, so it's important to evaluate the energy efficiency of each option.

6. Cost and Scalability: Assess the cost and scalability of each desalination method. Some methods may be more cost-effective or easier to scale up for large-scale operations.

Ultimately, the most efficient way to desalinate crude oil will depend on a combination of these factors. It may be beneficial to consult with experts in the field or conduct a feasibility study to determine the best approach for your specific circumstances.

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