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Study of Crude Oil Desalting Process in Refinery

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Abstract

Desalting is a water-washing operation performed initially at the production field and thereafter at the refinery site for additional crude oil cleanup. Desalting is a water-washing operation performed initially at the production field and thereafter at the refinery site for additional crude oil cleanup. Crude oil often contains fine saline water droplets, salt crystals, suspended solids and traces of metals. Large amounts of dissolved salts can affect the crude refining process quite significantly. It can, for instance, foul heat exchangers, block pipe lines and generally affects the performance of other refinery equipment. In order to avoid salts-related problems, salts must be removed from the crude oil for this reason and to prevent corrosion, plugging, and fouling of equipment, electrical desalting plants are often installed in crude oil production units. This paper investigates the effect of four factors (density, freshwater injection, heating, and mixing) on the efficiency of the dehydration/desalting process for Iranian crude oil.

Keywords: Oil desalting, Dewatering, Salinity, Emulsion.

Introduction

Crude oils are complex mixtures obtained from many parts of the world, and all crudes contain dilute dispersion/emulsion of ultrafine water droplets containing a variety of salts, solids and metals. These emulsions might be quite stable due to the presence of natural surfactants in oil such as asphaltenes, resins, naphthenic acids, fine solids, etc. (Chopra, 2001).

Adverse effects of these impurities can result in shortened unit run lengths and reduced equipment reliability. To prevent corrosion, plugging, fouling of equipment, electrical desalting plants are often installed in crude oil production units in order to remove water-soluble salts from an oil stream. The refiners often wash the crude oil with fresh water, add chemical (demulsified), and use electrical desalting vessel to remove the added water and most of the inorganic contaminants from the crude oil (Chopra, 2001).

Desalting is a water-washing operation performed initially at the production field and thereafter at the refinery site for additional crude oil cleanup, where the salt and water content specifications are even more rigid because of their negative effect in the downstream processes due to scale formation, corrosion, and catalyst deactivation. Desalting involves mixing heated crude oil with washing water, using a mixing valve or static mixers to ensure a proper contact between the crude oil and the water, and then passing it to a separating vessel, where a proper separation between the aqueous and organic phases is achieved.

Since emulsions can be formed in this process, there is a risk of water carryover in the organic In order to overcome this problem chemical demulsifies are added to promote the emulsion breaking. When this operation is performed at a refinery, an electric field across the settling vessel is applied to coalesce the polar salty water droplets, and, therefore, a decreasing in water and salt content is achieved. The understanding of the different variables that affect the desalting process, especially the effect of the amount of chemical demulsifies used, is imperative in order to optimize operating costs. According to data published by Vafajoo (Vafajoo et al., 2007).

Another common technique has been improved for removing soluble and insoluble organic and inorganic contaminants from refinery wastewater, such as gravity settling separation and mechanical coalescence, coagulation and air flotation, electrostatic and electro

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coagulation separation. However, these methods would lead to a huge production of sludge and complicated operation problems. Membrane technologies have greatly used in separation facilities to separate liquid/liquid or liquid/solid mixtures due to the suitable pore sizes and capability of removing emulsified oil droplets and other organic contaminants. Ultrafiltration has been demonstrated as an efficient method in wastewater treatment, especially submerged membrane ultrafiltration that has been successfully applied to the refinery wastewater treatment. Thus, a stricter discharge standard is required in order to ensure the wastewater discharged is safe to the environments. For instance, in Malaysia, the effluent discharged from industrial sectors should comply with the national primary regulatory of discharged Standard-Standard B (Yuliwati et al., 2012). The two most typical methods of crude-oil desalting, are chemical and electrostatic separation which use hot water as the extraction agent (Pak & Mohammadi, 2008).

Challenge of crude distillation unit optimization

The efficiency of a refinery to produce petroleum distillates is directly linked to:

- The crude oil that is delivered to the refinery
- The equipment of the refinery
- The maximum throughput of crude oil and petroleum products
- The ability to produce the distillates with the highest value at maximum yield.

Optimizing the process conditions of the crude distillation unit is a main challenge for each refinery. It increases profit by producing the required range of distillates at maximum yield and at minimum cost. To achieve this goal, full and real-time monitoring and control of each incoming stream of crude oil and outgoing distillate stream is an inevitable requirement to ensure:

- Minimum influence on production capacity for each required distillate due to crude oil changes • Minimum influence on distillate quality upon crude oil switching
- Maximum production of high value distillates. Overlapping characteristic boiling ranges exist between two neighboring refinery fractions. Maximum distillation profit is achieved by shifting the cut points towards the highest value products
- Maximum stability of the quality of each distillate throughout the entire distillation process
- Minimized production of off-spec or borderline materials and, as a result, the need for re-reprocessing or blending. The quality and the cost of crude oil depends on its origin. Blending various types of crude oil is required to reduce the cost of the crude oil feed to be distilled and to adapt the crude oil feed so that it can be processed properly by the equipment available in the refinery.

The implementation of a crude analyses will have a cost-reducing effect, as it has an impact on the energy consumption of the de-emulsifier, the consumption of wash water, a reduction in the corrosion of the pipelines and equipment, and it predicts the API of the feed entering the crude distillation unit. Optimal performance of the entire process is achieved by mounting the analyzers before, between and after the disasters (Figure 1).

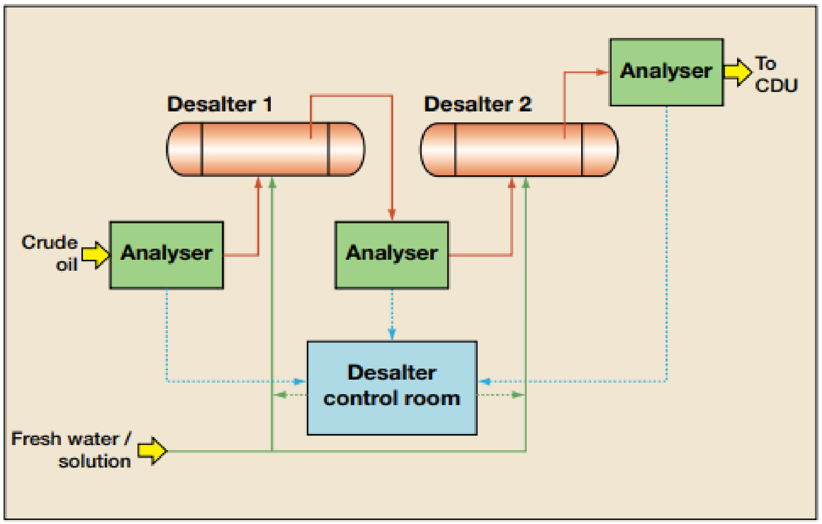

Fig. 1. Flow chart of the crude analyzer setup in a desalted system

Formation of water-in-oil emulsions

In secondary oil recovery processes, the oil is contacted with formation water or water injected to produce the oil drain water. Water is used as a piston to push the oil from the well during the production process and then remove to the refinery (Daaou M, Bendedouch , 2011). In the reservoir, the fluid velocity is very slow (1 ft/day) to produce the emulsion, and emulsion is not formed during the two phase flow in porous media but later in equipment where oil is processed. Hence, the shear is responsible of making emulsion by pumping through valves, pipes, elbows, and others (Pereira, 2009).

Damage to environment may occurs when petroleum or its products are spilled into the sea or the river, due to which water–oil emulsions are also formed. These emulsions (called ‘‘chocolate mousse’’) has special properties and characteristics (Fingas & Fieldhouse , 2003; Fingas & Fieldhouse, 2012). Changes in the emulsions properties, such as viscosity and stability, are notable due to internal phase increasing (Delgado, 2005).The formation of water/oil emulsions is generally caused by the presence of resins and asphaltenes present in the oil, which play the role of natural emulsifiers (Kilpatrick, 2012)

There are three method of desalting process:

1. Chemical desalting methods.
2. Electrical desalting method.
3. Filtration method.

Chemical desalting methods

In chemical desalting, water and chemical surfactant (demulsified) 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.

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 2) 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.

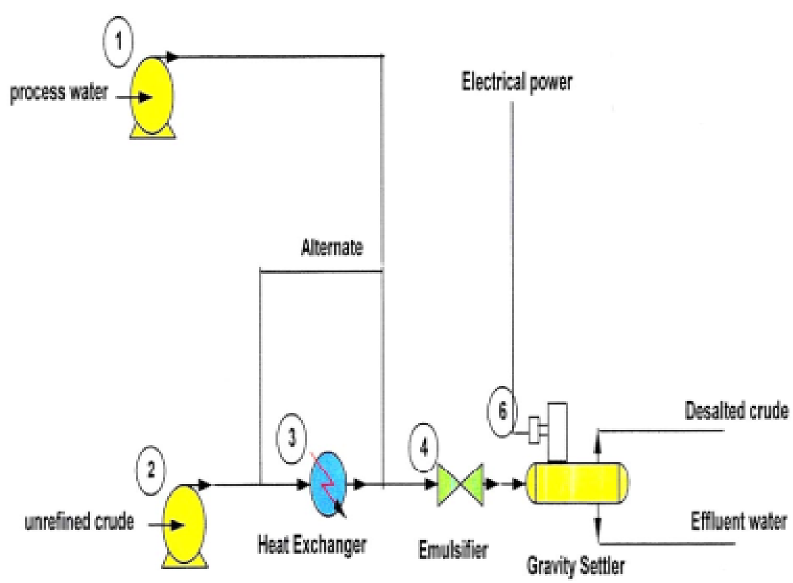

Fig. 2. Electrical Desalting Process

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.

Factors affecting desalting performance

Temperature effect

Heat causes a decrease in viscosity, thickness, and cohesion of the film surrounding water drops. Heat also reduces the continuous phase (oil) viscosity, helping water drops to move freely and faster for coalescing. Controlling the temperature during operations is a very delicate job. Any excessive heat might lead to evaporation, which results not only in a loss of oil volume but also in a reduction in price because of a decrease in the API gravity (Al-Otaibi et al., 2003).

Liquid density and viscosity usually decrease with temperature. This means that increasing operation temperature will raise settling rate and therefore, improve separation. In a given desalted, separation improvement means that a larger quantity of oil can be desalted at the same time. This would suggest that a higher temperature is more convenient. However, crude oil conductivity increases with temperature and so does the power requirement of the process. Additionally, higher temperatures imply an increase in heating costs. Given these opposing facts, it is expected that there is an optimum temperature. In the case of Iranian heavy crude oil feedstock, it was necessary to know the dependence of effective parameters on the temperature to determine if an optimum temperature exists (Fetter , 2005).

Dilution with freshwater effect

It is obvious that salt removal from crude oil is directly proportional to the amount of wash water although the lower values of demulsifier amount and operational temperature (Sellami et al., 2016). Salts in emulsion sometimes come in solid crystalline form. So, the need for freshwater to dissolve these crystal salts arises, and dilution with freshwater has become a necessity in desalting/dehydration processes. Freshwater is usually injected before heat exchangers to increase the mixing efficiency and to prevent scaling inside pipes and heating tubes. Freshwater is injected so that water drops in emulsions can be washed out and then drained off. Hence the term ‘‘wash water." The quantity/ratio of freshwater injected depends on the API gravity of the crude, but, generally, the injection rate is 3-10% of the total crude flow. To improve the efficiency of W/C, the wash water injection must be operated at the optimum point. Beyond that point, experience has shown that excessive water may lead to deterioration in the pH range of the water volume as a whole. Ranges of pH above or below 7.0 may cause severe problems in emulsion breaking and precipitation of hydrocarbon solids (e.g., naphthalene) into the continuous water phase (Al-Otaibi et al., 2003).

Oil viscosity effect

The resistant force against the approaching move of the water droplets is known as the film thinning force, which mainly depends on the oil viscosity. A well-known fact among the workers in petroleum dewatering and desalting units is that water separation in the summer is more effective than winter. This refers to the rigorous temperature dependency of oil viscosity, as the oil viscosity is reduced at higher temperatures, the film thinning force declines and water droplets coalesce easier (Mohammadi et al., 2012).

Mixing effect

Mixing is used in a desalting/dehydration process to promote further dispersion of dilution water and demulsifier/chemical with the emulsion. It is also used to help smaller water droplets coalesce, enhancing the S/R efficiency and, in particular, affects the W/C efficiency. High shear actions form emulsions. Similarly, when dilution water (freshwater) is added to an emulsion, one needs to mix them to dissolve the salt crystalline and to aid in coalescing finely distributed droplets. Mixing works in three steps: (1) helps smaller drops to join together, (2) mixes chemical/demulsifier with the emulsion, and (3) breaks the free injected volume of wash water into emulsion-sized drops and evenly distributes it (Al-Otaibi et al., 2003).

Conclusion

In this paper is various processes of crude oil treatment in oil refinery were discussed including the process of desalting. It was also highlighted how salts in treated crude might effect on its quality and refinery units. Moreover, the importance of control systems, crude oil in refineries was discussed. Crude oil usually includes water, salty materials, suspended solids, and solvable metal particles. Desalting or dehydration is the first step in the refining process. This process is done to reduce or remove contaminants, corrosion, plugging and fouling of equipment. This paper investigates the effect of four factors (density, freshwater injection, heating, and mixing) on the efficiency of the dehydration/desalting process for Iranian crude oil). These factors are systematically varied, and efficiency is analyzed.

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