RESEARCH ARTICLE

Investigation of the Pre-treatment for Reducing Salt and Sediments in Khurmala Oil Field

Maha Raoof Hamoudi*, Akram Humoodi, Sirwan Ahmed

Department of Natural Resources Engineering and Management, School of Science and Engineering, University of Kurdistan Hewler, Erbil, Kurdistan Region - F.R. Iraq

***Corresponding author's email:** m.hamoudi@ukh.edu.krd

Received: 16 February 2019 **Accepted:** 09 May 2019 **Available online:** 18 June 2019

ABSTRACT

Oil produced in most of the oil fields is accompanied by water in the form of an emulsion that must be treated. This water normally contains dissolved salts, principally chlorides of sodium, calcium, and magnesium. If crude oil is left without treatment, the salt will cause various operational problems. This research investigates experimentally the effect of major factors on the efficiency of the desalting process for a Khurmala crude oil in Kurdistan Region. These factors are chemical treatment, PH value of water, temperature, and pressure drop. One of the factors is systematically varied when the others are constant and the efficiency is analyzed. It was found that the best desalter efficiency can be concluded when the Embreak dosage is 100 ppm, PH of wash water 6.5 in average, the optimum temperature is 55°C, and pressure drop of mixing valve is 1.5 bars and the best desalter efficiency was in acidified condition.

Keywords: Desalter efficiency, Desalting, Emulsions, Khurmala crude oil, Salt and sediment removal

1. INTRODUCTION

Crude oils, as a primary energy source worldwide, require the development of special techniques and practices according to the current needs of the petroleum industry. This depends on the various activities and priority of energy markets. The oil industry is devoted to study activities of a site, determining its feasibility and subsequent drilling, and production of crude oil. For the development of an oil field, various technologies can be used and those are increased exponentially; the results are increasing effectiveness. In addition to reducing the time of completion operations, as long as no problems arise in the equipment used. The fundamental problem when crude oil is obtained from reservoirs is the contaminants in water and sediments. Large amounts of sediment and water emulsions (EMs) with crude oil, those contaminants must be removed to improve transportation and refining (Aske, 2002).

Oil produced from oil wells at oil fields is usually in the form of water-oil or oil-water EM containing considerable proportion of water and salts dissolved in it (Humooudi *et al.*, 2017). This oil when transported through pipelines or further processed in refinery and equipment can cause corrosion threats for the production system. The saline water in the oil contains oxygen which is the significant component causing corrosion. Therefore, separation of water and salts from oil is very important before the oil is acceptable for further transportation or treatment at a refinery or oilfield. This process of oil and water salts separation in oilfields is called demulsification. The salt content of crude oil almost always consists of salt dissolved in small droplets of water that are dispersed in the crude. The purpose of a desalting system is to reduce the salt content of the treated oil to acceptable levels. When the salinity of the produced brine is not too high, merely ensuring that there is a low fraction of water in the oil can reduce salt content.

Access this article online

DOI: 10.25079/ukhjse.v3n1y2019.pp35-46 **E-ISSN:** 2520-7792

1.1. Khurmala Oil Field

The crude oil was provided by Khurmala oil and gas (KOG) fields. KOG project is located in Southwest of Erbil-Kurdistan Region, 35 km from Erbil city, as shown in Figure 1. The KAR Group, Kurdistan-based oil service company, operates the oil field and it has 60 wells distributed around the project zone named: North, Middle, and South wells stations. Each group of the wells provides oil and gas to the central process station (CPS), where CPS complex is responsible for separating impurities in oil and gas (as sludge and undesirable condensates) with production of heavy acid gases (large content of hydrogen sulfide – H_2S and carbon dioxide CO_2). One of the biggest technical limitations in processing crude oils in Khurmala is the presence of large amount of EM composed fundamentally of high salt content and sediments.

2. CRUDE DESALTING PROCESS

Crude oil desalting process is a water washing operation performed at the refinery site to convert the crude oil into refined and purified petroleum liquid. In parallel, the following mechanisms are obtained:

- Remove salts and inorganic particles.
- Purifying process.
- Decrease erosion and fouling.
- Remove residual water from unrefined petroleum.

The desalting process is utilized for expulsion of the salts such as chlorides of calcium, magnesium, and sodium and different pollutions; as these are destructive in nature (Mason *et al.*, 1995). The raw petroleum originating from field separator will keep on having some water/salt water and slag entrained with it. Water washing expels a significant part of the water-solvent minerals.

The desalting process is composed of the following steps, as shown in Figure 2:

- Dilution water injection and dispersion.
- Emulsification of diluted water in oil.
- Distribution of the EM in the electrostatic field.
- Electrostatic coalescence.
- Water droplet settling.

The crude oil passes through the cold preheat train and is then pumped to the desalter by crude charge pumps (Montiel, 2010). The recycled water from the desalter is injected in the crude oil containing sediments and produced salty water. This fluid enters in the static mixer which is a crude/water disperser, maximizing the interfacial surface area for optimal contact between both liquids.

The wash water should be injected as close as possible to the emulsifying device to avoid the first separation with crude oil. Wash water can come from various sources including relatively

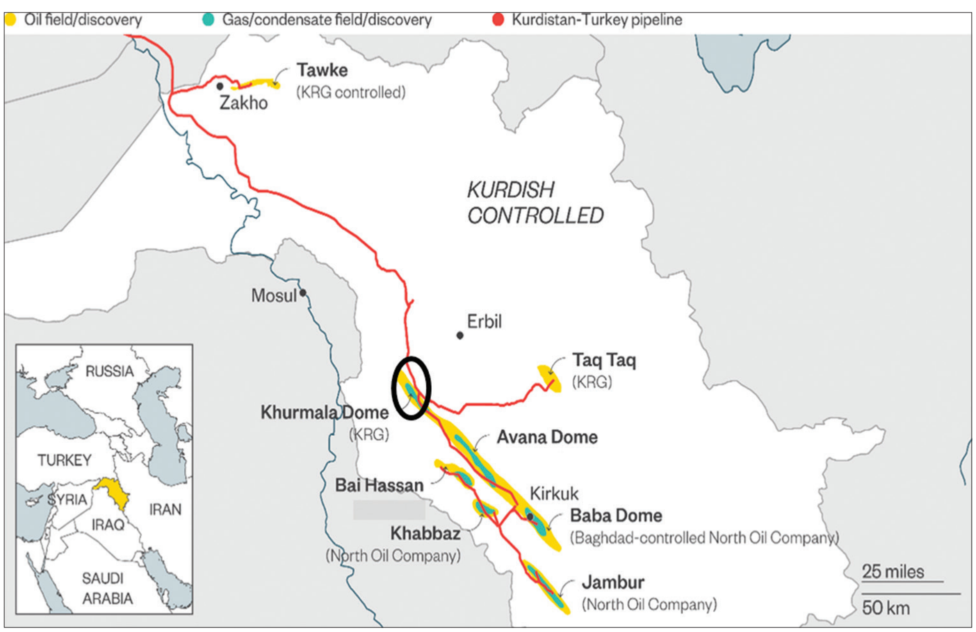

Figure 1. Khurmala oil and gas project Erbil-Kurdistan Region (Zagros, 2017)

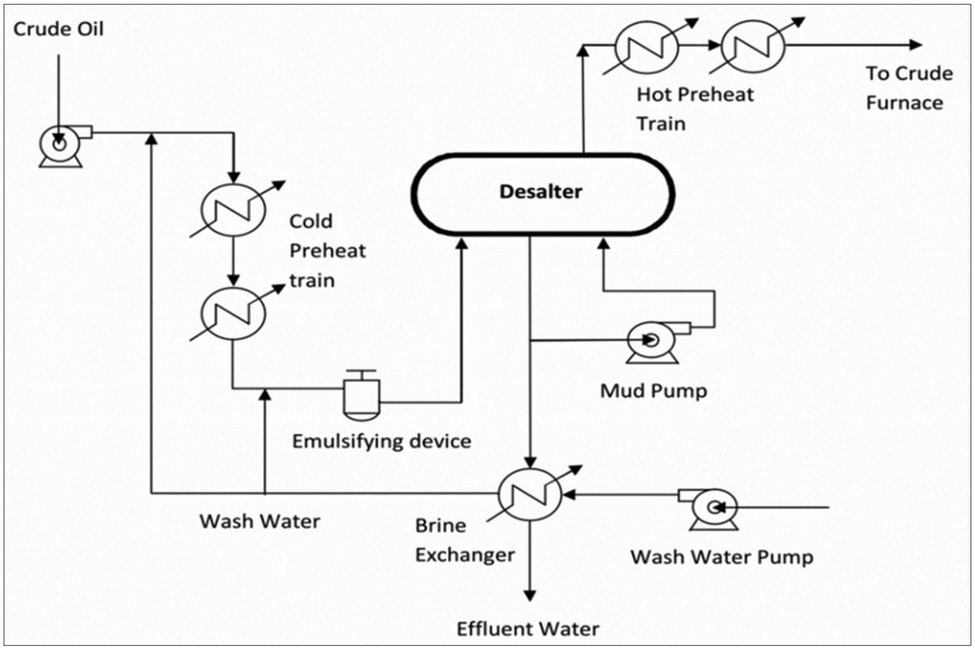

Figure 2. Complete flow system of the desalting process (Mason *et al.*, 1995)

high salt sea water and stripping water. The static mixers are installed upstream the emulsifying devices to improve the contact between the salt in the crude oil and the wash water injected in the line. The oil/water mixture is homogeneously emulsified in the emulsifying device. The emulsifying device (as a mixing valve) is used to emulsify the dilution water injected upstream in the oil. The emulsification is important for contact between the salty production water contained in the oil and the wash water. Then, the EM enters the desalter where it separates into two phases by electrostatic coalescence.

The electrostatic coalescence is induced by the polarization effect resulting from an external electric source. Polarization of water droplets pulls them out from oil-water EM phase. Salt, being dissolved in these water droplets, is also separated along the way, as illustrated in Figure 3.

The produced water is discharged to the water treatment system (effluent water). It can also be used as wash water for mud washing process during the operation. A desalting unit can be designed with single stage or two stages. The two stages of desalting system are normally applied, which is consisted of two Electrostatic Coalescers (Desalter).

3. OPERATING VARIABLES IN THE DESALTER

The important factors in the desalter operation are unrefined stream rate, temperature, and weight, blending valve weight drop and wash water rate, quality, and desalting voltage (Mandal, 2005). Unrefined petroleum temperature charged to the desalter is the exceptional significance of the great operation of desalter. Lower temperature lessens desalting effectiveness (DE) in light of expanded thickness of oil while higher temperature decreases desalting proficiency due to the major electrical conductivity of the rough. The weight in the vessel must be proceeded at a high incentive to evade loss of raw petroleum weight, which results in unsafe conditions, undependable operation, and lost desalting proficiency. Unrefined petroleum contains the disintegrated salt in water and residue. Setup water streams with unrefined in two sorts: Free and emulsified. The free water is not warmly blended in the rough and is found in bigger drops scattered all through the oil stage. This sort of water is anything but difficult to expel by gravity oil-water separators, wet tanks, and desalting vessels. Emulsified waters are personally blended and discovered spread in little drops in the oil stage. This kind is difficult to expel by straightforward settling gadgets, so further treatment, compound infusion, freshwater weakening (water stream), pressure drop (Δp), warming, and power are required (Fahim, Al-Sahhaf, and Elkilani, 2009).

The expansion of diluent water, warming, and applying power can improve gravity detachment. The principal target of a desalting plant is to break the movies encompassing the little water beads, blending beads to frame bigger drops, and permitting water drops to settle out amid or in the wake of

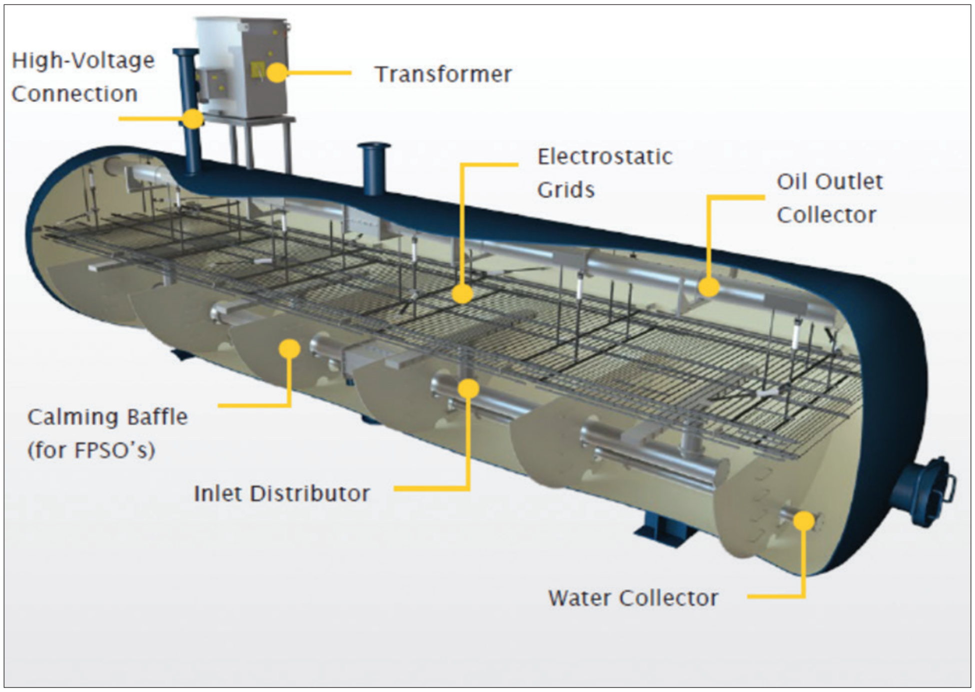

Figure 3. Desalter electrostatic coalescence process (Group, 2017)

mixing. The most vital factors influencing desalting execution that has been recognized and examined include:

- Demulsifier injection (ppm).
- Temperature (°C).
- Mixing valve differential pressure, Δp (kg/cm^2).
- Electricity, voltage (kV).
- Adding water (m^3/h).

4. METHODOLOGY

This study focuses on a field design operation, as this method allows studying the experimental variables with a minimum number of trials. However, the intention of the research is to get lower amounts of salts and sediments, as it can be achieved from Khurmala raw crude. Standard methods for determining salt content, BS and W and API, were applied. The indicators or dependent variables are defined as the level of salt removal (SR) (%); lowest salinity obtainable (LSO) and desalting efficiency (DE) to get the best operating condition required. Application of field research applied stages requires that once material balance of desalter has been made; in this case, the process will determine the effect of desalting process to reduce the amount of salt and sediments in the received raw Khurmala crude oil. The advantages of the desalting process for Khurmala oil field are mentioned in below:

- Reducing the cost of equipment maintenance.
- To avoid the suddenly plant shutdown.
- Reducing the rate of corrosion at the equipment of the whole plant.
- To get the plant in service for the longest time.
- Controlling the chemical material injection during the operation.

5. EXPERIMENTAL WORK

5.1. Desalter Operational Data

The following data show the operation conditions for the desalter that has been used in this work.

- Flow of Khurmala crude oil: 160–200 m^3/h.
- Flow of wash water: 10 m^3/h.
- Temperature: 40–60°C.
- System pressure: 19 barg.
- ΔP= 1–1.6 barg.
- Voltage applied: 20 KV.

5.2. Materials Used

5.2.1 Crude oil

Crude oil collected from the Khurmala oil field-Erbil-Kurdistan. The characteristics of the Khurmala crude oil are illustrated in Table 1.

5.2.2. Demulsifier

An oil-soluble demulsifier with commercial name Embreak 2W157D was used.

5.2.3. Glacial acetic acid

This acetic acid (CH3COOH) has been chosen for this work because this acid is less hazardous for the health, low cost and can be used in the oil and gas industry because it has low corrosion effect. The following is the physical properties of the acetic acid: Density; 1.049 g/ml at 25°C, assay; ≥99.7%, and molecular weight; 60.05 g/mole.

5.3. Experimental Procedure

There are many factors that affect the desalter performance (Buettner *et al.*, 1972). These factors have been studied in this research. The studied parameters are crude oil temperature (°C), chemicals (demulsifier) dosage (ppm), effect of the pressure drop (Δp), amount of acetic acid (CH3COOH), and constant electrical field (kV).

5.3.1. Procedure for determining the right dosage of EM break 2W-157:Bottle test (method ASTM D4870)

Taking 100 ml of Khurmala crude oil in a special test tube of centrifuge (centrifuge tube). Add 50–100 ppm of diluted demulsifier (note: Diluted demulsifier by its solvent (diesel), 1:1000 demulsifier ratio). Add dilute demulsifier depending on the actual dosage of demulsifier into the desalter at the following dosage: 10, 20, 40, 60, 80, 100, 120, 140, 160, 180, and 200 ppm of diluted demulsifier into the tube. Shake vigorously about 200–400 times, then introduce the tube into the water bath for about 120 min and reading all phases each 5 min. Read the separated amount of water and EM layers. After that place it into the centrifuge setting at 50°C for about 15 min [Figure 4]. Remove test tubes from the centrifuge and record the levels of water, EM, and crude oil.

5.3.2. Determination of the amount of acetic acid

The following is the procedure to reduce the PH value of the desalter wash water with the suitable amount of the acetic acid: Add 1000 ml wash water in a baker and place it in a magnetic stirrer and place the electrode in the beaker containing the water sample, then read the pH of water, Figure 5. Add a few drops of acetic acid to the water and

Table 1. Properties of Khurmala crude oil

Test	Method	Unit	Value
Density at 15°C	ASTM D 1298	Kg/l, temperature °C	0.8538
API gravity at 15°C	ASTM D 1298	°API	34.22
Viscosity 40°C	ASTM D-7042	CSt	5.55
Total acid number	ASTM D 664	mg/kg	0.31
Total sulfur wt%	ASTM D 4294	Mass %	2.14
Mercaptan sulfur	UOP 163	mg/kg	219
Total nitrogen	ASTM D 5762	mg/kg	1040
Acid value (black oils)	ASTM D 664	mgKOH/g	0.195
Pour point (max)	ASTM D 6749	°C	−41
Microcarbon residue Tester (MCRT)	ASTM D 4530	Mass %	4.09
Salt as NaCl in crude	ASTM D 3230	(PTB)	100
Reid vapor pressure	ASTM D 323	Pressure, psi	7
Sediment	ASTM D96	Vol.%	0.5
Water	ASTM D96	Vol.%	0.5

MCRT: Microcarbon residue tester, CSt: Centistoke, PTB: Pounds of NaCl per thousand barrels of crude oil, API: American Petroleum Institute

Figure 4. Bath water temperature (PM Tamson Inst.)

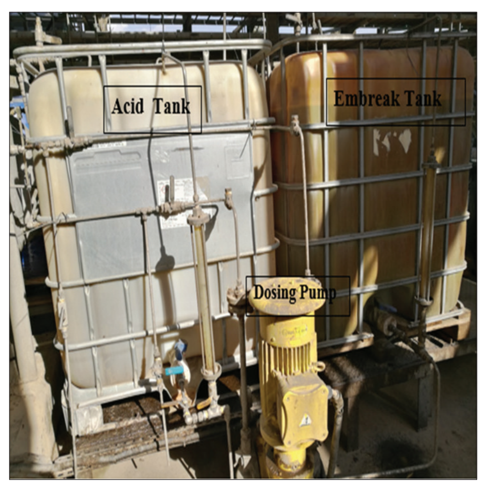

Figure 5. Chemical material at Khurmala oil field

stir well. Wait until getting a stable reading and read the PH. Repeat the step with continuous addition of acetic acid and read the PH. The last PH given of a water sample is taken in the range.

5.3.3. Determining desalter efficiency by material balance

In this section, two applications have been used for reducing the sediment and salt in the crude oil processing. The first one is without using the acidic tank before the desalter and the second application is applying the acidic tank before the desalter, as shown in Figures 6 and 7.

Determination of Khurmala crude oil quality from the desalter A and B: Is the same crude oil only one sample is taken from a tank before entering the unit and split flow. This sample will be certified for laboratory in KOG project. Determination of Khurmala crude oil quality after desalting process: In this step, a sample of the outlet of wash water and treated crude oil was sampled to determine quality after treatment and to know if wash water changed the physicochemical conditions, all were done applying standard test in KOG laboratory. At this step, the efficiency of desalting process by material balance applying (a) % of SR,

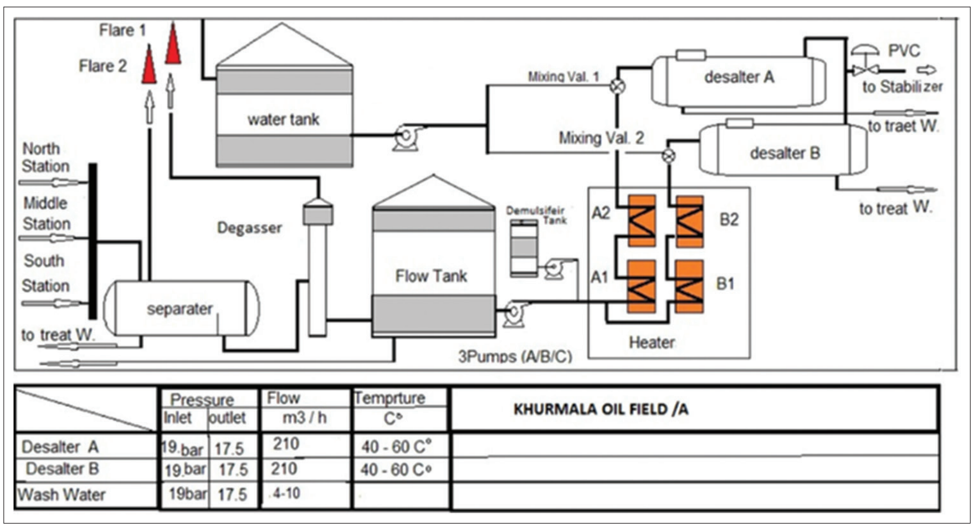

Figure 6. Process flow diagram of desalting process at Khurmala oil field without acid injection

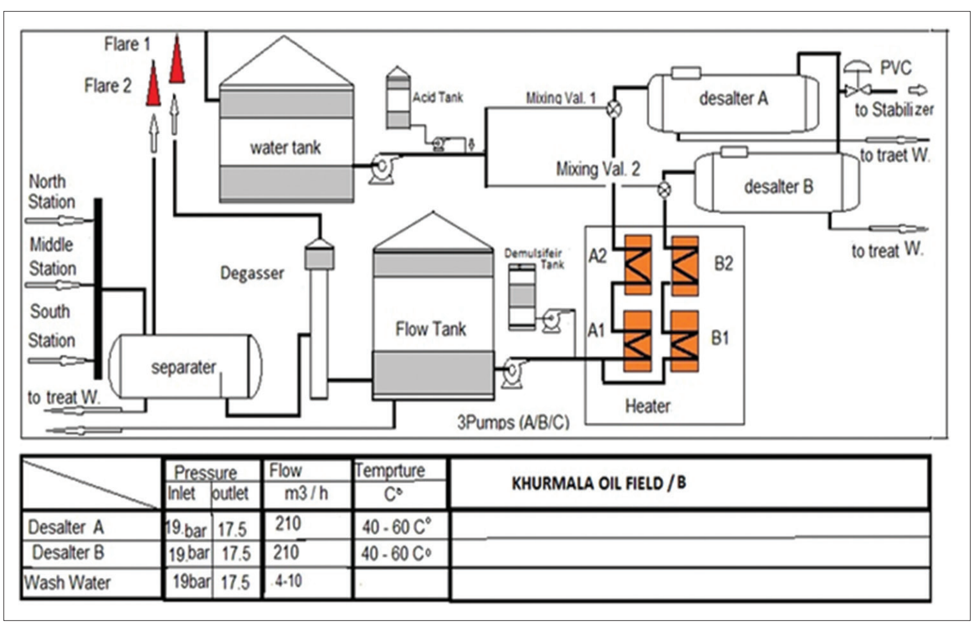

Figure 7. Process flow diagram of desalting process at Khurmala oil field with acid injection

(b) lowest salt content obtainable, and (c) desalting efficiency was calculated as in below:

Step 1: Calculation of SR efficiency factor.

$$SR = \left[\frac{(SD - SC)}{SD}\right] \times 100 \quad (1)$$

Where,
SR: SR efficiency factor
SD: Salt inlet to the desalter
SC: Salt outlet from desalter

Step 2: Calculation of lowest obtainable salinity.

$$\text{Lowest obtainable salinity} = A = C * \left\{ \left\{ \frac{SC}{\left[W . \frac{SW}{300} \right]} \right\} / (X - W) \right\} \quad (2)$$

Where, C=0.1% H_2O, A: Lowest obtainable salinity, W=10% wash water, X=6% of H_2O, SW=Conductivity of wash water inlet, SC: Salt outlet from desalter.

Step 3: Efficiency of desalting process.

$$\text{Efficiency} = \left[\frac{(SC - SD)}{(SC - A)}\right] \times 100 \quad (3)$$

Where,
A: Lowest obtainable salinity
SC: Salt outlet from desalter
SD: Salt inlet to the desalter.

5.3.4. Determination of the suitable pressure drop (ΔP)

It is important to find the suitable pressure drop valve. In the desalter operation process, the variation of pressure drop is ranged between 1 and 1.6 bar (as used in Kar refinery) with constant other variables during the operation.

5.3.5. Determining the effect of temperature

In the desalter operation process, the temperature variation is ranged between 40 and 60°C with constant other variables during the operation.

6. RESULTS AND DISCUSSION

6.1. Effect of Chemical Injection on Desalter Efficiency

It is important to mention that the suitable dosage of demulsifier is required in the desalter separation phases because this demulsifier separates the crude into crude, EM, and water. Criteria to be used to select the correct demulsifier include as follows:

- The greater amount of water removed.
- The highest percentage of SR from the organic phase to the aqueous phase.
- The lower and more stable EM value.

The results are presented in Table 2. The phases can be observed after changing the chemical injection (Embreak) concentration where, at initial stage, all are one phase and then overall phase starts to separate into water (w), EM, and free organic crude oil. In Figure 8, all phases appear during the test. Figure 9 shows the heterogeneous phases which mean that at this stage; the chemical injection has no impact. At the Embreak concentration of 100 ppm, all phases can be observed, as shown in Figure 8. The concentrations above 100 ppm dosage give more EM volume. Then, for 120 ppm, only the EM phase appears without water because the demulsifier is not acting properly, even after 140 ppm no phases appear (NC), so crude oil is totally emulsified. This zone is the oversaturated zone of demulsifier, dosage over this point has no practical or economical meaning, as shown in Figure 9. Figure 10 shows a comparison between the crude phases and Embreak injection volume (ppm) at different concentrations. Using different concentrations of Embreak injection, as mentioned before, to determine the lowest volume of water, sediment and salt content in Khurmala Crude Oil was applied using the centrifugation to measure BSW (water + sediment) and Salt Content (PTB) in crude oil phase.

After separation of phases, centrifugation was applied to get the final value of each phase. The results, highlighted line,

Table 2. Centrifugal test for Embreak demulsifier and salt content

Embreak (ppm)	Water and sediment (ml)	Salt content (PTB)
10	0.45	109.7
20	0.55	107.3
40	0.55	103.8
60	0.6	92
80	0.6	81.4
100	0.2	71.3
120	0.45	77.7
140	0.45	85.2
160	0.5	92.5
180	0.55	112.4
200	0.5	113.2

PTB: Pounds of NaCl per thousand barrels of crude oil

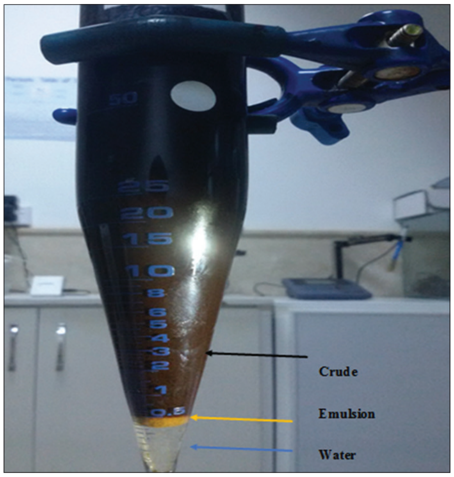

Figure 8. Crude separation phases

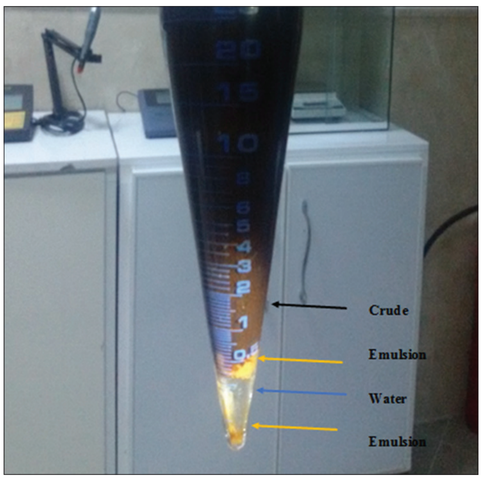

Figure 9. Crude separation with heterogeneous mixture

shown in Table 2, indicate high change (lowest PTB as salt content) at fixed dosage. In Figure 11, it can be seen that 100 ppm of dosage gives the lowest value of salt content with 71.3 PTB and lowest BSW in the crude oil phase with 0.2 ml, as shown in Figure 12. This indicates that sediments and salts were transferred to free water phase.

6.2. Effect of pH on Desalter Efficiency

Knowledge of the volume of acetic acid required for reducing the pH of the wash water from 8.3 to 5.98, to get the effective efficiency for desalter during the operation is very important. The results of laboratory experiments are presented in Figure 13. The amount of acetic acid used for reducing the pH of the wash water from 8.3 to 6.6 is 0.1 ml of CH3COOH for 100 ml water. According to this procedure, 1 l of acetic acid is added to 1 m^3 of wash water to get the 6.6 pH in desalter operation. In addition, the pH that is required for the best desalter efficiency is 6.6 to avoid the corrosion and the cost of acetic acid.

All changes were positives and refining process specification can be achieved. Because when the PH increase at basic condition, the conductivity and total dissolved solids (TDS) will gradually decrease from 73 % to 70% and from 74% to 71%, respectively. However, in acidic condition, when the PH is reduced from 6.7 to 6.5 m, the conductivity and TDS is regularly increasing and based on that the desalter efficiency will increase, as it is illustrated in Figures 14 and 15.

Figure 14 shows that the pH reduction is quite slight in basic condition; moreover, the conductivity and TDS are changing slightly low. However, in acidified condition, the pH reduction variable is quite high if compared with no acidified condition as it is shown in Figure 15. All changes in variables regard to the dosage volume of acetic acid. So, more salt dissolved into water will increase conductivity and TDS. If electrodes voltage and dosage of demulsifier is right, water will achieve saturation condition at once. Furthermore, desalter without acidification is working bellow specification and with acidification works exceeding specifications.

All the changes of the variables directly affect on the desalter efficiency as shown in Figures 16 and 17, the efficiency of desalter significantly increases in acidified condition when the pH is 6.35, the efficiency is in the right condition at 91%. According to the desalter efficiency, the salt removal ranges between 79 to 90.6 % and sediment removal ranges between 91.4 to 96 %. These results represent the quality at critical parameters in wash water inlet and outlet. It is important to remember, if a wash water is working according to solvation reactions and salts, and some inorganic compounds are transferred to the water during electrolysis of crude oil EM, the salt content and sediment in crude oil will be reduced proportionally to the amount of salt transferred to wash water. Besides, Figure 16 illustrates results about SR, LSO, and efficiency of desalting process.

6.3. Effect of Temperature on Desalter Efficiency

Operational conditions: At flow rate of 160 m^3/h with variable temperature. Figures 18-20 show the effect of temperature on sediment, salt, and water removal rate, respectively, in acidification and non-acidified conditions. Settling rate depends highly on temperature. Liquid density and viscosity usually decrease with increasing temperature. The effect is even greater regarding viscosity as the

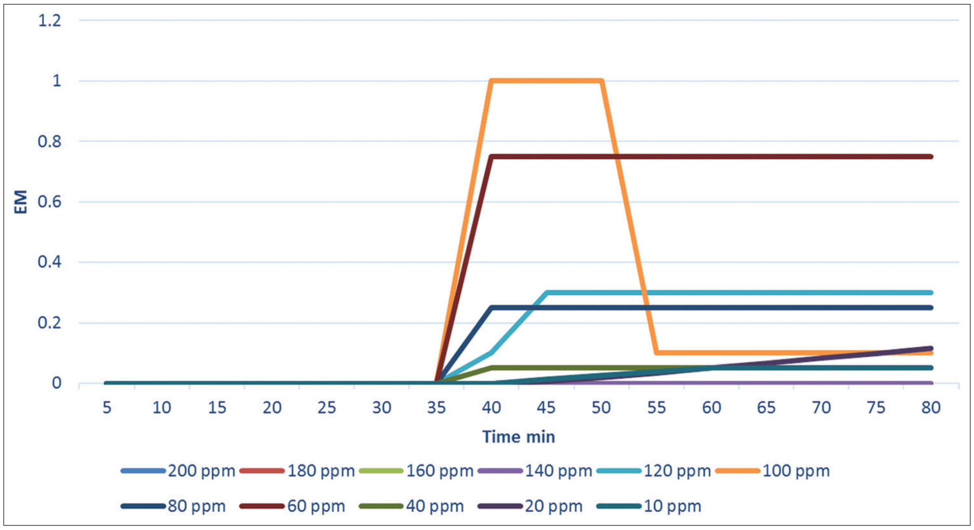

Figure 10. Comparison between the crude phases and Embreak injection volume (ppm) at different concentrations

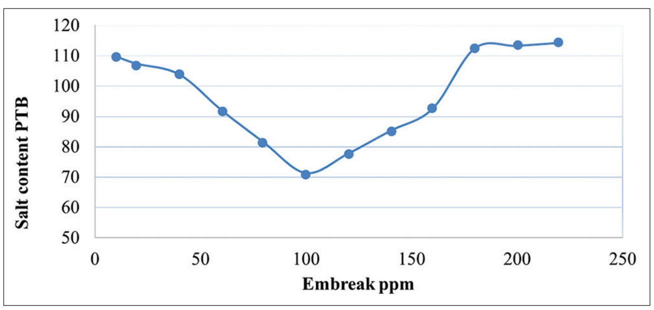

Figure 11. Behavior of salt content with dosage

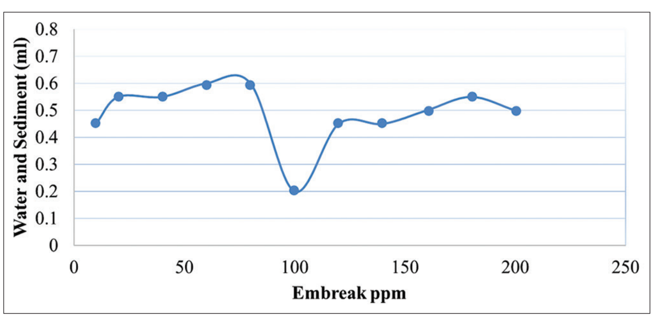

Figure 12. Behavior salt content with Embreak injection ppm

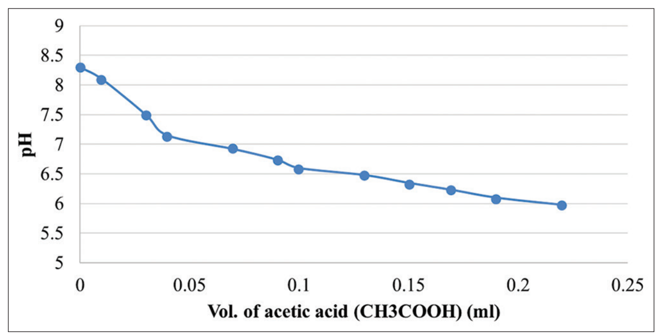

Figure 13. Volume of acetic acid required for reducing the pH of wash water

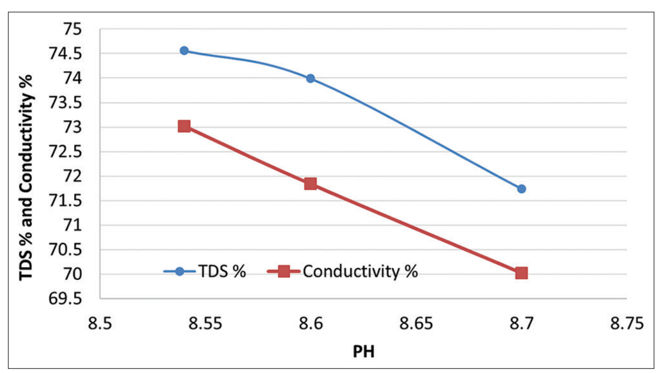

Figure 14. Relation between total dissolved solids, conductivity, and pH at basic condition

dependence is exponential. This means that increasing operating temperature will raise settling rates and, therefore, improve separation. In a given desalter, separation improvement means that a larger quantity of oil can be desalted in the same time. In addition, higher temperature implies an increase of heating cost. It is illustrated that there is an optimum temperature 55°C as appeared in Figures 18-20 which show that the desalter efficiency will increase from 92.6, 75, and 92% in non-acidified condition to 97, 91, and 93%, respectively, in acidified condition. After that, the efficiency will descend as a result of rising temperature. This phenomenon would suggest that the optimum temperature is more useful for achieving effective desalter efficiency.

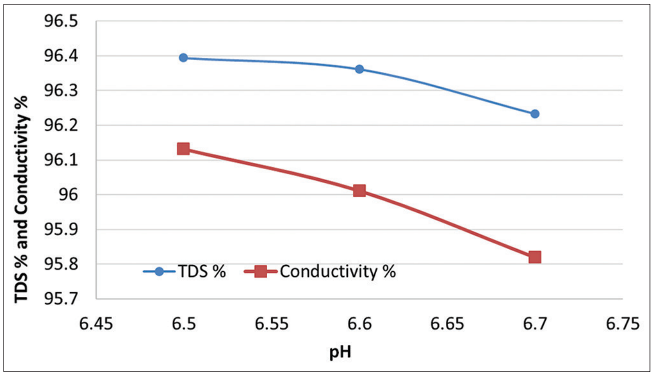

Figure 15. Relation between total dissolved solids, conductivity, and pH at acid condition

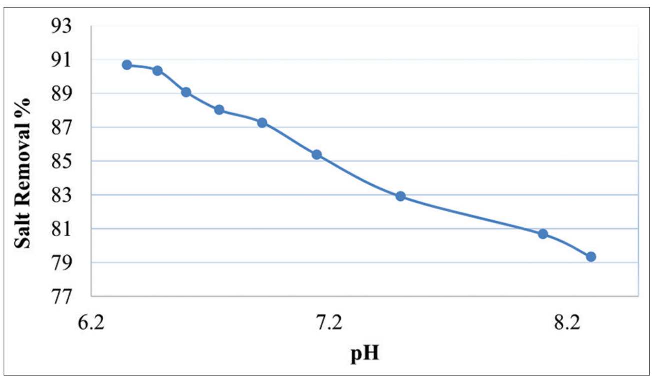

Figure 16. Desalter efficiency with salt removal

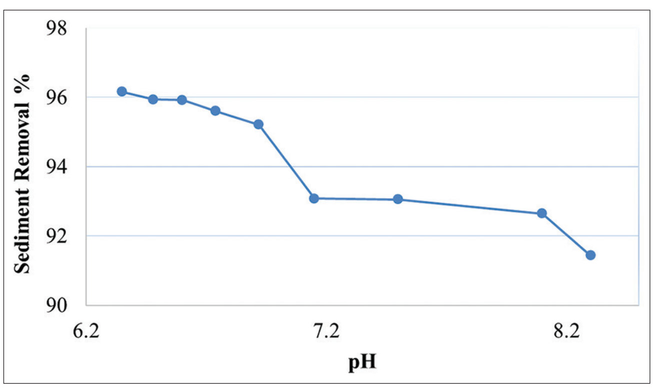

Figure 17. Desalter efficiency in acidic condition with sediment removal

6.4. Effect of Pressure Drop on Desalter Efficiency

Operational conditions: At flow rate of 160 m^3/h. with variable pressure drop. The salt and sediment decrease as the pressure drop increases in both conditions. The highest salt and solids removal efficiency were 90 and 94%, respectively, at differential pressure (ΔP) 1.5 barg. In a comparison between no acidification and acidification, the SR amount is 10% because the salt was highly dissolved in

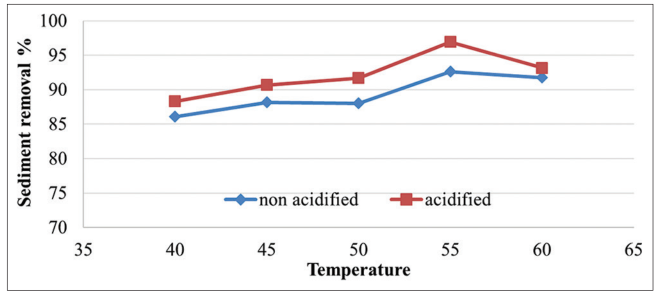

Figure 18. Effect of temperature on sediment removal

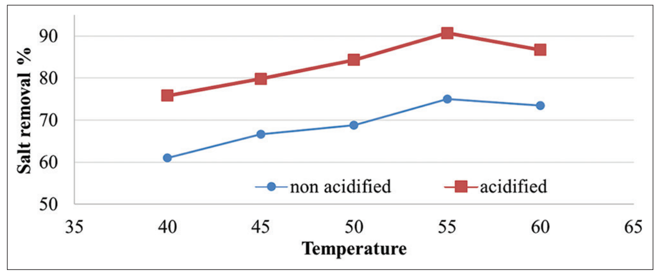

Figure 19. Effect of temperature on salt removal

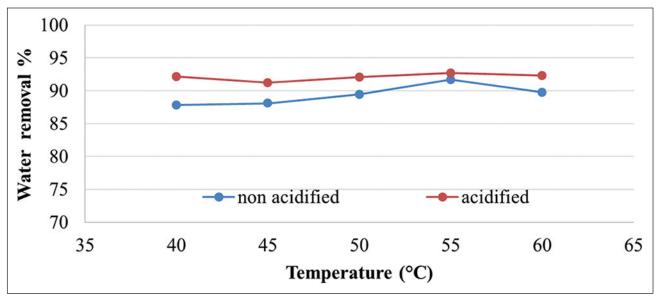

Figure 20. Effect of temperature on water removal

acidified condition due to the pH of wash water is 6.5–7.0. In addition, the sediment removal amount is 2% due to the providing source which differs on a daily basis. This difference leads sometimes to unpredicted behavior, but the general trend of the current is obvious, as shown in Figure 21, above that the efficiency will decrease. Moreover, the conventional static mixer/mixing valve yields a high pressure drop which is if combined with non-homogenous shear force serves to generate undesirable stable EM of water and crude oil; Figures 21-23 show the optimum value for optimum pressure drop (mixing valve) for salt, sediment, and water removal, respectively. The mixing can also be improved by increasing the pressure drop across the mixing valve. The increased mixing will also mean that the EM will be harder to separate. The highest efficiency for salt, water, and sediment removal was reached at differential pressure of 1.5 barg.

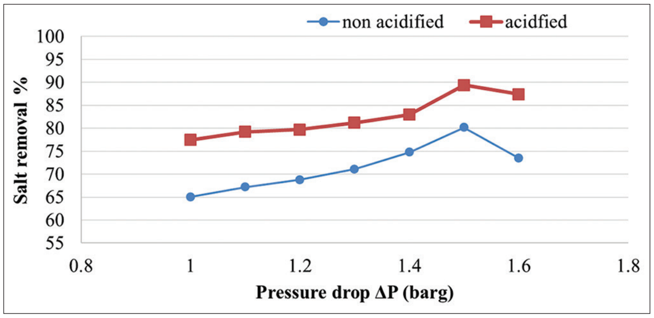

Figure 21. Effect of pressure drop on salt removal

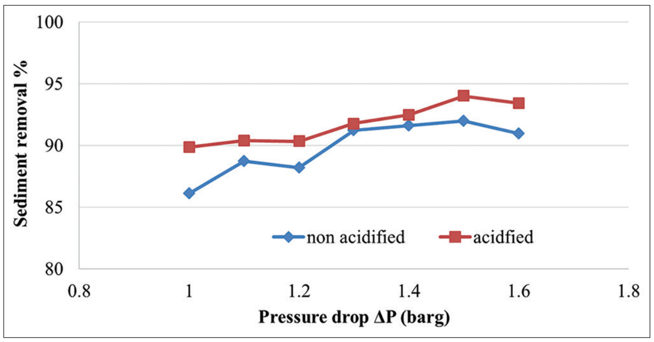

Figure 22. Effect of pressure drop on sediment removal

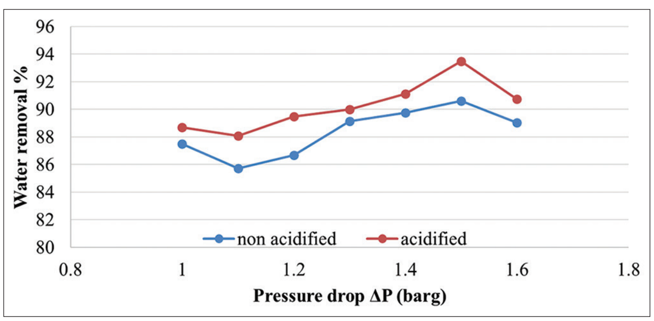

Figure 23. Effect of pressure drop on water removal

7. CONCLUSIONS

The effects of different variables on the desalting efficiency were investigated at a constant crude oil flow rate of 160 m^3/h, transform voltage 20 KV, and wash water flow of 10 m^3/h. The following conclusions were obtained:

- It was found that the concentration of 100 ppm of injected demulsifier gives a higher desalting efficiency.
- The optimum value of SR in the crude oil desalting process is measured when the pH of wash water is in average of 6.5.
- The best desalter efficiency is reached when the desalter temperature was 55°C in acidified condition.
- In non-acidified condition, it was found that the desalter efficiency at the same temperature is lower than acidifying condition.
- The effective separation of crude oil phase is determined when a desalter pressure drop of mixing valve was 1.5 barg; consequently, the best efficiency of desalter is measured in acidified condition.
- The crude oil separation in non-acidified condition is determined when a desalter pressure drop of mixing valve was 1.5 barg; therefore, the desalter efficiency is lower than acidifying condition.

8. RECOMMENDATIONS

The followings are recommended for future work:

- It is recommended to apply the second stage of desalter to get the best efficiency treatment.
- Using different types of the chemical injection demulsifier material to improve the performance of desalter.
- To get the best separation of crude oil, it is suggested to use different voltage tap for a transformer.
- Install softener to reduce the raw water hardness and pH of wash water.

9. NOMENCLATURE

- A-lowest obtainable salinity, fraction
- C-minimum percentage of water, %
- SC-Salt outlet from desalter PTB,
- SD-Salt inlet to the desalter, PTB
- SR-SR efficiency, %
- SW-Conductivity of wash water inlet
- X-Percentage of water, %
- W-Percentage of wash water, %
- ΔP-Differential pressure, barg.

REFERENCES

Aske, N. (2002). Characterization of Crude Oil Components, Asphaltine Aggregation and Emulsion Stability by Means of Near Infrared Spectroscopy and Multivariate Analysis, *Thesis*. Norwegian University of Science and Technology.

Humooudi, A., Hamoudi, M. R. & Ali, B. M. (2017). Corrosion mitigation in crude oil process by implementation of desalting unit in Erbil refinery. *American Scientific Research Journal for Engineering, Technology, and Sciences*, 36(1), 224-241.

Buettner, E., Matschat, K., Mohr, R. & Oppenlaender, K. (1972). Crude Oil Demulsifiers. Zagros: U.S. Patent 3,684,735.

Fahim, M., Al-Sahhaf, T. & Elkilani, A. (2009). *Fundamentals of Petroleum Refining*. 1st ed. London: Elsevier Science.

Group, F. (2017). Electrostatic Coalescers. Available from: http://www.frames-group.com/getattachment/93cca68a-a976-4e6a-8f5c-82ede1620f92/Product-Leaflet-Electrostatic-Coalescer.pdf.aspx?ext=.pdf.

Mason, S.L., May, K. & Hartland, S. (1995). Drop size and concentration profile determination in petroleum emulsion separation. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 96(1-2), 85-92.

Montiel, R. (2010). *Estimulación de Pozos*. DF-Mexico: Mc Graw Hill. p. 22-23.

Mandal, K. K. (2005). Improve desalter control. *Hydrocarbon Processing*, 84(4), 77-77.

Zagros, W. (2017). Pure Play Kurdistan Independent. Western Zagros. *Corporate Presentation*.