

## **Original Research Article**

# **Investigating the Impact of Wash Water Pump Rate on the Efficiency of Desalting Process of Crude Oil, a Case Study of X-Field in Iraq**

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### **ABSTRACT**

Desalting is an essential process in the oil industry to remove salts from crude oil. These salts, which include fine saline water droplets and salt crystals, can have a significant impact on the crude refining process. If left untreated, they can foul heat exchangers, block pipelines, cause scales, corrosion, foaming, plugging and affect the overall performance of other equipment. To avoid these salt-related problems, it is crucial to remove salts from the crude oil. This paper presents a case study of the effect of wash water pump rate on the efficiency of the desalting process for crude oil in the X-field in Iraq. The desalting process was evaluated based on the wash water pump rate. Crude oil samples were collected downstream of the desalter at various wash water flow rates, on weekly basis for about ten weeks, and the average salinity were measured in parts per million (ppm). The results of the investigation show that there is an inverse relationship between the salinity of the crude oil and the wash water pump rate. As the salinity of the crude oil increases, the wash water pump rate decreases. At wash water pump rate of 6 m<sup>3</sup>/hr. and below, the salinity of the crude oil exceeds the 30-ppm export specification; implying that a lower wash water pump rate leads to inadequate desalting of the crude oil. The study also unraveled the causes and consequences of inadequate wash water pump rate such as: clogged inlet or outlet, insufficient power supply, passing valve, worn-out or damaged impellers, mechanical failure, piping issues, sealing problems, and increased operational costs. To optimize the wash water pump rate, a procedure was also developed in this study. This method addresses the identified causes and consequences of an inadequate wash water pump rate in effectively desalting crude oil. This study has unraveled the importance of the wash water pump rate in the desalting process and highlights the need to maintain an optimal pump rate to effectively remove salts and avoid associated problems in the refining process.

*Keywords: wash water pump, pump rate, dehydrating, desalting, salinity, crude oil, efficiency*

### **1. INTRODUCTION**

Crude oil dehydration and desalting processes are based on the removal of water droplets from the crude oil. In the case of crude oil desalting, the dehydration process is preceded by wash water dosage upstream of the desalter, which reduces the salinity of the residual water in the crude oil [1]. Crude oil dehydration and desalting processes are employed to remove water and salts, ensuring that the crude oil meets specified quality requirements and industry standards. These processes are critical in preventing corrosion, fouling, and catalyst deactivation in refining equipment, as well as maintaining product quality [2;3]. Effective dehydration and desalting processes are essential to meet specific moisture content, salt content, and other quality parameters to ensure optimal refinery performance and to comply with regulatory standards and ensure the efficient refining and utilization of crude oil [4; 5]. Additionally, the water of salt inoculated by tanker during shipment might subside to the total content of salt at the refinery. In most of the circumstances, the crude oil's salt content comprises the dissolved salt in tiny water droplets which are distributed in crude oil [1]. The limit of the salt content of the residual water in oils as received at petroleum refineries is usually in the range of 10 to 300 PTB

(pounds of salt per thousand barrels of oil), based on spot samples of many different crude oils as delivered to refineries [6]. The presence of salt water presents serious corrosion and scaling problems in transportation and refinery equipment. Also, it causes fouling problems in pipes and heat transfer equipment and deactivation of catalysts employed at the refinery. The oil phase will be needed such treatment involves emulsion treatment, dehydration and desalting processes [7].

Treatment of emulsions has always ranged from simple methods such as a gravity settlement to highly sophisticated methods such as microwave desalting and dehydration systems [8,9]. The development of treatment systems has always been evaluated in terms of quantities of salt and water being removed. Desalting process is to make an emulsion and to break this emulsion. Make an emulsion in order to contact all existing dispersed salts (chlorides) in the untreated crude and collect them by means of added fresh water [10,11].

Hanoon et al,[1] conducted an experimental study of desalting crude oil on AL-NOOR crude oil. They observed that the process of desalting was difficult for these reasons, that the variance amongst the oil density and water density was small and the oil viscosity was relatively large so that the rate of droplet settling of water was few in the desalter. They also added that heavier oil as well tend to include additional amount of natural emulsifiers in comparison to the lighter crude oil, this behaviour aided coalescence of a water droplet and allowed the formation of stable emulsions in the desalter. More so, they proposed a method to extract water from crude oil emulsion, which involved determining the conductivity of the water in crude oil which in turn aided in the determination of the amount of salt in the emulsion and the volume of extracted water from crude oil. Their method addressed the removal of reservoirs water from crude oil in order to reduce the wear and tear of equipment for storing and transporting crude oil, which contributes to reducing costs and maintaining environmental integrity

Al-otaibi et al,[8] investigated experimentally the effect of five factors (gravity settling, chemical treatment, freshwater injection, heating, and mixing) on the efficiency of the dehydration/desalting process for a Kuwaiti crude oil and a commercial demulsifier. They varied these factors systematically and analysed the efficiency of the desalting system. They defined two efficiencies: a Salt Removal (SR) efficiency and a Water Cut (WC) dehydration efficiency. They carried out the investigation through changes made to a single factor at a time as well as multiple variations of factors and based on experimental data, showing the variation of the two efficiencies as a function of the various factors. They drew two main conclusions for the system they conducted study on. They reported that excessive amounts of a demulsifying agent had adverse effects on the desalting/dehydration process and that, the most important factor that improved both efficiencies ( $S=R$  and  $W=C$ ) were found to be the settling time. Efficiencies up to 75% were obtained at settling times of 5 minutes. This factor was simulated and confirmed profitable for both major and marginal fields and, stressed that the traditional settling-tank technique would be inadequate, and other means of improving production quality become a must in the experimental runs, through the use of a centrifuge. The implication of their findings was that future desalting/dehydration systems for oil and demulsifier study should be based on centrifugal techniques. Their findings raised the issue of new technologies to be applied in the field of emulsion treatment. They observed that as water content increases with crude oil, wellhead pressures decrease, and the lifting costs also increases.

Bai and Wang [12] conducted an experimental study of crude oil desalting using hydro cyclones and observed that dilute dispersion/emulsion of ultrafine water droplets containing a variety of salts is usually present in crude oil and stressed the need to remove the water and the dissolved salts, so that corrosion, plugging, and fouling of equipment can be prevented. They averred that electrical desalter is an effective method in crude oil desalting. However, they observed that to overcome the shortcomings of electrical desalting system, such as larger equipment volume, complex high tension electricity system, they proposed a new process of crude desalting that was based on hydro cyclone technology. They added that preliminary industrial experiments have been carried out to prove the feasibility of desalting using hydro cyclone. However, they studied the effects of several dimensionless units, such as Reynolds number, Euler number and pressure drop ratio and observed that an increase in inlet Reynolds number will decrease the pressure drop ratio and with an increase in inlet Reynolds number, Euler number increases gradually. They also observed that the inlet Reynolds number has distinct effect on dehydration efficiency of the hydro cyclone and that under the condition of inlet Reynolds number less than 5400, an increase in inlet Reynolds number will improve the separating efficiency and reported that the separating efficiency reached maximum when Reynolds number is close to 5400, and that a further increases in Reynolds number cause performance deterioration. They concluded that the salt concentration can be reduced from  $8\text{mgL}^{-1}$  to  $3\text{mg L}^{-1}$ , and that the dehydration efficiency ranges from 86% to 99% with the feed flowrate of  $2.7\text{-}3.0\text{ m}^3\text{h}^{-1}$  through the hydro cyclones.

Desalting of crude oil is the first step in the refining process and essential for problem free plant operation. Raw crude oil contains water, salts, and other impurities. If these salts and heavy metals are not removed, they can react with heat forming acids that corrode equipment used in subsequent processes. Additionally, salts can cause the accumulation of

deposits, leading to the obstruction of heat exchangers or the blockage of trays in process towers. To wash down this salt content, wash water is injected into the crude oil stream through the use of wash water pump.

This study investigates the effects of wash water pump rate on the efficiency of the desalting process for crude oil in the X-field in Iraq. X-field is designed to process crude oil to meet the vapor pressure and water content specifications required for the downstream desalting/dehydration units, which further process oil to meet 0.5% Basic Sediment and Water (BS&W) content and less than 30 ppm of salt in the final crude.

### 1.1 Causes and Consequences of Inadequate Wash Water Pump Rate

The following are the causes and consequences of inadequate wash water pump rate during refining of crudes. The causes of inadequate wash water pump rate are:

1. **Clogged or blocked inlet or outlet:** When the inlet or outlet of the pump is clogged with debris, sediments or foreign objects, they can inhibit flow of water and reduce the discharge flow rate.
2. **Insufficient power supply:** Inadequate or insufficient power supply to the pump, may hinder the pump not to operate at its full capacity, resulting in a lower discharge flow rate.
3. **Passing valves:** If the valve on the re-circulation line back to the wash water tank is passing, this implies that some volume of the discharged wash water will flow back to the tank. This can disrupt the flow of water and reduce the discharge flow rate.
4. **Worn-out or damaged impeller:** The impeller is responsible for generating the centrifugal force that moves water through the pump. If the impeller is worn-out, damaged, or misaligned, it can impede the flow, leading to a decrease in the discharge flow rate.
5. **Mechanical failure:** Various mechanical issues, such as a faulty bearing, damaged shaft, or worn-out seals, can hinder the pump's performance and result in a decreased flow rate.
6. **Piping Issues:** Problems in the piping system, such as undersized or blocked pipes, excessive bends, or inadequate pipe supports, can cause flow restrictions and reduce the discharge flow rate.

### The consequences of inadequate wash water pump rate

A low wash water pump flow rate in a desalting system can have several consequences, such as:

- I. **Poor Desalting Performance:** The wash water pump plays a crucial role in the desalting process by flushing out impurities and maintaining the efficiency of the system. A low pump flow rate can lead to inadequate flushing, resulting in reduced desalting performance and lower production of fresh water.
- II. **Fouling and Scaling:** Inadequate wash water flow can contribute to fouling and scaling within the desalting system. Without sufficient wash water, salts, particulate matter, and other contaminants may accumulate on the system's surfaces, leading to decreased efficiency, increased energy consumption, and potential damage to equipment.
- III. **Increased Operational Costs:** Limited wash water flow may necessitate more frequent system shutdowns for maintenance and cleaning, leading to increased operational costs. Additional expenses may arise from the need to replace or repair fouled equipment and membranes due to reduced efficiency and performance.

To maintain optimal desalting performance and to prolong the life of the system, it is important to ensure an adequate wash water pump flow rate and ensure a proper maintenance procedure in place.

### 1.2 Study Area

The study was carried out in a crude oil desalting unit located as X-field in Iraq, approximately about 20 km south-west of Basrah. Figure 1 is a simplified overview of a crude oil separation, dehydration, and desalting system in the X-field. The purpose of the crude oil separation, dehydration and desalting system is to receive well fluids from X-field Flow Station through an individual oil processing train, de-gas, dehydrate, de-salt and cool the crude oil to meet storage and export specifications.

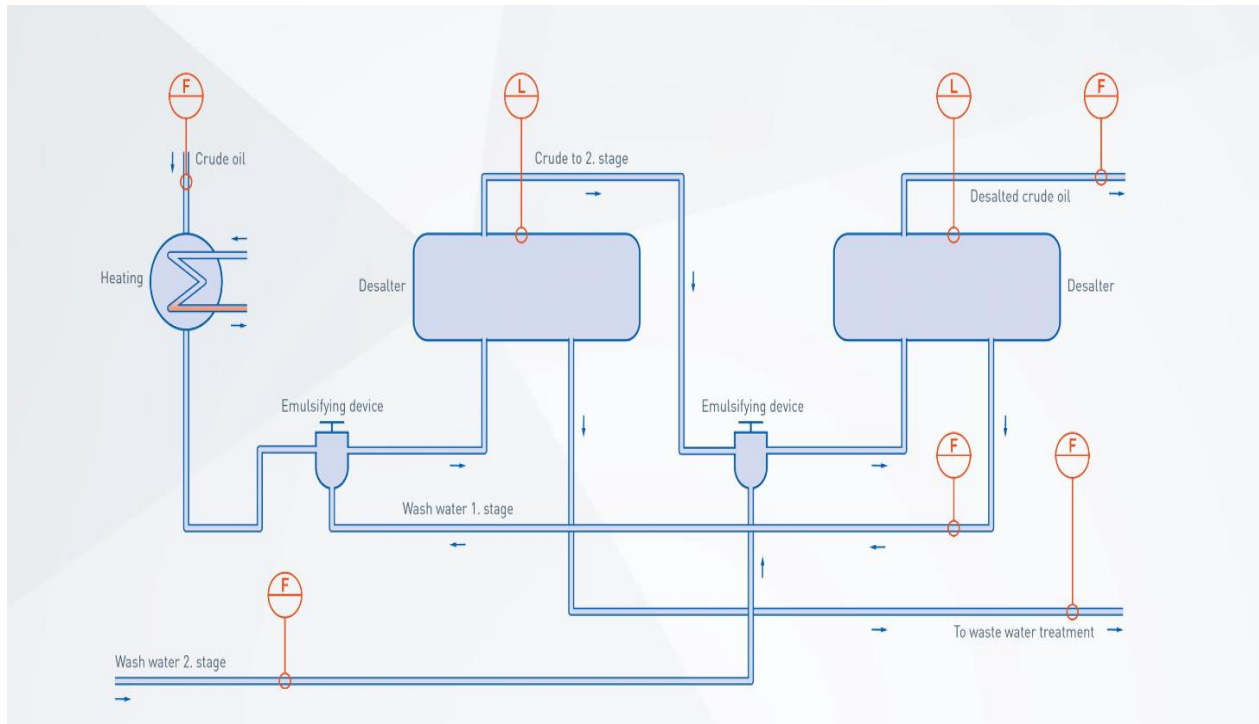


Figure 1: Simplified Overview – Crude Oil Separation, Dehydration and Desalting System (X-field, 2023).

The crude oil separation, dehydration and desalting system consist of a 1st stage separator, crude/crude exchanger, crude oil heater, a 2nd stage separator, charge pumps, dehydrator, desalter, wash water recirculation pumps and a crude oil rundown cooler. The oil production train is sized to process and deliver 45,000 bopd. The system is designed to process crude oil to meet the vapor pressure and water content specification of 5% required for the downstream desalting/dehydration units; which on further processing is expected to meet 0.5% volume of Basic Sediment and Water (BS&W) content and less than 30 ppm of salt in the final crude. A Sand Handling System is provided to allow online jetting of the separators, dehydrators and desalters to take place. This process removes any deposited solids (sand) or scale build-up in the bottom of the vessels by the injection of produced water. The sand slurry from the dehydrator and desalter is routed to the De-sanding System. Figure 1 also have embedded process and instrumentation systems that monitors and ensures that the operating condition of the desalting process are working optimally.

Figure 2 is a pictorial view of how Figure 1 is represented in the Distributive control system (DCS), for control of process variables. Looking at it closely, shows the process set points and process parameters (Temperature, Pressure, Level and Flow rate etc.). The crude oil feed to the desalter is commingled with re-circulation water from the Wash Water System before entering at the bottom of the desalter. The desalted crude oil exits the top of the vessel and is routed to the Crude/Crude Ex-changer. The produced water interface level shall, under normal operating conditions, operate and below the electrostatic grid. To ensure that the level of the desalter is closely monitored and controlled, the desalter vessel is designed with sampling points (N11, N12, N13, N14, and N15). The lower sample points, N15 and N14 indicates water, N13 indicates oily water emulsion while N12 and N11 indicates oil. Hence, whenever the water interface level increases beyond N15, N14 (Above electrostatic grid), the salinity in the crude oil will be high. At this point, tricock operation is carried out to ascertain the water interface level and to effect the appropriate control.

## 2.0. METHODOLOGY

### 2.1 Equipment and Materials

The following equipment was used in the crude oil separation, dehydration and desalting system. These equipment are integrated in the Figure 2

Table 1: List of equipment description and tag number for the system

| EQUIPMENT DESCRIPTION           | EQUIPMENT TAG NO. |
|---------------------------------|-------------------|
| 1 <sup>st</sup> Stage separator | SP-001            |
| Crude/crude Exchanger           | A-001             |
| Crude oil exchanger             | F-001             |
| 2 <sup>nd</sup> stage separator | SP-002            |

|                          |          |
|--------------------------|----------|
| Charge Pumps             | A-001A/B |
| Dehydrator               | D-001    |
| Desalter                 | D-002    |
| Crude oil rundown cooler | C-001    |
| Re-circulation pumps     | R-001    |

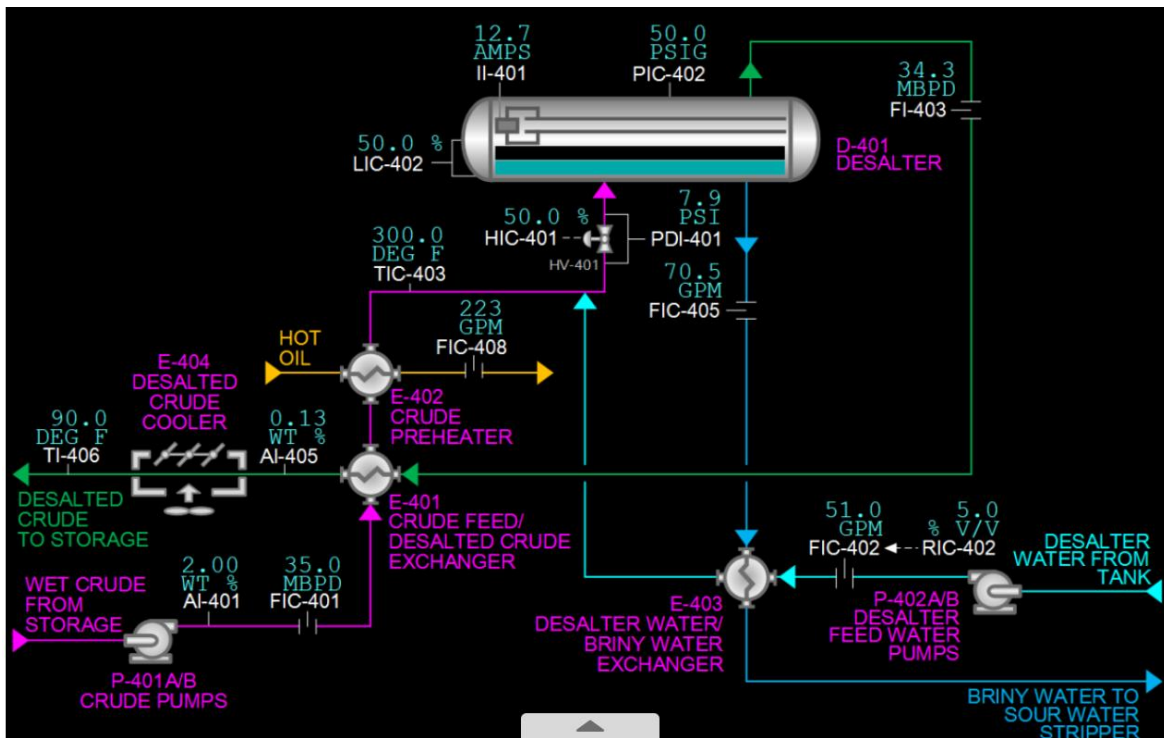


Figure 2 is a typical process flow scheme diagram of a desalting unit in X-field.

Produced fluids are directed to the X-field from an X-field Flow Station via the offsite interconnecting pipeline to the crude oil 1st stage separator. The inlet pipeline includes an offsite Motor Operated Valve (MOV) and a Shutdown Valve (SDV) upstream of the 1st stage separator. Well fluids are initially directed through the three-phase high pressure 1st stage separator, which separates the majority of hydrocarbon gas and produced water from the wet crude oil. Wet crude oil is directed to the crude/crude ex-changer, produced water is directed to the Produced Water System, gas is compressed using the HP export compressors and/or piped to the export pipeline. The 1st stage separator is capable of handling 45,000 bpd of crude oil, 40,000 bpd of produced water and 35.4 MMscfd of produced gas. Crude oil from the 1st stage separator is preheated in the crude/crude ex-changer, before entering the crude oil heater where crude oil is further heated using fuel gas burnt in a combustion chamber. This is carried out to assist further water and gas removal in the downstream low pressure 2nd stage separator. The 2nd stage separator is a three-phase low pressure separator, which directs water to the Produced Water System, separated gas to the LP compressors and crude oil to the dehydrator/desalter for further processing. The 2nd stage separator is capable of handling 40,000 bpd of crude oil, 5,300 bpd of produced water and 15MMscfd of produced gas. As the separated, hot crude oil is now at significantly lower pressure than the produced fluid from the X-field Flow Station, two 100% duty centrifugal charge pumps are provided in parallel to pump oil through downstream dehydrator and desalter, which facilitate the removal of inorganic chlorides (salts) and water-soluble contaminants from the crude oil. This is achieved by injecting wash water into the oil, emulsifying and coagulating droplets for removal using an electrostatic charge. As further cooling is required before the hot crude oil can be directed to the storage tank, the oil is passed through the crude/crude ex-changer in counter-current flow with the wet crude oil preheated from the 1st stage separator. This pre-cools the dry oil before flowing to the crude oil rundown cooler to a temperature of between 50°C (winter) and 60°C (summer), acceptable for storage. To enhance the performance of the dehydrator and desalter, Wash Water Heat Exchanger and Wash Water Pumps (A/B) is used. Water separated in the desalter is pumped back to the dehydrator using Wash Water Re-circulation Pumps (A/B), while the desalted crude oil is cooled using the crude/crude ex-changer and routed, through crude oil rundown cooler, directing crude oil to either the crude oil on-spec or off-spec storage tank, where sample could also be collected from the storage tank for analysis.

## 2.2 Design parameters

The wash water pump are electric motor driven, horizontal, single stage centrifuged pumps with the following specifications:

Table 2: Wash Water pump operating conditions

| ITEM                  | DESCRIPTION   |
|-----------------------|---|
| Operating temperature | -5 °C to 55 °C  |
| Suction Pressure      | 0.1 barg (1.45psi)  |
| Discharge pressure    | 10.1 barg (146.5psi)  |
| Differential pressure | 10 barg (145psi)  |
| Differential head     | 102m  |
| Designed temperature  | 85 °C   |
| Designed pressure     | 12.3 (178.4psi)   |
| Casing                | Carbon steel  |
| Impeller              | Standard steel (12% chrome)   |
| Flow rate             | 19.1m <sup>3</sup> /hr (normal), 21m <sup>3</sup> /hr (rate) 7m <sup>3</sup> /hr (turndown) |
| Power (motor)         | 18.5 kw   |

The wash water heat ex-changer is a plate and fin type heat ex-changer with the following specifications as shown in Table3

Table 3: Wash Water Heat Ex-Changer Operating conditions

| Equipment                 | Wash water heat exchanger                 |         |                             |         |
|---------------------------|---|---------|-----------------------------|---------|
|                           | Wash water stream (Cold)                  |         | Produced water stream (Hot) |         |
|                           | Summer                                    | Winter  | Summer                      | Winter  |
| Inlet Temperature         | 40.0 °C                                   | 60.0 °C | 90.0 °C                     | 90.0 °C |
| Outlet Temperature        | 80.0 °C                                   | 80.0 °C | 68.4°C                      | 49.1 °C |
| Operating Pressure        | 7.0 barg (101.5psi)                       |         | 6.0 barg (87psi)            |         |
| Pressure Drop (Allowable) | 1.0 barg (14.5psi)                        |         | 1.0 barg (14.5psi)          |         |
| Design Temperature        | 125 °C                                    |         | 125 °C                      |         |
| Design Pressure           | 14.0 barg (203psi)                        |         | 14.0 barg (203psi)          |         |
| Design Flow Rate          | 19.50 kg/hour                             |         | 36.50 kg/hour               |         |
| Dimension –HE             | 1216mm length: 1596mm height: 540mm width |         |                             |         |
| Internal Arrangement      | 45 titanium plates                        |         |                             |         |

### Wash Water Streams

In a desalter of crude oil, injected wash water is used to reduce the concentration of salts in the crude oil. This is done by mixing the wash water with the crude oil in a mixing valve. The mixing valve is designed to create a turbulent flow that promotes the mixing of the wash water and crude oil.

### Nature and Source of Data

The nature and source of data used for this study were all primary data obtained from the process plant at X-field. This sampling exercise was carried out for a period of 70 days.

### Method of Data Collection

Crude oil samples were collected with the aid of a sampling bottle under operating conditions from the downstream of the desalting unit, in the treatment plant to analyse the samples for data generation.

### Sample and Sampling Techniques

Samples are taken from the process streams to verify system and equipment efficiency daily. The Desalter is provided with a series of sample points equally spaced across the vessel at varying heights (Nozzle N11 N12, N13, N14 and N15). These sample points are referred to as "Tricocks" and are provided for sampling and monitoring the actual level of the water, oily water emulsion, and oil within the vessel. The lower sample points, N15 and N14 may indicate water, N13 may indicate oily water emulsion and N12 and N11 may indicate Oil. The Tricocks can also be used to verify the interface level as indicated by instrumentation. To take samples, the valves that controls the respective nozzles are turned on and sampling is done using sampling bottles or by visual observation. This procedure which was used in this study, is applicable to the X-field in Iraq.

### 3. RESULTS AND DISCUSSION

Measurements of salinity in ppm after treatment of the crude oil from the downstream of the desalter over a period of time are shown in Figure 5 through Figure 10. Information on the process variables (flowrate, temperature, pressure and level) are obtained from the process history (trend) in the Distributive Control System (DCS). From the results shown in Figure 5 through Figure 10, it can be observed that, there are cases where the measurements of salinity in morning and evening varies. This was caused by the changes in the process variables such as the flowrate, temperature, pressure, water-oil interface level and the de-emulsifying agents.

Optimal flow rates ensures adequate contact between the crude oil and water, allowing for efficient salt removal and separation [13]. Higher temperatures improve the solubility of salts and aids their removal and also promotes emulsion resolution [14]. Proper interface level control system ensures that water and oil phases are adequately separated, avoiding emulsion formation and improving the quality of the desalted crude oil [15]. Use of optimal pressure is key to effective separation to prevent blowby or carryover during separation. High pressure-drop operations results in a good mixing between wash water and the emulsion leading to a decrease in the salt content in the bulk of the oil phase; facilitating effective salt removal and water-oil separation [3]. The use of demulsifying agents or chemical additives can aid in separating water and oil phases during desalting. Proper selection and dosage of demulsifiers are crucial to enhance the efficiency of the separation process. The oil salinity decreases remarkably with the increasing of chemical demulsifier rate [13]; although, effectiveness of demulsifiers can be influenced by temperature, pressure, and the specific characteristics of the crude oil.

Therefore, to ensure efficient desalting operation, the crude oil flow rate, temperature, and pressure, along with the pressure drop in the mixing valve and the quality and rate of wash water should be at optimum during operations. All these parameters play vital roles and are significant and are the major causes of the variations in the measurements during the morning and evening periods.

The behavior of the wash water rate and the salinity of the crude oil sample is depicted in Figure 3 through Figure 13. A common feature in these figures is that as the wash water rate decreases, the salinity of the crude oil increases and vice versa; which is in agreement with previous investigations [16, 17]. The wash water rate when optimally managed could enhance the quality of the crude oil, improve overall efficiency and aid cost savings [18]

Figure 3 illustrates the crude oil salinity trend with a wash water flow rate of  $15\text{m}^3/\text{hr}$ . Although, the salinity of the crude oil meets the export requirement at this rate, the wash water pump is operating above the turndown rate and not at its maximum capacity of  $19.7\text{m}^3/\text{hr}$ . Figure 4, shows the behavior of crude oil salinity in the mornings and evenings at a wash water pump flow rate of  $10\text{m}^3/\text{hr}$ . Once again, it was observed that the salinity of the crude oil meets the export requirements at this flow rate and the pump is operating below the turndown rate of  $19.7\text{m}^3/\text{hr}$ .

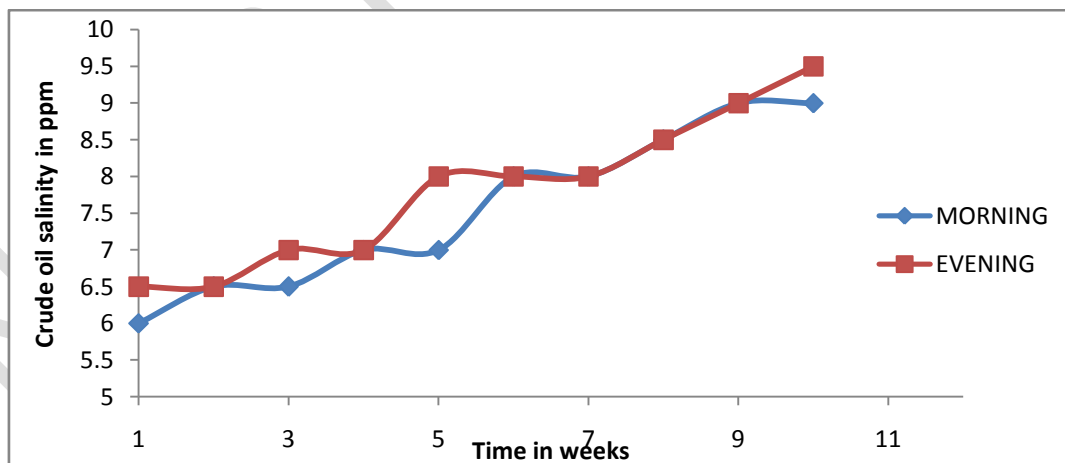


Figure 3; Timeframe vs crude oil salinity when wash water is flown at  $15\text{m}^3/\text{hr}$  maximum efficiency.

Figure 5 shows the measurements of crude oil salinity for a wash water flow rate of  $8\text{m}^3/\text{hr}$ . It was observed that although, the salinity at this flow rate meets the export specifications, there was an increase in the salinity due to the wash water pump operating beyond its maximum capacity and turndown rate. This could inhibit the efficiency of the pump over time.

At a flow rate of  $7\text{m}^3/\text{h}$ , the salinity of the crude oil was approaching the benchmark requirement for export as shown in Figure 6. However, a significant increase in salinity was observed because the wash water pump was operating below its maximum rate, but slightly above the turndown rate. The noticeable variations in salinity measurements in the mornings and evenings can be attributed to the introduction of a new well with a high flow rate to the treatment facility. This occurred during weeks 3 and 5-7, and involved 12-hour intervals.

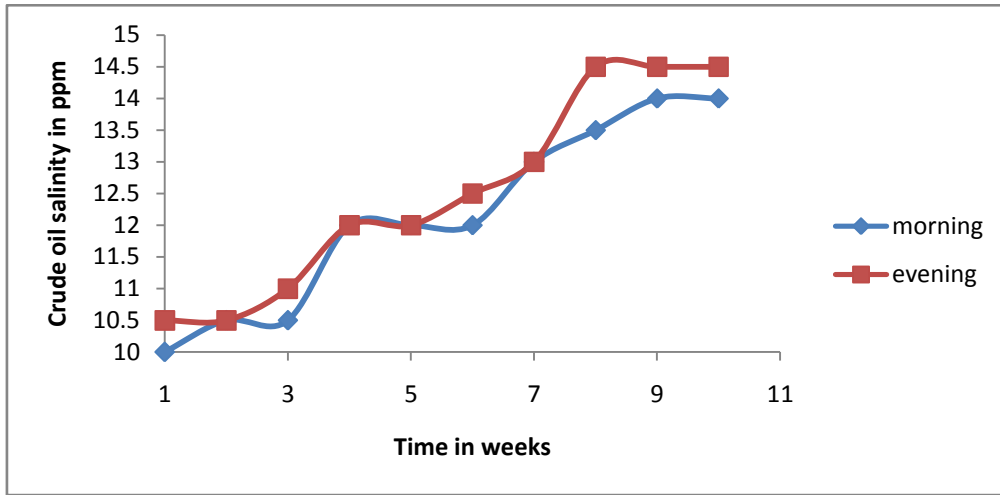


Figure 4: Timeframe vs crude oil salinity when wash water is flown at  $10\text{m}^3/\text{hr}$  maximum efficiency.

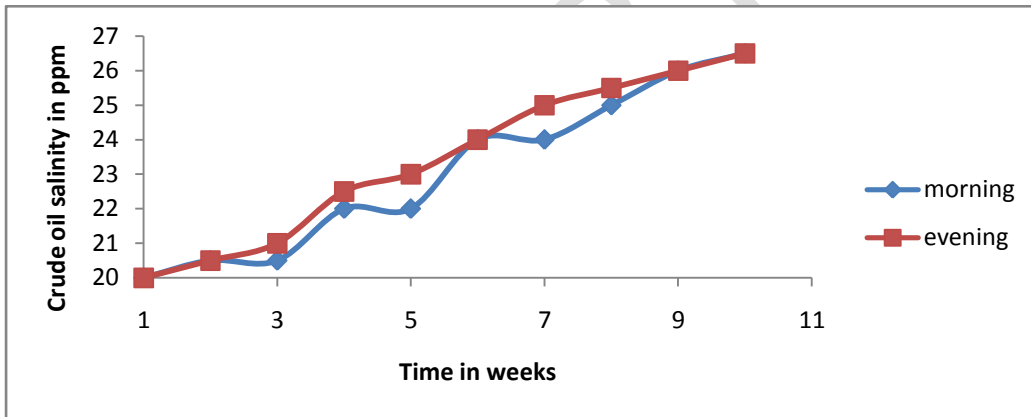


Figure 5: Timeframe vs crude oil salinity when wash water is flown at  $8\text{m}^3/\text{hr}$  maximum efficiency.

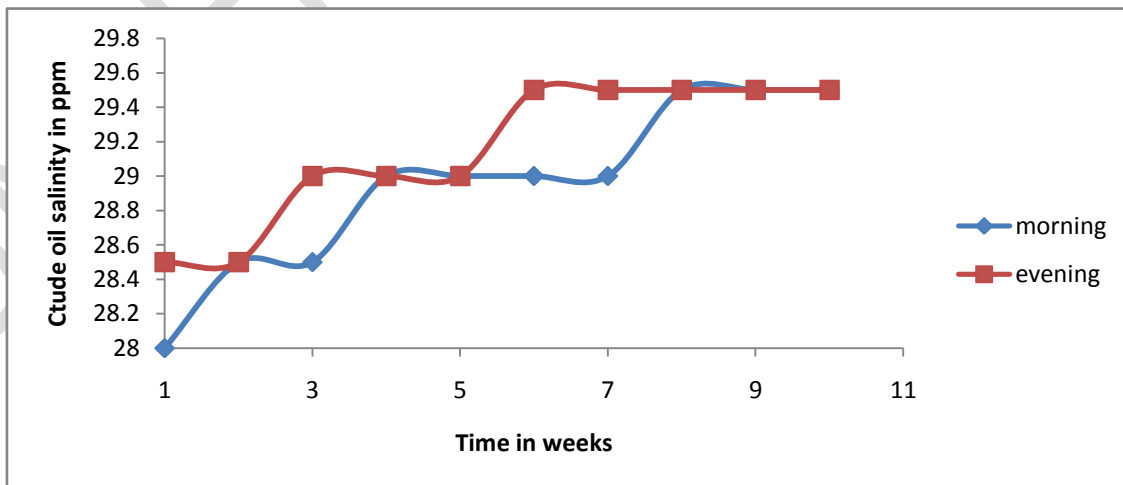


Figure 6; Timeframe vs crude oil salinity when wash water is flown at  $7\text{m}^3/\text{hr}$  maximum efficiency.

Figure 7 illustrates the variation in crude oil salinity when the wash water flow rate is set at  $6\text{m}^3/\text{hr}$ . When the wash water flow rate was set at  $6\text{m}^3/\text{hr}$ , the salinity of the crude oil exceeds the required benchmark of 30ppm for export. This increase in salinity is above tolerable limits and pose significant challenge of the desalting process. A similar trend was observed when the wash water flow rate was decreased to  $5\text{m}^3/\text{hr}$  as shown Figure 8.

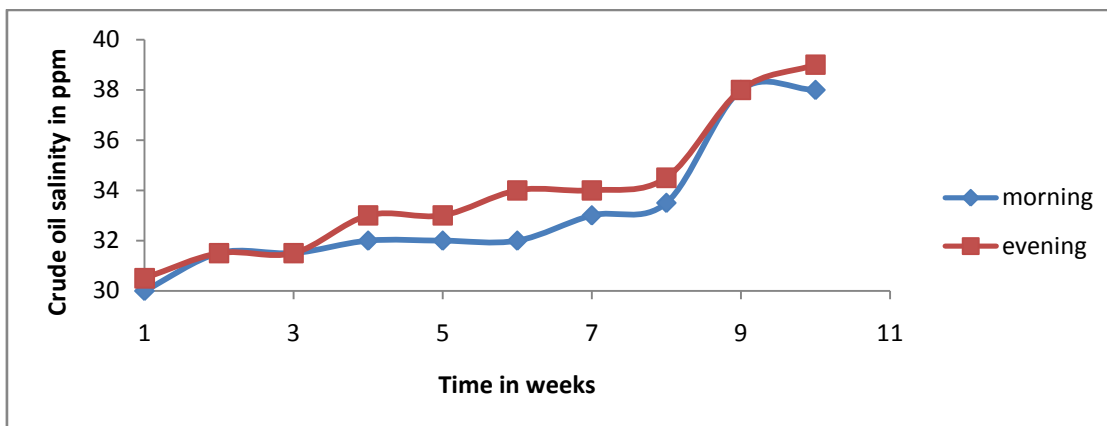


Figure 7: Timeframe vs crude oil salinity when wash water is flown at  $6\text{m}^3/\text{hr}$  maximum efficiency.

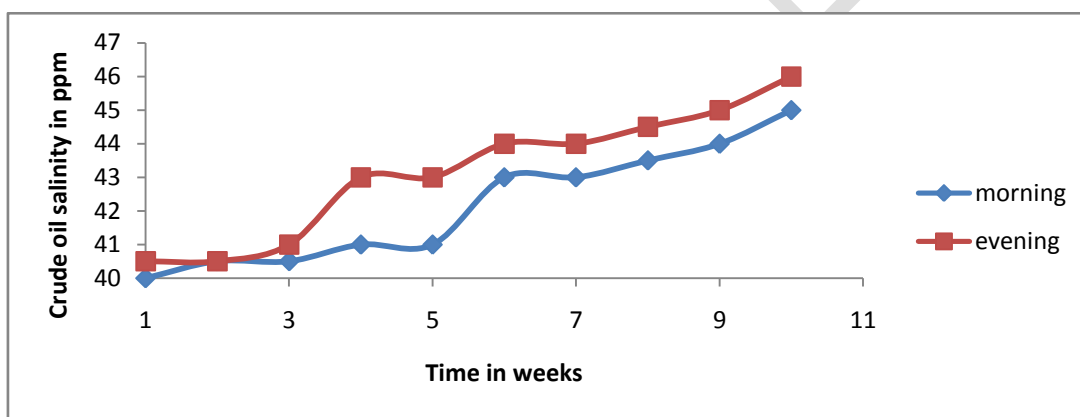


Figure 8: Timeframe vs crude oil salinity when wash water is flown at  $5\text{m}^3/\text{hr}$  maximum efficiency

Figure 9 shows the crude oil salinity at the various wash water pump rates for 10 weeks in the mornings. As can be seen in Figure 9, the higher the wash water pump rate the lower the salinity and vice versa [19]. The minimum crude oil salinity in the mornings was observed when the flow rate was  $15\text{m}^3/\text{hr}$  while the maximum was observed at a flow rate of  $5\text{m}^3/\text{hr}$ . Also, it can be observed in Figure 9, that except for the flow rate of  $7\text{m}^3/\text{hr}$ , the crude oil salinity for at other wash water pump flow rates changes as the week progresses. A similar trend was also observed for measurements taken in the evenings as shown in Figure 10 for the 10 weeks under which this study was carried with the minimum and maximum crude oil salinity occurring at  $15\text{m}^3/\text{hr}$  and  $5\text{m}^3/\text{hr}$  respectively.

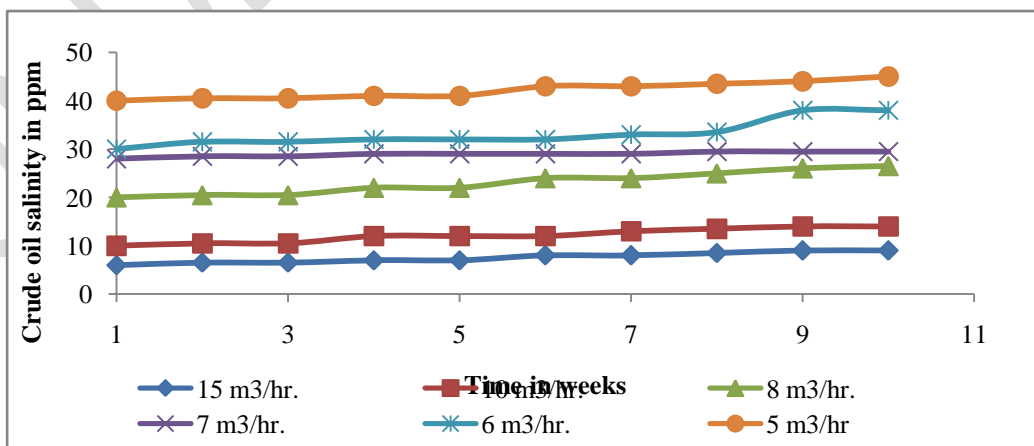


Figure 9: Measurements of crude oil salinity in the mornings at different flow rates for 10-weeks

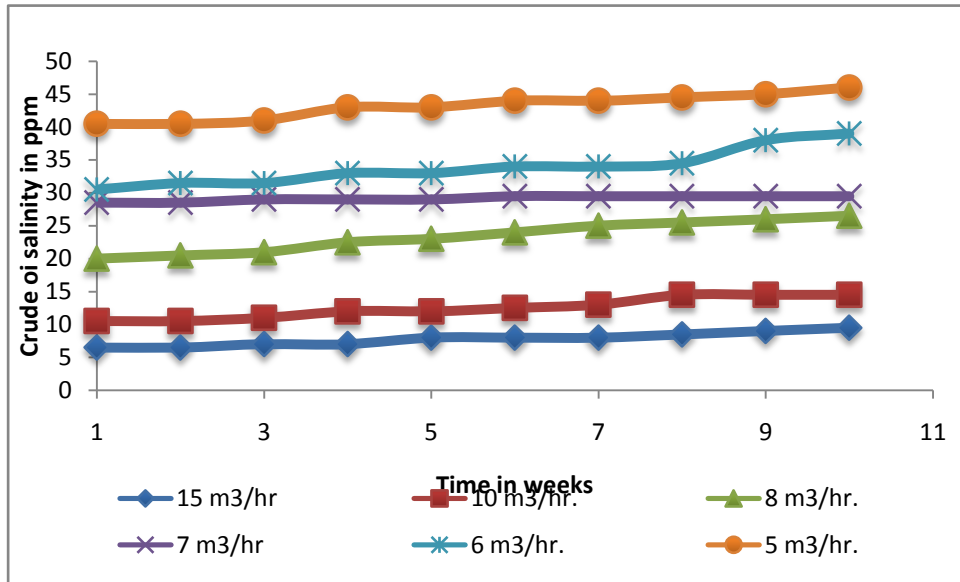


Figure 10: Measurements of crude oil salinity in the evenings at different flow rates for 10-weeks

Figure 11 presents an average performance analysis of the wash water pump at different flow rates during the mornings and evenings. It could be seen that when the flow rate is between  $15\text{m}^3/\text{hr}$  and  $7\text{m}^3/\text{hr}$ , the salinity of the crude oil remains within the required range or comes close to meeting the benchmark specifications. However, as time progresses, the wash water pump flow rate decreases and eventually falls below the turndown rate, leading to having salt contents in crude above the acceptable tolerance limit of 30ppm.

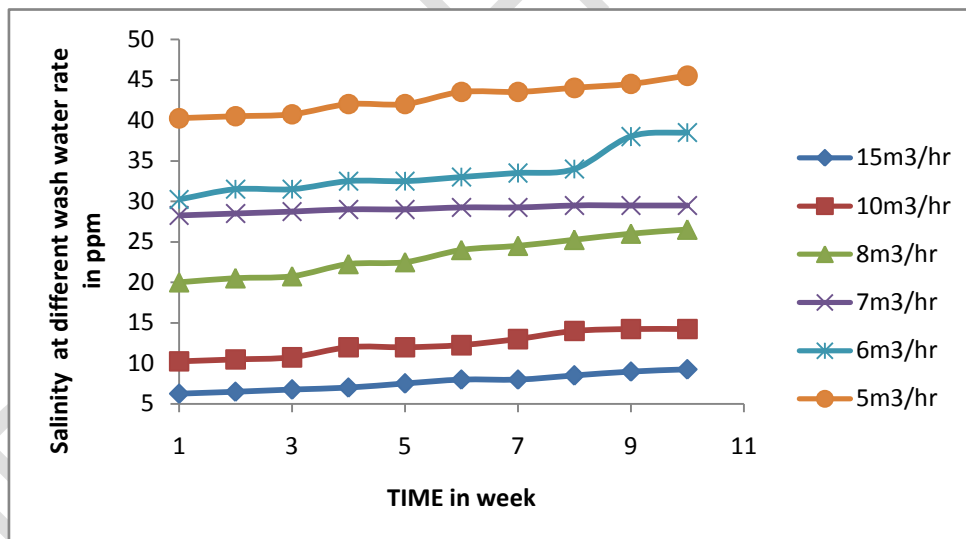


Figure 11: Average of mornings and evenings crude oil salinity at the various wash water pump flow rates

### The Proposed Method of Optimizing the Wash Water Pump Rate

The flowchart for the proposed method developed in this study for optimizing the wash water pump rate during a desalting process is shown in Figure 12. The recommended minimum operating flow rate of the pump is  $7\text{m}^3/\text{hr}$  and maximum flow rate of  $19.1\text{m}^3/\text{hr}$ . It is also recommended that wash water control valve be operated in a cascaded mode to observe the volume of crude oil produced at a given wash water flow rate. Once the optimization is completed in line with the procedure shown in Figure 12, the process could be put into a cascade mode to enhance the plant efficiency. This would lead to increase in production, reduced maintenance cost, reduced downtime and meeting of the target market specification of the crude oil.

#### 4. CONCLUSION

Desalting is an important process before refining crude oils. Salts in crude oil are associated with myriads of problems that inhibits plant efficiency and promote plants sub optimal performance. During a typical desalting process, different process variables are considered to achieve the desired and tolerable salinity specifications in crude oil. One of these variables that strongly influence the salinity in crude oil during a desalting process is the wash water pump flow rate. In this work, the influence of low and high water pump flow rates on the crude oil salinity was investigated considering the operations in the morning and evening. Samples were collected on weekly basis for 10 weeks and results tabulated. Prior to the desalting process, the crude oil was commingled with re-circulation water before entering the desalter and Tricock operations were performed to monitor the water-oil interface to ensure effective control. The average salinity of the crude oil after treatment in the desalter at various wash water flow rates were determined at the end of each test. It was observed from this investigation that the higher the wash water pump rate the lower the salinity and the ability of the desalting process to attain desired export salinity specifications and vice versa. Also, no much significant changes were observed in the measurements during the morning and evening hours and the results were consistent irrespective of the period the measurements were taken. More so, an optimization flow chart was also developed from this study to show how to optimize the wash water pump for a typical desalting process to meet export salinity specifications and reduce operational costs..

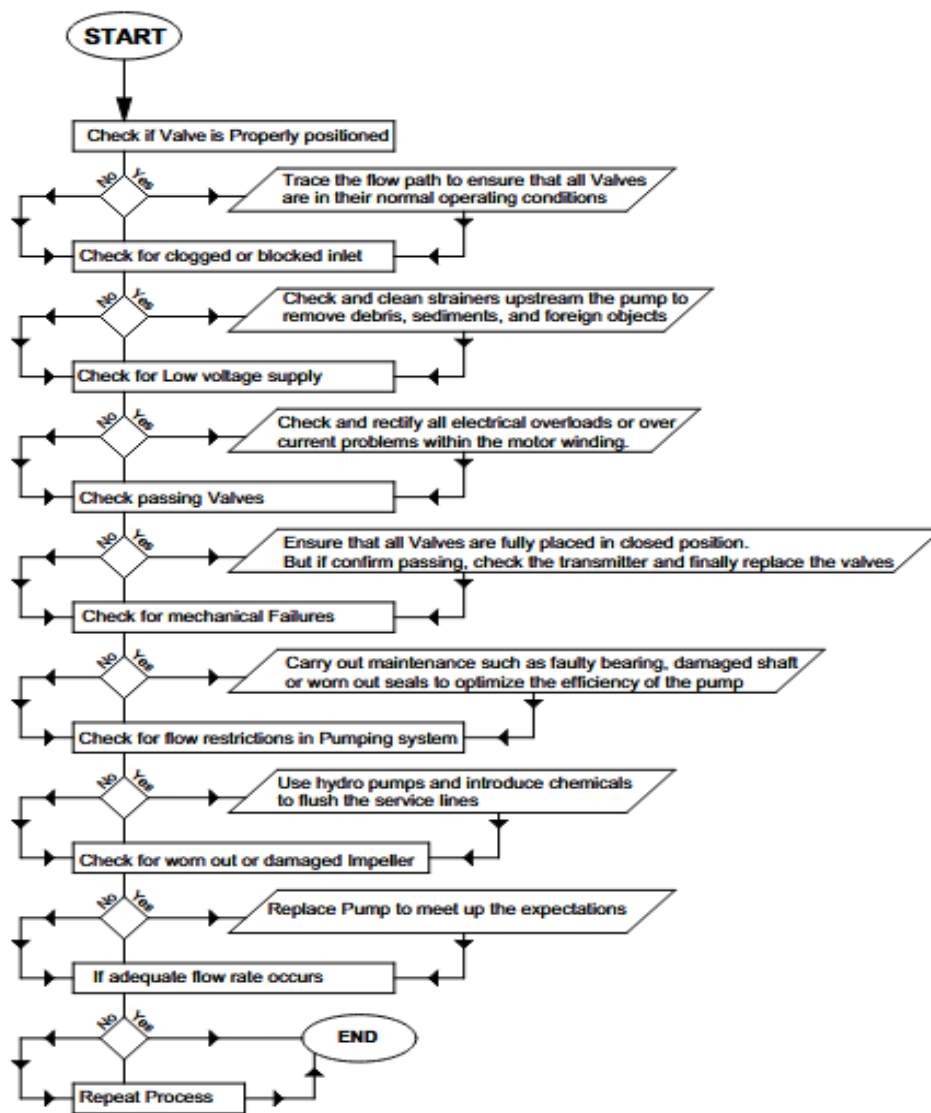


Figure 14: Proposed Method of Optimizing the Wash Water Pump Rate

#### REFERENCES

[1]. Hanoon .H, Ali N, Huwaidah IA, Maryam JJ. Experimental study of desalting crude oil, Periodicals of Engineering and

- [2]. Gary JH, Handwerk GE. Petroleum Refining: Technology and Economics (4th Ed.). CRC Press 2000
- [3]. Axens S, Kurita C, SUEZ W. Our desalting rate drops away quickly when we use heavier feeds. What is the problem here? Digital Refining. 2021
- [4]. Alqaheem DY, Alomair A. Hydrogen recovery from ARDS unit by membranes: A simulation and economic study, Results in Engineering. 2022;:15,100559
- [5]. Nassim.T, Mojgan A, Hassan M P, Mohamed R N E. Parametric optimization of a crude oil treatment unit to maximize oil production, Chemical Engineering Research And Design. 2023; 190.20-32.
- [6]. Ibrahim. DS, Sami NA. Experimental Study of Desalting and Dehydration of Two Samples of Iraqi Crude Oils, Petroleum Science and Technology. 2015;33(15-16):1533-1539
- [7]. Abdel-Aal HK, Aggour M, Fahim MA. Petroleum and gas field processing. New York: Marcel 2003.
- [8]. Al-Otaibi M, Elkamel. A, AL-sahhaf T, Ahmed AS. experimental investigation of crude oil desalting and dehydration chemical engineering. communication, 2003:190: 65- 82,
- [9]. Fortuny M, Silva EB, Filho AC, Melo RLFV, Nele M, Coutinho RCC, Santos AF. Measuring Salinity in crude oils: Evaluation of methods and an improved procedure. Fuel.2008;.87: 1241–1248
- [10]. Hasan SW, Ghannam MT, Esmail N. Heavy crude oil viscosity reduction and rheology for pipeline transportation. Fuel.2010; 89: 1095–1100
- [11]. Abdul-Wahab S, Elkamel A, Madhuranthakam CR., Al-Otaibi MB. Building inferential estimators for modeling product quality in a crude oil desalting and dehydration process, Chemical Engineering Process. 2006;45: 568–577
- [12]. Bai ZS, Wang.HL Crude Oil Desalting using hydrocyclones ChemicalEngineering Research and Design. 2007; 85 (A12) 1586–1590
- [13]. Sellami MH, Naam R, Temmar M. Optimization of Operating Parameters of Oil Desalting in Southern Treatment Unit (HMD/Algeria). Journal of Petroleum and Environmental Biotechnology, 2016; 7(2): 1-6
- [14]. Pruneda E, Garfias J, Escobedo E. Optimum Temperature in the Electrostatic Desalting of Maya Crude Oil. Revista de la Sociedad Química de México. 2005
- [15]. Behin J Aghajari M. Influence of water level on oil–water separation by residence time distribution curves investigations. Separation and Purification Technology. 2008; 64. 48-55.
- [16]. Ehsan R, Hamzeh G, Sajjad R, Fabio L, Alberto G. Analysis of the performance of crude oil desalting, Fuel. 2021; 291-120046
- [17]. Sellami M H, Hanza B, Naam R, Mouner T. Optimal processing parameters of electrostatic crude oil desalting .Annal of Science Technology. 2015; 7-7
- [18]. Ahmed E A, Wash water in crude oil industry, benefits, functionality and optimization plan. 2023
- [19]. Djebedjian B, Gad H, Khaled I, Rayan MA. Experimental and Analytical Study of a Reverse Osmosis Desalination Plant, Mansoura Engineering Journal, 2009; 34(2): 71-92