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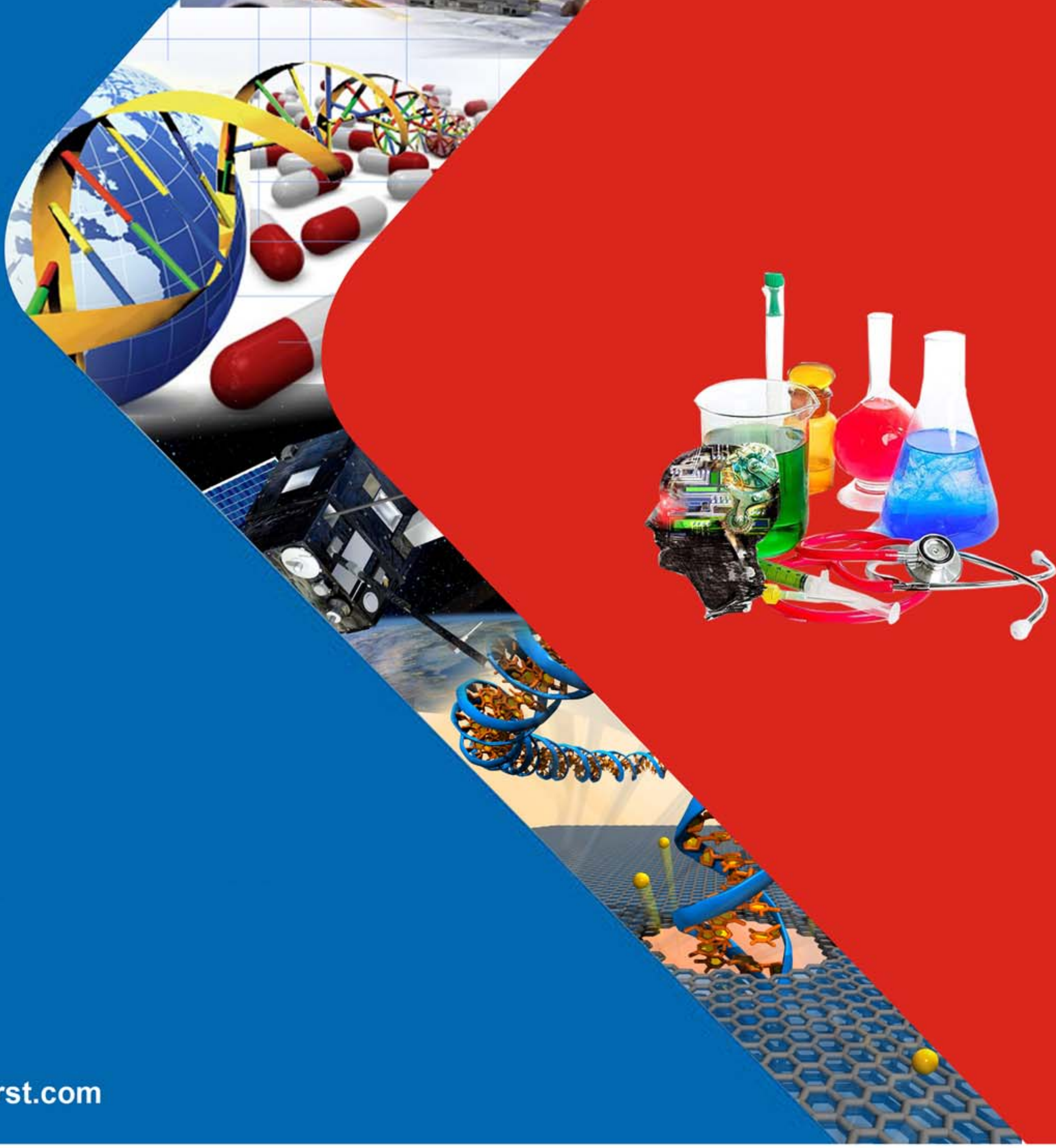

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Case Study

NEW MODEL TO ELIMINATE SALTS FROM SARIR CRUDE OIL: A CASE STUDY

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Desalting technique used in the Sarir Field (in Libya) has been studied. Salt content after electric desalter is found to be high. In order to obtain the best economical solution of the problem, extensive study was carried out on various conventional desalting techniques as well as the innovative methods of crude oil desalting. On the basis of research work it is suggested to replace the existing crude oil desalting system with the new one comprising of major equipment as multiple-orifice plate mixers, hydrocyclone disaster and pressure filter using diatomaceous earth as a filter medium. The data showed that on adopting the new technology, the production operating cost was reduced significantly and the salts content in the crude oil was diminished remarkably. For instance, Sodium Chloride (NaCl) content was reduced to 0.13 1 bs/1000 bbls, Ca^{+2} to 18.02 ppm and Mg^{+2} to 10.227 ppm. Furthermore, there was a great improvement in the API of crude oil (37.8).

Keywords: Hydrocyclone desalting, Crude oil, Multiple-Orifice plate Mixers, Pressure filter

INTRODUCTION

In the petroleum industry, there is a great variation in the salt content of crude oils depending mainly on the source and, possibly, on the producing wells or zones within a field. The amount of mineral salts varies with the geologic formation and can be as high as 200,000 ppm (Asomaning *et al*., 2000). In addition, at the refinery, salt water introduced during shipment by tanker may contribute to the total salt content (Chawla, 1987). In almost all cases, the salt content of the crude oil consists of salt dissolved in small droplets of water that are dispersed in the crude (Schramm, 1992). The chemical composition of these salts varies, but the major portion is nearly always sodium chloride with lesser amounts of calcium and magnesium chlorides. In fact, the presence of salt in the crude oil leads to several problems during transporting and the refining processes, including corrosion of lines, fouling, and also the deactivation of catalysts employed at the refinery.

Crude oil usually contains suspended solids, traces of water-soluble metals and inorganic salts. The salts, presented in crude oil, are mainly

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chlorides with the following approximate composition (Asomaning *et al.*, 2000; Chawla, 1987; Schramm, 1992):

- Sodium Chloride 75% by weight
- Magnesium Chloride 15% by weight
- Calcium Chloride 10% by weight

These salts are present in crude oil in the form of fine suspension of droplets and permanent emulsions (Bartley, 1982; Sun and Shook, 1996). It is essential to remove the contaminants of crude oil in order to reduce corrosion, plugging and fouling of equipment and to prevent poisoning of various oil refinery catalysts (Al-Kandari, 1997; Binford and Hart, 1995; Xia *et al.*, 2004; Pal, 1994). Desalting of crude oil is usually carried out at or near to the oil field production sites (Asomaning, 2000).

There are two methods, typically used for desalting of crude oil: electrostatic and chemical (Isaacs, 1990). In electrostatic separation, high voltage electrostatic separators are used for desalting whereas in chemical desalting chemicals and water are added to the crude oil in order to promote desalting through contact of water and oil. After the oil has been washed and mixed as an emulsion of oil and water, demulsifying chemicals are then added and the emulsion is transferred to a tank for settling out (Mukherjee and Kushnick, 1988; Mohammed *et al.,* 1994; Johansen *et al.,* 1989; Sjoblom *et al.,*1990).

At Sarir field in Libya electrostatics technique was used to remove the salts from crude oil. However, after desalting the quantity of salt in crude oil was still higher than expected (Sodium Chloride (NaCl) 2.6 1 bs/1000 bbls, Calcium (Ca) 910.23 ppm and Magnesium (Mg) 511.36 ppm). In this present work a detailed study was performed to find out the best economical solution of the problem.

REPLACEMENT/ADDITION OF EQUIPMENT FOR SHIFTING OVER TO INNOVATIVE TECHNOLOGY

After through research and literature study, it is found that we can improve the quality of crude significantly by the addition of a pressure filter in the system and by the replacement of following equipment:

A. Throttling valve with multiple-orifice plate mixers (MOM) and

B. Electric Desalter with hydrocyclone desalter.

Replacement of Throttling Valve with Multiple-Orifice Plate Mixers (Mom)

The mixing step in the desalting of crude oil is usually carried out by pumping the crude oil and wash water separately through a mixing device. Normally this mixing device is simply a throttling valve. It is recommended to replace the existing throttling valve with the multiple-orifice plate mixers. By this replacement, the degree of mixing will be enhanced significantly (Al-Otaibi, 2004). Figure 1 shows Replacement of throttling valve with multiple – Orifice plate Mixers. Table 1 shows some characteristics of Sarir crude oil before and after (desalting). One can observe that there is a slight modification in the API of the crude. Although there was a great reduction in the total dissolved solids, the salt concentration is still very high. This may cause numerous problems during crude oil production and transportation. Moreover, desalting

Figure 1: Replacement of Throttling with Multiple_Orifice Plate Mixers (H K Abdel, M Aggour and M A Fahim, 2003

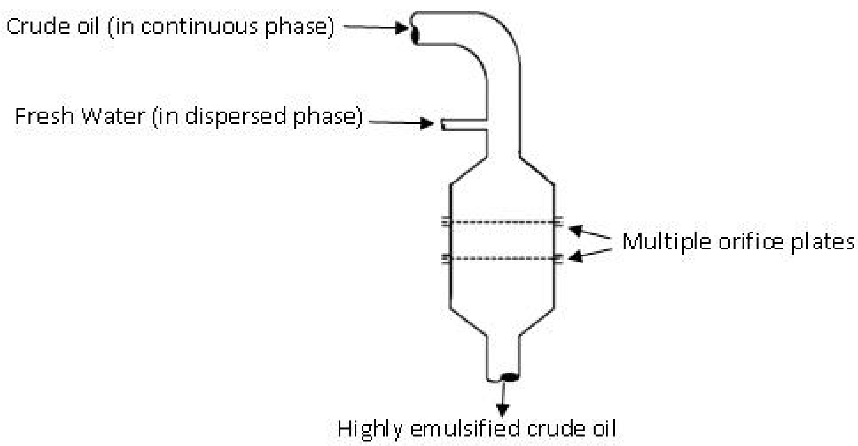


Table 1: Characterization of Sarir Crude Oil Before and After Modification (Desalting)

Characteristics	Natural/Mining Characteristics	After Modification (Desalted Crude Oil)
Gravity, Degrees API	37.8	36.7
Specific Gravity (60°F/60°F)	0.864	0.8328
Total Sulfur, ppm wt	0.26	0.031
Total Nitrogen, wt.pct	0.11	0.013
Pour point, °F, cs	66.00	>30
Viscosity at 70°F	25.00	17.0
Viscosity at 100°F	10.00	6.0
Vanadium, ppm wt	6.00	0.72
Nickel, ppm wt	14.00	2.24
Salt (NaCl) 1bs/1000bbls	2.6	0.312
Iron (Fe)	0.284	0.034
Calcium (Ca),ppm	910.23	182.046
Magnesium (Mg), ppm	511.36	102.27
Fluoride (F)	2.84	0.312
Total dissolved solids (TDS), ppm	10113.63	1213.64

Source: Platts, 2013; Oocities.org, n.d.; American Bureau of Shipping, 2001 of crude oil in this step was carried out by electric desalter which is inefficient. There is always a great safety risk while operating the electric desalter (Al-Otaibi *et al.*, 2005). The operating cost of Electric desalter is also very high. It is therefore proposed to replace the existing electric desalter with a hydrocyclone desalter. Hydrocyclone desalter is a useful equipment to remove the water and dissolved salts from the crude oil in order to minimize corrosion, plugging, and fouling of equipment (Al-Otaibi *et al.*, 2005). Preliminary industrial experiments have been performed to prove the feasibility of hydrocyclone desalter over the electric desalter. Rahman *et al*. studied the effect of several dimensionless units, such as Reynolds number, Euler number and pressure drop ratio (Rehman *et al.*, 2003). It has been found that an increase in inlet Reynolds number decreases the pressure drop ratio. While Euler number increases gradually with a Reynolds number increase in inlet. When Reynolds number

Figure 2: Fluid Flow in Hydrocyclene (Z.S. Bai, H L Wang, 2007)

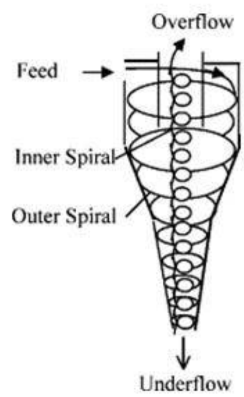


Table 2: Characterization of Sarir Crude Oil Before and After Replacement of Electric Desalter with Hydrocyclone Desalter

	Crude Oil Characteristics	
	Before Replacement Of Electric Desalter	After Replacing The Electric Desalter With Hydrocyclone Desalter
Gravity, Degrees API	37.8	36.7
Specific Gravity (60°F/60°F)	0.864	0.8328
Total Sulfur, ppm wt	0.26	0.031
Total Nitrogen, wt.pct	0.11	0.0067
Pour point, °F, cs	66.00	>30
Viscosity at 70°F	25.00	17.0
Viscosity at 100°F	10.00	6.0
Vanadium, ppm wt	6.00	0.72
Nickel, ppm wt	14.00	2.24
Salt (NaCl) 1bs/1000bbls	2.6	0.156
Iron (Fe)	0.284	0.034
Calcium (Ca),ppm	910.23	182.046
Magnesium (Mg), ppm	511.36	102.27
Fluoride (F)	2.84	0.156
Total dissolved solids (TDS), ppm	10113.63	1213.64

of inlet is ranging from 5000 to 5800, the salt concentration is reduced to less than 3 mg l^{-1}. Figure 2 illustrates the Fluid flow in hydrocyclone. The Tabulated data in Table 2 demonstrate some characteristics of Sarir crude oil before and after replacement of electric desalter with hydrocyclone desalter. One can notice that there is no modification either in the physical properties or in the salt content of the crude.

Addition of a Pressure Filter (leaf type) with Diatomaceous Earth as a Filter Media

Diatomaceous earth is nothing but naturally occurring rock with an abrasive having chalk-like feel. Silica present in the rock (about 85%) makes up the major part of the rock (Fields *et al.*, 2002). It also contains sodium, magnesium, and iron. The diatomate composite is chemically inert with no odor or taste (Oocities.org (n.d)). This is why diatomaceous earth is an attractive option for filtering the crude oil. Pressure filters are enclosed in pressure chambers and crude oil is pumped to the pressure filters. Diatomaceous earth filters are highly attractive as they are relatively cheap to install and they do not use chemicals. The data in Table 3 illustrate that there was a great improvement in the quality of crude oil after adopting the new technology (Sodium Chloride NaCl to 0.13 1bs/1000 bbls, Ca to 18.02 ppm, Mg to 10.227 ppm and API 37.8) along with significant reduction in operating/production costs. The proposed technology also has very low safety hazard as compared to the high-tension electrical hazard of the existing technology. Figure 3 shows Pressure filter (leaf type) with diatomaceous earth as a filter media (Figure 3 is a product of DicaLite®).

ADVANTAGES OF PROPOSED TECHNOLOGY OVER THE EXISTING (ELECTRIC DESALTER) TECHNOLOGY

Main advantages over the existing one are as under:

- Use of small equipment volume as compared to the existing technology.

Figure 3: Press Filter (leaf type) with Diatomaceous Earth as a Filter Media (The Above Figures is a product of DicaLite®)

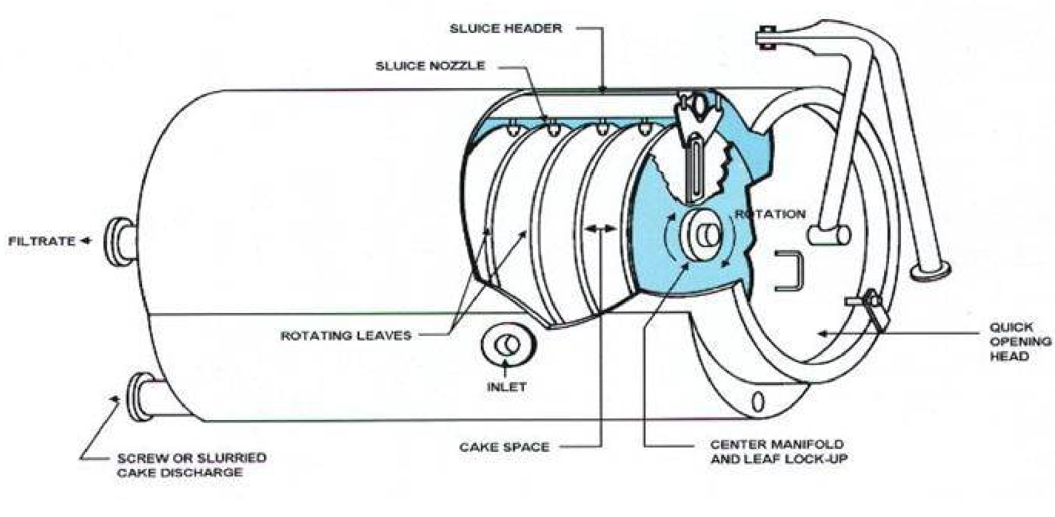
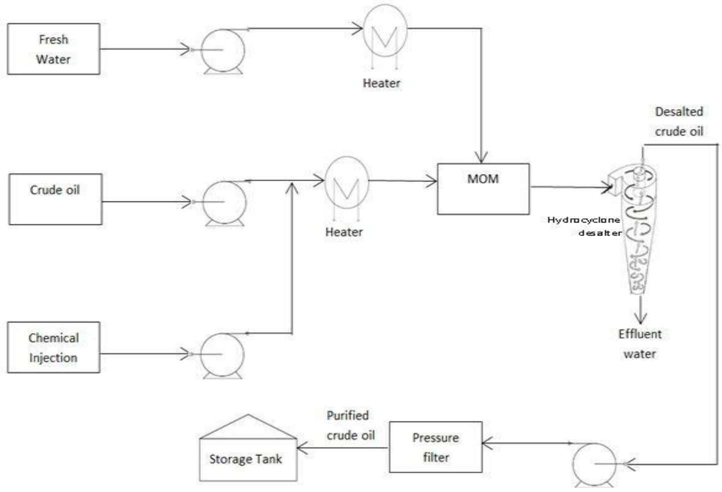


Table 3: Characterization of Sarir Crude Oil After Treatment with Electric Desalter and the Proposed Technique

Characteristics	Electric Desalter Crude Oil Characteristics	Proposed Technique Crude Oil Characteristics
Gravity, Degrees API	36.7	37.8
Specific Gravity (60°F/60°F)	0.8328	0.864
Total Sulfur, ppm wt	0.013	0.0052
Total Nitrogen, wt.pct	0.0055	0.0022
Pour point, °F, cs	>30	>30
Viscosity at 70°F	17.0	17.0
Viscosity at 100°F	6.0	6.0
Vanadium, ppm wt	0.72	0.72
Nickel, ppm wt	0.7	0.7
Salt (NaCl) 1bs/1000bbls	0.13	0.13
Iron (Fe)	0.0142	0.0142
Calcium (Ca),ppm	45.51	18.02
Magnesium (Mg), ppm	25.57	10.227
Fluoride (F)	0.142	0.0568
Total dissolved solids (TDS), ppm	505.68	202.27

Figure 4: Process Flow Diagram of Proposed Technology



- Low operating/production cost of proposed technology.
- Low electrical hazard as compared to high tension electricity hazard

PROCESS FLOW DIAGRAM OF PROPOSED TECHNOLOGY

Description of Process Flow Diagram

Crude oil is fed to multiple-orifice plate mixture (MOM) by passing through the heater. Chemical injection is done in the crude oil at the inlet of the heater. Fresh water is also fed to the multiple-orifice plate mixers after passing through the heater. Multiple-orifice plate mixers are used to enhance the degree of mixing. Emulsion of crude oil from the multiple orifice plate mixture is then fed to the hydrocyclone where separation of water soluble salts and crude oil takes place. As a result crude oil with very small amount of salt comes out from the top of the hydrocyclone whereas solution with high concentration of salts is obtained from the bottom of hydrocyclone. Crude oil from the hydrocyclone is then pumped to the pressure filter. The pressure filter is a leaf type filter which is coated with diatomaceous earth as a filter element. Diatomaceous earth is a very good filter media and by passing the crude oil through this media, the quality of crude oil is significantly improved up to the appreciable level. The crude oil after passing through the pressure filter is fed to the storage tank. Figure 4 introduces the Process Flow diagram of proposed technology.

CONCLUSION

Proposed technology is a more viable option than electric desalter technique as it improves the quality of crude oil significantly with high reduction in operating cost.

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