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Drag Reduction of AL-Ahdab Crude Oil Using Chemical Additives

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Abstract

The viscosity of crude oil has a crucial role in drag reduction during pipeline transportation; hence additives are required to enhancing the flow properties of AL-Ahdab crude oil. In this work, the potato starch biopolymer and CTAB surfactant are utilized to achieve the target. The drag reduction experiments were carried out at different crude oil flow rates (20-35-50 liters/min), pipe diameters (0.5-0.75 -1 inch), and different concentrations of potato starch (500-2000 ppm) and CTAB (100-500 ppm). The results showed that these additives had minimized flow resistance in various operating conditions, the drag reduction percent increased with increasing of additives concentration increase. The maximum drag reduction achieved using CTAB and potato starch is 41.6% and 36.3%, respectively, at 50 liters/min and 1-inch pipe diameter.

Keywords: potato starch, CTAB, drag reduction agent (DRA), AL-Ahdab Field crude oil.

تقليل إعاقة جريان نفط خام حقل الاحدب باستخدام الإضافات الكيمياوية

الخلاصة: تقليل إعاقة جريان النفط الخام لحقل الاحدب النفطي في الانابيب النفطية من اجل تحسين تدفقة وتقليل الطاقة المستهلكة في الضخ بواسطة استخدام بعض الإضافات الكيمياوية التي لها تاثير مباشر في تقليل الاحتكاك بين جزيئات النفط الخام وجدران الانابيب مثل polymers وsurfactants . في هذا البحث تم استخدام نشأ البطاطس ك biopolymer وال CTAB ك surfactant في منظومة مختبرية مغلقة وبمعدلات جريان مختلفة (20_35_50) لتر/دقيقة وانابيب مختلفة الأقطار (1_0.75 _0.5) انج وتراكيز مختلفة من نشأ البطاطس (500_2000) ppm وكذلك تراكيز مختلفة من ال CTAB (100_500) ppm وكانت النتائج التي تم الحصول عليها اعلى drag reduction لنشأ البطاطس وال 41.6% CTAB و 36.3% على التوالي عند معدل جريان 50 لتر/دقيقة والانبوب ذي القطر 1 انج.

1. Introduction

AVariety of industries, including long distance liquid transport, district heating and cooling, fire-fighting activities, irrigation systems and the petroleum maintenance and transport

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industries, benefit from the use of polymer and surfactant additives to design optimum operations of the pipelines. Drag reduction additives have been used to improve the flow of petroleum pipelines, because of their significant commercial success in cost reduction and energy use. The best known use is polymers to increase the flow of crude oil in the TransAlaska Pipeline network, which has raised the rate of flow of 1 ppm drag reducer by 33%. Burger et al . [1] have documented the use of DRAs in pipeline pipelines like the North Sea Oseberg Sector.

Drag reduction in the oil fields, rising water injection, and thus the output rate of oil, energy savings and corrosion level, will bring many additional significant benefits [1]. The application of drag reduction agents for wastewater can be much less costly than the construction of existing, wider pipes in sewage pipes and stormwater drains. The pumping energy costs of ash, tar, sediments etc. transported by pipelines can be minimized by polymer additives. For the transportation of solids in many places around the world, this application is very relevant [2].

For operations like increasing the speed of submarine systems, the drag reduction phenomenon can be applied (e.g., torpedoes and submarines). A 20% drag reduction is of great significance, and increases the flow speed by 8 percent [3]. Drag reduction polymers have also been used in the oil industry over the last 40 years. The diagnosis of cardio- or circulatory disease is one such use of drag-reduction polymers [4]. Surfactants have been widely used in DHC to minimize pumping power or increase the flow rate as they are very durable and recover from degradation compared to polymers easily.

In wide district heat systems the use of drag reducing surfactant additives greatly reduced the energy in the tube flow. Saeki[5] has documented the maintenance of cationic surfactants in aqueous systems , leading to a 20% -60% lowering of pumping capacity. Tensile DRA has also been used to help prevent ice slurries from agglomerating [6]. Ice slurry systems have shown improved performance in 13 advanced cold heat storage, transport and heat exchange systems due to their ice dispersion capability and their efficiency in dragging[7]. As the drag reduction is closely linked to energy efficiency, they should attract more publicity and will be used more quickly. The aim of this research is to conduct an a drag reducting experiment using East Baghdad crude oil.the additive used in the experiment are Cetyl trimethyl ammonium bromide (CTAB) and potato starch.

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2. Experimental Work

2.1 Feedstock and Chemicals

The crude oil feedstock was obtained from East Baghdad Field. The specifications of the Iraqi crude taking from the same refinery plant labortary shown in Table (1). Cetyltrimethylammonium bromide (CTAB) $C_{19}H_{42}BrN$ and Potato starch $(C_6H1_0O_5)_n$ $.(H_2O)$ are used as additive.

2.2 Chemical additives

Cetyl trimethyl ammonium bromide (CTAB):

Cetyl ammonium ammonium bromide is a white powder surfactant detergent that is available from the Himedia business, containing molar mass (364.45)g per mole and 99% pure.

Potato starch:

The starch (C6H10.3) n. (H2O) is a biopolymer supplied with a density of (0.81) g/m3, a molar mass of CDH-fine chemical company, soluble water (33.3) mg soluble in (1) mL and purity 99 percent. Any value of molar mass, density, solubility and purity for both potato starch or CTAB are taken from the cover of the tins.

Table (1) Specifications of Al- Ahdab crude oil

Property	Value
Viscosity at 25 C (centipoise)	42.6
API at 15.5 ºC	22.9
Density at 30°C(g cm^{-3})	0.9153
Asphaltene content wt.%	7.09
Sulfur content wt.%	4.629

2.3 Drag Reduction Experiments

Experiments on the reduction of crude oil drag in the drag reduction unit shown in Figure (1).this unit included two pumps (feeder and receiver) with a capacity of 60 liters, for rough oil circulation and three steel pipes of different sizes of 0.0127 m (0.5inch), 0.01905 m (0.75 inch), and 0.0254 m (1 inch) of diameter (pipe thickness was 2 mm, with 4 m length

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equipped with tube input and outlet pressure gauges. A 40 liter crude oil rectangular tank (was supplied for every flow to the feed tank that pumped the pipes at ambient temperature and was recirculating by the second pump from the receiving tank). First, in each pipe a blank crude oil with a different flow rate of 20, 35, 50 liters / min pumped, and after reaching a steady state, the pressure drop was recorded in each case. Therefore in the raw oil with a specific concentration range (500-2000 ppm), respectively (100-500 ppm), the potato starch and CTAB surfactant are also applied to the raw oil where select these amounts based on the best results have obtained in the tests. All tests on drag reduction with additives were conducted with the same blank crude oil variables.

2.4 Reservoir tank of crude oil

The reservoir tank was made from commercial steel plate. This tank is lifted about 30 cm from the ground by steel base and supported with two, exit pipes, connected to two centrifugal pumps. The volume of the tank is 60 L.

2.5 Pumps

A centrifugal pump of stork type with constant high speed (flowrate =45 m^3/hr.; power =25 H.P.) provided with two flanges, was used to circulate the solution from the reservoir tank through pipes. This pump was provided with a bypass from tank at a point before the entrance of solution to the testing section, in order to control the flowrate.

2.6 Valves

In order to control the amount and direction of solution flowrate through the system, eight ball valves were used. Two valves (fifth and sixth) were opened that located in the bypass to control the flow rates of crude oil entering the first testing section (0.0127 m) pipe. While (first, second, third and fourth) valves were kept closed that located to ensure the crude oil pass through one of the three testing sections.

In the second step .two valves (third and fourth) were opened that located in the bypass to control the flow rate of crude oil entering the second testing section (0.0191 m) pipe .while (first ,second ,fifth and sixth) valves were kept closed that located to ensure the crude oil pass through only in the pipe we need to. And so on in the other testing pipes for all runs.

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2.7 Pressure measuring devices

To measure the differences of the pressure drops between two points, nine calibrated pressure gauges were used. Three pressure gauges of one bar were located at the section pipe, discharge and pump. The three pressure gauges of one bar were manufactured by (Dura gauge, AISI 316 tube, steel socket, U.S.A).

2.9 Flow meter

The volumetric flowmeter of the solution passing through the testing section was measured by using calibrated flow meter of maximum flowrate (3.6 m^3/hr.), which is located at the end of closed system pipe prevent any disturbance in the flow.

2. Pipes

Three sizes of pipes used in the drag reduction unit. The inner diameter of them was 1⁄2 inch (0.0127 m), 3/4 inch (0.0191 m), and 1inch (0.0254 m). The pipes were made of stainless steel to prevent any corrosion and to withstand the high shear force of the flow.

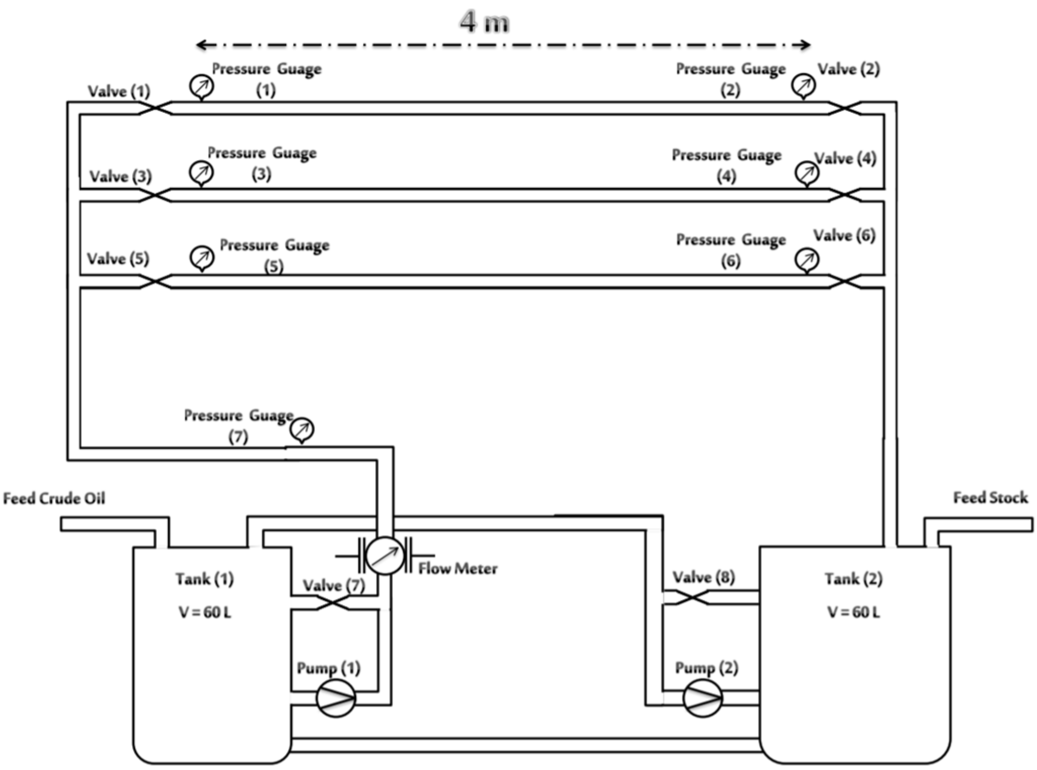

Fig.(1): Crude oil drag reduction unit

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3. Results and Discussion

3.1 Drag Reduction

Drag reduction performance is generally expressed in the percentage reduction in drag. It is calculated according to Eq. 1

$$DR\ \% = \frac{(\Delta p_b - \Delta p_a)}{(\Delta p_b)} * 100 \qquad \ldots\ldots\ldots\ldots(1)$$

Δpa= pressure drop after the addition of additives

Δpb =pressure drop before the addition of additives

Fig. (2): Photo of drag reduction unit

3.2 Effect of Concentration

As a drag reducer at various concentrations, potato starch and CTBA surfactants were added to the crude oil. The effect on the drag reduction for 50 liters / min flow rate in 0.0127 m pipe diameter on the potato starch concentration (500-2000 ppm). With the increase in starch concentration, the drag reduction in crude oil increased. At 2000 ppm potato starch, the average DR percent was 34.7% as shown in Figures (3 to 5). Figures (6 to 9) show the effect of drag

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reduction of CTAB levels (100-500 ppm). With the rise in surfactant concentration, the drag reductions in crude oil increased. At 500 ppm of CTAB, the overall DR level was 39%.

It is clear that the two additives have a strong effect on crude oil drag, but the influence of CTAB is significant. Higher additive rates have a micelle structure within the fluid flow which can minimize turbulent flux formation. Surfactants contribute to drag reduction in turbulent pipelines. Their drag reduction capacity is due to rod-like micellular forms at low concentrations. The micelles run in a system for suppressing friction and rising viscosity, which can be higher than in other polymers. The new characteristics of tensioners are due to the self-repair capacity [8].

When we used the biggest diameter (0.0254 m or 1 inch) there were not drop pressure in the pipe at 20 L/min because the flow was not enough to cause pressure on the pipe so this value was zero.

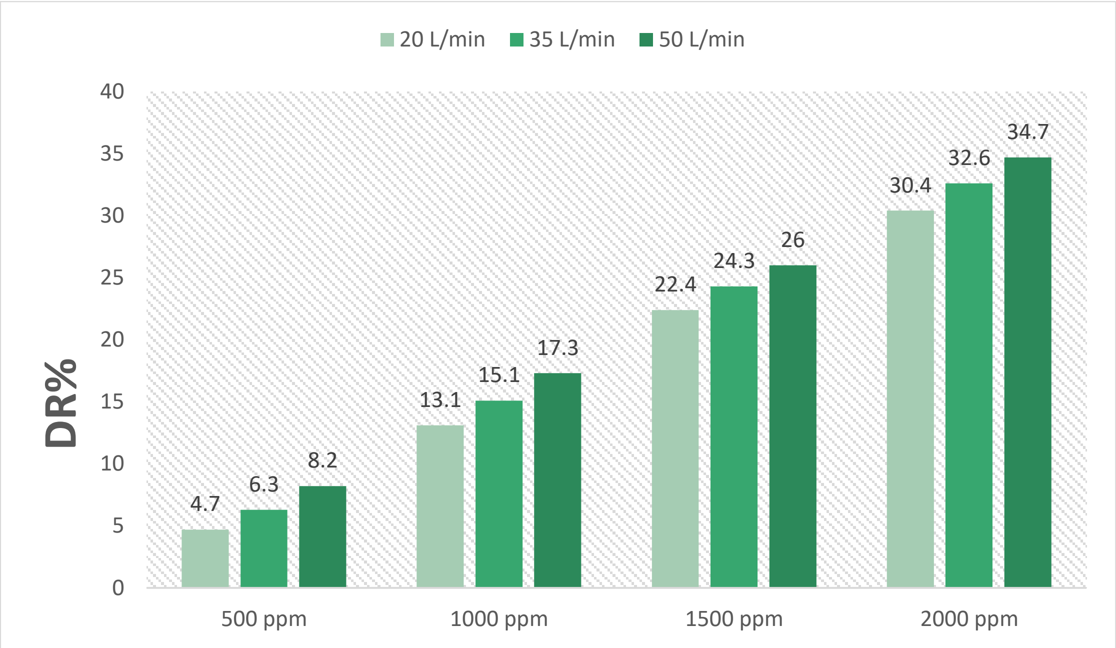

Fig (3): Effect of potato starch concentration on drag reduction through 0.0127 m pipe

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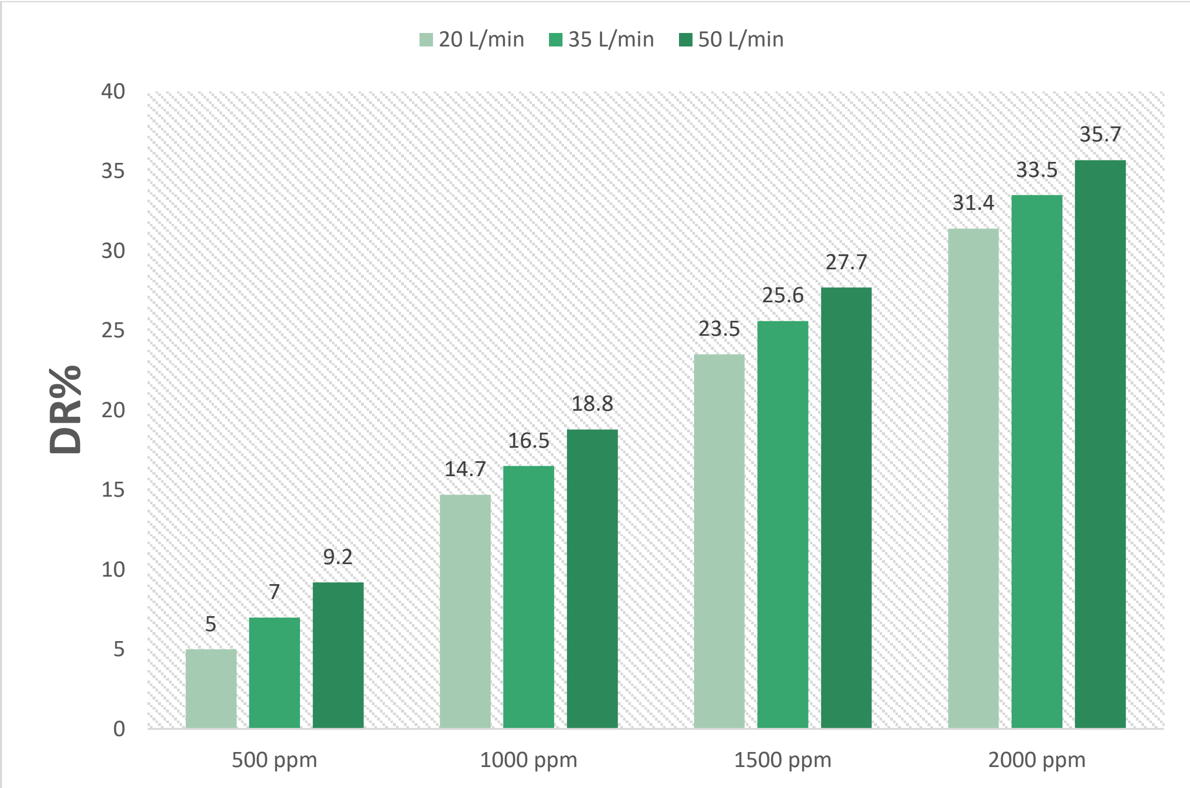

Fig. (4): Effect of potato starch concentration on drag reduction through 0.0191 m pipe

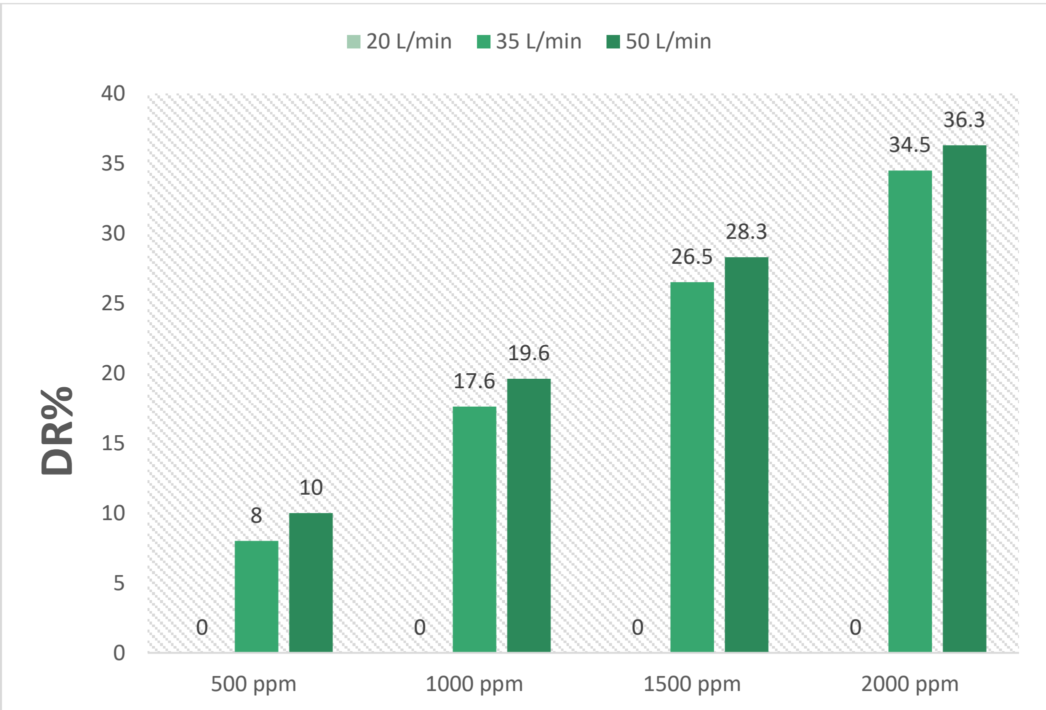

Fig. (5): Effect of potato starch concentration on drag reduction through 0.0254 m pipe

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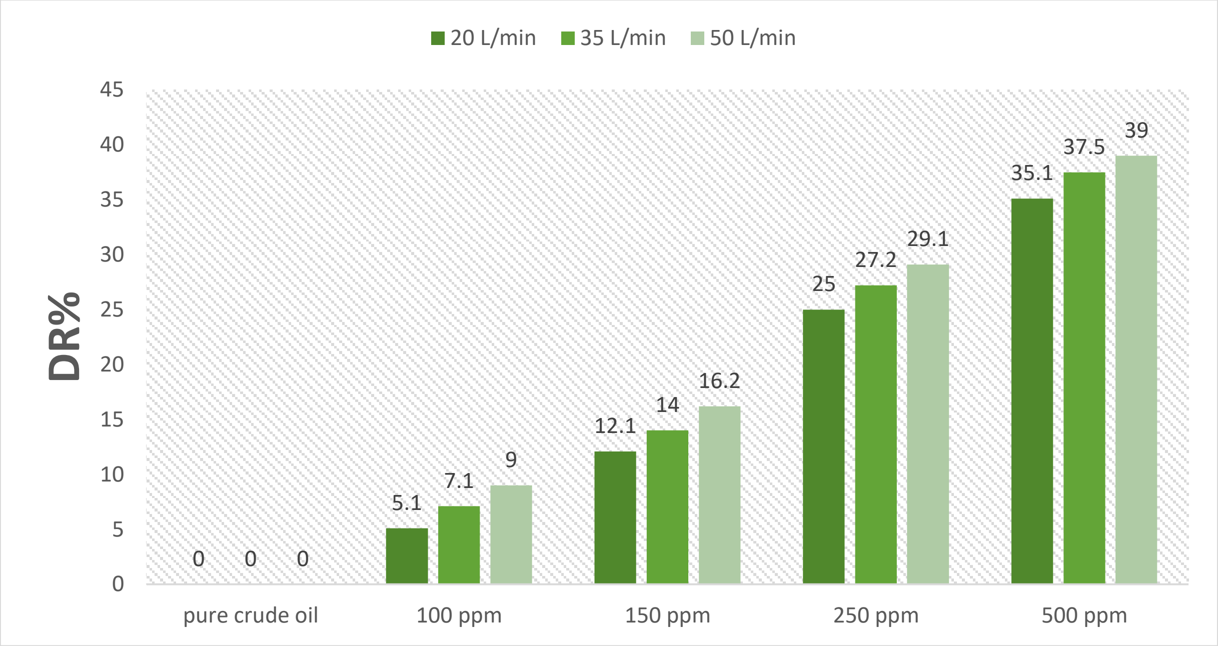

Fig (6): Effect CTAB conc. In drag reduction percentage through 0.0127 m pipe

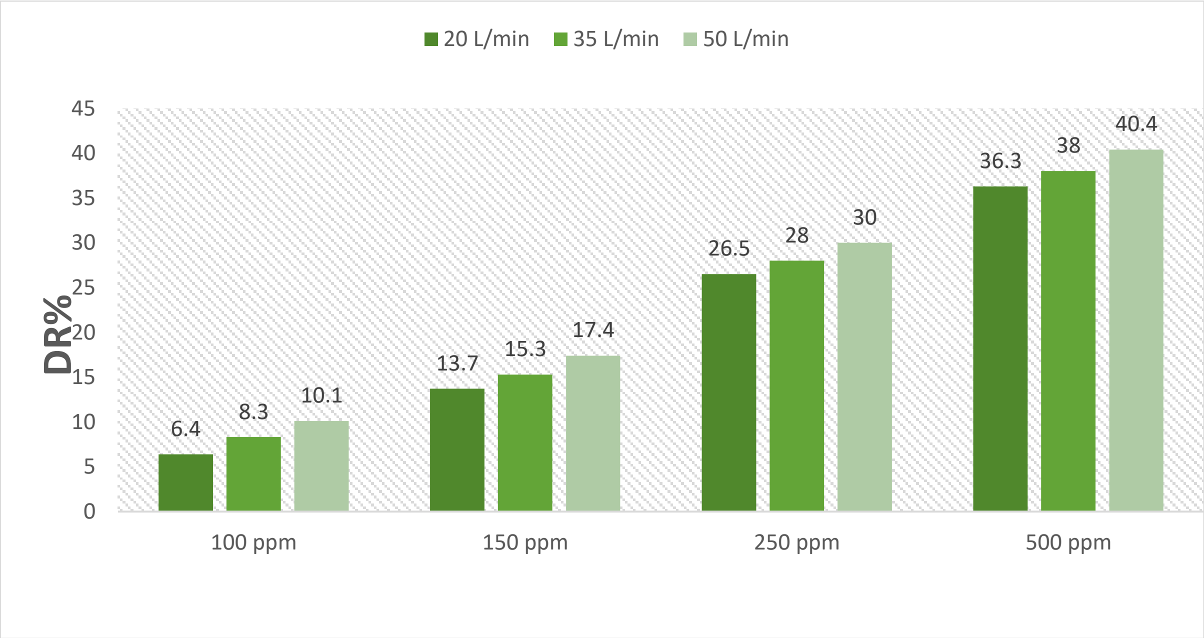

Fig. (7): Effect of CTAB concentration on drag reduction through 0.0191 m pipe

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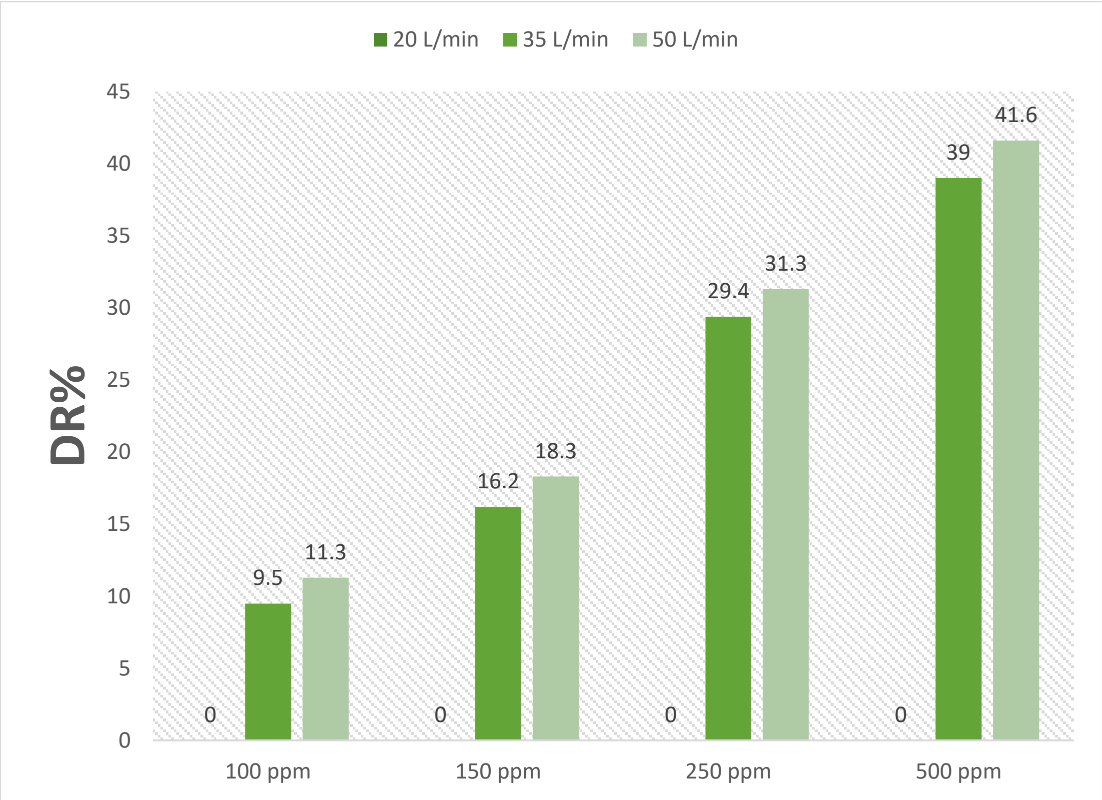

Fig. (8): Effect of CTAB concentration on drag reduction through 0.0254 m pipe

For both additives the effect of the flow rate has been studied. Figure 9 shows the impact of the raw oil flux rate on the drag decrease of 20-50 liters / min and the potato starch concentration of 2000 ppm and CTAB 500 ppm in 0.0127 m pipe diameter and the Reynold numbers for the flow rate of crude oil were between (8944) and (22330). The results showed that, with increased crudity oil flow, the drag reductions were increased by 39% and 34% respectively, with CTAB and potato starch being decreased by a combined drag reduction of 50 liters per min. It should be pointed out that the increase in flow rate includes an increase in turbulence within the tube and provides the drag reducer with a more effective medium. The relationship between velocity and additive-managed turbulence that is agreed with the flow rate behavior can be clarified [9].

The drag-reduction behavior has demonstrated a major effect on the characteristics of the fluid flow in the turbulent area by the addition of a small amount of polymer (20 g) or surfactants (5g). This can be considered an effective drag reduction agent, especially at relatively high levels.

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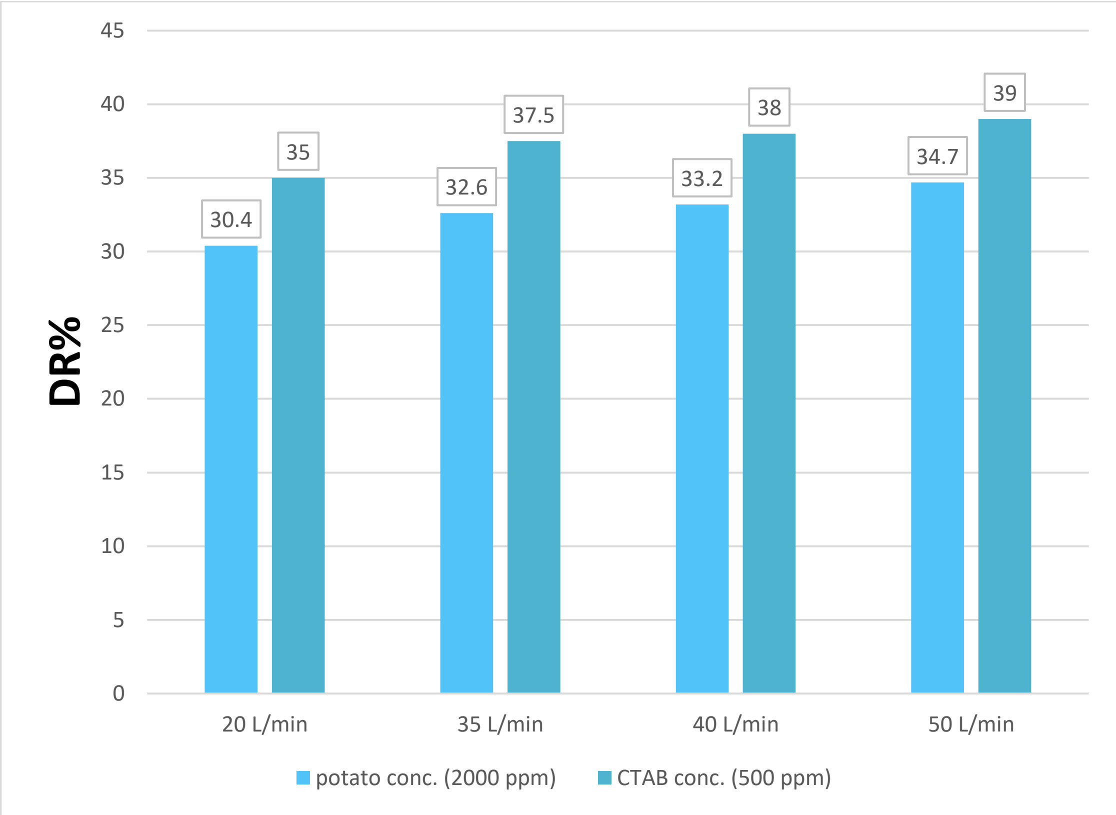

Fig. (9): Effect of flow rate on drag reduction through 0.0127 m pipe

3.3 Effect of Pipe Diameter

With concentrations of 2,000 ppm potato starch and 500 ppm CTAB at a flow rate of 50 liters / min, 3 pipes of the size 0.0127, 00.01905 and 0.0254 m were used. With the tube diameter increasing, the drag reduction for both additives is shown in Figure (10). The average drag decrease was 41.6% and 36% obtained respectively in 1-inch-diameter CTAB and Potato starch, while the CTAB surfactant demonstrated a high output in all pipe diameter relative to all potato starch.

The wider edges of a larger pipe using a lot of central flow power triggers an increase in drag reduction. In small pipes there is another activity that abundantly holds the number of small edges formed than large edges produced in the large pipes. Some small borders required excess energy to monitor and create a pattern from the main stream. In addition, the uneven energy absorbed by the small eddies that some did not succeed in overcoming viscous resistance and instead decreased the energy loss of the central flow [10].

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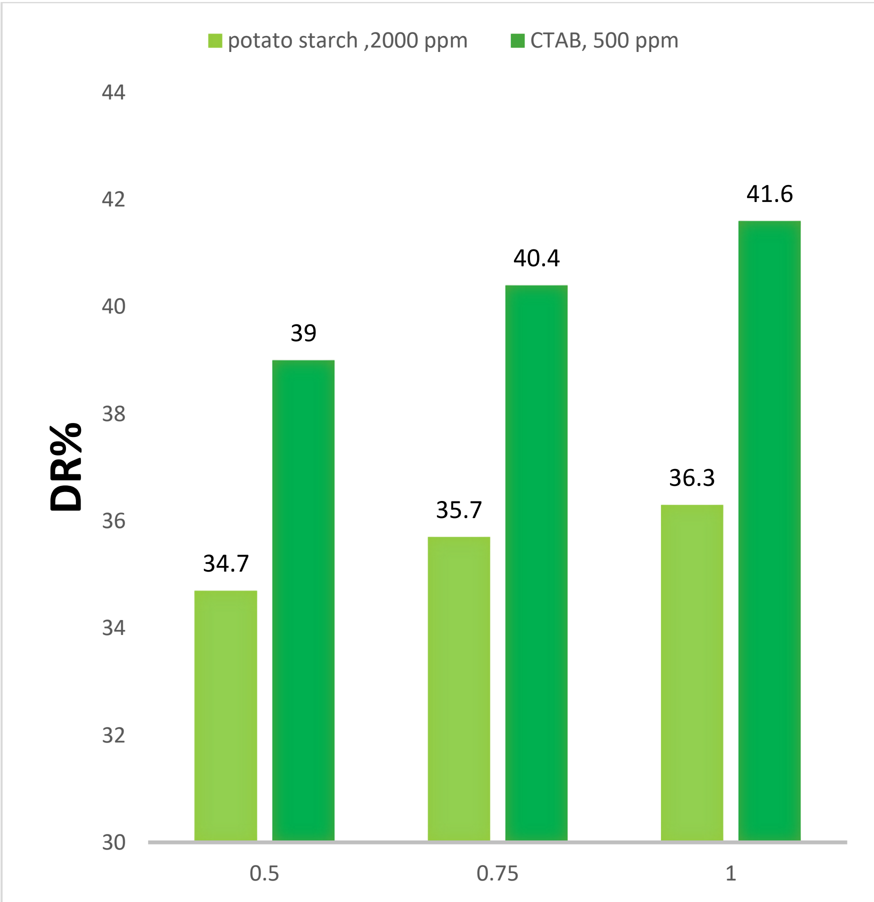

Fig. (10): Effect of pipe diameter on drag reduction

3.4 Additives effect on friction factor:

As a drag reduction at various concentrations, pulp starch and the CTAB surfactant have been applied to the crude oil. Figures 11 and 12 display the impact on the drag reduction at various flows and pipe diameters of the potato starch content (500-2000 ppm). The friction factor was calculated according to formula

$$f = \frac{\Delta p.D/4L}{\rho.v^2/2} \;\ldots\ldots\ldots(2)$$

Where;

ƒ: friction factor

Δp: pressure drop

L: pipe length

ρ: density of the fluid

V: velocity of the fluid

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3.5 Percentage Flow Increase (FI%):

Traditionally, drag reducers are used to minimize the pressure drop in the pipe line when moving crude oil from one position to the next. As the crude iol flows over the wall and consumes more energy, frictional pressure decreases. Percentage drag reduction can be calculated after the pressure drop reading through pipes and that important to find percentage flow increase as follow: [8]

$$FI\% = \left(\frac{1}{\left(1-\frac{DR\%}{100}\right)^{0.55}} - 1\right) * 100\% \quad \ldots\ldots\ldots\ldots(3)$$

Where DR% : drag reduction percentage.

$$Re = \frac{\rho.v.d}{\mu} \quad \ldots\ldots\ldots\ldots(4)$$

Where;

d: the diameter of the pipe.

μ: the viscosity of the crude oil

While the maximum *%Dr* of 39%, 40.4% and 41.6% were obtained in the pipes but having different diameters using 500 ppm CTAB. This is because surfactants have the potential to restore themselves and return to the original form after they have passed through the high shear stress areas. The polymer degrades in many applications and can therefore maintain efficiency with a very high number of Reynolds without risk of shear degradation, when subject to high shear and cannot reform, therefore the polymer is not able to be successful in recirculating method.

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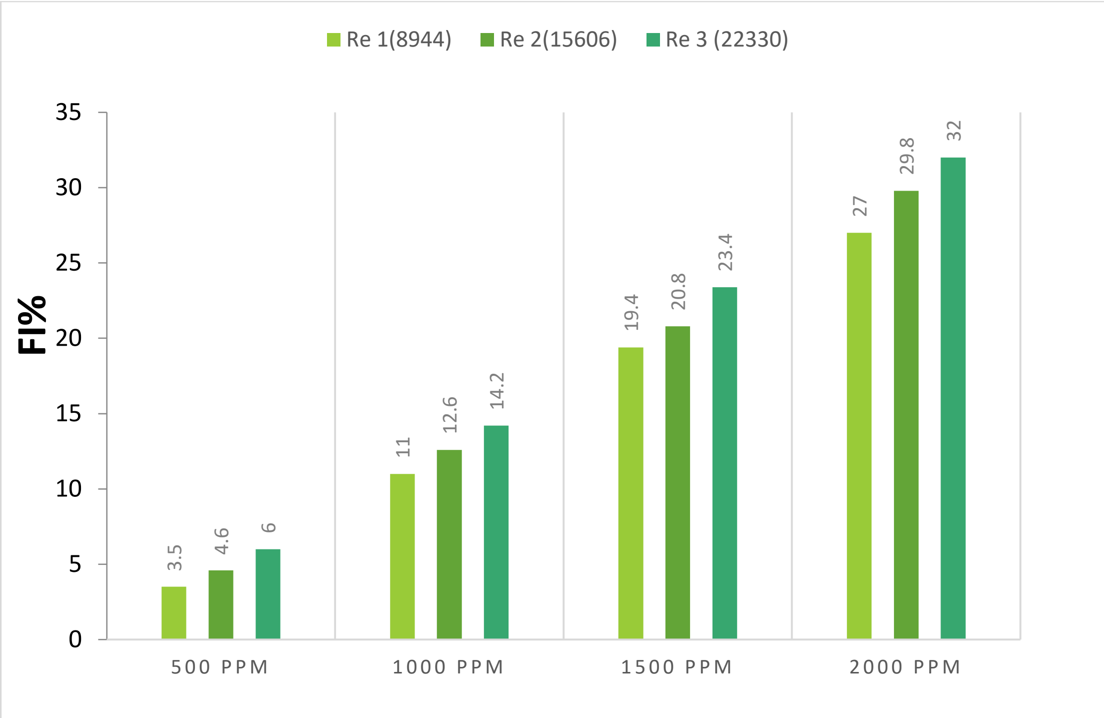
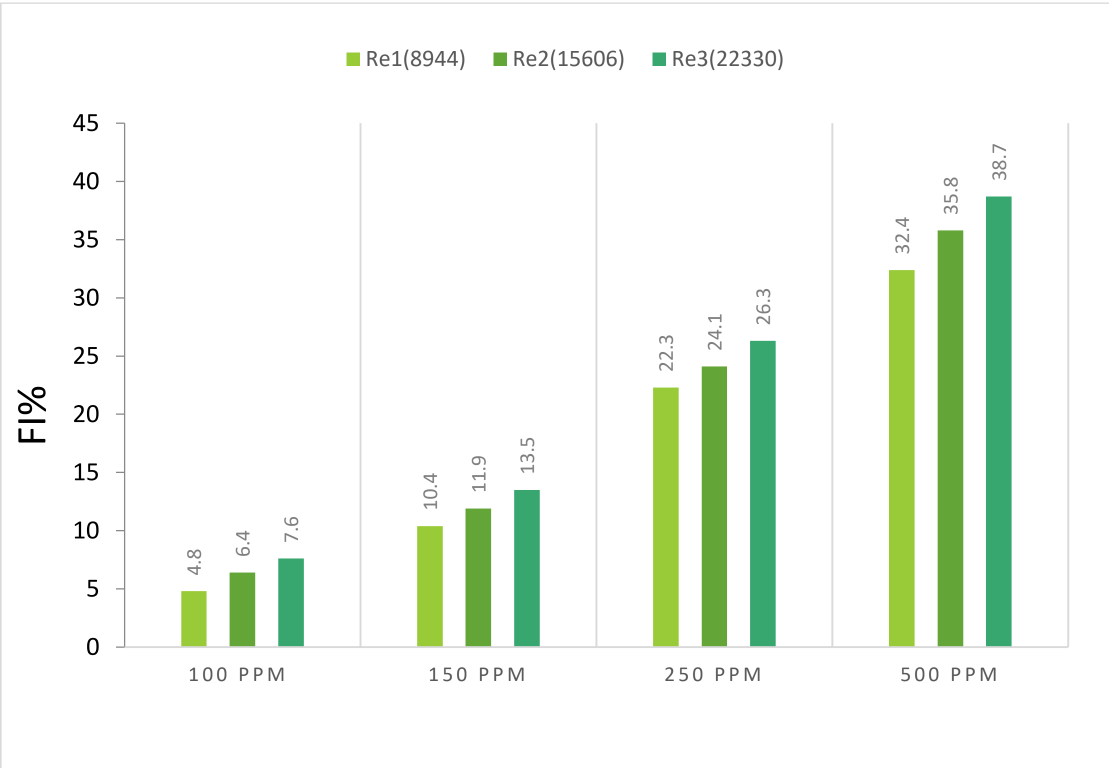


Fig. (11): Effect potato starch concentration in increasing flow (FI%) through 0.0191 m pipe.



Figure(12): Effect of CTAB concentration in increasing flow (FI%) through 0.0191 m pipe.

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4. Conclusions

In the cycle of crude oil transport through the pipeline at high flow rates it is desirable to use the potato starch biopolymer and CTAB surfactants. In addition to good viscosity reduction results, a good drag reduction was achieved by both the adopted additives. The potato starch and CTAB, both viscosity and drag reduction agents, have emerged simultaneously. However, in contrast to potato starch CTAB has demonstrated higher viscosity and drag decreases at lower concentrations. The low cost of potato starch, on the other hand, offsets the lower quality, particularly with an acceptable level of performance close to CTAB.

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