Improvement Heavy Oil Transportation IN Pipelines (laboratory study)

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Abstract :

Since from the past, drag has been identified as the main reason for the loss of energy in pipelines and other similar transportation channels. The contribution of this drag is due to mainly viscous of the flow as well as friction against the pipe walls. These energy losses can be identified through pressure drop, which will results in more pumping power consumption.

Due to their very high viscosity heavy oil cannot be transported as such in pipelines and required additional treatments [1].

This work studied flow increase (%FI) in heavy oil at different flow rates (2 to 10 m^3/hr) in two pipes (0.0381 m & 0.0508 m) ID. By using different additives (toluene and naphtha) with different concentrations (2, 4, 6, 8 and 10) %wt at 27°C.

The results of this study showed Increasing values of FI % and Maximum Dr% of 40.48% and 37.03 % were obtained using heavy oil containing 10% wt of naphtha flowing in pipes of 0.0508 and 0.0381 m I.D. at 27°C respectively.

Increasing values of %Dr with increasing of Reynolds number, fluid velocity and additive concentration, the used additives (toluene and naphtha) reduce the high viscosity of used heavy oil, and naphtha is more efficient as viscosity reducer than toluene.

All these results show treatment heavy oil and improvement their transport in pipelines.

Keywords: Heavy oil, transportation, drag reduction.

Introduction:

Drag reduction is a phenomenon in which the friction of a liquid flowing in a duct in turbulent flow is decreased by using small amount of additives. This is beneficial because it can decrease pumping energy requirements. Some current applications where drag reduction has been applied include oil transmission pipelines, district heating and cooling systems. Different types of additives can be used in these systems and include surfactants, fibers, aluminum disoaps, and polymers. Drag reducing additives are effective because they reduce the turbulent friction of a solution. These results will decrease the pressure drop across a length of conduit and likewise reduce the energy required to transport the liquid [2].

1. Drag reduction by using surfactants

Abdul-Hakeem tested different types of surfactants, three anionic surfactants plus one non-ionic surfactant as drag reducers in turbulent pipe flow of Iraqi crude oil within three pipe diameters of 0.5, 1, and 3 inch I.D. The investigator concluded that the percentage drag reduction (%DR) increases by increasing the surfactant concentration (within certain limits), solution flow rate and pipe diameter. Maximum percentage drag reduction of 56.5% was achieved at concentration of 200 ppm SDBS surfactant. Finally, the drag reducing mechanism was explained by the interaction of surfactant micelles with the crude oil, which allows the turbulence to be suppressed [3].

2. Drag reduction by using polymers

Motier used polymeric drag reducing agents to facilitate the pipeline transportation of crude oil and some refinery products (reducing the frictional loss associated with turbulent flow of liquids). Motier obtained the best performance with gasoline and fuel oil in his experiments. The great effectiveness has been found in the low viscosity Kirkuk crude oil. The variability in performance was a function of the viscosity of crude [4].Shao and Lin studied the mechanism of drag reduction by polymer (polyacrylamide) additives. The researchers concluded that the visualization of mixing layer shows that the addition of polymer will enhance coherent structure. The measurements of the turbulent intensities and Reynolds stresses by LDA show that polymer additives do not simply suppress the turbulent fluctuation as they expected. In

pipe flow, the axial turbulence intensity is increased while the radial turbulence intensity is decreased. This means that the turbulence structures are changed rather than suppressed [5].

3. Viscosity reduction

Blending with a less-viscous hydrocarbon such as condensate, naphtha, kerosene or light crudes its called dilution. However ,in order to attain acceptable limits for transport, a fraction as high as 30% of diluents by volume is necessary and implies large pipeline capacity. Problems may also arise with regard to diluents availability [6].

Dilution could be a solution for heavy oil, but requires a large investment for the installation of an additional return pipeline.

Anhorn et al. studied Methyl Tert-Buty Ether (MTBE) and Tert-Amyl Methyl Ether (TAME) in laboratory experiments as alternative thinners for heavy oils [7].

One of the modern techniques in drag reduction is by the addition of different quantities of chemical additives (such as polymer, surfactant or fiber) to liquids transported in pipelines. That in some cases, it is necessary to increase the transported liquid flow rate in built pipelines to avoid any extra costs and time spend on building new pipelines to have the same flow improvement needed.

Another types of chemical additives are solvent, which have the ability to dilute heavy oil transported in pipelines, but requires a large investment for the installation of an additional return pipeline.

The objectives of this study are:

1. To study the effect of additive, quantity and type of solvent on the flow in pipelines.

2. To study the effect of fluid flow rate on transportation in pipelines.

3. To study the influence of solvents that reduced the viscosity of heavy oil with significance to their functions in the drag reduction in pipelines.

Experimental work:

Description of circulating flow loop system the description of main parts of the flow system as shown in figure (1). It represents the flow system apparatus used in the present work, which consist of reservoir tank of solution, pump, flow meter, pipes, valves, pressure transmitter, digital screen, chiller and digital thermometers.
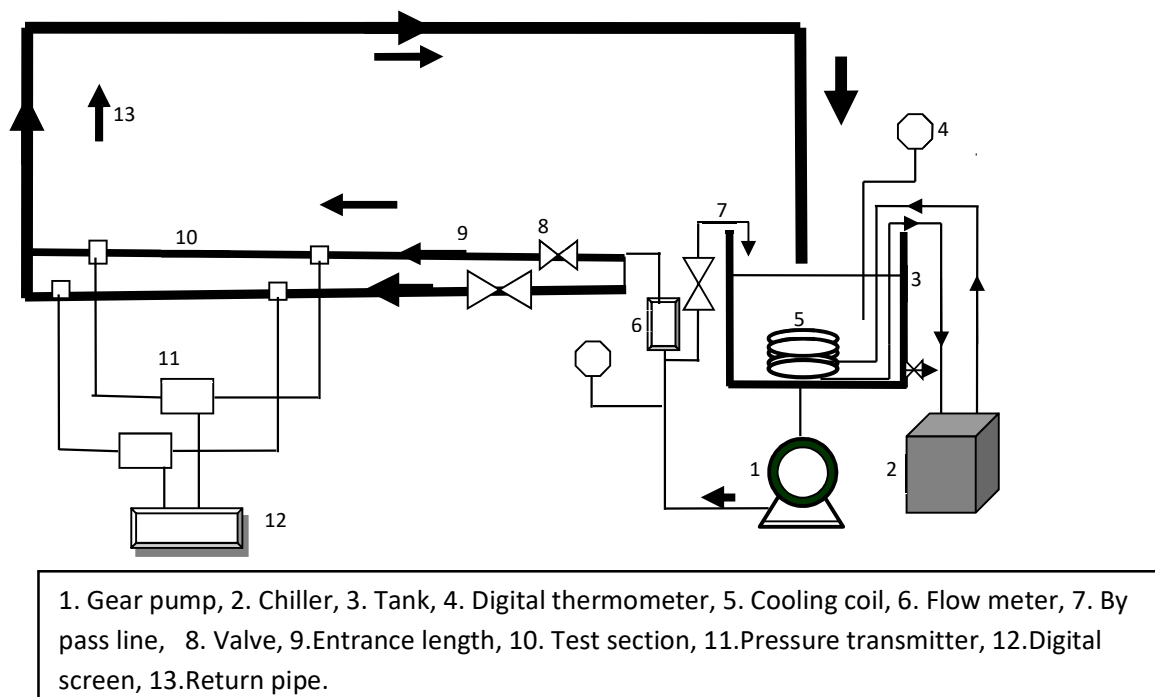

1. Gear pump, 2. Chiller, 3. Tank, 4. Digital thermometer, 5. Cooling coil, 6. Flow meter, 7. By pass line,   8. Valve, 9.Entrance length, 10. Test section, 11.Pressure transmitter, 12.Digital screen, 13.Return pipe.

Fig. (1) Schematic diagram of flow system

Material used

1. Liquid

The used heavy oil was taken from Al-Doura refinery with a physical properties as given in table (1).

Table (1) Physical properties of heavy oil.

Temperature °C	Specific gravity	Kinematic viscosity c.st
27	0.979	574.75

2. Solvents

Toluene and naphtha were used as drag reducing agents and to dilute the viscosity with concentration 2, 4, 6, 8 and 10% by weight. Solvents were provided by Al-Doura refinery.

Experimental procedure

1. The reservoir was filled with 75 liter of corresponding fluid heavy oil.
2. The heavy oil is permitted to flow in only one pipe. The flow rate of solution was controlled by bypass section until this rate reached a specific value.
3. The pressure drop is read by transmitter which is connected with the digital screen.
4. Steps 2 and 3 are repeated with different flow rates. Keeping in mind that this operation is carried out at constant temperature.
5. The above steps are redone but with the different additives of solvents to the heavy oil.
6. Steps 2 to 5 are repeated for the other pipe.

Using different solvent types and concentrations, the above procedure is redone for the sake of observing the effect of these parameters on pressure drop.

- Maximum Dr% of 40.48% and 37.03 % were obtained using heavy oil containing 10% wt of naphtha flowing in pipes of 0.0508 and 0.0381 m I.D. at 27°C respectively.
- The maximum volumetric flow rates in (0.0508 and 0.0381) m I.D. pipes were 10 m^3/hr.

The Naphtha has a large efficiently than Toluene as solvent to the chemical structure

and used as drag reducer. The effect of the used additives(toluene and naphtha) on drag reduction as shown in figures(2-3).
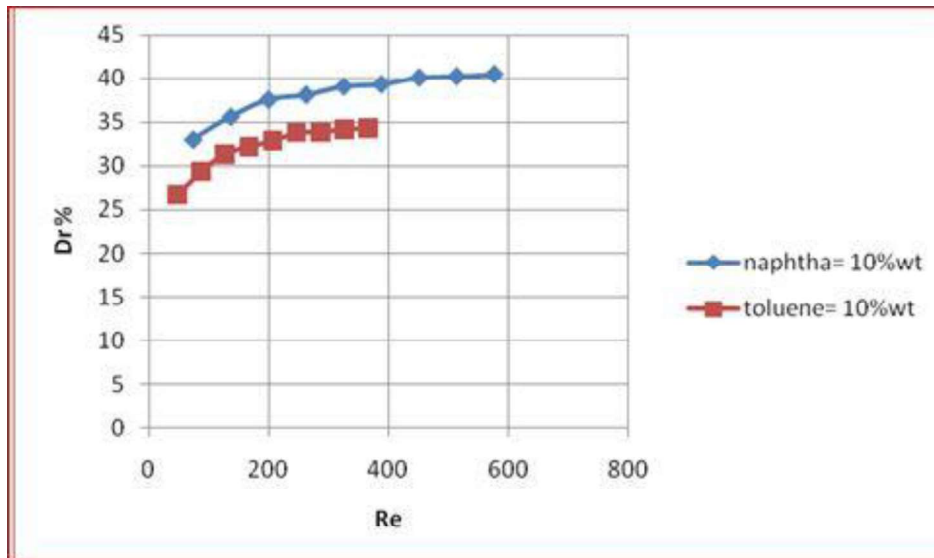

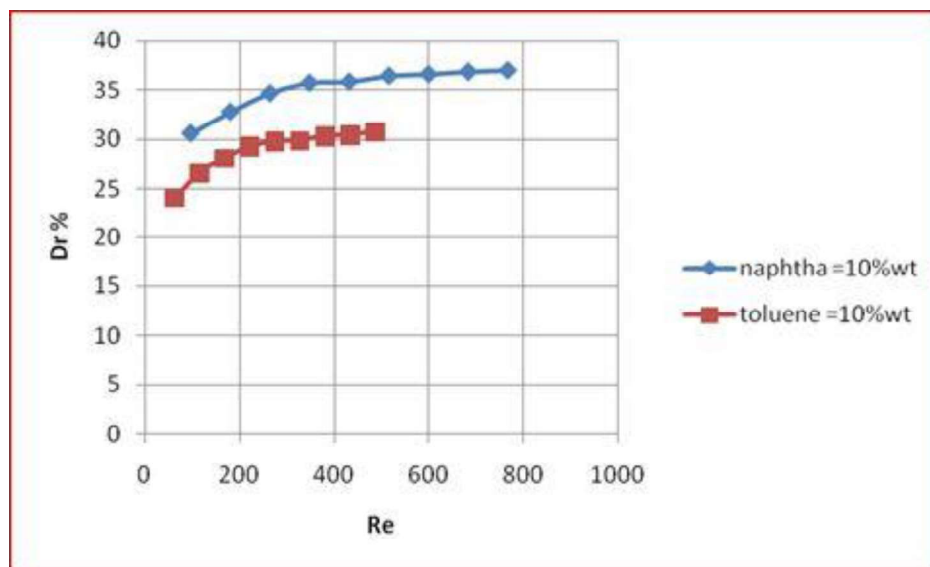**Fig. (2) Effect of Re on %Dr in heavy oil flowing through 0.0508 m I.D. pipe**

Fig. (3) Effect of Re on %Dr in heavy oil flowing through 0.0381 m I.D. pipe .

The effect of solution of velocity (v) on the percentage drag reduction (%Dr) in term of dimensionless group (Re) was done which showed the drag reduction percentage increases with increasing fluid velocity. Increasing the fluid velocity means increasing the Reynolds number inside the pipe, this will provide a better media to the drag reducer to be more effective. The behavior of increasing %Dr with velocity of fluid may be explained due to relation between degree of Reynolds number controlled by the solution velocity and the additive effectiveness as shown in figures (4-7).
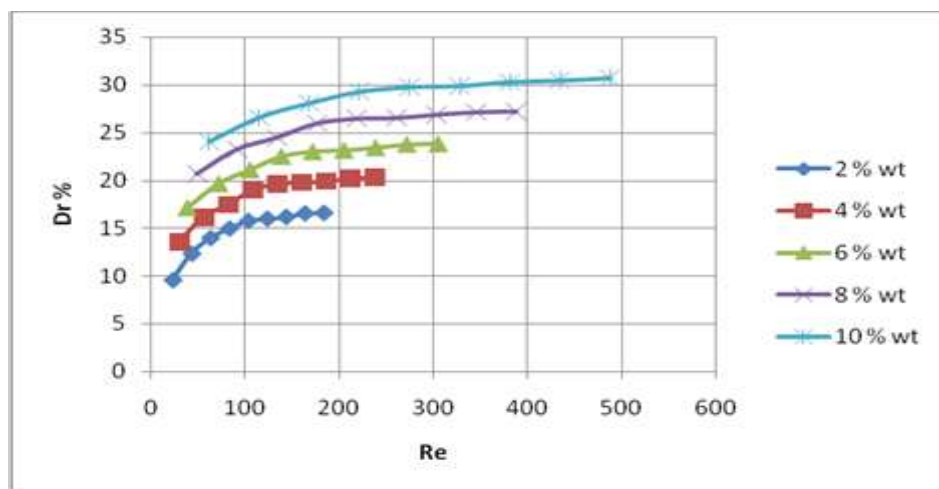

Fig.(4) Effect of Reynolds number on percentage drag reduction for toluene in heavy oil flowing through 0.0381 m I.D. pipe.
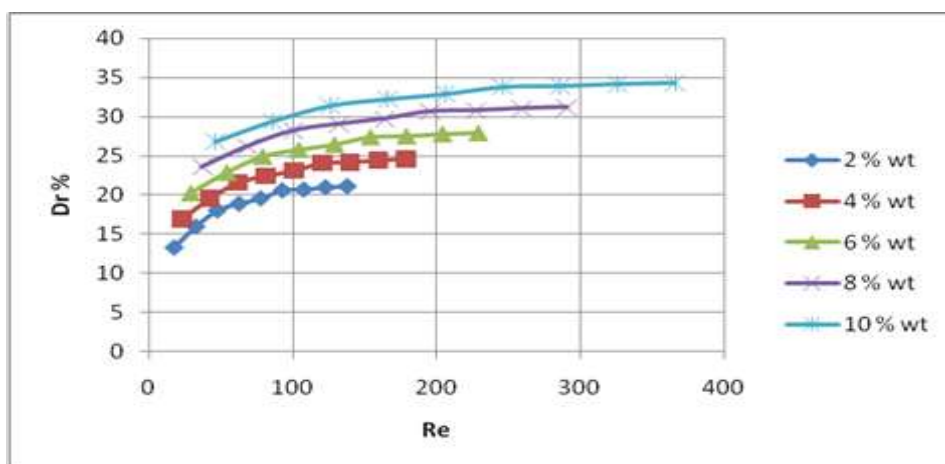

Fig.(5) Effect of Reynolds number on percentage drag reduction for toluene in heavy oil flowing through 0.0508 m I.D. pipe.
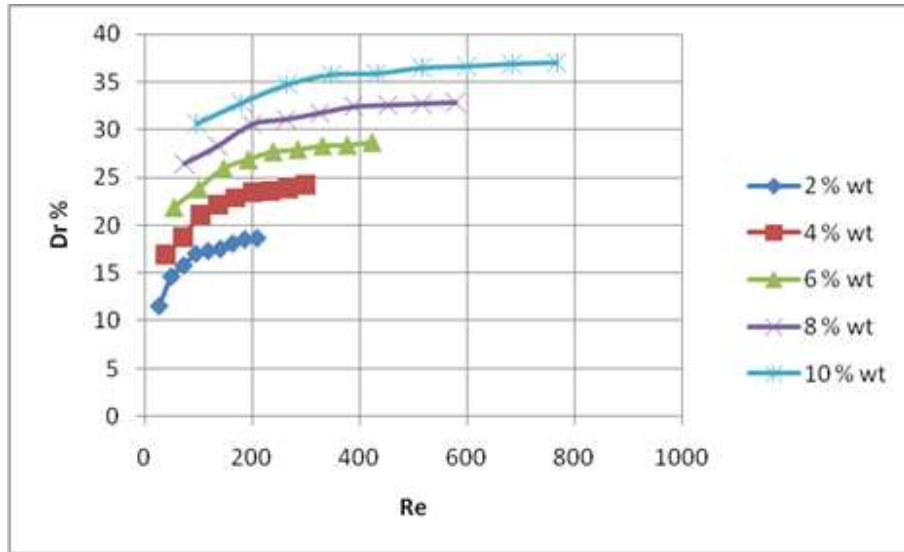
Fig.(6) Effect of Reynolds number on percentage drag reduction for naphtha in heavy oil flowing through 0.0381 m I.D. pipe.
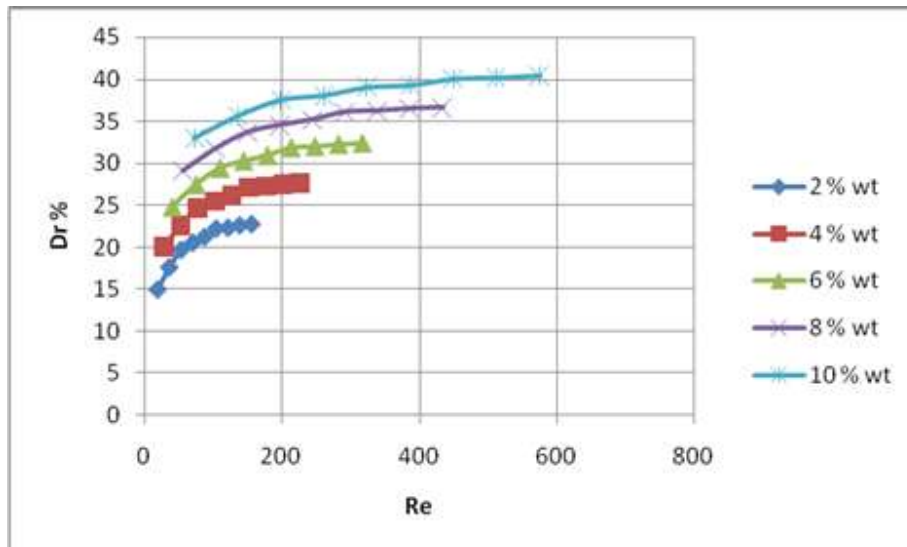

Fig.(7) Effect of Reynolds number on percentage drag reduction for naphtha in heavy oil flowing through 0.0508 m I.D. pipe.

The effect of concentration of the additive types on the viscosity reduction. The used additives affect the physical properties of present used heavy oil, while the viscosity was reduced which indicated that we treated high viscosity and diluted heavy oil after addition as shown in figure(8).
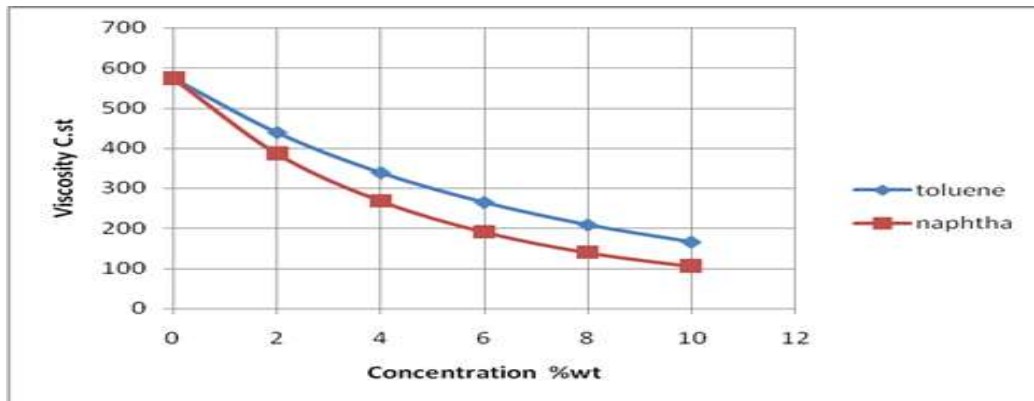
Fig. (8) Effect of different concentration on viscosity for naphtha and toluene in heavy oil.

Conclusions

1. Maximum %Dr of 40.48% was obtained using heavy oil containing 10% wt of naphtha flowing in pipes of 0.0508 m I.D. at flow rate 10 m^3/hr.
2. The solvents (toluene and naphtha) reduced drag of used heavy oil.
3. Drag reduction percent or flow increase percent are increased with increasing velocity of solution, increasing concentration of additives.
4. The solvents (toluene and naphtha) were found to dilute the high viscosity when used with heavy oil.
5. The drag reduction occurs because of the interaction of the additives with heavy oil due to increasing the intermolecular distance within the oil and decreases the viscosity and density.
6. The solvents (toluene and naphtha) change the physical properties of present used heavy oil, while the viscosity was reduced which indicated that we treated high viscosity and improved their transport in pipelines.

Symbols

C   : Solvent concentration

%Dr : Percentage drag reduction

%FI   : Percentage flow increase

Re   : Reynolds number ($\square$VD/$\square$)

T   : Temperature

%Wt: Percentage weight

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