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Study Influence of adding Surfactant to polymers in Reduce Friction in Pipelines

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Highlights

- **Polymers used as drag reduction agent but are not economical.**
- **The efficiency of surfactant is very low.**
- **The use complexes of polymer and surfactant decrease friction in pipeline.**
- **Rotating Disk Apparatus to check degradation of additives.**

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ABSTRACT

When polymers (DRA) passes through high shear force areas like pumps and elbows that causes from turbulent flow will lose their drag reduction abilities. In this research, the effect of adding a nonionic surfactant (tween 20) to the cationic polymer (Poly (acrylamide-co-diallyl-dimethylammonium chloride)) in reducing friction in the pipeline has been examined by using rotating disk apparatus to verify its ability in decrease the friction in pipelines. The influence of adding polymer, surfactant and Reynold number in enhancing flow in pipelines were examined. The results appeared that 40% drag reduction could be obtained by using this complex.

1. Introduction.

In the oil and gas industry, transporting liquids (particularly crude oils) through pipelines is one of the applications that consume the most power because of the turbulent flow modes by which liquids are transported. Turbulent flow modes can cause a massive dissipation of pumping power as a result of the reverse and chaotic movements of the structures inside the pipes (eddies), which grow and massively multiply through the pipe length. Drag forces can occur between moving fluids and stagnant pipe walls or even between two fluid layers. They are proportional to the velocity of laminar flows and to the squared velocity of turbulent flows (Benzi, 2010).

Over the last few decades, many scientists have suggested various techniques to reduce drag (i.e., drag reduction methods) and therefore improve liquid flow through pipelines. These methods can be classified into either passive or active, depending on their implementation. Passive methods take their inspiration from nature and simulate sharkskin microstructures, creating what are called "Riblets" (El-Samni *et al.*, 2007). Different passive techniques have been invented and implemented, including dimples, oscillating walls, compliant surfaces, and even microbubble injection in pipelines. However, these techniques have failed to efficiently reduce the drag and have high implementation cost (Du *et al.*, 2002).

Polymeric additives are proven to have a massive impact on the behavior of turbulent flow in pipelines because of their unique viscoelastic properties that suppress turbulent eddies. In many cases, polymeric DRA loses its drag reduction abilities when exposed to high shear forces exerted by the turbulent flow caused by pumps. This action is irreversible, thereby requiring the re-injection of fresh polymers (Abdulbari *et al.*, 2012).

Surface active agents have since been tested as DRAs by many scientists. Used as DRA, these additives have no real commercial or industrial application because of their low drag reduction efficiency and high concentrations. On the other hand, the advantage of using surfactant molecules as DRA is their ability to reform their shape, pass through high shearing areas, and capacity to regain their drag reduction ability, which is nevertheless relatively lower than that of polymeric DRA (Alramadhni *et al.*, 2013).

The adding surfactants to the polymers can improve the performance of the polymers because this complex will form micelles and these micelles will rearrange their form after they passing pumps (Xiaodong Dai *et al.*, 2017).The objective of this study is to investigate the interaction between polymer and surfactant. The polymer selected was Poly (acrylamide-co-diallyl-dimethylammonium chloride) (PAMC), and non-aionic (Tween 20) were selected as surfactant. The drag reduction of mixture was calculated and compared to the drag reduction achieved by pure polymer and surfactant. The effect of additive concentration and reynolds number on the friction in pipeline also have been examined in this research.

2. Materials and methods.

2.1 Materials.

In general, two types of materials were investigated in the present work, polymer, and surfactant with different polarities cationic and non-ionic. The cationic Polymer (**PAMC)** 10 wt. % in H_2O and non-ionic surfactant Tween 20 used without further purification.

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2.2. Method.

2.2.1 Preparation of Solutions,

All the purchased additives are water soluble and the tested solutions from these additives are created by adopting the following steps:

1. The concentration of the additives was determined in weight parts per million (ppm) by adopting the weight/weight basis.
2. The stock solution was prepared by dissolving the desired weight of the additives into distilled water and by stirring using a magnetic stirrer for 4 h.
3. The final solution for RDA testing was left for 24 h. to allow for maximum additive penetration.

2.2.2 Rotating disk apparatus.

The RDA in the present work was designed and fabricated for the purpose of testing drag reduction and mechanical stability of the investigated liquids by applying shearing force and measuring the torque. Fig. 1 shows a photo of the fabricated RDA. The Reynolds number in the RDA was calculated using the formula presented in Eq. (1).

$$Re = \frac{\rho \times R^2 \times \omega}{\mu} \tag{1}$$

Where

Re= Reynolds number (dimensionless)

ρ= density of the fluid, 1000 (kg/m^3)

R = radius of the disk, (14 cm)

ω = rotational speed of the disk, (rpm)

μ= viscosity of the fluid = 0.001 n. s /m^2(c.p)

Because the amount of additives (polymer, surfactant or mixture) are very little, the properties of fluid (density and viscosity) were taken for pure water.

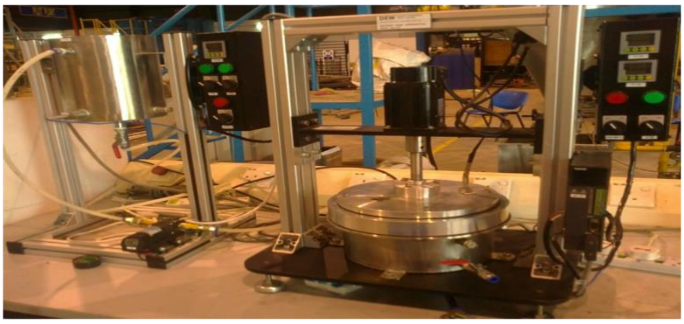

Fig. 1. Rotating Disk Apparatus rig.

3. Result and discussion.

Fig. 2. displays influence concentration of PAMC on the drag reduction at different Reynolds number. The drag reduction of 50 ppm PAMC has achieved 10% at Re = 980000. By increasing concentration of PAMC to 700 and 1000 ppm the drag reduction enhanced to 27% and 34% respectively at the same value of Re. As a result, the torque of polymer additive reduces clearly, when the concentration of additive increase and this is more obviously at higher Reynolds number values. Fig. 3. displays influence concentration of surfactant on the drag reduction at different Reynolds number values. The drag reduction efficiency of surfactant solution not enhanced by rising surfactant concentration from 50 to 1000 ppm at different Reynolds number values.

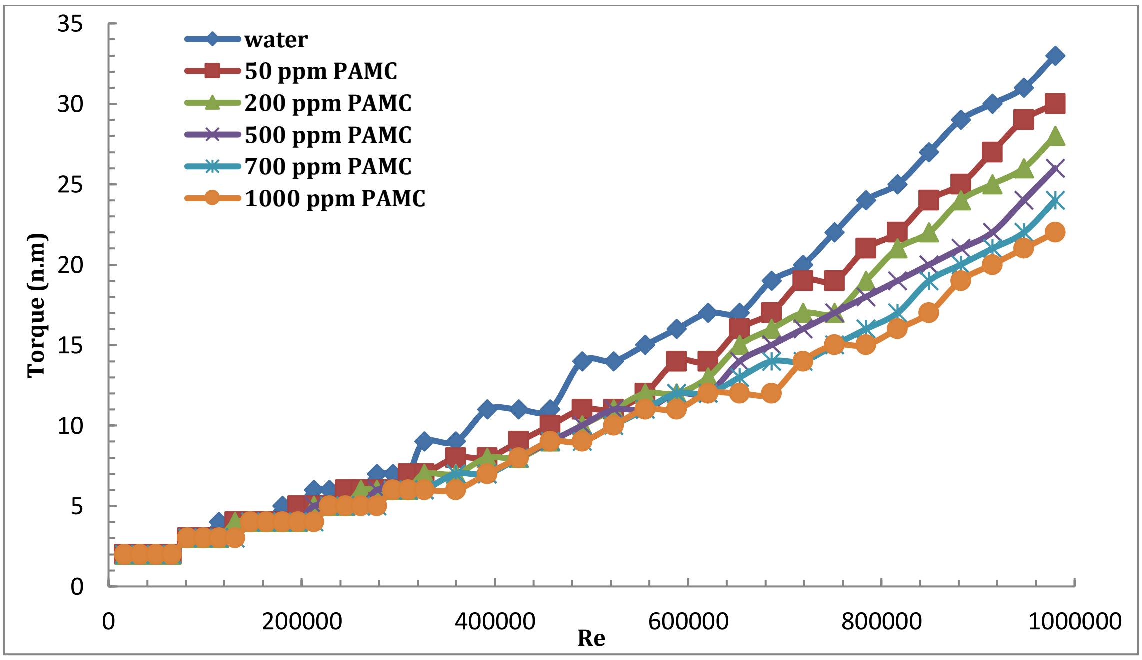

Fig. 2. Influence increment concentration of polymer on the torque as a function of Reynold number.

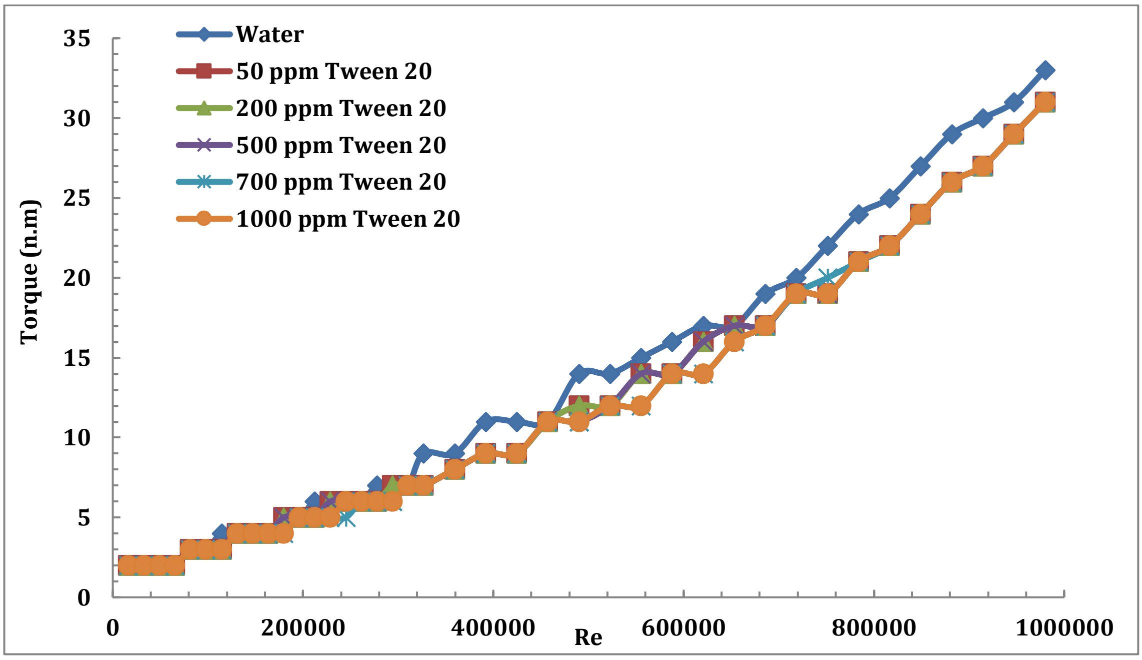

Fig. 3. Influence surfactant concentration on the drag reduction at different Reynolds number values

The influence of adding the surfactant to the polymer on drag reduction at different Reynolds number values shown in Fig. 4. It is clear that the drag reduction efficiency enhanced by using polymer surfactant mixture. The drag reduction efficiency of PAMC-Tween 20 mixture at Re = 980000 and 500 ppm was 24% while the percentage drag reduction of PAMC was 20% at the same conditions. This enhancing in drag reduction was a result of interaction between the polymer and surfactant. By using a TEM test we can see the picture of the interaction between these materials clearly.

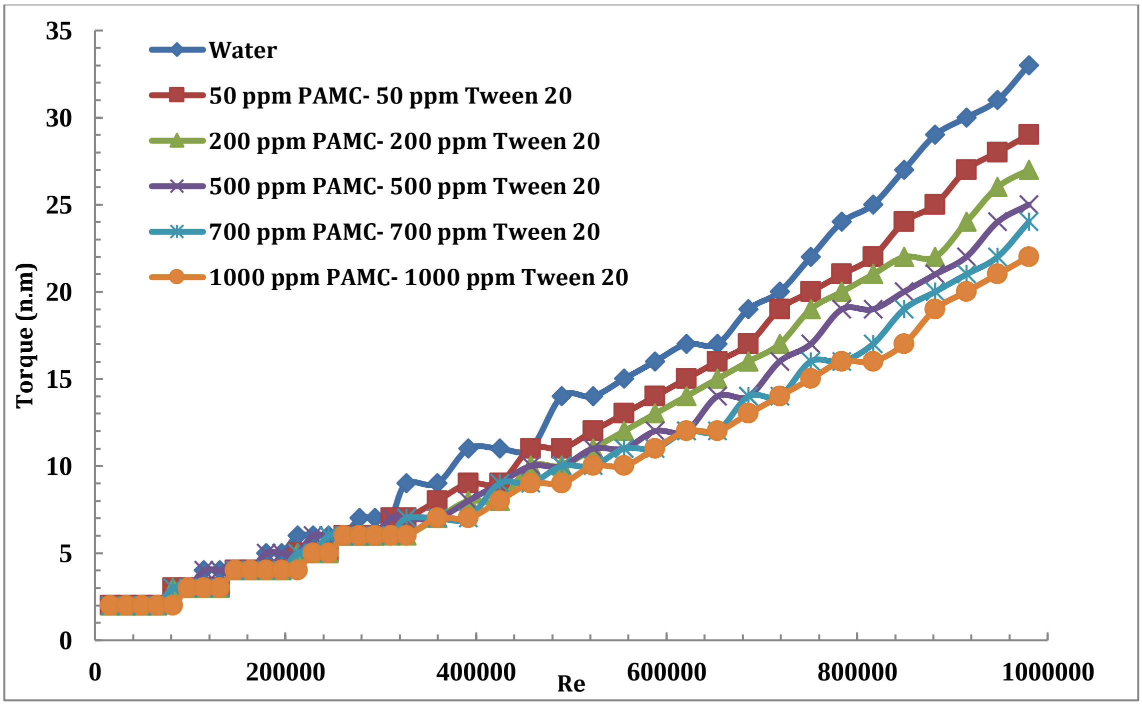

Fig. 4. Displays effect adding a surfactant to the polymer on the drag reduction.

4. Conclusion.

In conclusion, the influence of polymer concentration, surfactant concentration, Reynold number and mixture of polymer-surfactant on the drag reduction efficiency have been studied. The drag reduction efficiency resulting by mixture 1000 ppm PAMC–Tween 20 was 40%. In other words, the interaction between polymer-surfactant solution plays a vital role in enhancing the flow in pipes and declining the friction between the fluid and surface of the pipe.

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