Journal of Petroleum Science and Engineering xx (xxxx) xxxx–xxxx

Contents lists available at ScienceDirect

Journal of Petroleum Science and Engineering

journal homepage: www.elsevier.com/locate/petrol

Energy analysis of oil-water flow with drag-reducing polymer in different pipe inclinations and diameters

T. Al-Wahaibi*, A. Abubakar, A.R. Al-Hashmi, Y. Al-Wahaibi, A. Al-Ajmi

Department of Petroleum and Chemical Engineering, Sultan Qaboos University, P.O.Box 33, Al-Khoud, P.C. 123, Oman

A R T I C L E I N F O

Keywords:
Oil-water flow
Pressure gradients
Energy analysis
Drag-reducing polymer

A B S T R A C T

In this study, the energy analysis of oil-water flow with polymer additives in terms of the reduction in head loss, which results in reducing the pumping power required to overcome the head loss and in turn increasing the throughput was carried out. Three acrylic pipes with internal diameters of 30.6, 55.7 and 74.7 mm were used in the study. The 30.6-mm ID pipe was positioned at horizontal (0°), upward (+5° and +10°) and downward (−5°) inclinations while the 55.7-mm and 74.7-mm ID pipes were only at horizontal position. The oil-water flow conditions of 0.4 – 1.6 m/s mixture velocities and 0.1 – 0.9 input oil volume fractions were used. Master solution of 2000 ppm concentration of water-soluble polymer – a high-molecular-weight anionic copolymer of polyacrylamide and 2-Acrylamido-2-Methylpropane Sulfonic acid – was prepared and injected at controlled flow rates to provide 40 ppm of the polymer in the water phase at the test section. It was found that the presence of the polymer positively influenced the three parameters investigated. Specifically, the head loss was reduced from 0.0885 to 0.0378 m, translating to a saving of 57.3% in pumping power requirement and 61% increase in the throughput at a flow condition in the 30.6-mm ID pipe where the performance of the polymer was highest.

1. Introduction

Oil and gas industries have traditionally used drag reducers to reduce the pressure drops for the transport of fluids over long distances. A typical example is the significant increase in the oil flow rate as a result of pressure drop reduction by adding 10 ppm polymer in the 1300 km trans-Alaska pipeline (Burger et al., 1982). The skin friction drag which appears when fluid flows over a wall surface is partly responsible for the pressure losses in pipelines and it can consume large amounts of power and sometimes cause emission of harmful gases. The use of pumps in fluid flow is to overcome this friction drag by increasing the pressure of the fluid. Unfortunately, using several pumps through the pipeline has some restrictions as it can be very costly and can increase the pipeline pressure beyond the maximum allowable operating pressure (*MAOP*). One way to still increase the pipeline capacity if the output pressure has reached *MAOP* is by looping. However, the looping also has its own challenges like the need to shut down the pipeline and its high fixed cost, which can decrease the efficiency of the operation. Therefore, the use of additives known as drag-reducing agents is one of the safest and least costly methods of increasing system capacity and efficiency without changing the pipeline conditions. This is why the drag reduction technique for wall turbulence has become very important in industrial application (Karami and Mowla, 2012).

Polymers are the best drag-reducing additives because they have the ability to drastically reduce the power necessary to drive fluids downstream by simply dissolving very small amounts of polymers in the working fluids. A drag-reducing polymer acts as a flow improver to pipelines that can either provide an increase in the flow (using the same amount of energy) resulting in a much higher throughput, or alternatively maintain the same flow rate while using considerably less energy for pumping (Gyr and Bewersdorff, 1995).

The advantage of using polymer additives instead of applying several pumps and/or looping to increase transportation efficiency can be viewed from energy analysis of the system in Fig. 1. In the analysis of piping systems, pressure losses are usually expressed in terms of the equivalent fluid column heights which are referred to as the head losses. The head losses which are caused by viscosity and are directly related to the wall shear stresses, represent the additional heights that the fluids need to be raised by the pumps in order to overcome the frictional losses in the pipes. As depicted in Fig. 1, it is clear that the pipe pressure at the final system head (h_2) will exceed the *MOAP* if the flow rate is increased from Q_1 to Q_2. The addition of the DRP will change the system head curve such that the pipe pressure at the final system head (h_2') is reduced to below *MAOP*.

Several studies have been carried out after the discovery of the

* Corresponding author.
E-mail address: alwahaib@squ.edu.om (T. Al-Wahaibi).

http://dx.doi.org/10.1016/j.petrol.2016.10.060
Received 20 April 2016; Received in revised form 19 October 2016; Accepted 31 October 2016
Available online xxxx
0920-4105/ © 2016 Elsevier B.V. All rights reserved.

Nomenclature

Roman letters Description Unit

AMPS	2-Acryamido-2-Methylpropane Sulfonic acid [dimensionless]
DR	Drag reduction [%]
DRP	Drag-reducing polymer [dimensionless]
FI	Flow rate or throughput increase [%]
f_m	Mixture friction factor [dimensionless]
f_{m-DRP}	Mixture friction factor at maximum drag reduction [dimensionless]
g	Acceleration due to gravity [m/s^2]
$h_1 and h_2$	Heads at different conditions [m]
h_L	Head loss [m]
h_{L-DRP}	Head loss with drag-reducing polymer [m]
IDorD	Pipe internal diameter [m]
L	Pipe length or distance between two pressure impulse lines [m]
MAOP	Maximum allowable operating pressure [Pa]
$Q_1,\ Q_2$	Volumetric flow rates at different conditions [m^3/h]
Q_T	Total volumetric flow or throughput [m^3/s or m^3/h]
U_m	Mixture velocity [m/s]
W_{PS}	Saving in power consumption or requirement [%]
ΔP	Pressure drop [Pa]

Greek symbols Description Unit

β	Angle of pipe inclination [deg]
ρ	Fluid density [kg/m^3]
ρ_m	Mixture density [kg/m^3]
α_o	Oil fraction or oil cut [dimensionless]

Subscripts

c	Core phase
L	Loss
m	Mixture
o	Oil phase
PS	Power saving
s	Superficial
T	Oil-water mixture or total
w	Water phase
1	Initial
2	Final

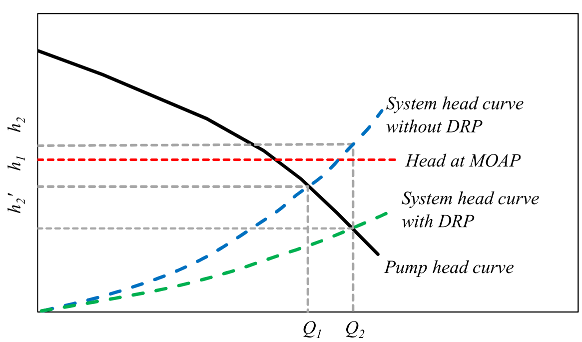

Fig. 1. Effect of DRP on head loss of pipeline system.

polymer drag reduction in order to gain more insights into the phenomenon especially in single phase flow. The study of Virk (1975) revealed that DRPs suppressed the formation of turbulent bursts in the buffer (or elastic) sub-layer and in turn suppressed the formation and propagation of turbulent eddies. He found the elastic sub-layer in between the viscous sub-layer and the outer turbulent core region of the flow. This finding was generally accepted in subsequent investigations (Pinho and Whitelaw, 1990). Essentially, Virk (1975) also found that the onset drag reduction by polymer additives occurs at the same Reynolds number regardless of the polymer concentration though drag reduction occurs at lower Reynolds number when the molecular weights of the polymers are increased. Another mostly reported observation is that drag reduction rapidly increases with increase in the polymer concentration until it levels off at maximum

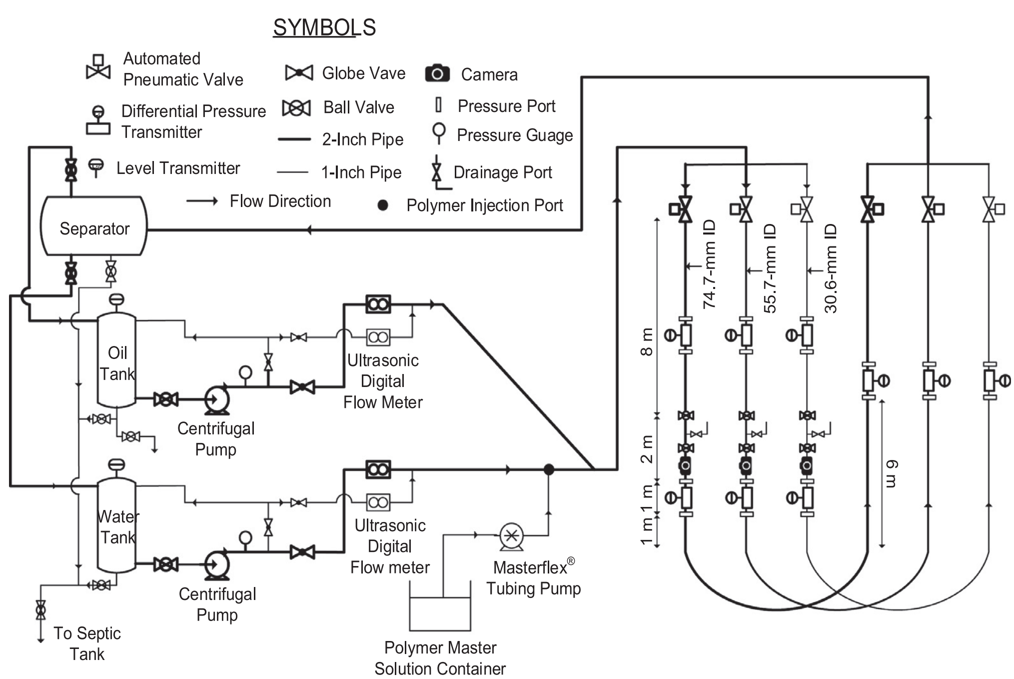

Fig. 2. Schematic of two-phase oil-water flow loop.

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات