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JUDUL : INVESTIGATING THE EFFECT OF GAS FLOW RATE ON THE DRAG REDUCTION PERFORMANCE IN GAS OIL – SOLID GAS FLOW SYSTEM

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INVESTIGATING THE EFFECT OF GAS FLOW RATE ON THE DRAG REDUCTION PERFORMANCE IN GAS OIL- SOLID GAS FLOW SYSTEM

NOR`AQILAH BINTI NORAHZAN

A thesis submitted in fulfillment
of the requirements for the award of the Degree of
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JANUARY 2012

SUPERVISOR`S DECLARATION

"I hereby declare that I have read this thesis and in my opinion this thesis has fulfilled the qualities and requirements for the award of Degree of Bachelor of Chemical Engineering (Gas Technology)"

Signature	:	…………………………………….
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STUDENT`S DECLARATION

I declare that this thesis entitled "Investigating the effect of gas flow rate on the drag reduction performance in gas oil- solid gas flow system" is the result of my own research except as cited in references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree."

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To my beloved Mum and Dad for always being there for me,
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ABSTRACT

Phenomenon on drag reduction in gas-liquid system has to be emphasized in the past decade because of the importance in academic and industry. Drag has long been identified as the main reason for the loss of energy in fluid transmission like pipelines and other similar transportation channels. The main contributor to this drag is the turbulence of the flow as well as friction against the pipe walls, which will results in more pumping power consumption, increasing in production rates, pipelines capabilities and faster transportation. In this study, injection of gas into the pipe flow as a drag reducing agent was investigated. The experimental procedure also investigates the effects of liquid flow rate, powder addition concentration and particle size of suspended solid. The gas that used to inject in the pipelines is an air gas. Particular attention was focused to the influence on the pressure drop due to the injection of air gas into the horizontal 1.5 inch or 0.0381 meter pipe flow. The experimental results showed that the drag reduction is more superior towards bigger particle sizes, higher in liquid flow rate of diesel concentration and increasing the solid addition concentration. Percentage of drags reduction increases by increasing the particle size. The maximum percentage of drag reduction in the 630 μm particle size with 300ppm solid addition concentration for 9.5 m^3/h liquid flow rate is 61.43 %.

ABSTRAK

Fenomena pada pengurangan seretan di dalam sistem gas-cecair telah diberi penekanan dalam dekad yang lalu kerana kepentingan dalam akademik dan industri. Seret telah lama dikenal pasti sebagai sebab utama untuk kehilangan tenaga dalam penghantaran bendalir seperti saluran paip dan lain-lain saluran pengangkutan yang serupa. Penyumbang utama kepada seretan ini adalah pergolakan aliran serta geseran terhadap dinding paip, yang akan menyebabkan penggunaan kuasa yang lebih mengepam, meningkatkan kadar pengeluaran, keupayaan saluran paip dan pengangkutan yang lebih cepat. Dalam kajian ini, suntikan gas ke dalam aliran paip sebagai satu ejen mengurangkan seretan disiasat. Prosedur eksperimen juga menyiasat kesan kadar aliran cecair, serbuk kepekatan Selain itu, saiz zarah pepejal terampai dan tambahan dalam kepekatan diesel. Gas yang digunakan untuk menyuntik di saluran paip gas udara. Perhatian khusus tertumpu kepada pengaruh kepada kejatuhan tekanan akibat suntikan gas udara ke dalam inci mendatar 1.5 atau 0.0381 meter paip aliran. Keputusan eksperimen menunjukkan bahawa pengurangan daya seret lebih ke arah saiz zarah yang lebih besar, lebih tinggi dalam kadar aliran cecair kepekatan diesel dan meningkatkan kepekatan tambahan yang kukuh. Peratusan drags kenaikan pengurangan dengan meningkatkan saiz zarah. Peratusan maksimum pengurangan heret dalam saiz 630 µm zarah dengan kepekatan tambahan 300ppm kukuh untuk 9.5 m^3 / h kadar aliran cecair adalah 61.43%.

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LIST OF ABBREVIATIONS/ SYMBOLS

DRA	Drag Reducing Agent
DR	Drag Reduction, dimensionless
D.I	Internal pipe diameter, meter
%DR	Percentage Drag Reduction
m	Mass, kg
ppm	Parts per million
ΔP_a	Pressure difference after adding additives, N/m^2
ΔP_b	Pressure difference before adding additives, N/m^2
NRe	Reynolds number, dimensionless
Q	Volumetric flow rate, m^3/hr
ρ	Density, kg/m^3
μ	Viscosity, kg/s.m
Dp	Diameter Pipe
PDRA	Polymer Drag Reduction Agent
MDR	Maximum Drag Reduction

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Since from the past, drag in the pipeline has been identified as the major problem for the losses of energy during transportation. Drag or sometimes called fluid resistance is referring to the forces that opposite to the relative motion of an object though in the fluid dynamics. Drag happened between the fluids, and the pipe wall causes substantial pressure drops along such pipelines as the fluid flow there though. These energy losses can be identified through pressure drop, which will result in more pumping power consumption.

The drag reduction phenomenon was first observed by Toms (1948) about 60 years ago. The idea of drag reduction when he studied the effect of polymer added into a turbulent Newtonian fluid. He revealed that the addition of small amounts of polymers in turbulent flow can produce a significant result in reducing frictional drag. Since that time, nearly 7000 studies on drag reduction have been published.

Drag reduction serves as a typical approach to save pumping power in pipelines or other transportation channels and equipments, particularly those which handle crude oil and refined products. Pumping power saving corresponds to the reduction of pressure drop in these media. Studies of the drag reduction agent have proven its ability in reducing pressure drop.

Drag Reducing Agents can be classified into three major categories such as polymers, surfactants and suspended solids. The most effective drag reducing agent that commonly used in industry is polymers. A few parts per million (ppm) of the additive can greatly reduce the turbulent friction factor of fluid flow in a pipe (Toms, 1948). There are two types of polymer, which are synthetic polymer and natural polymers. Synthetic polymers are come from petroleum oil and meanwhile natural polymers can be extracted from resources in nature.

Synthetic polymers such as polyethylene oxide (PEO), co- polymer (Magnafloc 1011) of polyacrylamide, carboxymethyl cellulose, polythene oxide, and sodium-acrylate are rarely used as a drag reducing agent in turbulent flow. The results after injections of these polymers into pipelines caused drag reduction in pressure loss; especially at high mixture velocity by clearly change in the flow pattern (Al-Sarkhi et al., 2001; Soleimani et al., 2004; Al-Wahaibi et al., 2007; Al-Yaari et al., 2009).

However, natural polymeric additives attracted less attention in industrial applications but the benefits of a natural polymeric are similar to the synthetic polymers. The explorations of newer sources of mucilage are increased with increasing in industry demand. Currently, many researchers have discovered the potential of natural polymers in the drag reduction phenomenon. The successful in a formulation Okra-natural mucilage and Aloe Vera mucilage as a natural drag reduction agent gave the impressive result and able to increase the flow rate of fluid in a pipeline at the same pressure drop by reducing the friction drag (Hayder et al., 2011).

The second drag reducing agents are surfactants. Surfactant is a blend of surface active agent. It works as an agent who can greatly lower the surface tension of a liquid even though it presents in a very low concentration. The surfactant concentrations necessary to achieve maximum drag reduction in order of a few hundred or thousand ppm, depending on the surfactant type, Reynolds number, and temperature and flow geometry (Andrej et al., 2010).

The third drag reduction agents are suspended solid as known as fibers. Fibers in suspension can interact and entangle even at low populations and can form bundles or entities that behave differently from the individual fibers. According to Duffy et al. (2002), fibers interlock at moderate concentrations to form three-dimensional structures or networks which in liquid suspension alter the transport properties of the suspension

Another phenomenon that can be defined as the drag reduction is the injection of gas into non- Newtonian liquid. The injection of gas with high speed into liquid metals or slag is widely used in the pipelines industry. The injection of gas could reduce the pressure loses in the liquid flow rates .There are some speculations that the injection of gas can change the critical concentration of oil and water where phase inversion occurs and that the pressure drop increase during phase inversion can become larger by Ioannou et al. (2005).

In the single liquid cases with low mixture velocity, the pressure drop decreases with increasing gas injection. It can decrease more at large values of the water fraction than at smaller values at the point of phase inversion (Descamps et al., 2006). At low superficial gas velocities the pressure drop decreases as mean velocity superficial gas phase is increased. It also can reaches to a minimum value for the critical velocity in the transition from laminar to turbulent flow.

The pressure gradient increases steadily after past this velocity. The drag reduction by gas injection in Newtonian fluid is more effective than that for shear shinning fluid when the dimensionless liquid height remains in the area of high value in the turbulent gas-laminar liquid stratified flown (Jing-yu et al., 2009).

There are three types of gas injectors that used in industry as drag reduction. Although the methods of gas injector have different way but it has the same purpose to reduce the pressure in the pipelines.

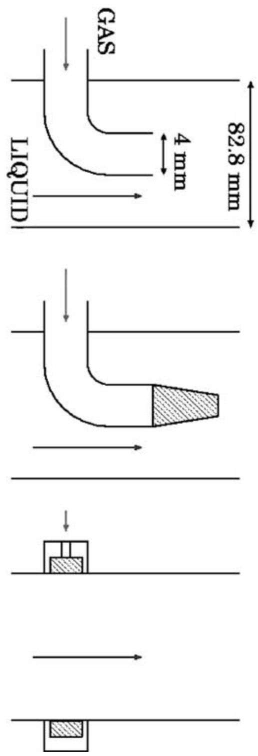

Figure 1.1: From top to bottom: nozzle injector, conical porous injector, circular porous injector

Source: Descamps (2006)

In the present investigation, air will be injected in gas oil – solid two phase flow in pipelines. Drag reduction performance will be investigated with different gas flow rates due to the injection of air gas. The injection of gas can reduce pressure drop and the pattern flow will move smoothly. The benefits when using drag reducing phenomenon is allowing a greater production flow rate at an economical cost and reduction of operating costs such as pumping power.

1.2 PROBLEM STATEMENT

Cost saving is one of the most essential concerns in any industry. One of the key to the present concern is by cutting down on the power consumption. Many flows in industrial applications such as oil pipelines are in turbulent flow. The turbulent flow with high velocity in the pipe flow system causes the formation of eddies in many different length scales and characterized by larger pressure drops and pumping power requirements than those of laminar flows. The scale of turbulent eddies in a larger contribution of turbulent energy production to mean mechanical energy loss. The energy losses in the pipe flow system can affect the production efficiency and economical cost like pumping power. Pump is widely use for effective fluid transportation before drag reduction phenomenon. The installations of pump cause the plant more costly because of drag in the turbulent flow. By using pump into the plant, the high energy consumption is needed.

1.3 OBJECTIVES

Based on the research background and problem statements described in the previous section, there are the following objectives of this research:

1. To investigate the effects of gas flow rate on the drag reduction in the gas oil- solid two phase flow system.
2. To study the effects of liquid flow on the drag reduction efficiency
3. To investigate the effect of powder addition concentration
4. To investigate the effect of particle size diameter of sand as suspended solid in the pipeline systems.

1.4 SCOPES OF STUDY

The following scopes have been identified in order to achieve the objectives:

1. Injection of air gas will be applied to study the influence of gas as drag reduction performance in the flow system
2. The pressure readings of the testing section will be collected to calculate pressure drops, followed by the percentage of drag reduction.
3. Diesel will be used as the transporting fluid in this study.
4. The addition of sand particle concentration.
5. 71 µm and 315 µm and 630 µm of particle size as suspended solid
6. Volumetric flow rate of fluid will be used to calculate the velocity and Reynolds Number (Re) of the fluid.

1.5 RATIONALE AND SIGNIFICANCE

Drag reduction is the alternative way to reduce pumping power losses during transportation through pipelines. So that, injecting the drag reduction would decrease the friction pressure losses in a pipeline. The reduction of the frictional pressure during flow can exceedingly reduce the cost of pumping power. Furthermore, power saving is very important to save the cost in the plans. The present study focuses on injecting gas into the gas oil – solid two phase in the pipelines that can reduce pressure loses and save the environmental. The gas that used to inject in the pipelines is a gas air. Under some conditions, the available quantities of gas with associated liquid could be transported without building a new pipeline or perhaps without increasing pump horsepower.

CHAPTER 2

LITERATURE REVIEW

Drag reduction is a term that frequently used to characterize the reduction in friction turbulent flow through pipes resulting in an increase of fluid flow or decrease in pressure loss. Drag reduction in turbulent flow is an important phenomenon for practical applications in fluid transport. The friction pressures in laminar flow cannot be changed unless the physical properties of the fluid are changed.

2.1 TYPE OF FLOW

There are three types of flow which are Laminar, Transitional and Turbulent flow. The purpose when calculating heat transfer or pressure and head loss it is important to know if the fluid flow is laminar, transitional or turbulent. Laminar flow happens when dealing with small pipes and low flow velocities. Laminar flow can be regarded as a series of liquid cylinders in the pipe. Non – laminar flow is called turbulent flow.

Turbulent flow happens at high flow rates and with larger pipes. In turbulent flow, eddies and wakes make the flow is unpredictable. The transitional flow actually is a mixture of laminar and turbulent flow. This happens when the turbulent in the center of pipe and the laminar flow near the edges. Each of these flows behaves in different equations that predict their behavior and have different manners in terms of their frictional energy loss while flowing in the pipelines (Witold et al., 2008).

In these cases, turbulent or laminar flow could be determined by the dimensionless Reynolds Number. The Reynolds number is important in analyzing at any type of flow when there is substantial velocity gradient such as shear. The Reynolds number is proportional to inertial force that divided by viscous force.

$$Re = \frac{\rho V D}{\mu} \tag{2.1}$$

Where V is the mean velocity of the object relative to the fluid (m/s), μ is the dynamic viscosity of the fluid (Pa·s or N·s/m² or kg/(m·s)), D is diameter of the pipe (m)and ρ is the density of the fluid (kg/m³) .

At high Reynolds numbers, the inertial forces, which are proportional to the fluid density and the square of the fluid velocity, are more significant compared to viscous forces, and therefore the viscous forces cannot inhibit the random and rapid fluctuation of the fluid. This condition of flow is known as turbulent flow. Whereas in low or moderate Reynolds number, the viscous forces are significant enough to restrict the fluid fluctuation and keep the fluid under smooth ordered motion; and this is known as laminar flow (Abulencia et al., 2009).

Critical Reynolds number, Re_{cr} is the value where the flow becomes turbulent and this value varies for different geometries and flow conditions. The transition from laminar to turbulent flows is also dependent on other factors; such as pipe surface roughness, surface temperature, vibration and fluctuations in the flow. In most practical conditions, having Reynolds number lower than 2300 is considered as laminar flow, above 4000 is turbulent flow and in-between is transitional (Abulencia et al., 2009).

Figure 2.1 shows the velocity profile of both laminar and turbulent flow. A laminar flow has a true parabola velocity profile, slightly pointed at the middle and tangent to the wall of the pipe. The average velocity of a fully developed laminar flow is about one-half of the maximum velocity flow in a pipe. In turbulent flow, the profile is resembles a flattened parabola and the average velocity is about 0.8 times the maximum velocity (Abulencia et al., 2009).

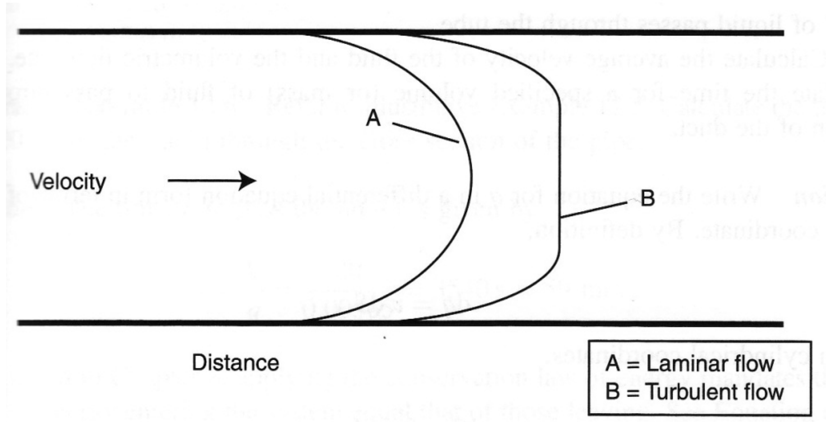

Figure 2.1: Velocity profile of laminar and turbulent flow

Source: Cengel (2006).

2.1.1 Laminar Flow

Laminar flow sometimes known as streamline flow has motion that is very regular and predictable. This can be seen when a water faucet is turned on low. The flow of water in straight lines and the motion is rather smooth. The laminar flow usually would be in the smooth flow of a viscous liquid through a tube or pipe. There are different velocities of flow from zero at the walls to a maximum along the centerline of the pipelines (Abulencia et al., 2009).