FORMULATION NEW FLOW IMPROVER IN AQUEOUS USING NATURAL MUCILAGE EXTRACTED FROM ALOE VERA

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ABSTRACT

In the present research, natural polymer of aloe Vera tested as drag reducing agent in aqueous media flow in pipelines. After research in the literature dealing with drag reduction phenomena, there was no evidence that aloe Vera was used as flow improver before this in the drag reduction field. Aloe Vera mucilage with concentration from 100 to 400ppm was tested in 2 different internal diameters (0.0254m and 0.0381m) pipes and 5 different flow rate which are represented by Reynolds number. All the experimental work was carried out in a built-up closed loop liquid circulation system with four testing sections of 2m long pipe were investigated. The experimental results showed that the drag reduction increases corresponding with increasing of Re, additive concentration and pipe length and reduction of pipe diameter. The results show, aloe Vera polymer can perform as a good drag reducing agent with maximum percentage drag reduction of 71% obtained at I.D 0.0254m and 15472.694 of Reynolds number for 400ppm of solution.

ABSTRAK

Objektif menjalankan kajian ini adalah mengkaji keupayaan formulasi polimer asli yang bertindak sebagai agen pengurangan seretan yang berlaku di dalam aliran paip. Selepas kajian yang lama dibuktikan bahawa kajian terhadap aloe Vera adalah yang baru dan tidak pernah diuji oleh saintis yang lain.Polimer asli dengan kepekatan 100ppm, 200ppm, 300ppm dan 400ppm akan diuji di dalam kerangka ujian yang mempunyai paip lutsinar berukuran 0.0254 meter D.I, dan 0.0381 meter D.I dengan 1.5 meter panjang dan 5 Nombor Reynolds yang berlainan. Daripada keputusan yang diperolehi, peratusan pengurangan seretan tertinggi adalah 71% pada 0.0254m I.D dan Nombor Reynolds 15472.694 untuk Polimer asli dengan kepekatan 400ppm. Peratusan pengurangan seretan didapati meningkat apabila halaju cecair yang diwakili oleh Nombor Reynolds meningkat, peningkatan kepekatan agen pengurangan seretan dan pengurangan diameter dalaman paip. Keputusan juga menunjukkan peratusan pengurangan seretan pada tahap maksimum sebelum degradasi mekanikal berlaku yang disebabkan rotasi pump semasa eksperimen perbezaan tekanan dijalankan. Berdasrkan keputusan, agen pengurangan seretan memberikan peratusan pengurangan seretan yang tinggi tanpa penambahan pum. Objektif dalam menjalankan kajian ini telah tercapai dengan menentukan kaedah paling berkesan dalam mengekstrak polimer asli yang bergantung kepada kesan halaju cecair, kepekatan agen pengurangan geseran dan diameter dalaman paip terhadap peratusan pengurangan seretan.

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LIST OF SYMBOLS / ABBREVIATIONS

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
Re	-	Reynolds number, dimensionless
Q	-	Volumetric flow rate, m^3/hr
ρ	-	Density, kg/m^3
μ	-	Viscosity, kg/s.m

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CHAPTER 1

INTRODUCTION

1.1 Study background.

Drag is a mechanical force that generated by the interaction and contact of a solid body with a fluid (liquid or gas). For drag to be generated, the solid body must be in contact with the fluid. Drag is generated by the difference in velocity between the solid object and the fluid which are in motion. If there is no motion, there is no drag occur [1]. The remarkable ability of low concentrations of certain additives to reduce the frictional resistant in turbulent flow of the pure solvent is known as drag reduction. It is well known that polymers are the most effective drag reducers. It is not unusual to see up to 80 percent drag reduction with only a few parts per million of added polymer [2].

Drag reduction agent also known as drag reducer or flow improver is high-molecular-weight polymers that improve the fluid flow characteristics of low-viscosity petroleum products. Drag reduction agent can reduce pumping costs by reducing friction between the flowing fluid (gasoline) and the walls of the pipe [3]. When DRA dissolves in crude oil the polymer molecules begin to uncoil and outspread as they interact with the pipeline flow. This interaction is complex; the long chain molecules dampen turbulent bursts near the pipe wall as if they were acting as tiny shock buffers. This dampening effect reduces frictional pressure loss resulting in a decrease in energy consumption or an increase in flow rate [4].

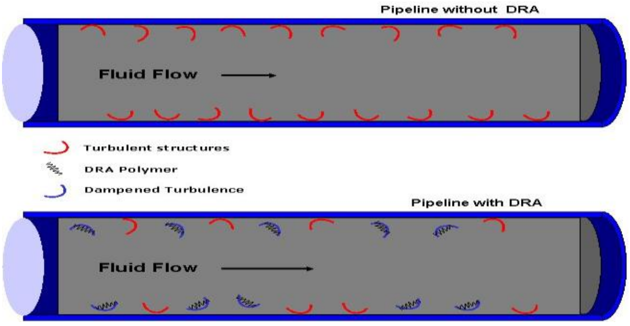


Figure 1.1 Fluid flow through pipelines with and without DRA

In achieving drag reduction efficient, a new material, natural polymers will be study. The natural polymer is aloe Vera mucilage. There are three methods of extracting aloe Vera which are Cold Method, Thermal Method of water and solvent extraction of ethanol. These three methods will be explained in the in methodology in chapter three. These natural polymers then will be used to detect the most optimal drag reducing efficiency in pipeline.

Aloe Vera gel is the commercial name given to the fibre free mucilaginous exudates extracted from the hydro parenchyma of the succulent leaves of aloe Vera. The viscous, pseudo plastic nature of aloe Vera gel, due mainly to the presence of polysaccharides composed of a mixture of acetylated glucomannans is lost shortly after extraction, apparently due to enzymatic degradation. To stabilize aloe Vera gel and delay its degradation by admixture with natural polysaccharides [5].

Toms (1949) was the first to report the existing phenomenon of drag reduction. He obtained friction reduction up to 50% compared with a pure solvent using a 0.25% solution of poly (methylmethacrylate) in monochlorobenzene. He used tubes of various diameter and observed that (i) drag reduction occurs in turbulent flow; (ii) for a given polymer concentration and Reynolds number, it increases as the pipe diameter is reduced and also (iii) the drag reduction occurs when the wall shear stress exceeds a critical value which later came to be known as 'onset of drag reduction' [6].

1.2 Problems statement.

Drag reduction or flow improving in pipelines carrying petroleum products or crude oils, was one of the main challenges especially in the last few decades when the term power saving, raised up due to the rapid increase in global power consumption. One of the major sectors that deal with huge amounts of power losses is the liquids transportations through pipelines. It is known that, liquids (water, crude oil and refinery products) are transported in pipelines in a turbulent mode (Reynolds number higher than 2500) and that will lead to huge pumping power losses along the pipelines (especially strategic pipelines). Drag Reducing Agents (DRA`s) were used in the past few decades to improve the flow in pipelines and to increase it without the need for any changes in the geometry of the pipeline system. [7]

1.3 Objectives.

The objectives in this present research are:

1. Identify the most suitable plant or vegetable to use as a raw material which is aloe Vera.
2. Identify the suitable time or age of aloe Vera to use in the experiment so the amount of mucilage is high.
3. Identify the most suitable procedures in extracting natural polymer of aloe Vera.
4. Investigate effect of the drag reduction agent in pipelines.
5. Identify the effect of dried skin of aloe Vera as a fiber in drag reduction.
6. Investigate the most suitable flow rate, pipe diameter and concentration in reducing pressure drop.

1.4 Scope of study.

Survey shows very limited or almost no work on processing of aloe Vera as DRA. High percentage of mucilage in aloe Vera creates a need to do more research and study on this field. Study on extraction of aloe Vera mucilage and drying of aloe Vera skin was, therefore, started in undergraduate research project. In this study, technique of extraction with optimum temperature, preserve the quality of mucilage by antibacterial and antioxidant, solubility and the commercial value of aloe Vera mucilage is investigated. In brief the scope of the study is stated as below;

1. Aloe Vera mucilage used as a Drag Reduction Agent.

2. Extract aloe Vera mucilage using three different suitable methods to find out the method that can save time and cost.

3. Choose the best method of extraction out of three methods to maximize the yield.

4. Dry aloe Vera skin and use as fiber to reduce drag to avoid any waste.

5. To increase shelf life of aloe Vera by using Rosmarinic acid as antibacterial and antioxidant.

6. Following qualities of aloe Vera mucilage is measured; optimum temperature to preserve the best qualities of aloe gel, optimum amount of Rosmarinic acid added, optimum age of aloe Vera to become mature and produce high percentage of mucilage and the solubility.

1.5 Rationale and significant.

This significant of this research is to develop another environmental friendly product to overcome lost of energy in transporting liquid using pipelines especially in long distance transportation such as in an offshore platform and oil rig. This is because, by studying the effects of drag reduction, its can help to reduce pumping pressure or increase flow rate when transporting the liquids from one distance to another [8]. Therefore, the cost and time can be saving by adapting Drag Reducing technology in pipeline system. This research also can determine the most suitable natural polymeric Drag Reducing Agent by identify the most suitable treatment in extracting natural polymer which is aloe Vera mucilage. As a result, environment can be safe because this natural polymer is an environmental friendly (biodegradable) DRA.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Formulation of new flow improvers in aqueous media that extracted from aloe Vera mucilage is a very important research to overcome the pressure and energy loss in pipelines during transport fluid like crude oil and refinery. The important subchapters that will be discussed in this chapter is about flows of fluid in pipeline, types of flow, energy consumption during transport fluids, friction in pipeline, definition of drag reduction, information of drag reduction agent, types of flow improver, definition of mucilage and finally commercial application of DRA.

2.2 Flows in pipeline

2.2.1 Classification of fluid flow

Fluids mechanics is the science that deals with the behavior of fluids at rest or in motion and the interaction of the fluid with the solids or other fluid at the boundaries. There is wide variety of fluid flow problems encountered in practice, and it is usually convenient to classify them on the basis of some common characteristics to make it feasible to study them in groups. There are many ways to classify fluid flow problems, and here we present some general categories [9].

2.2.2 Viscous versus viscid regions of flow

When two fluid layers move relatively each other, a friction force develops between them and the slower layer tries to slow down the faster layer. This internal friction to flow is quantified by the fluid properties viscosity, which is the measure of internal stickiness of the fluid. Viscosity is cause by cohesive force between the molecules in liquids and by molecular collisions in gases. There is no fluid with zero viscosity, and thus all fluid flows involve viscous effects to some degree. Flows in which the frictional effects are significant are called viscous flows. However, many flows of practical interest, there are regions (typically region not close to solid surface) where viscous forces are negligibly small compared to inertial or pressure forces. Neglecting the viscous term in such in viscid flow regions greatly simplifies the analysis without much loss in accuracy [9].

2.2.3 Internal versus external flow

A fluid flow is classified as being internal or external, depending on whether the fluid is forced to flow in a confined channel or over a surface. The flow of an unbounded fluid over a surface such as a plate, a wire or a pipe is external flow. The flow in a pipe or duct is internal flow if the fluid is completely bounded by solid surface. Water flow in a pipe, for example, is internal flow, airflow over a ball or over an exposed pipe during a windy day is external flow. The flow of liquids in a duct is called open channel flow if the duct is only partially filled with the fluid and there is a free surface. The flow of water in rivers and irrigation ditches are example of such flows. Internal flows are dominated by the influence of viscosity throughout the flow field. In the external flows the viscous effects are limited to boundary layers near solid surfaces and to wake regions downstream of bodies [9].

2.2.4 Laminar versus turbulent flow

Some flows are smooth and orderly while other are rather chaotic. The highly ordered fluid motion characterized by smooth layer of fluid is called laminar. The word laminar comes from the movement of adjacent such as oils at low velocities and is characterized by velocity fluctuation is called turbulent. The flow of low viscosity fluids such as air at high velocity is typically turbulent. The flow regime greatly influences the required power for pumping. A flow that alternates between being laminar and turbulent is called transitional [9].

2.2.5 Natural flow versus forced flow

The fluid flow is to be natural or forced; depending on the how the fluid motion is initiated. In forced flow, a fluid is forced to flow over a surface or in a pipe by external means such as a pump or a fan. In natural flow, any fluid motion due to natural means such as the buoyancy effect, which manifests itself as the rise of the warmer (and thus lighter) fluids and the fall of cooler (and thus denser) fluid. In solar hot water system, for example, the thermo siphoning effect is commonly used to replace pumps by placing the water tank sufficiently above the solar collectors.

2.2.6 Steady versus unsteady flow

The terms steady and uniform are used frequently in engineering, and thus it is import to have clear understanding of their meanings. The term steady implies no change at the point with time. The opposite of steady is unsteady. The term uniform implies no change with location over a specified region. These meanings are consistent with their everyday use (steady girlfriend, uniform disturbance). The terms unsteady or transient are often used interchangeably, but these terms are not synonyms. In fluid mechanics, unsteady is the most general term that applies to any flow that is not steady, but transient is typically used for developing flows. When a rocket engine is fired up, for example, there are transient effects (the pressure builds up inside the rocket engine, the flow accelerates) until the engine settles down and operates steadily. The term periodic refers to kind of unsteady flow in which the flow oscillates about a steady mean [10].

2.2.7 Compressible versus incompressible flow

A flow is classified as being compressible or incompressible, depending on the level of variation of density during flow. Incompressibility is an approximation, and a flow is said to be incompressible if the density remains nearly constant throughout. Therefore, the volume of every portion of fluid remains unchanged over the course of its motion when the flow or the fluid is incompressible. The densities of liquids are essentially constant, and thus the flow of liquid is typically incompressible. Therefore, liquids are usually referred to as incompressible substances. A pressure of 210 atm, for example, causes the density of liquid water at 1 atm to change by just 1 percentage. Gases, on the other hand, are highly compressible. A pressure change just 0.01 atm, for example, causes a change of 1 percent in the density of atmospheric air [9].

2.3 Types of flow in pipelines

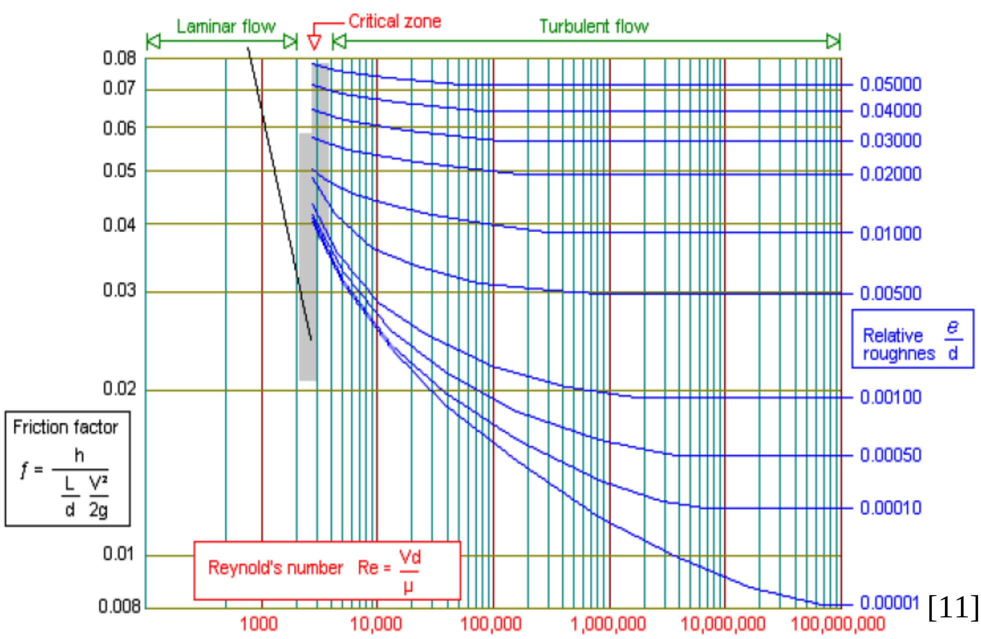
There are in general three types of fluid flow in pipes which are laminar, turbulent, and transient. The type of flow is determine by the Reynolds Number (laminar when $Re < 2300$, transient when $2300 < Re < 4000$, turbulent when $4000 < Re$) which is depend on on the geometry, surface roughness, flow velocity, surface temperature and types of fluid. [10]

2.3.1 Reynolds Number

After exhaustive experiments in the 1880s, Osborne Reynolds discovered that the flow regime depends mainly on the ratio of internal forces to viscous forces in the fluid. The Reynolds number is important in analyzing any type of flow when there is substantial velocity gradient (i.e. shear.) It indicates the relative significance of the viscous effect compared to the inertia effect. The Reynolds number is proportional to inertial force divided by viscous force [9]. The Reynolds number (Re) of a flowing fluid is obtained by dividing the kinematic viscosity (viscous force per unit length) into the inertia force of the fluid (velocity x diameter).

$$\text{Kinematic viscosity} = \frac{\text{dynamic viscosity}}{\text{fluid density}} \qquad (1)$$

$$\text{Reynolds number} = \frac{\text{Fluid velocity x Internal pipe diameter}}{\text{Kinematic viscosity}} \qquad (2)$$



[11]

Figure 2.1 Effect of Reynolds number on Friction Factor

2.3.2 Laminar flow

Laminar flow generally happens when dealing with small pipes and low flow velocities. Laminar flow can be regarded as a series of liquid cylinders in the pipe, where the innermost parts flow the fastest, and the cylinder touching the pipe isn't moving at all [10]. Where the Reynolds number is less than 2300 laminar flow will occur and the resistance to flow will be independent of the pipe wall roughness. The friction factor for laminar flow can be calculated from 64 / Re. Fluids with a high viscosity will flow more slowly and will generally not support eddy currents and therefore the internal roughness of the pipe will have no effect on the frictional resistance [11].

2.3.3 Turbulent Flow

One of the major considerations when designing liquid waste fuel storage and burner supply systems is trying to maintain turbulent flow. The need to maintain turbulent flow is usually associated with the need to keep solids suspended in the fluid, so that the solids do not settle and plug the piping. However, maintaining turbulent flow may not be necessary if the fluid viscosity is sufficiently high enough to impede the settling of the solids. Indeed if the viscosity is too high it may not be possible to achieve turbulent flow without special pumps and high pressure rated piping. In most cases it is worthwhile to try to achieve turbulent flow since it reduces the flow resistance of the fluid and consequently the pressure losses in the piping system due to this flow resistance [12]. In turbulent flow vortices, eddies and wakes make the flow unpredictable. Turbulent flow happens in general at high flow rates and with larger pipes [10]. Turbulent flow occurs when the Reynolds number exceeds 4000. The friction factor for turbulent flow can be calculated from the Colebrook-White equation [11]:

$$1/\sqrt{f} = 1.14 - 2\log_{10}\left(\frac{e}{D} + \frac{9.35}{\mathrm{Re}\sqrt{f}}\right) \quad \text{for Re} > 4000 \qquad (3)$$