# STUDYING THE EFFECTS OF NATURAL MUCILAGE PREPARATION PROCEDURES ON ITS PHYSICAL PROPERTIES AND DRAG REDUCING EFFICIENCY

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# STUDYING THE EFFECTS OF NATURAL MUCILAGE PREPARATION PROCEDURES ON ITS PHYSICAL PROPERTIES AND DRAG REDUCING EFFICIENCY

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## ABSTRACT

In this present experiment, the objective is to investigate the effectiveness of new formulated natural polymer as drag reducing agent (DRA). Two different methods with additives concentrations at 80ppm, 150ppm and 300ppm weight percent were tested in set up rig with three different pipe diameters which are 0.0127 meter D.I, 0.0254 meter D.I and 0.0381 meter D.I and testing section length of 1.5 meter. The result shown highest %DR in Thermal Method was 67.2619% with 300ppm concentration and 0.0127m D.I pipe diameter at Reynolds Number equal to 62.140.16. Meanwhile, %DR in Cold Method is at 62.96% at 0.0127mD.I pipe diameter, at 300ppm concentration flow trough Reynolds Number equal to 24856.05. Generally, average %DR was higher for Cold Method compare to Thermal Method. The average %DR for Cold Method is slightly higher than %DR for Thermal Method about 3.33%. The average %DR is considered by taking all %DR results. %DR was found to be increase when flow rate that related to Reynolds Number increase. %DR also increased when additives concentration increased. Adding few ppm concentration additives in water shown there are slightly effects in its physical properties. In the other hand, %DR increased when internal pipe diameter decreased. %DR was increased until maximum %DR before mechanical degradation occurs due to pump rotation during pressure drop experimentation. The methods in extracting natural polymeric DRA also give slightly different in %DR. The result is adding DRA will give higher %DR on pipeline flows without adding pumps. The objectives in doing this present research has been achieved by determined the most suitable extracting method depend on effects of water flow rate represented by Reynolds Number, additives concentration and internal pipe diameter on %DR.

# ABSTRAK

Objektif dalam menjalankan kajian terbaru ini adalah mengkaji keupayaan formulasi polimer asli yang bertindak sebagai agen pengurangan seretan yang berlaku di dalam aliran paip. Terdapat dua kaedah mengekstrak polimer asli iaitu Kaedah Sejuk dan Kaedah Haba dengan kepekatan 80ppm, 150ppm, dan 300ppm. Polimer asli ini akan diuji di dalam kerangka ujian yang mempunyai paip lutsinar berukuran 0.0127 meter D.I, 0.0254 meter D.I, dan 0.0381 meter D.I dan 1.5 meter panjang. Daripada keputusan yang diperolehi, peratusan pengurangan seretan tertinggi adalah 67.26% yang diperolehi daripada Kaedah Haba manakala 62.96% untuk Kaedah Sejuk. Pada nilai purata, Kaedah Sejuk telah memberikan bacaan lebih tinggi berbanding Kaedah Haba dengan perbezaan 3.33%. Bacaan purata ini diambil kira berdasarkan semua keputusan yang diperoleh. 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 efek terhadap halaju cecair, kepekatan agen pengurangan geseran dan diameter dalaman paip terhadap peratusan pengurangan seretan.

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| | | |
|---|---|---|
| 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 |
| $\Delta P_a$ | - | Pressure difference after adding additives, $N/m^2$ |
| $\Delta P_b$ | - | Pressure difference before adding additives, $N/m^2$ |
| Re | - | Reynolds number, dimensionless |
| Q | - | Volumetric flow rate, $m^3/hr$ |
| $\rho$ | - | Density, $kg/m^3$ |
| $\mu$ | - | Viscosity, kg/s.m |

## LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Study background.

Drag by definition means 'a heavy, pulling action'. Drag also identifiable as the mechanical force that exists in the pipeline that more suitable to be define, as friction exists at the near wall region that decreases velocity. In the other hand, in fluids flow, drag reduction means lessen the effects of friction of turbulent flows that occur in pipeline.

The histories begin with Issac Newton in 1642- 1727, the first who explore various aspects of fluid resistance which involving inertia, viscous and wave. In 1842-1912, Osborne Reynolds described original experiment in many field including pipe resistance. He advised two parameters for viscous flow, adapted equations of motion of a viscous fluid to mean conditions of turbulent flows. All this theories give ideas to Tom who is first leader in inventing drag reducing technologies. In Toms effect, the hydrodynamic resistance to the flow of a low-molecular-mass fluid (water, solvents, low-viscosity oil products) in the region of Reynolds numbers usually corresponding to a turbulent flow significantly decreases upon introduction of a very small amount (a few tens ppm) of a polymeric additive. (Malkin et. al, 1995).

In achieving drag reduction efficient, a new material, natural polymers will be study. The natural polymer is okra mucilage synthesis from okra fruit. There are two methods extracting the okra which are Cold Method and Thermal Method. These two 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.

## 1.2 Problems statement.

The demand in power saving in order to reduce cost for liquid transportation had really hesitated global consumers. This phenomena lead to the growth of researches in order to minimize the power supply in pipeline systems. Currently, Drag Reducing Agent (DRA) have marked as an economic and environmental friendly alternatives to reduce power losses in pipeline, thus increased the flow capacity without adding any installment or extra energy. However, there is mechanical and chemical restriction in using polymeric DRA. These restrictions due to the structures of polymer that easily degraded due to shear forces and free radicals that reduce the effectiveness of polymeric DRA.

## 1.3 Objectives.

The objectives in this present research are to:

- Identify the most suitable procedures in extracting natural polymer by using okra mucilage as raw material.
- Investigate the drag reduction ability of new formulated natural DRA which is okra mucilage.
- Investigate the most suitable flow rate, pipe diameter and concentration in reducing pressure drop.

## 1.4 Scope of study.

In reducing pressure drop in pipeline by using natural polymers as DRA, there are manipulated variables and constant variables to be set up. By manipulating variables, pressure drop can be determined by manometer. There also some limitations of these studies to ensure all results are base on parameters. The limitations are:

- Using two different methods in extracting okra mucilage which are Cold Method and Thermal Method.
- Using one length of pipeline which is 1.5meter.
- Using water as the solvent.
- Using three different concentrations which are 80ppm, 150ppm, and 300ppm.
- Using three different pipe diameters which are 0.0127meter DI, 0.0127meter DI, and 0.0381meter DI.
- Using different flow rate that related to all parameter and dependable on pipe diameter and pressure drop.

## 1.5 Rationale and significant.

Rationally, this research can help to develop another environmental friendly alternative to overcome losing energy in transporting liquid using pipelines especially in long distance transportation such as in Trans Alaskan Pipelines (TAPS), Turkey-Iraq Pipeline, Bas Strait (Australia) Pipeine, Bombay Off Shore (India). This is because, by studying the effects of drag reduction, its can help to reduce energy supply in transporting the liquids from one distance to another. Therefore, cost 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 okra mucilage as raw material. As a result, environment can be safe because this natural polymer is an environmental friendly (biodegradable) DRA.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

In achieving most inexpensive solution by maintaining the flow rates and installments, DRA been used as an alternative to minimize pressure drop in pipelines. However, there are major problems in using polymeric DRA which is polymer is easily degraded due to mechanical force and chemical degradation. Drag reducing agent (DRA) is an additive that highly viscous disperse in pipeline to help reducing friction pressure losses. In economic view, by adding DRA, pressure losses can reduce. So, cost of production can minimize by reducing energy consumption in pumping system and installments of pipelines and delayed pump station. In this chapter discussed the literature review on turbulent flow. Besides, it also discussed about DRA. This review also compared polymer DRA with surfactant DRA and suspended solid DRA. Next subchapter outlined drag-reducing mechanism. Last subchapter explained economical benefits in using DRA.

## 2.2 Fluid flows.

In the fluid dynamic concept, there will are main different characteristic of flows which are laminar flow and turbulent flows. For laminar flows as in Figure 1, there will be no major problems because at laminar flow of liquids can be assume as steady state. Laminar flows have uniform velocity that is $\partial V / \partial t \equiv 0$. Laminar is a stable, smooth parallel flows which do not encounter disruption between flow layer because of high momentum diffusion and low momentum convection. The Reynolds Number of laminar flow is below than 2100 (Bruce et. al, 2006).

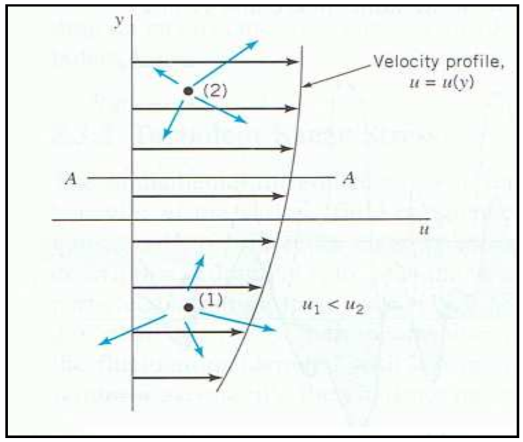


Figure 2.1: Laminar Flow Mechanism

The problems start to occur when flows momentum convert their energy in time of period from high momentum diffusion and low momentum convection to low momentum diffusion and high momentum convection. This phenomenon called turbulent.

Turbulent is an unstable, chaotic flow denominated by recirculation (fluid molecules rotation), eddies and apparently randomness of the flow alignment. Turbulent is cause by increasing of velocity in fluid motion denoted by $\partial V / \partial t \neq 0$. Turbulent furthermore can cause fluctuation of parameters such as velocity, pressure and temperature. The Reynolds Number of turbulent flow is greater than 4000 (Bruce et. al, 2006). These fluctuations lead to high momentum convection and the production of unsteady vortices or eddies which lead to an increase in skin friction. (Laura et. al, 2007).

When fluids motion increase due to momentum convection, which transporting energy and molecules trough pipes and so increase various velocity of fluid motion. There also molecules tend to be stagnant at their origin place which influence by inertia. Inertia is the resistance of molecules has to a change in its state of motion. Therefore, the static molecules will forms boundary layers between pipe wall and the molecules of solvents.

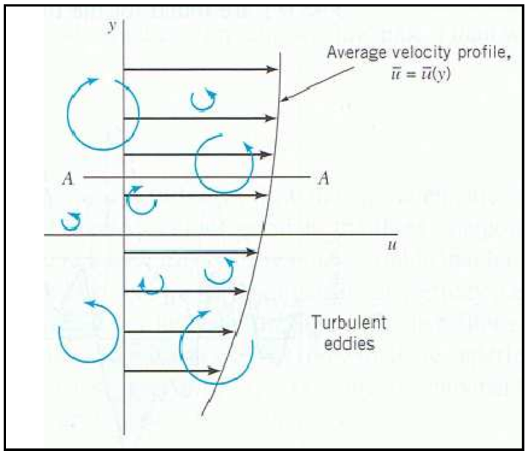


Figure 2.2: Turbulent Flow Mechanism

Illustrated by Figure 2.2, flux momentum across from point A to point B in x direction. The acceleration is equal for all solvents molecules. Because of inertia existed at pipeline wall, so the flux momentum in some how will be in opposite direction. This called drag. Energetic molecules at the center of pipeline will be slow down by solvent molecules at the outer of pipelines. The rate of change in momentum known as shear force. In addition, there are attractive forces between solvents molecules (Bruce et. al, 2006). This phenomenon happen base on the law of momentum convection which state, “Total momentum of any group of objects remains the same unless outside forces act on the objects”. Because of random motion of the flows, eddies will formed.

In turbulent flows, the friction at the wall of the pipes will lead to the further decrease of flows and tendency to form vortices is high because the friction will ‘hold’ liquid molecules at the buffer region. Therefore, friction in boundary will increase drag. Thus, energy will be loss due to formation of vortices and eddies. Buffer region is a part in the pipeline which the molecules of water has losses their energy and the alignment of flows and will be ‘stuck’ at the pipeline wall because molecules of liquid do not have enough energy to against wall friction.

### 2.3 Drag Reducing Agent.

Drag reducing agent (DRA) is one of the innovations in enhancing the flow in pipeline. To ensure the pipeline is in place and to avoid harmful damage or corrosion before its time, many companies will increase their flowrate. This will lead to various motions called turbulent flows. As known, turbulent flows will increase vorticity force and decrease velocity. So, DRA usually will be injected at the centered pipeline during peak time which means the pump down in the flow line condition. DRA can bursts the buffer zone, increase streaks in pipeline, decrease vorticity force and increased velocity of flow without supplying extra energy.

Drag reducing agent are any material that reduces frictional pressure during fluid flow in a conduit or pipeline. Using DRA allows increased flow using the same amount of energy or decreased pressure drop for the same flow rate of fluid in pipelines. Drag reducing agent are the additives of polymer, surfactants or suspended solid that act as the helper to prevent eddies in turbulent flows. These additive are helping to save the energy by reducing the recirculation effects (prevent liquids molecules to rotate) that existed in turbulent flow. (Lumley, 1969) definition of drag reduction is “Drag reduction is the reduction of skin friction in turbulent flow below that of the solvent”. DRA can affect the solvent by changing viscosity of the solvents. Fluid elasticity in DRA also hinders the oscillation-induced streaming suggested by (Vlassopoulos and Schowalter, 1994).

#### 2.3.1 Polymeric DRA

(Gadd, 1971) cited polymer additive is the resistance to elongation strain, resulting shear formation and busting in wall near region. DRE also can also interact chemically by binding molecules of DRE and the solvents. (Massah and Hanratty, 1997) concluded polymer drag reduction could cause the changing in molecular structures of liquids that tend to produce Reynolds stress. The Reynolds shear stress also strongly reduced, especially near the wall, and this is done by a polymer stress,