STUDYING THE EFFECT ADDITION OF CHITOSAN AND SUSPENDED SOLID AS DRAG REDUCING AGENT WITH DIFFERENT VALUE OF CONCENTRATIONS IN TURBULENT WATER FLOWING SYSTEM

NORIMAN HAMIZAN BIN HAMDAN

Thesis submitted to the Faculty of Chemical and Natural Resources Engineering in
Partial Fulfillment of the Requirement for the
Degree of Bachelor Engineering in Chemical Engineering

Faculty of Chemical & Natural Resources Engineering
Universiti Malaysia Pahang

APRIL 2009

I declare that this thesis entitled "*Studying the effect Addition of Chitosan and Suspended solid as Drag Reducing Agent with Different Value of Concentrations in Turbulent Water Flowing System*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	: ....
Name of Candidate	: NORIMAN HAMIZAN BIN HAMDAN
Date	: 16 APRIL 2009

To my beloved father and mother

ACKNOWLEDGEMENT

First and foremost, thanks to God Almighty for the guidance and aid in giving me the strength to complete this project research. At last I had completed my final year project and thesis. I realize that not easy to do alone the undergraduate research project. There need patient and focus. Behind this hard work there have the person who understand and support until the end of the project end.

The greatest thank is to technician at the FKKSA laboratory such as En. Hafiz, En. Razak, En. Zulhabri, and En. Anwar. Also thanks to my friend Nur Khadijah, Siti Nurafini, Zainur Azizi, M. Fakhrur and Lim Meow Suan which give full cooperation and nice tolerance.

The next credit goes to my parents En.Hamdan bin Nasir and Pn.Norhaya binti Md Said and also my beloved siblings for their endless encouragement and great support throughout this period of one year.

My sincere appreciation also goes to my supervisor, Dr Harder A. Abdul Bari for his relentless motivation and guidance for this research project to be completed.

I hope this research project will be helpful for those who need reference. Finally I would like to express my gratefulness to all of them who involved directly or indirectly in the completion of my final year project and thesis. Thank you.

ABSTRACT

Drag is the force that resists the movement of a solid object through a fluid (a liquid or gas). As the point to solve the matter, drag reduction is introduced. Drag reduction can reduce the energy loss and pressure drop in the pipe. As the result, it can reduce of using power to transfer the fluid and save the cost. There are many drag reducing agents (DRA) that can use nowadays. Chitosan is one of the polymers DRA which is biodegradable and have high potential to reduce the drag into 70%. Chitosan is made from the nature that safe to use such as shells of shellfish such as crab and shrimp. There are suspended solid (sand) give effect to drag reduction. The variable is manipulated according to the subject studied. The variables that take part are pipe diameter, pipe length (testing point distance), flowrate, concentration of the DRA use and the suspended solid particle size. The chitosan is prepared with 2%, 4% and 6% of acetic acid addition and the concentration that use in this experiment is 200ppm, 400ppm, 600ppm and 800ppm. Pipeline diameter that used is 0.5 inch, 1.0 inch and 1.5 inch and the pipe length is 0.5 m, 1.0 m, 1.5 m and 2.0 m. Suspended solid particle size is 200µm, 500µm and 800µm. The medium that use to perform drag reduction is created for each variable can take place. Raw water is use and the pressure drop of raw water without additive is taken. The concentration is tested one by one and the pressure drop is taken for each concentration. The obtained data is analyzed and the result showed the percentage of drag reduction (%DR) is increase with increase the concentration and the suspended solid can reduce the drag about 40%.

ABSTRAK

Drag adalah daya yang menghalang pergerakkan objek melalui bendalir (cecair atau gas). Untuk mengatasi masalah ini, cara-cara mengurangkan drag telah diperkenalkan. Pengurangan drag boleh mengurangkan pengunaan kuasa dan perubahan tekanan dalam paip. Ia juga boleh mengurangkan kuasa untuk mengalirkan bendalir dan menjimatkan kos. Terdapat banyak ejen pengurangan drag pada hari ini. Chitosan adalah salah satu ejen polimer yang biodegradasi dan berupaya mengurangkan drag sebanyak 70%. Chitosan dihasilkan dari sumber alam yang selamat seperti kulit ketam atau udang. Terdapat juga bahan pepejal (pasir) yang boleh mengurangkan drag. Terdapat banyak parameter yang dikaji iaitu diameter paip, panjang paip (titik jarak percubaan), kadar aliran, kepekatan ejen pengurangan drag dan saiz pepejal. Chitosan disediakan dengan 2%, 4% dan 6% asid asetik dan kepekatannya adalah 200ppm, 400ppm, 600ppm dan 800ppm. Diameter paip yang digunakan ialah 0.5 inch, 1.0 inch and 1.5 inch dan panjang paip ialah 0.5 m, 1.0 m, 1.5 m and 2.0 m. Saiz pepejal yang digunakan ialah 200µm, 500µm and 800µm. Alat kajian yang disediakan khas boleh menkaji parameter yang telah ditentukan. Air mentah digunakan dalam kajian ini dan bacaan perubahan tekanan diambil. Kepekatan ejen pengurangan drag dikaji satu per satu untuk semua kepekatan yang ditentukan. Keputusan yang dihasilkan di analisa dan keputusannya menunjukkan persen pengurangan drag meningkat dengan meningkatnya kepekatan ejen pengurangan dan pepejal Berjaya mengurangkan drag di dalam paip sebanyak 40%.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DR	-	Drag Reduction
%DR	-	Percentage Drag Reduction
DRA	-	Drag Reducing Agent
L	-	Length
D	-	Diameter
ppm	-	Part per million
m	-	Meter
m^3	-	Meter Cubic
µm	-	Micro meter
ΔP	-	Pressure drop
in	-	Inch
h	-	Hour
ml.	-	Milliliter
R_E	-	Reynolds Numbers
g.	-	gram
mg.	-	milligram
kg.	-	kilogram

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The effect of drag reduction in turbulent flows by additives was apparently discovered by (Toms, 1948), and has been known since then as the Toms phenomenon. It is well known that the addition of a small amount of additives to a turbulent Newtonian fluid flow can result in a drag reduction and received attention since publication of (Mysels, 1949). However, low concentration suspensions mostly show negligible effect in laminar flows which is having Reynolds number less than 2100. The main purpose of drag reduction is to delay the onset of turbulent flows. In other words, a drag reducer will shift the transition from a laminar flow to a turbulent flow to higher flow velocity.

Numerous experimental investigations following Toms' discovery have confirmed the effect and characterized it. Virk et al (1967) has investigated about effect of dilute polymer solution turbulent pipe flow, followed by a dimensional analysis. It was determined the characteristic of Tom's phenomenon which is the maximum drag reduction asymptote and the shear stress for drag reduction is exist. The maximum drag reduction asymptote is known as Virk's asymptote. This asymptote is observed in the velocity profile and in the friction–flow rate domain. It universally and not depend on system and additive properties. The characteristic of the surfactant reducer is differ from polymeric reducer in several aspects particularly having higher level of drag reduction crossing the Virk's maximum drag reduction asymptote (L. Zakin et al, 1997 & 1998). Virk observed that the equation (1) is the formula that gives maximum possible drag reduction asymptote, where the drag reduction is insensitive to polymer properties:

$$\frac{1}{f^{1}} = 19\, log_{1} \qquad f^{1} \qquad 32.4 \qquad 1$$

L.Zakin (1997 & 1998) and coworkers also provided the equation (2) that given maximum drag reduction for surfactant reducer because of the friction factors significantly lower than the predicted by maximum drag reduction asymptote for high polymer solutions are predicted.

$$f \quad 0.32 \quad \cdot \qquad (2)$$

The several characteristic of the Tom phenomenon research have explains the concept of drag reduction. Lumley (1969 & 1977) reported that the polymer molecules are elongated or stretch in the turbulent boundary layer because of increase of extensional viscosity.

De Gennes (1990) model is based on elasticity properties of the solute polymer which is cause of elongated polymer molecule by elastic absorption. Direct numerical simulation investigation of Den Toonder and co-workers (1997) come out with drag increases when the elastic contributions are taken into account.

There exist a number of drag reducers such as water-soluble polymers, surfactants, microbubbles and suspended solid. The drag reduction also can occur in the flow that contains a suspended solid. Presence of the suspended solid can reduce the drag resistance to flow (Vanoni, 1946 & 1960). The resistance to flow is decreases due to damping of turbulence in the presence of suspended solid (Vanoni, 1946 & 1960). On the other hand, the turbulent decrease in presence of suspended solid (Gyr, 1967 & Hino, 1963). Drag reduction up to effective, decreasing the turbulent. A suspended solid transport is affected by the suspended solid shape, size, and concentration (Vanoni, 1977). Vanoni and Nomicos (1960) showed that the suspension loading and the particle properties (size, density, and shape) affected the amount of settling in the stream.

1.2 Problem Statement

Drag reduction not only applied in chemical industries but it widely used in many sectors such as medical, mining, include oil-well fracturing operations, crude oil and refined petroleum product transport through pipelines, hydraulic machinery, fire fighting, sewerage and flood water disposal, irrigation, hydrotransport of solids, water-heating circuits, jet cutting, and marine and biomedical applications. Drag reduction in purpose can reduce the energy loss. For the simple example, the pressure drops at the nozzle are not same. At the water feed the pressure drop is high but at the water out the pressure drop is low. It because of the turbulent flow occurs inside the nozzle. Mechanical degradation is caused by mechanical energy input to the polymers in solutions, which means passing the solution through pumps or pipes or both. Mechanical degradation has long been associated with shear flow. To some extent, the shear flow causes the degradation of dilute poly(enthylene oxide) solutions (Sellin, 1982). Pump is device that uses to move the fluid from low pressure to high pressure which can accelerate the fluid to enhance the flow of the fluid. Before drag reduction is covered, pump is widely use for effective fluid transportation. Installation of pump into the plant not feasible to solve the turbulent flow that causes drag. But it can cause the plant is costly. Using the pump needs the high energy consumption but low production.

Natural drag reducers which are active ingredient are found in the shells of crustaceans, such as lobsters, crabs, and shrimp, and in certain other organisms is the environment friendly. It has low potential for toxicity and its abundance in the natural environment.

1.3 Study Objectives

Objective of this research to be achieved is:

1. Investigate the drag reduction ability of new formulated natural drag reducing agent (chitosan) with different concentration.

2. Study effect on drag reduction in presence of two drag reducing agent with different characteristic.

1.4 Scope of Study

The scope of study for this research is identify to be the variable that manipulated which is the pipe length L, pipe diameter D, suspended solid size, and additive concentration C.

1.5 Rationale and Significance

The use of drag reduction can give many good implications. Drag reduction enhance the flowrate by add the drag reducing agent. The most successful application of drag-reduction phenomenon has been in reducing the drag in crude oil transport through Trans Alaskan Pipelines (TAPS) and other pipelines in several countries. The first large-scale use of hydrocarbon-soluble drag reducer addition in TAPS was accomplished in 1979. The technology made spectacular advancement since then. Within 10 years, the effectiveness of additives increased 12 times (Motier et al, 1989). Drag reduction can overcome the energy lost in the pipeline. Energy demand to operate the plant can be reducing because pump use in the plant is minimized. So, it can save the cost. In order to care about the pollution to environment, the drag reducing agent that use is biodegradable and environmental friendly.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the theoretical particulars that will be covered are drag, laminar and turbulent flow, drag reduction, drag reducing agent, drag reduction mechanism and finally the commercial and economic benefits.

2.2 Drag Forces in Pipeline Flow

In fluid dynamics, drag (sometimes called fluid resistance) is the force that resists the movement of a solid object through a fluid (a liquid or gas). The most familiar form of drag is made up of friction forces, which act parallel to the object's surface, plus pressure forces, which act in a direction perpendicular to the object's surface (Raymond et al, 2004).The other force that can occur is lift which is summation of the force that exert on the object . Fluids mechanics draws no distinction between two cases of relative motion, namely, when a body moves rectilinearly at constant speed through a stationary fluid or when a fluid travels at constant velocity past a stationary body (John Finnemore, 2002). It is a common experience that a body meets some resistance when it is forced to move through a fluid, especially a liquid. Before discuss about drag reduction, it is necessary to describe the structure of turbulent flow in a pipeline. Pipe line with turbulent flow has three parts. In the very center of the pipe is a turbulent core. It is the largest region and includes most of the fluid in the pipeline. This is the zone of the eddy currents and random motions of turbulent flow. Nearest to the pipeline wall is the laminar sub layer. In this zone the water molecule rigid because of the friction exerted on the pipe line surface. This drag phenomenon can perform and affect the flow system which is the water molecule start to flow intermittent. The fluid moves laterally in sheets. Between the laminar layer and the turbulent core lies the buffer zone.

2.3 Laminar and Turbulent Flow

There are generally two types of flow; laminar and turbulent. In the pipe line, maybe laminar flow or turbulent flow can occur. Laminar flow can occurs when a fluid flows in parallel layers, with no disruption between the layers. Between laminar flow and turbulent flow, there is transitional flow. Osborne Reynolds (1842 – 1912) was the first to distinguish the difference between the flows through experimentally device. The following characteristics are observed if the water flows through a pipe of diameter D with an average velocity V by injecting neutrally buoyant dye into the pipe. The characteristics easily can identified by manipulate the flowrate. For the first experiment, the flowrate is set too low enough and the dye streak will remain as it used to be can be observed. There are only slightly blurring because the dye molecule start to diffuse into the surrounding water. For the second flowrate which is larger than the first one, the observation shown that the dye streak fluctuates in time and space. Alternating burst of irregular behavior appears along the streak. For the high flowrate, the dye streak almost immediately becomes blurred and spreads across the entire pipe in a random fashion. These three characteristics, denoted as laminar, transitional and turbulent flow, respectively (Munson et al, 2006).

This particular process shows the initiation of the Kelvin-Helmholtz Instability (Kelvin, 1871) in a shear flow. Kelvin–Helmholtz instability can occur when velocity shear is present within a continuous fluid or when there is sufficient velocity difference across the interface between two fluids (Kelvin, 1871). It means that, when two parallel streams of different velocities are adjacent to each other, the flow can be unstable to perturbations.

The distinction between laminar and turbulent pipe flow and its dependence on an appropriate dimensionless quantity was first pointed out by Osborne Reynolds in 1883. The flow in a round pipe is laminar if the Reynolds number is less than approximately 2100. The flow in a round pipe is turbulent if the Reynolds number is greater than approximately 4000. For Reynolds numbers between these two limits, the flow may switch between laminar and turbulent conditions in an apparently random fashion (transitional flow) (Munson et al, 2006).

2.4 Drag Reduction

Reduction of drag is closely associated with the reduction of fuel consumption in automobiles, submarines, and aircraft; improved safety and durability of structure subjected to high winds; and reduction of noise and vibration. But some cases drag produces a very beneficial effect (Cengel et al, 2006). For example, parachute activity which is use the drag concept. Sometimes, drag came as problem that gives bad affect. In pipe line, drag is one of the factors that cause the energy loss. So, there is method that used to prevent energy loss which is passive and active techniques (Choi, 1996). Active technique is addition weather polymers, surfactants or suspended solid into solvent to reduce the drag force. Compared to passive technique, active technique is better in term efficiency. It can achieve about 80% level of drag reduction. Among all the techniques, additions of minute amount of high molecular weight polymers and surfactants have been very active area of research ever since Toms reported it in 1949 (Toms, 1949). Between polymers, surfactants and suspended solid, there are no good drag reducing agent. It all depend on the chemical involve in pipe line because there are differences between these additive. The friction pressures observed in laminar flow cannot be changed unless the physical properties of the fluid are changed. The current class of drag reducing agents does not change fluid properties and hence they are effective only in turbulent flow.

2.5 Drag Reducing Agent

Generally, there are three type of drag reducing agent which is polymer, surfactant, and suspended solid. Rheology of this drag reducing agent is important part of drag reduction. Though very dilute drag-reducing solutions have rheological behaviors similar to Newtonian solvents except for the anionic polyacrylamide solutions having shear-thinning behaviors at drag-reducing concentration of 50 ppm (Vlassopoulos et al, 1993 & 1994), their extensional effects may be important.

2.5.1 Polymer

Polymer is one of Drag Reducing Agent. Drag reduction using polymeric additives is an active field of research in non-Newtonian fluid mechanics. It been investigated in aqueous and hydrocarbon liquids.

Table 2.1: Several type of polymer of drag reducing agent

Water-soluble polymers	**Solvent-soluble polymers**
Poly (ethylene oxide)	Polyisobutylene
Polyacrylamide	Polystyrene
Guar gum	Poly(methyl methacrylate)
Xanthan gum	Polydimethylsiloxane
Carboxymethyl cellulose	Poly(cis-isoprene)
Hydroxyethyl cellulose	

The polymeric additive solutions often display a shear-rate depended shear-thinning rheology (Hoffmann et al, 1987) with the exception of some surface-active polymers (or polymeric surfactants) such as hydroxyethyl cellulose and polyethylene oxide. As the average molecular weight of polyethylene oxide is increased from 2 x 10^5 to above 5 x 10^6, the solution concentration to achieve about 70 % drag reduction on a rotating disk is reduced from 600 to 100 ppm (JW Hoyt, 1986). In other words, the higher the molecular weight, drag reduction is greater for a given concentration and Reynolds number. High molecular weight polymers ($>10^5$) are very effective