FLUID FLOW IN HORIZONTAL PIPELINE WITH LEAKAGE

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Specially dedicated to

The loving Creator who fills our universe with thousands of knowledge to explore

The beloved supportive, loving and caring husband

Not yet quite understand ummi's situation, Lil Asma

The one who never tired on pushing me in completion of this dissertation
Ummi, abah, mama and abah-in-law

The understanding and never ending support from
murabbi, usrahmates and akhawat

And the never left behind siblings
Thank you for your time baby-sitting Lil Asma

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ABSTRACT

Transportation of fluids in pipelines requires a keen monitoring in order to detect major malfunction such as leakage. In the petroleum industry, leaks of hydrocarbon products from pipelines will not only represents the loss of natural resources, but it also may potentially cause a serious, dangerous and severe environmental damage or pollution and potential fire disaster, as well as economic loss. In this study, we would like to see the pattern or trend of pressure and fluid velocity in a leakage pipeline. The patterns of selected different parameters on variable pressure and fluid velocity are compared. The selected parameters are friction, pipeline diameter, pipeline length, and pipeline wall thickness. Two governing equations which are continuity and momentum equations are approximated by using characteristic line method. The governing equations are then discretized by using finite difference method and solved numerically. A set of data is collected with the help of *MATLAB*, the result of the study are plotted in *Microsoft Excel* and analysed. The study shows parameter pipeline wall thickness is the factor that contributes less effect for fluid flow in pipelines with leakage.

ABSTRAK

Pengangkutan bendalir dalam saluran paip memerlukan pemantauan terperinci untuk mengesan kerosakan utama seperti kebocoran. Dalam industri petroleum, kebocoran produk hidrokarbon dari saluran paip bukan sahaja akan menyebabkan kehilangan sumber semula jadi, tetapi ia juga berpotensi menyebabkan kerosakan yang serius, merbahaya dan teruk ke atas alam sekitar atau pencemaran dan berpotensi menyebabkan bencana kebakaran, dan juga kerugian ekonomi. Dalam kajian ini, kami ingin melihat corak atau trend tekanan dan halaju bendalir dalam saluran paip yang bocor. Corak parameter yang berbeza ke atas pemboleh ubah tekanan dan halaju bendalir dibandingkan. Beberapa parameter yang dipilih ialah geseran, garis pusat paip, panjang paip, dan ketebalan dinding saluran paip. Dua persamaan kawalan iaitu persamaan kesinambungan dan persamaan momentum dianggarkan dengan menggunakan kaedah garis ciri. Seterusnya persamaan kawalan didiskritasi dengan menggunakan kaedah pembezaan terhingga dan diselesaikan secara berangka. Satu set data dikumpul dengan bantuan *MATLAB*, keputusan kajian diplot dalam *Microsoft Excel* dan dianalisa. Kajian ini mendapati bahawa parameter ketebalan dinding saluran paip merupakan faktor yang kurang memberi kesan bagi aliran bendalir dalam paip yang bocor.

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LIST OF SYMBOLS

A	Pipe cross-sectional area [m^2]
a	Wave speed [*m/s*]
B	Pipe wave velocity constant
C^+, C^-	Positive and negative characteristic equation sets
c_1	Pipe loading condition
D	Pipe diameter (inner) [*m*]
D/Dt	Total derivative
E	Young's modulus [N/m^2]
E	Wall roughness of pipe [*mm*]
F	Darcy-Weisbach friction factor
g_x	Acceleration due to gravity [m/s^2]
H	Hydraulic head [*m*]
P	Pressure [*Pa*]
Q	Flow rate [m^3/s]
R	Pipe friction constant
R_1	Pipe Radius [*m*]
r	Radial pipe position [*m*]
u_r, u_θ, u_x	Radial, rotational and axial components of fluid velocity [*m/s*]
u	Fluid velocity (axial) [*m/s*]
V	Fluid velocity [*m/s*]
x	Distance along length of pipe [*m*]
z	Pipe elevation [*m*]
α	Bulk modulus of water [N/m^2]

ε_T	Circumferential strain
λ	Unknown multiplier used in Method of Characteristics derivation [*m/s*]
μ	Fluid viscosity [Ns/m^2]
ρ	Fluid density [kg/m^3]
σ_θ	Circumferential pipe stress [N/m^2]
σ_z	Axial pipe stress [N/m^2]
τ	Shear Stress [N/m^2]
υ	Poisson’s ratio

CHAPTER 1

INTRODUCTION

1.1 Research Background

Nowadays, developing countries are paying more and more attention in oil industry. The demand for oil is much higher than what it actually produces. Not many countries in this world are lucky to have this limited natural resources lying underneath the ground within their border. Big developing countries are competing with each other to become the prominent supplier in the oil industry.

The oil industry is a very important industry in the world because lots of things actually rely and depends on the price of the oil. It has been observed that whenever the oil prices increase, various products will face price increment as well. Furthermore, whoever controls the oil industry, controls the world market.

That is why every country would like to establish its own oil plantations. The cost of installation, operational optimization, maintenances, timing of increasing facility capacity and long term utilization of pipelines are took into considerations by countries afar before establishing it.

In addition to that, transportation of oil in pipelines requires a keen observation and monitoring in order to detect major malfunctioning like leakage for example. A small leakage may seem as a tiny problem and does not bring any effects to the world. I dare to say such speculation is far from truth. In the oil industry, a small and tiny leakage from pipelines may potentially cause dangerous environmental damage as well as bring economic loss to countries, industries and companies.

As the oil or petroleum industry constantly evolves, the need for fault detection and isolation (FDI) in pipelines becomes more and more important, both to save the environment from possible harm, as well as prevention of economic loss. Gratefully, many sites in petroleum industry are obligated to include some sort of FDI.

Benjamin Franklin, who was the founding fathers of the United States and in many ways was "the First American" once said,

“A small leak will sink a great ship”.

Pipelines do break all the time. In the United States of America, Exxon’s Pegasus pipeline can carry more than 90,000 barrels per day of crude oil from Pakota, Illinois to Nederland, Texas. At the end of March 2013, Pegasus had a leak and spilled between 3,500 - 5,000 barrels of crude oil into neighbourhood streets and lawns in Mayflower, Arkansas.

Whereas, Shell with a similar or what not might be a worse story had three major oil spills within the same week. The last one was in Texas where they estimated that 700 barrels of oil had been lost, amounting to almost 30,000 gallons of crude oil. With the correct model and measurements it may be possible to detect faults like these so that the pipeline can be closed off before it causes too much damage.

In 2012, they believed there had been a leakage in pipelines that then caused oil spill seeps into the Miri River located in Sarawak, Malaysia. The massive oil spill forced a major water treatment plant near it to shut down due to interruption of 125 million litres of water supply for daily consumption to a population of 300,000 people in the city.

According to the experience of European transit countries, the transit of oil may causes great losses regarding the ecological situation thus counteracting the intended political and economic benefits. The leaks caused by damage of pipelines are usually very dangerous. Intensive leakage can stimulate explosions, fires and to some extend may cause environmental pollution, which then will lead to an ecological catastrophe.

Leakages may result, for example, from bad workmanship or from any destructive cause, due to sudden changes of pressure, corrosive action, or lack of maintenance. In most cases, the deleterious effects associated with the occurrence of leaks may present serious problems. For instance, the leak of highly inflammable or poisonous gas and fluids may be lethal if it occurs in populated areas. Whereby, leakages occurring in oil pipelines constitute a loss of energy and the price of which is increasing at exorbitant rates. That is unreasonably high. In submerged lines leaks might lead to environmental pollution.

Although it seems that small leaks are not so dangerous, but in practice it is important to carry out special actions preventing such kind of leaks as well, because the spilt oil can damage the corrosion resistant cover of pipeline and can cause the corrosion processes. The damage can be worse. Figure 1.1 shows a simple illustration of a leakage in a pipeline.

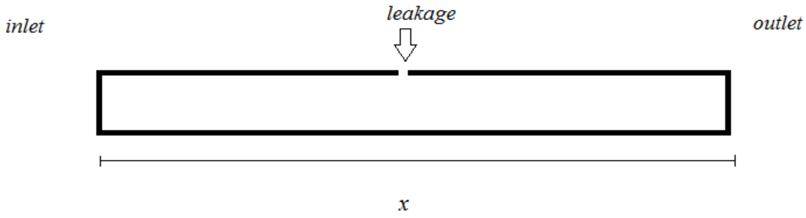

Figure 1.1 Simple leakage pipeline

That is why the determination of damage place in pipelines in time is the significant problem. There are many scientific articles, research and journals denoted to the problem of the leak-detection modelling. The pipeline damage character is determined by the leak intensity. At the same time the smaller the intensity of leak, the harder the discovery of damage is and much harder to find where the leak is situated.

In this study, we are interested on seeing the pattern of pressure and fluid velocity for a fluid flow in a leaking pipeline. A several parameters will be selected in order to see any changes of the pressure and fluid velocity's pattern or trend. We would like to know how far the parameters gives effect to pressure and fluid velocity in pipeline.

1.2 Problem Statement

Leakage in oil pipelines may cause major effect to the environmental health. When the oil seeps into the river, it will cause water pollution and affecting the aquatic life. That is not just all. It will also affects human's daily routine. If the polluted water seeps into the ground, underground water will be contaminated and lots of money are going to be spent for repairing cause in order to improve the situation.

In addition, it will also bring major loss to economic growth as well. Maintaining pipelines from corrosion and leakage is very important. There are lots of methods proposed and experimented in order to detect pipeline leakage. Unfortunately, to conduct an experiment is very costing and time wasting as well. The pressure and fluid velocity of oil in a leaking pipeline can also be seen by using mathematical approach.

1.3 Objectives of the Study

1.3.1 To formulate a mathematical model for flow in a leakage pipeline.

1.3.2 To obtain and solve the model using numerical method.

1.3.3 To analyze results of the pressure and fluid velocity pattern in a leakage pipelines due to different parameter.

1.4 Scope of the Study

There are many types of pipelines. But, in this research, we will only focusing on horizontal pipelines. We are also interested in looking at the effects of friction, pipeline diameters, pipeline length and pipeline wall thickness towards fluid flow in leakage pipeline. Hence, we use the developed model for the flow in pipelines where its solution is sought numerically.

1.5 Significance of the Study

The significant of the study is to prove method proposed by other researchers before this. The proven method can be applied in order to prevent cost and time wasting. By looking at the pattern or trend of the effects of selected parameters on fluid flow, the selected parameters may took into consideration in reducing pipeline leakage in future.

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