UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPLICATION OF FUZZY LOGIC MODELLING IN FLUID FRICTION OF BORE PIPE

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

by

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DECLARATION

I declare that this report entitled *"Application of Fuzzy Logic Modelling in Fluid Friction of Bore Pipe"* is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……

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Date : 18th December 2017

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours. The supervisory is as follow:

……

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ABSTRAK

Gesekan bendalir adalah perlawanan terhadap gerakan objek melalui cecair atau gas. Untuk memindahkan jumlah cecair yang diberikan melalui paip memerlukan ukuran tenaga tertentu. Perbezaan tenaga atau tekanan mesti ada untuk membuat cecair bergerak. Sebahagian daripada tenaga itu hilang kepada rintangan untuk mengalir. Rintangan aliran ini dipanggil kehilangan turus kerana geseran. Pemodelan logik kabur adalah salah satu jenis kemajuan intelek yang dapat membantu untuk menghitung dan meramalkan hasil eksperimen. Beribu-ribu data boleh digunakan dan peramalan boleh dibuat berdasarkan data ini. Oleh itu, menjimatkan masa dan mengurangkan kos dalam melakukan eksperimen. Logik kabur adalah teknik matematik yang berkaitan dengan data dan masalah yang tidak spesifik yang mempunyai banyak penyelesaian berbanding dengan satu. Di samping itu, sistem pemodelan logik kabur menawarkan potensi untuk andaian yang lebih bersesuaian daripada pemodelan masalah kehidupan nyata. Kajian ini memperkenalkan pemodelan logik kabur dalam geseran bendalir untuk meramalkan kehilanga turus geseran paip . „Matlab fuzzy logic toolbox" digunakan untuk membantu dalam pemodelan kabur. Jumlah perbezaan purata dihitung untuk membandingkan nilai ramalan daripada pemodelan logik kabur dengan nilai eksperimen dan teori. Analisis menunjukkan bahawa pendekatan pemodelan logik kabur memberikan nilai yang lebih baik dan lebih dekat kepada nilai sebenar.

ABSTRACT

Fluid friction is the resistance to an object's motion through a liquid or gas. To move a given volume of liquid through a pipe requires a specific measure of energy. An energy or pressure difference must exist to make the liquid to move. A part of that energy is lost to the resistance to flow. This resistance to flow is called head loss because of friction. Fuzzy logic modelling is one of the types of artificial intelligence that can help to calculate and forecast the output of an experiment. Thousands of data can be applied and forecasting can be made based on this data. Hence, saving time and diminish cost in conducting experiment. Fuzzy logic is a mathematical technique that deals with the unspecific data and problems that have many solutions rather than one. In addition fuzzy logic modelling system offers the potential for a more amenable, less assumption approach to the modelling of real life problems. This research introduces a fuzzy logic modelling in fluid friction in order to forecast the head loss in pipe. A Matlab fuzzy logic toolbox is utilized to help with the fuzzy modelling. The mean absolute error is calculated to compare the forecasting value by fuzzy logic modelling with experimental and theoretical value. The analysis shows that the fuzzy logic modelling approach gives better and closer value to actual values.

DEDICATION

I dedicate my dissertation work to my family and friends. A special feeling of gratitude to my loving parents, Baskaran and Amuthaa whose words of encouragement and push for tenacity ring in my ears. I also dedicate this dissertation to my friends who supported me throughout the process. I will always appreciate all they have done, especially Ravindran and Kathires for helping me develop my technology skills. I dedicate this work and give special thanks to my best friend Suhasri and my beloved supervisor Ezzatul Farhain Binti Azmi for being there for me throughout the entire research. Both of you have been my best cheerleaders.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AI	-	Artificial intelligence
FL	-	Fuzzy logic
ANFIS	-	Adaptive Neuro-Fuzzy Inference System
ABS	-	Anti-lock braking system
FIS	-	Fuzzy inference system
h	-	Head loss
u	-	Federation of Malaysian Manufacturers
μ	-	Dynamic viscosity
ρ	-	Mass density
Q	-	Flow rate
d	-	Internal diameter of pipe
g	-	Acceleration due to gravity
T	-	Time
V	-	Volume
π	-	Pi
L	-	Length
l	-	Litre
m/s^2	-	Metre per Second Square
m/s	-	Metre per second
f	-	Friction coefficient
kg/m^3	-	Kilogram per metre cube
kg/ms	-	Kilogram per metre second
m	-	Metre
GUI	-	Graphical User Interface
m^3/s	-	Metre cube per second

CHAPTER 1

INTRODUCTION

1.1 Introduction

The investigation of mathematical modelling is a system of a framework utilizing scientific ideas and language. Therefore mathematical modelling scientific displaying utilizing different mathematical structures that is graphs, equations, diagrams, scatterplots, and tree diagrams to certifiable real world situations also to solve and formulating the scientific issues. The model conveys a deliberation that brings down the issues to its pivotal attributes. Scientific models are utilized as a part of the common sciences and engineering disciplines and additionally in the sociologies. A model can disclose a framework and to consider the result of various segments, and to make forecasting about behaviour. One of the mathematical modelling that utilized as a part of this research is Fuzzy Logic modelling. Fuzzy logic is fundamental to the improvement of human-like capacities for artificial intelligence, at times referred to as artificial general intelligence that representation of generalized human subjective capacities in programming so that can looked with a surprising undertaking and artificial intelligence framework could discover an answer. Also, in this research, Fuzzy logic is endeavoured to apply in fluid friction to anticipate the head loss in pipe. Fluid friction is the resistance to an object's movement through a fluid or gas. At the point when the movement is happening in a fluid, it is referred to as viscous resistance. Resistance to an object traveling through a gas, for example, air, is named friction. The estimation of head loss in pipe for the research is acquire by doing the fluid friction experiment and furthermore by calculated utilizing a pipe friction equation. At that point compare the both head loss

value and the values anticipated by Fuzzy logic modelling and guarantee the value is near the experimental and calculated value.

1.2 Rational of the study

The reason of the study is to measure friction head loss in pipe by doing experiment, calculated by a pipe friction equation, and predicted by using Fuzzy Logic modelling. From this, we can study the difference between the data obtain from experiment, calculated by using pipe friction equation and the data predicted by the Fuzzy Logic modelling.

1.3 Problem Statement

Nowadays, the person who involved in academics study, principally students faces a major problem when they have to spend much time and money to accumulate the data for an experiment. These researches improve to reduce time and cost spent in handling an experiment by using the Fuzzy logic modelling. In addition, as engineering student, we can study the forecasting data by using the Fuzzy Logic modelling.

1.4 Objective

The objectives of the study are:

i. To study Fuzzy Logic modelling in friction head loss in pipe and velocity for flow of water through smooth bore pipes.
ii. To establish Fuzzy Logic modelling from fluid friction data by using Matlab software.
iii. To determine the difference between the values obtain from experiment, calculated by a pipe friction equation and predicted from Fuzzy Logic modelling.

1.5 Significance

The significances of the project are:

i. This research will save the time and cost of the engineering students and also may help other researchers in handling the experiment in the future.
ii. The Fuzzy Logic modelling will allowed as many data as wished to be process.
iii. The Fuzzy Logic modelling also can forecast the best output needed.
iv. The Fuzzy Logic modelling is alternative way to determine the friction head loss in pipe rather than experimental or calculation.

1.6 Scope of study

This research will be concentrate on method of Fuzzy Logic modelling which applies in the engineering field. We gain the friction head loss data from the Fluid Mechanics laboratory of Faculty of Engineering Technology (FTK), Universiti Teknikal Malaysia Melaka (UTeM). Then the data will be compared with the data from calculated equation and predicted from Fuzzy Logic modelling.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

Research on artificial intelligence over the most recent two decades has fundamentally enhanced performance of both assembling and service frameworks. Right now, there is a dreadful requirement for an article that exhibits a comprehensive literature survey around the world, hypothetical structures and practical experiences in the field of artificial intelligence. This paper reports the state of the art on artificial intelligence in an integrated, sharp, and smooth refined way to demonstrate the encounters in the field. Particularly, this research delivers a wide audit of late development inside the field of artificial intelligence (AI) and its applications.

According to the father of Artificial Intelligence John McCarthy in 1958, it is "The science and engineering of making intelligent machines, especially intelligent computer programs". AI is an intelligent design and study of computer program. This program is established to perform as intelligent as the human or animal‟s behaviour. "The art of creating machines that performs functions that require intelligence when performed by people." (Kurzweil, 1990). AI is concerned with programs that respond to flexibly in situations that were not respectively anticipated by the programmer. "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991). Usually, we measure human‟s intelligence by observing how they solve problems and respond in unusual situation. Besides that, we evaluate computer programs in much the same way (Thomas, James and Yiannis, 1995).

AI is the study of intelligence behaviour in human, animal and machine and also the attempt to find ways in which such behaviour could be engineered in any of artefact. AI has been utilized for quite a while since the principal computer games. Alan Turing in 1950 presented Turing Test for assessment of knowledge and distributed Computing Machinery and Intelligence. Claude Shannon in 1950 distributed Detailed Analysis of Chess Playing as a search. There is few case of AI, one of the examples of AI that a great many people are most likely acquainted with is computer game. Moreover, turning your broiler on when you leave work as opposed to holding up to return home is an exceptionally advantageous capacity. An thermostat that knows when you're home and alters the temperature in like manner can enable you to spare cash by not warming the house when you're out.

2.2 Fluid mechanics

Mechanics is the most seasoned physical science that arrangements with both stationary and moving bodies affected by forces. Fluids are Newtonian, at the end of the day; there is a direct connection between the local shear stress and the local rate of strain, as first hypothesized by Isaac Newton (1642-1727). It is additionally expected that there is a straight connection between the local warm transition density and the local temperature gradient. The branch of mechanics that arrangements with bodies very still is called statics, while the branch that arrangement with bodies in movement is called dynamics. The subcategory fluid mechanics is characterized as the science those arrangements with the conduct of fluids at rest or in movement, and the interaction of fluids with solids or different fluids at the limits.

Fluid mechanics is additionally alluded to as fluid dynamics by considering fluids at rest as an extraordinary instance of movement with zero speed. Fluid mechanics itself is likewise isolated into a few classifications. The study of the movement of fluids that are for all intents and purposes incompressible is normally alluded to as hydrodynamics. A subcategory of hydrodynamics is hydraulics, which manages liquid flows in pipes and open channels. Gas dynamics manages the flow of fluids that experience huge density changes, for example, the flow of gasses through

nozzles at high speeds. The category aerodynamics manages the flow of gasses over bodies, for example, aircraft, rockets, and automobiles at high or low speeds. Some other particular classes, for example, meteorology, oceanography, and hydrology manage naturally occurring flows. Leonardo da Vinci (1452-1519) an overall genius born in Italy.

2.2.1 Utilization of Fluid Mechanics

Fluid mechanics is comprehensively utilized in daily activities and in the outline of modern-day frameworks of engineering from vacuum cleaners to aircraft. In this way, it is very important to build up a decent understanding of the essential standards of fluid mechanics. In any case, fluid mechanics assumes an essential part in the human body. The heart is constantly pumping blood to all parts of the human body through the supply routes and veins, and the lungs are the places of airflow in first one side then the other. Obviously, the fake hearts, breathing machines, and dialysis frameworks are outlined utilizing fluid movement.

The utilizations of fluid mechanics in an ordinary house widespread nowadays, for example the piping frameworks for chilly water, flammable gas, and sewage for an individual house and the whole world are depends mostly on the theory of fluid mechanics. Without a doubt, the operation of common fixtures depends on fluid mechanics, for example a cooler with tubes through the refrigerant flows, a compressor that pressurizes the refrigerant, and to make refrigerant ingests and deny warm by two warmth exchangers. Fluid mechanics assumes a noteworthy part in the plan of every one of these segments.

In an automobile there are numerous applications of fluid mechanics that we can consider. All components associated with the transportation of the fuel from the fuel tank to the barrels the fuel line, fuel pump, fuel injectors, or carburettors and additionally the integration of the gasoline and the air inside the cylinders and the cleansing of burning gasses in exhaust

pipes are analysed using fluid mechanics. Fluid mechanics is moreover applied as a part of the plan of the heating and air-conditioning system, the hydraulic brakes, the electricity steerage, computerized transmission, and lubrication structures, the cooling arrangement of the motor block which includes the radiator and the water pump, and even the tires. Numerous natural phenomena, as an instance, the rain cycle, climate styles, and the ascent of floor water to the best point of timber, winds, sea waves, and currents in huge water our bodies are additionally administered by using the standards of fluid mechanics as appeared in **Figure 2.1**.

Figure 2.1: Standards of fluid mechanics

2.2.2 Classification of fluid flows

Fluid mechanics can be characterized as the science that preparations with the behaviour of fluids at relaxation or in motion and the interaction of fluids with solids or one of a kind fluids at the limits. There is an extensive style of fluid go with the flow problems skilled in practice, and it is far typically useful to represent them on the basis of some primary characteristics to make it viable to observe them in groups. There are various techniques to classify fluid flow issues, and right here exhibited some general classes.

2.2.2.1 Viscous versus Inviscid Regions of Flow

A friction force created amongst them at the point when two fluid layers move relatively to each other and the slower layer tries to back off the speedier layer. The inward stickiness of the fluid is measured by internal resistance from flow and it evaluated by the fluid property viscosity. The durable forces between the atoms in liquids and by sub-atomic crashes in gasses will create viscosity. All the fluid flows include viscous impacts to some degree; therefore, there is no fluid with zero viscosity. A viscous flows means that a flows in which the frictional impacts are significant. When inserting a level plate parallel into a fluid stream of uniform speed that appeared in **Figure 2.2**, it will produce the viscous and inviscid regions of flow.

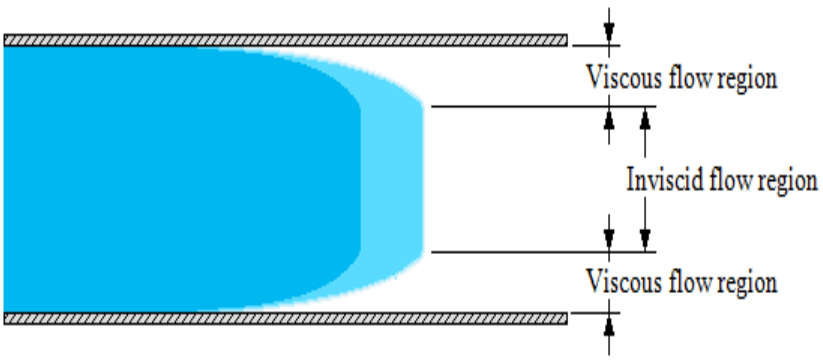

Figure 2.2: Fluid stream of uniform speed

2.2.2.2 Internal versus External Flow

A fluid flow is known as being inner or outer, contingent upon whether the fluid is pressured to flow in a constrained channel or over a floor. The flow of an unbounded fluid over a surface, for instance, a plate, a cord, or a pipe is outdoor flow. The flow in a pipe is interior flow if the liquid is totally surrounded by solid surfaces. Water flow in a pipe is known as interior flow, and airflow over a ball or over an uncovered pipe is known as outside flow as appeared in **Figure 2.3**. An open-channel flow is a flow of liquids in a pipe and the pipe is just in part loaded with the liquid and there is a free surface. The examples of such flows are water in rivers and water system trench.

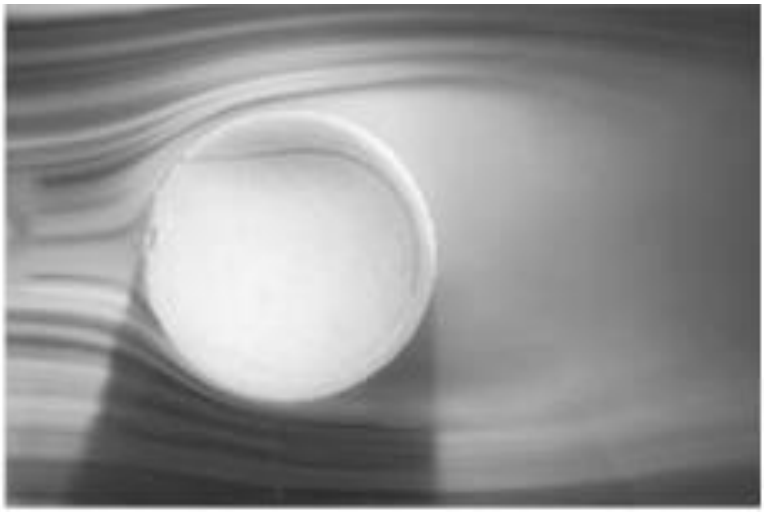

Figure 2.3: External Flow

2.2.2.3 Laminar versus Turbulent Flow

Some flows are very steady and rigid while another somehow messy. A laminar flow is a flow that is extremely precise by steady layers of fluid. The movement of adjacent fluid particles together in "laminates" is where the word laminar originates from. The examples

of laminar flow are the flow with high-viscosity fluids which is oils at low speeds. Turbulent flow as appeared in **Figure 2.4** is a flow that exceptionally cluttered smooth movement that ordinarily happens at high speeds and is characterized by speed fluctuations. The examples of turbulent flow of low-viscosity fluids are air at high speeds Transitional is a flow that exchanges between being laminar and turbulent, this examinations directed by Osborn Reynolds in the 1880s brought about the foundation of the dimensionless Reynold's number.

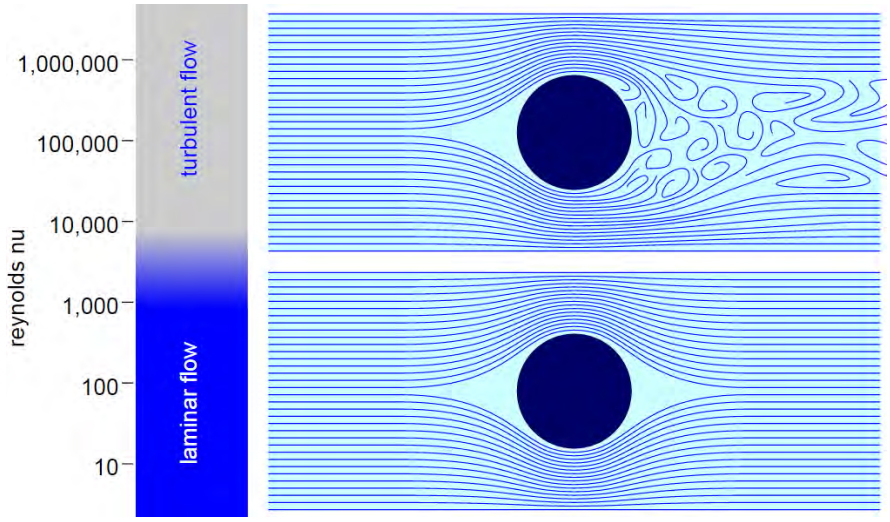

Figure 2.4: Laminar versus Turbulent Flow

2.2.3 Flow in pipes

Fluid or gas move through pipes or ducts is regularly utilized as a part of heating, cooling applications and liquid dispersion systems. J. Nikuradse in 1933, made an incredible commitment to the hypothesis of pipe flow by separating amongst harsh and smooth pipes. The fluid in such applications is generally compelled to flow by a fan or pump through a flow area. We give careful consideration to friction which is specifically identified with the pressure drop and head loss during move through pipes and ducts. The pressure drop is then used to decide the pumping power requirement. A typical piping framework includes pipes of various diameters associated with