UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PERFORMANCE EVALUATION OF FLUID FLOW IN A PIPE OF HEAT EXCHANGER

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

by

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I hereby, declared this report entitled “Performance Evaluation of Fluid Flow in a Pipe of Heat Exchanger ” is the results of my own research except as cited in references.

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APPROVAL

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

…………………………….

(Mrs. NURUL AMIRA BINTI ZAINAL)

ABSTRAK

Penukar haba adalah alat penting dalam semua sistem haba. a digunakan secara meluas dalam pelbagai peralatan industri seperti kawalan proses, penapisan petroleum, industri kimia dan lain-lain. Penjimatan bahan dan tenaga dipertimbangkan selari degan cabaran alam sekitar dan industry pada masa kini telah merangsang permintaan untuk kecekapan penukar haba yang berkesan. Untuk meningkatkan kecekapan penukar haba, seseorang perlu memikirkan peningkatan pemindahan haba dalam reka bentuk penukar haba. Jadi, kajian ini dijalankan dengan mereka bentuk penukar haba dan analisis dengan menggunakan perisian SolidWork. Tujuan kajian ini adalah untuk mengenalpasti tingkah laku bahan yang berlainan jenis iaitu tembaga, keluli tahan karat dan aloi kuning dalam dua model penukaran haba yang berbeza. Model pertama penukar haba ialah minyak kepada minyak. Model kedua penukar haba ialah minyak kepada air. Akhirnya bahan yang terbaik dalam kedua-dua model penukar haba boleh ditentukan dengan menggunakan simulasi pengiraan dinamik bendalir (CFD). Melalui keputusan simulasi, tembaga adalah yang paling cekap menukarkan haba berbanding keluli tahan karat dan aloi kuning dalam reka bentuk penukar haba ini.

ABSTRACT

Heat exchanger is an important device in all thermal systems. It is widely used equipment in numerous industries such as process control, petroleum refining, chemicals industry and etc. Energy and material saving considerations as well as environmental challenges in the industry nowadays have stimulated the demand for high efficiency of heat exchanger. To improve the efficiency of heat exchanger one must think of heat transfer enhancement in heat exchanger. So, this study is carried out with thermal designing and analysis by using SOLIDWORK software. The aim of this study is to investigate the behavior of different type material of heat exchanger i.e. copper, stainless steel and brass in two different models of heat exchanger. The first model of heat exchanger is set to be oil to oil heat exchanger. The second model of heat exchanger is set to be oil to water heat exchanger. Finally the best material in both models of heat exchanger can be determined using computational fluid dynamics (CFD) simulation. Through the simulation results, copper is the most efficiency heat transfer compared to stainless steel and brass in heat exchanger design. For the cooling agent, this study shows that water is more efficient cooling agent compared to the oil because water is able to absorb heat faster than oil.

DEDICATIONS

I acknowledge my sincere indebtedness and gratitude to my parents and my family for their love, support and sacrifice throughout my whole life. Their sacrifice had inspired me from the day I born until what I have become today. From the day I have born, they have teach me about how to learn and write. Without them, I cannot achieve the success, I cannot find an appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to achieve what I have today. Lastly, I would like to thanks all person which contributes to my bachelor degree project directly or indirectly. I would like to acknowledge their comments and suggestions, which has crucial for the successful completion of this project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CATIA	-	Computer Aided Three-dimensional Interactive Application
CAE	-	Computer-Aided Engineering
CAD	-	Computer Aided Design
k-ε	-	K-epsilon
k-ω	-	K-omega
CFD	-	Computational Fluid Dynamics
DNS	-	Direct Numerical Simulation
V	-	Mean velocity in pipes
D	-	Diameter of pipe
N	-	Kinematic viscosity of fluid
ρ	-	Density of fluid
μ	-	Dynamic viscosity of fluid
f	-	Friction Factor
τw	-	Shear Stress
Re	-	Reynolds number
C	-	Celcius
Mm	-	Milli Meter
PSM	-	Projek Sarjana Muda
FTK	-	Fakulti Teknologi Kejuruteraan
UTeM	-	Univesiti Teknikal Malaysia Melaka
SW	-	SolidWorks
2D	-	Two Dimensional
3D	-	Tree Dimensional

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter will explained the background of the study, problem statements, objectives, scope of this study and result expectation. The structure of the report of the study is briefly explained as well to ensure a better visualization of the sequence of the entire study.

1.1 Background of the Study

Heat exchangers are equipment that is commonly used to transfer heat between two fluid at different temperatures. Heat exchanger is an important device in various thermal systems for example condenser and evaporator in refrigerant system, boiler and condenser in steam power plant. (Nawras Shareef Sabeeh et al. 2014) state that, in the scientific physical fluid will separated by heat transfer surface, which is transfer from hot to cold agent. There are multiple type of heat exchangers such as shell and tube heat exchanger. Shell and tube exchanger consist a series of tube containing heated or cooled with the fluid being circulated over the tube. (Saunders et al. 1988), it used for highly pressure application owing to its robustness.

Different type of heat exchanger is plate heat exchanger commonly use in chemical process and other industrial application with specific consideration from food industry due it's to compact design, a very light surface area over small volume which modified per requirement, (Mazen et al. 2012). Plate and shell heat exchanger is a combine plate design with shell and tube to high operating temperature, compact size and low fouling. To name a few, (Yousefl, H.Mohammadi 2012), state that plate fin heat exchanger have a high degree of compactness that will saving materials.

Meanwhile, double pipe heat exchanger has concentric tube as develop with one fluid flow inside and another fluid flow with in circumventing second part. According to (Targui et al. 2008), flow in double pipe heat exchanger is either co-current or concurrent.

In recent years, many of researchers worked on the heat transfer and hydrodynamic characteristics of fluids in tube heat exchangers. The heat exchanger usually considered to be at a steady state and estimate resistance is use to calculate the temperature change between the fluid and the bore hole edge, see (Bernier et al. 2001), (Ground and Remund 1999), (Shonder and Beck 1999), (Xu X and Splitler 2006). According to (Lee and Lam 2008), (Marcotte and Pasquier 2008), (Acuna et al. 2009), (Incropera et al. 2007) numerical modelling and field measurement show that a constant temperature boundary condition is more representative of reality, and this result as an exponential variation in the fluid temperature with distance X around the pipe circuit.

The main concern of this study is actually to access and study the fluid behaviour in heat exchanger by using numerical simulation i.e Computer Aided Three-dimensional Interactive Application (CATIA) and SolidWork. CATIA is use to design and model a straight tube of heat exchanger based on fixed geometry. Meanwhile SolidWork software is used to investigate the flow behaviour in a straight pipe of heat exchanger. This study analysed two types of fluid which are water and oil to determine which one of this two fluids show a better flow in heat exchanger. In addition, the heat exchanger model used three different material which are copper, stainless steel and brass to identify the best material of a straight pipe of heat exchanger.

1.2 Problem Statement

Heat exchangers are widely used in food processing industry, dairy industry, biochemical processing, pharmaceutical, chemical plants and petroleum plants. Nevertheless, the effective using heat exchanger in those processes above is still questionable. Furthermore, failure of heat exchanger process is possible to retarded production of industries. As an example, the steam generators of nuclear power stations will be discussed as a problem statement. The main issues of steam generator have been focused by a report in USA which accounted about 3.2 % lost capacity factor in 1998, (Whyatt et al.1995). For the steam generators of nuclear power stations, thermal reactors, the average tube failure is 0.24 % per year based on plugging rate alone and 0.4-0.5 % per year based on plugging and sleeving, (Benjamin et al.1995).

Testing the properties of heat exchanger behaviour is the technique to increase heat exchanger performance. Therefore, this study is conducted to assess the fluid behaviour in heat exchanger by using numerical simulation. This study will use two different type of fluid with different viscosity to observe the behaviour of this two type of fluid in heat exchanger. In addition, will chose three different of material to make comparison and finally determine the best material of heat exchanger. The numerical simulation is used because it is effective and moreover, the use of numerical simulation is becoming increasingly important with the increase of computing power available.

1.3 Objective of this Study

Based on the background and problem statement stated above, the objectives of this project are stated below:

1. To design and model a straight tube pipe of a heat exchanger by using CATIA.
2. To simulate numerically the fluid flow interaction in a straight tube pipe of a heat exchanger by using SolidWork.
3. To study the behaviour between two different fluids which are water and oil in three different material types of heat exchanger which are copper, stainless steel and brass.

1.3 Scope of Study

In order to obtain the objectives of this study, the scope of the study is specified. In this study, a computer- aided design i.e CATIA and SolidWork is used to investigate the fluid behaviour in a straight tube of heat exchanger. The geometry of the heat exchanger is based on measurement from the previous study (cited papper). Additionally, this study will consider two different fluids which are water and oil.

Other than that, material of heat exchanger is classified into three different materials which are copper, stainless steel and brass. For the simulation part, SolidWork software is employed. SolidWork is a Computer Aided Engineering (CAE) simulation software platform. As the simulation part, SolidWork software is employed is in order to obtain the result to archive the objective of this study.

1.5 Outline of the Report

This report is divided into five chapters including this introducing chapter. Chapter 1 briefly discusses some general introducing and highlight the objectives of this study also the problem statement and scope of the study.

Chapter 2 makes review about the literature review of this study, meanwhile some mathematical formulation which describe on model description is discussed in Chapter 3.

Followed by Chapter 4, complete pre- processing result of the problem is obtain in detail and will be discussed briefly.

Chapter 5 finally provides the conclusion of this study as well as some suggestion and recommendation for future study.