ANALYSIS OF PRESSURE TRANSIENT IN HYDRAULIC SYSTEM (UTeM)

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**This report is submitted
in fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering (Thermal Fluid)**

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2017

DECLARATION

I declare that this project report entitled "Analysis of Pressure Transient in Hydraulic System" is the result of my own work except as cited in the references

Signature : ....

Name   : MOHAMAD SYAFIQ HUSNI BIN RAMLI

Date   : ....

APPROVAL

I hereby declare that I have read this project report and in my opinion, this report is sufficient in terms of scope and quality for the award of the Bachelor degree of Mechanical Engneering (Thermal-Fluid).

Signature   :   ....

Name of Supervisor :   DR. AHMAD ANAS BIN YUSOF

Date   :   ....

DEDICATION

To my beloved mother and father

ABSTRACT

Water Hammer/ Hydraulic Transient in a problem that happened to all type of pipe that have the fluid flow on it. It caused due to the pressure difference in the pipe which happened when the velocity of the fluid flow is suddenly stopped when the valve is closed. This effect will caused the damage to the pipes when the pressure exceeding the maximum pressure that can withstand for the pipe. The analysis of the hydraulic transient/water hammer is done to overcome this problem from happen in the pipeline especially in hydraulic system and it needs to create a simulation circuit of the hydraulic system. The designing of the system included system layout, the components of the hydraulic parts and the various type of sensors. The design phase can be categories into 3 sections which is by using MATLAB software simulation to create the circuit and requirement components. Secondly is to modify the hydraulic system according to the variables needed. Finally, putting few pressure sensors and flow rate sensor to get the data needed. Besides, the hydraulic transient/water hammer effect value can get from each variables used and need to compare which is the most factor that can create the higher hydraulic transient/water hammer in the system.

ABSTRAK

Water Hammer / Hydraulic Transient dalam masalah yang berlaku kepada semua jenis paip yang mempunyai aliran bendalir di dalamnya. Ia disebabkan oleh perbezaan tekanan di dalam paip yang berlaku apabila halaju aliran bendalir tiba-tiba berhenti apabila injap ditutup. Kesan ini akan menyebabkan kerosakan kepada paip apabila tekanan melebihi tekanan maksimum yang boleh ditahan untuk paip. Analisis *Water Hammer / Hydraulic Transient* dilakukan untuk mengatasi masalah ini berlaku terutamanya dalam sistem hidraulik dengan cara menghasilkan litar simulasi sistem hidraulik. Ia perlu untuk mereka bentuk satu sistem termasuk susun atur sistem, komponen bahagian hidraulik dan meletakkan pelbagai jenis sensor. Fasa reka bentuk boleh menjadi kategori kepada 3 bahagian iaitu dengan menggunakan simulasi perisian MATLAB untuk mewujudkan litar dan keperluan komponen. Kedua adalah untuk mengubah suai sistem hidraulik mengikut pemboleh ubah yang diperlukan. Akhirnya, meletakkan beberapa sensor tekanan dan sensor kadar aliran untuk mendapatkan data yang diperlukan. Selain itu, nilai *Water Hammer / Hydraulic Transient* kesan boleh didapati bagi setiap pemboleh ubah yang digunakan dan perlu membandingkannya bagi mengetahui faktor terbesar yang menyebabkan *Water Hammer / Hydraulic Transient* itu lebih tinggi di dalam sistem.

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to Allah S.W.T. for giving me good health for compliting this PSM II (Projek Sarjana Muda II). Besides, I would like to express my appreciation to my supervisor Dr. Ahmad Anas bin Yusof for giving me the opportunities to do this project with him and for all of his support, comment and advices. He never hesitated to advice and guiding me eventhough I confronted problems.

Other than that, I would like to thank a senior named Saiful Akmal Sabaruddin for spending time, teach and guiding me a lot to finish up this project. He helped me a lot of skill on using MATHLAB Software and MS Excel during the project period. I also like to thank to laboratory assistant, Mr. Ikmal for his kindness during all this time.

I would like to thanks to my beloved family who always give me non-stop support and motivation during completing my project. I'm appreciated their understanding so much. Not forget to all my course mates for their commitment and always with me by giving the inspiration and motivation for me to completing this project. Finally, thank you to the people who are around me who give me support which is direct or indirect for the contribution in this work.

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LIST OF SYMBOLS

P   =   Pressure

Q   =   Flow rate

ρ =   Fluid Density

e   =   Thickness of pipeline

D   =   Diameter of pipe

E   =   Modulus of Elasticity

K   =   Bulk Modulus

c   =   Speed of sound for Fluid

CHAPTER 1

INTRODUCTION

1.1   Background

Hydraulic Hybrid Vehicle (HHV) technology is brand new technology that compete to the more conventional Hybrid Electric Vehicle (HEV) technology as already found nowadays. (RohanHatti, 2015). Additional storage for HHV consists of pressurize oil or water. The pressurized water will be store in the accumulator in term of potential energy by using pump. After the accumulator full, directional control valve (DCV) is utilized to channel the pressurized water to drive hydraulic motor. Regenerative brakes that has been used in certain hybrid, the energy lost normally occurred due to braking using the vehicle's inertia. (S.J. Clegg, 1996).

The flow rate of the system is controlled using electrical circuit by changing the speed of the motor. The performances of the system are measured and analyzed based on pressure, flow rate, torque of hydraulic motor, power output and power input of the system.

Transient weights are most essential when the flow rate is changed rapidly, such as resulting of fast or rapid valve terminations(closed) or pump stoppages. Such the disturbance happened, whether brought on by design or accident, may make voyaging or traveling pressure and very large magnitude of waves of the velocity. These transient of the pressure are superimposed on the enduring(steady)-state conditions present in the line when the time of the transient pressures happens. (Karl Kolmetz, 2014)

1.2   Problem Statement

Hybrid vehicles is considered as hybrid when it is using two or more power sources to operate the engine. Most of the heavy vehicles, such as lorries and buses require a lot of fuel consumption when accelerating after each stop. The fuel cost used is very high if the frequency it stops too often as it should accelerate again after that. At the same time, when the heavy vehicle brakes, energy that released is wasted. When the circuit or the flowing fluid are frequently open and closed, and when the flow is suddenly closed, it will cause the transient pressure or hydraulic transient occurred. It is very dangerous to the piping used in the circuit of the system. Based on the problems that occur, it will try to be solve by using a various variable to determine the causes of the hydraulic transient and to reduced it from happened in the system.
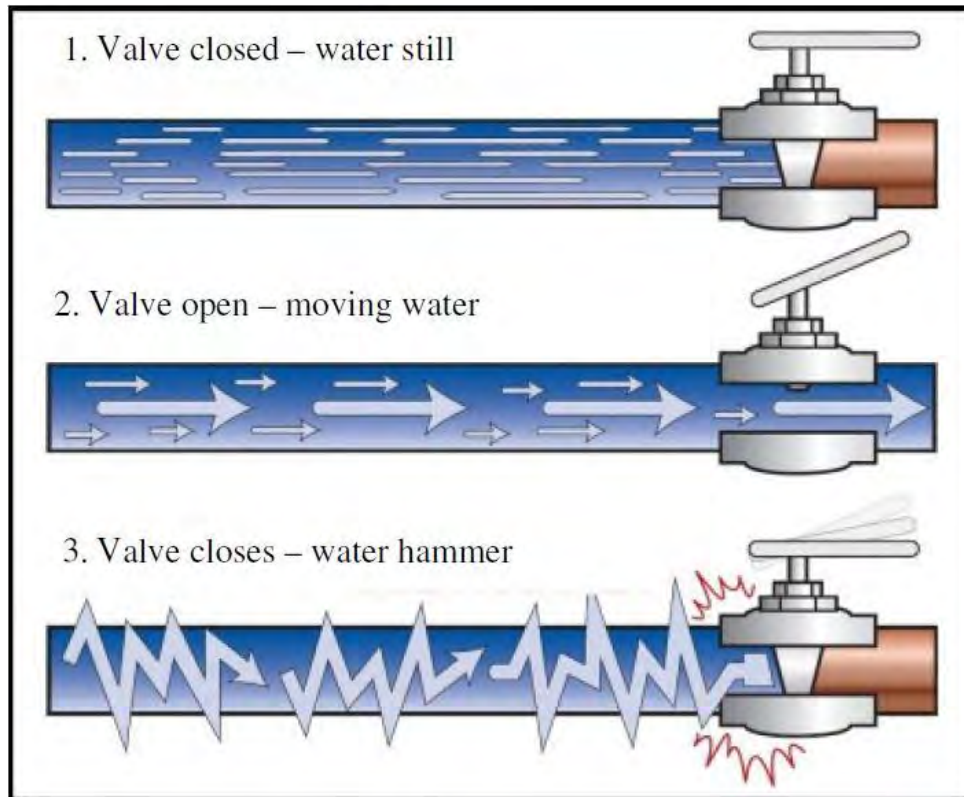
Figure 1.1: Hydraulic Transient (Water Hammer) Description

1.3 Objective

The objectives of this projects are as follows:

1. To study the effect of Hydraulic Transient/ Water Hammer on difference type of variables.

2. To analyze the data of Hydraulic Transient/ Water Hammer between simulation and Joukowsky Equation.

1.4   Scope of Project

The scope of this project is:

1. Develop a hydraulic transient /water hammer circuit in various type of variable by using MATLAB. (Objective 1)

2. Simulate the effect of hydraulic transient/water hammer by changing the variables of pressure, fluid used and length of pipeline. (Objective 1)

3. Analyze data gained by comparing from the variables used. (Objective 1)

4. Develop a hydraulic transient /water hammer circuit by using MATLAB. (Objective 2)

5. Simulate the effect of hydraulic transient/water hammer happened in circuit. (Objective 2)

6. Analyze data to measure the water hammer by using Joukowsky Equation. (Objective 2)

1.5 General Methodology

The actions that need to be carried out to achieve the objectives in this project are listed below.

1. Literature Review

   Journals, articles, and any materials that related about the rate of water hammer and its simulation, and how the water hammer/hydraulic transient working on the hydraulic hybrid system

2. Simulation

   Simulation of the water transient/water hammer in regenerative braking system will be made based on the data input. The data gained and compared after completing the whole hydraulic hybrid system of Tele-Operated Electro-Hydraulic Actuator by using MATLAB.

3. Analysis and proposed solution

   Analysis will be presented on how the hydraulic transient/water hammer occur in the hydraulic hybrid system. Solution will be proposed based on the analysis.

4. Report writing

   A report of this study will be written at the end of this project.

The methodology of this study is summarized in the flow chart as shown in Figure 3.

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┌─────────────────────────────────┐        ╭─────────────────────────────╮
│ 1)  Journal review              │        │                             │
│ 2)  Study the operation of      │        │     Literature Review       │
│     hydraulic transient         │        │                             │
│ 3)  Study of the MATHLAB        │        ╰─────────────────────────────╯
│     Software                    │                      │
└─────────────────────────────────┘                      ▼
┌─────────────────────────────────┐        ┌─────────────────────────────┐
│ 1)  Develop a hydraulic transient│       │                             │
│     /water hammer circuit in    │        │   Variable Change of the    │
│     various type of variable by │        │   System in Simulation      │
│     using MATLAB.               │        │                             │
│ 2)  Simulate the effect of hydraulic│     └─────────────────────────────┘
│     transient/water hammer by   │                      │
│     changing the variables of   │                      ▼
│     pressure, fluid used and length│     ┌─────────────────────────────┐
│     of pipeline.                │────────│     Block Modification       │◄───┐
│ 3)  Analyze data gained by      │        └─────────────────────────────┘    │
│     comparing from the variables│                      │                    │
│     used.                       │                      ▼                    │
└─────────────────────────────────┘                  ◇ Test the ◇            │
                                          No ◄────────◇   system   ◇          │
                                                      ◇           ◇           │
                                                           │ Yes               │
┌─────────────────────────────────┐                        ▼                  │
│ 1)  Develop a hydraulic transient│       ┌─────────────────────────────┐    │
│     /water hammer circuit by using│      │  Hydraulic Transient/Water  │    │
│     MATLAB.                      │       │  Hammer Simulation and      │    │
│ 2)  Simulate the effect of hydraulic│     │  Joukowsky Eqn.            │    │
│     transient/water hammer      │        └─────────────────────────────┘    │
│     happened in circuit.        │                      │                    │
│ 3)  Analyze data to measure the │                      ▼                    │
│     water hammer by using       │                 ◇ Data Obtained ◇    No   │
│     Joukowsky Equation.         │                 ◇   Satisfy     ◇─────────┘
└─────────────────────────────────┘                      │
                                                      Yes │
                                                          ▼
                                          ╭─────────────────────────────╮
                                          │     Report Preparation       │
                                          ╰─────────────────────────────╯
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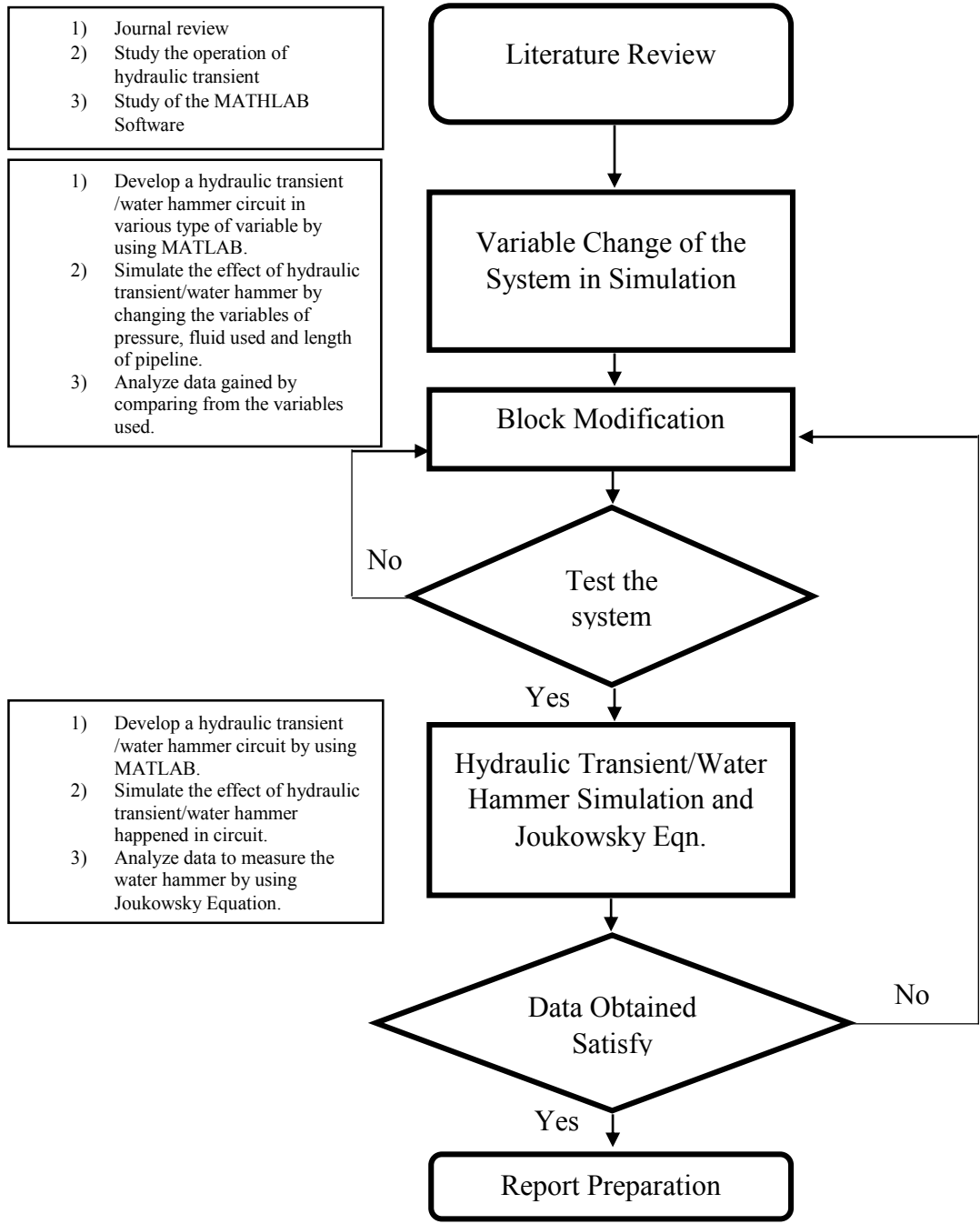
Figure 1.2: Flow chart of the methodology.

CHAPTER 2

LITERATURE REVIEW

2.1   Introduction

The literature review is a report assessment to discover information in the literature based on the selected area of study. The topic of the sources must identify and relate with the point and topics of the project so that improvement of the project can be continued.

Some related topics should be focused around, such as:

1.   Fluid Power of Hydraulic System

2.   Water Properties and their Effects

3.   Joukowsky Equation

4.   Hydraulic Transient/Water Hammer

2.2   Fluid Power of Hydraulic System

Liquid power is the innovation that identifies with the generation, control, and transmission of force utilizing pressurized liquids. Fluid power is called hydraulics when fluid is utilized as a medium to move in the system and pneumatics when gasses is utilized as a medium to move vitality in the system. Hydraulic transmit the power through pressure. Hydraulic that usually used as a part of industry is petroleum, oils, and synthetics oils. Compared to hydraulic oil, water is the first liquid used in the hydraulic system because it is readily available. By using the water hydraulic, the addictive need to put into the water to prevent freezing, rusting, and improved lubricants.

Fluid system has two different types, which is fluid transport and fluid power. Fluid transport system is used to achieve some purpose by using the moving of the liquid from one location to another location. Example include pumping stations for pumping water to homes, across pipes or gas lines, and system where chemical preparing or processing happens as different fluid are brought together (Esposito.A., 2009)

Fluid power system is designed to perform work by pressuring the fluid bearing in the cylinder or motor. Fluid cylinder produced only one axis motion of forced while the torque is produced by fluid motor. Actuator is the other name for fluid cylinder and fluid motor.

2.2.1 Components in Hydraulic System

Hydraulic system required about six (6) basic components in the circuit to operate, which are:

1. Reservoir (tank) – to store the hydraulic fluid used in the system

2. Pump – to force the hydraulic fluid to circulate through the system

3. Motor – using the electrical source in order to operate the pump

4. Valve – used to control the fluid direction, pressure and flow rate

5. Hose – to connect or carries the fluid around the hydraulic system (to another components)

6. Actuator – converts the fluid pressure (hydraulic energy) into mechanical force or torque. Actuator consists of two (2) which is cylinder(to provide linear motion) and motor(to provide rotary motion)

2.3 Water Properties and Their Effect

2.3.1 Density

Density of the hydraulic fluid will affect the losses of the hydraulic energy in the system. changes of the temperature and pressure in the hydraulic system will affect the density of a hydraulic fluid and it needs to keep the density as low as possible to reduce the losses of pressure and dynamic effects on the control valve. Water has about 10% higher of mass density than mineral oil (Trostmann and Clausen 1995).
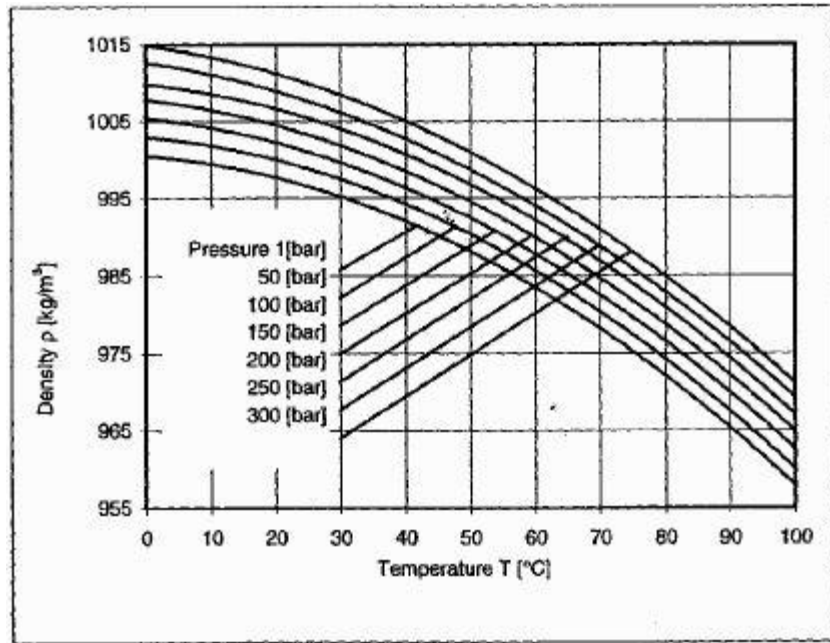
Figure 2. 1: Variation of mass density of pure water with temperature and pressure
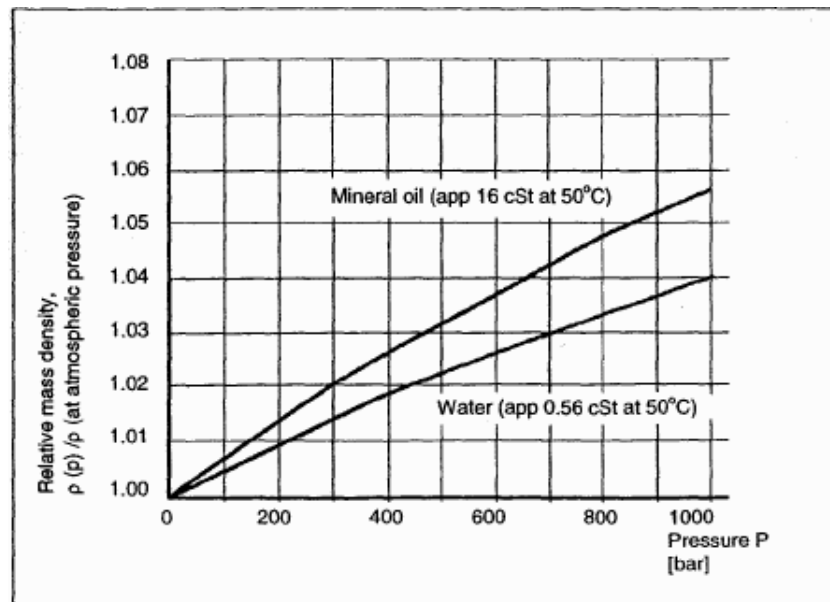
(Trostmann et al.2001).

Figure 2. 2: Comparison of the mass density of water with that of mineral oil at a given

temperature as pressure varies (Trostmann et al.2001).