Faculty of Manufacturing Engineering

ANALYSIS ON EFFECT OF BALL BLADDER SIZE DURING WATER HAMMER IN DOMESTIC WATER SYSTEM

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Master of Manufacturing Engineering (Manufacturing System Engineering)

2017

ANALYSIS ON EFFECT OF BALL BLADDER SIZE DURING WATER HAMMER IN DOMESTIC WATER SYSTEM

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A thesis submitted
in fulfilment of the requirements for the degree of Master of Manufacturing Engineering (Manufacturing System Engineering)

Faculty of Manufacturing Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

DECLARATION

I declare that this thesis entitled “Analysis on Effect of Ball Bladder Size during Water Hammer in Domestic Water 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	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion this report is sufficient in terms of scope and quality as a partial fulfilment of Master of Manufacturing Engineering (Manufacturing System Engineering).

Signature : ....

Name : ....

Date : ....

DEDICATION

I would like to give a very special appreciation to my beloved family and friends for always been there in the time of need. Thanks for giving me continuous support in order for me to fulfill the needs of my Master Project. To my beloved parents, Mohd Nasir bin Kassim and Sakina binti Shaik Ahmad Yusoff and to my supervisor, Dr Mohd Shahir bin Kasim, and all my friends who have encouraged, guided and inspired me throughout the study process.

ABSTRACT

This project is studying the effect of ball bladder size on hydraulic shock during water hammer for a domestic water system. Water hammer is a common phenomenon when pipe in our home is shut down suddenly and can cause pump failures, water system fatigue, pipe rupture and contaminated water backflow. Thus, produce loud banging or hammering noise. To prevent this phenomenon, a suitable accumulator is a must. A ball bladder type of accumulator has been chosen due to its flexibility, light in weight and capability to absorb the hydraulic shock during water hammer. There will be two parameters for the experiment, which are; pressure of water during water hammer and effect of ball bladder size on hydraulic shock. Then, these parameters will be the analysis for reducing the effect of water hammer for the future. The experiments were conducted by using DAQami software in order to understand the behaviour of the shock wave due to water hammer with the present of ball bladder. Therefore, from the analysis result, the accumulator with four ball bladders with the size of 862.52 cm^3 has the slowest time of water pressure increase when the test valve is shut down suddenly, no leaking at pipeline, no water droplets came out of the leaking and the sound of the pump is not noisy when the test valve is shut down immediately or suddenly. Besides that, the pressure of the shock wave is being reduced from 4.00 bar to 2.79 bar which was reduced to 1.21 bar (30%). Thus, an appropriate size of ball bladder will be determined for the domestic water system to prevent the water hammer with the size of 1523 cm^3 approximately to seven ball bladders.

ABSTRAK

Projek ini adalah untuk mengkaji kesan bebola pada kejutan hidraulik semasa tukul air berlaku untuk sistem air domestik. Tukul air adalah satu fenomena, di mana ianya berlaku apabila paip air di rumah ditutup dengan cepat atau tiba-tiba dan ianya boleh menyebabkan kegagalan pam, sistem air, paip pecah dan juga pengaliran balik air yang tercemar. Oleh itu, tukul air akan menghasilkan bunyi hentakan yang sangat kuat atau bunyi penukul di dalam saluran air domestik. Untuk mengelakkan fenomena ini berlaku, pemilihan penumpuk yang sesuai adalah satu kemestian. Penumpuk jenis bebola telah dipilih atas ciri-ciri berikut seperti kebolehlenturan, ringan dan keupayaan untuk menyerap kejutan hidraulik semasa tukul air berlaku. Projek ini akan menjalankan dua parameter, iaitu; tekanan air semasa tukul air berlaku dan kesan saiz bebola pada kejutan hidraulik. Kemudian, hasil kajian projek ini akan di analisis bagi mengurangkan kesan tukul air untuk masa hadapan. Ujikaji telah dijalankan dengan menggunakan perisian DAQami untuk memahami tingkah laku gelombang kejutan hasil daripada tukul air dengan kehadiran bebola. Hasil daripada analisis, penumpuk dengan empat bebola bersaiz 862.52 cm^3 mengambil masa yang lama untuk tekanan air naik apabila injap ditutup secara tiba-tiba, tiada kebocoran pada paip, tiada titisan air pada kebocoran dan bunyi pam tidak bising apabila injap ditutup serta merta atau tiba-tiba. Selain itu, tekanan gelombang kejutan dapat dikurangkan dari 4.00 bar ke 2.79 bar iaitu telah dikurangkan sebanyak 1.21bar (27%). Oleh itu, saiz bebola yang sesuai bagi sistem air domestik untuk mencegah tukul air ialah bersaiz 1523 cm^3 kira-kira tujuh bebola.

ACKNOWLEDGEMENTS

Bismillahirrahmanirrahim,

Alhamdulillah, thanks to Allah SWT, with his blessing and willing giving me the opportunity to complete this Master Project (MP). Firstly, I would like to express my deepest gratitude to my project supervisor, Dr Mohd Shahir bin Kasim who had guided me to complete this project successfully. I would like to express an appreciation for his idea, guidance, encouragement and professionally giving constant support in ensuring this project possible and run smoothly according to the planning schedule.

I also truly grateful to those lectures, especially Dr Ahmad Anas bin Yusof and staff in Faculty of Manufacturing Engineering and Faculty of Mechanical Engineering, that willing to help me in many ways. Sincerely thanks to them for their excellent cooperation, supports and inspiration during this project. Also, thanks to all my friends, those who have contributed by supporting my work, giving ideas and help me during this project started till it is fully completed.

Last but not least, deepest thanks and appreciation to my family for giving me encouragement and being with me during completing this project.

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LIST OF ABBREVIATIONS, SYMBOL AND NOMENCLATURE

DAQ	-	Data Acquisition
FKP	-	Fakulti Kejuruteraan Pembuatan
MP 1	-	Master Project 1
MP 2	-	Master Project 2
PVC	-	Polyvinyl Chloride
TR	-	Testing Rig
UTeM	-	Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

This chapter is about introducing the beginning of the proposed research. The title of this research is "Analysis on Effect of Ball Bladder Size during Water Hammer in Domestic Water System". This ball bladder accumulator will reduce the effect of water hammer in domestic water system. The content which will be discussed in this chapter is the background of study, problem statement, objectives and scope.

1.1 Background

Water operates in many conditions for example, making lives more pleasurable. Therefore, we must have the cautions not to overuse and abuse this precious resource. Water in its most complete form, it is odourless, nearly colourless and tasteless. In conditions of natural selection, human need water for living. So, water is the most important factor for the human organism. Without water, life is meaningless and disease will spread. All sorts of life require water, and if they do not receive enough of water, they will be deadened. In the past, water was used from the river, well and rainwater. In the new era, human can easily get water from the water storage tank or reservoir.

According to Department of Irrigation and drainage in 1982, Domestic Water system (DWS) defined as a system for the collection, handling, transmission, storage and distribution of water from source to consumers, for example, houses, irrigation facilities, industrial, commercial establishments, and public agencies for water related natural processes such as street flushing, fire fighting, and thus onward. DWS provides consumer with sufficient clean water. Common examples are gravity storage tanks and pressurized tanks located on the top floor of the building, connected to supply pumps. Domestic water supply is between 200 kPa to 690 kPa, but most home appliances are designed to operate with water pressure between 100 kPa to 830 kPa.

It is common that the low pressure of water supply is experiencing by domestic water user. However, some of the user facing high pressure, which can cause other problems. Gravity is the most effective way to bring water to the home. Therefore, the location for storage tank is higher so that water can flow by gravity. But not all can be supplied by gravity flow, some areas will require plumbing. Normally, water storage tank is filled at night when water use is lowest. The full tanks are then able to supply higher demand for water in the daytime. The water pressure at particular home will depend on the elevation of the home and proximity to the reservoir. The closer the home are to the elevation of the reservoir, the lower the pressure will be. Similarly, the lower the home is in relation to the reservoir, the higher the water pressure is supplied.

Do you always hear the sound of children playing marbles or sound of banging at night in your house? Timer range from 1 o'clock until 4 o'clock in the morning. This is due to water hammer, but then again, there are other things that create noise in water pipes which is the air in the pipe that easily confused with water hammer. The water hammer was literally blowing apart the system. Water hammer is known as hydraulic shock. It is caused by sudden changes of the water distribution network. Water hammer sounds are very common and something probably experienced. The sound is like a thumping or pounding in pipelines, for example by turning off a faucet, thus, witnessed the water hammer effect. Water hammer is the banging or thumping noise in pipelines, normally caused by pressure surge when a fluid changes direction instantaneously or is forced to stop. The sudden change in the liquid velocity generates a pressure wave which can have serious effects, ranging from pump defects to pipeline failures. The more severe water hammer is caused by the quick change at the inlet and the outlet of a water system.

The most usual causes are valves rapidly closing or pumps suddenly going online and offline. Fluid at liquid state is highly non-compressible. When an outlet valve closes quickly, the energy in the water flow will cause the nearest valve to compress. It acts like a spring, where the energy in the water system flows in a reverse direction, sending a shock wave until it hits a barrier, such as the pipeline joint. Energy from the shock wave reflects from the barrier and returns to hit the valve again. The shock wave moves back and forth within the pipeline until friction depletes the energy.

1.2 Problem Statement

Water hammer is a common phenomenon when a pipe in the house suddenly close. This produces a loud banging or hammering noise. The water hammer effect may cause pump failures, water system fatigue, pipe rupture and contaminated water backflow. Besides that, it can also lead to greater leakage and reduced reliability. Water hammer is a phenomena where it occurred when the flow been stopped suddenly, this phenomena is usually occurring from application of household appliances that use water as a medium to work, this phenomena cannot be prevented manually. Water hammer can cause pipeline failure due to high water pressure. For example, when the valve is close, the water downstream of the valve will attempt to keep falling, producing leaking at the pipe.

Therefore, the present of the accumulator can be solving to this water hammer problem. Unfortunately, existing accumulators are used mainly in large manufacturing plants and systems where they are used to absorb high capacity of pulsations and shocks. Such accumulators are not suitable for domestic uses which have a much lower volume and pressure have compared to the industries. When the water hammer occurs in houses, it is most likely that the pipelines have become waterlogged. To stop the water hammer, the only way is to shut off the water supply of the entire house, drain the whole system down, shut off all the valves and turn the water back on. The conventional method to solve the water hammer problems is very time-consuming.

Figure 1.1: Ball bladder accumulator.

Figure 1.1 shows the ball bladder accumulator that will be used in this project. Suitable accumulator is needed for domestic usage to prevent this problem. In order to have suitable accumulator, one of the factors that should be aware of is the size of ball bladder inside the accumulator. The ball bladder is needed to absorb the shock wave. Thus, the size of it must be accounted to have a suitable accumulator for domestic usage. Therefore, this master project is focused on study effect of ball bladder size on hydraulic shock during the water hammer for domestic water system. Then, the effect of the ball bladder size of water hammer will be analysis to study the behaviour of it.

1.3 Objective

The ultimate goal of this project is to study the effect of ball bladder size on hydraulic shock during water hammer for a domestic water system.

The specific objectives that need to be achieved are:

i. To investigate on rubber ball bladder condition during shock wave.
ii. To analyse the effects of ball bladder size of water hammer.
iii. To suggest the appropriate bladder size to absorb water hammer for domestic water system.

The purpose of this project is to study the effect of ball bladder size during water hammer.

1.4 Scope

The scopes that are being set as the guide of this research are:

i. To study the problems faced by domestic water system caused by the water hammer effect. Other factors which cause the damage of pipelines will not be discussed.
ii. To focus on the analysis of shock wave behaviour.
iii. To compare the efficiency of ball bladder size during shock wave.
iv. To understand the concept of hydraulic shock during water hammer.
v. Pressure limit was set 2.0 bar that suite for domestic supply water pressure.

1.5 Expected Outcome

Water hammer is highly noticeable while using appliances that require large volume of water. This is because the appliances use a quick-acting solenoid shutoff valve, where water stops suddenly when the valves are shut. Thus, shock wave happens when the water stops suddenly. Therefore, presence of accumulators is needed in water systems to reduce the harmful effects of water hammer. This project focuses on the size of ball bladder required in the accumulator to absorb the water hammer to reduce the damage in the pipeline.

1.6 Overview of report.

This report consists of five chapters that are divided into two parts which are Master Project 1 (MP 1) and Master Project 2 (MP 2). The first part MP 1 is structured into three chapters and the two chapters more are at MP 2. The first chapter is about the introduction of the project. It consists of background of the study involve the study the effect of ball bladder size on hydraulic shock during water hammer for domestic water system, problem statement of the project, scope, expected outcome, and lastly the overview of the report.

The second chapter is all about literature review. In this chapter, it comprises information about works from other researchers that related to this project's title. This chapter also explains about the domestic water system, water hammer, pipe leaking, and accumulator used to develop this project.

The third chapter describes the design process to achieve the objectives for this project. It includes overall methodology flowchart, preliminary work, and final prototype design. As a continuation from MP 1, MP 2 will cover the two more chapters which are Chapter 4 and Chapter 5. MP 2 focused more on experimenting and finding the result and discussion of the result. The result will be presented in Chapter 4 while Chapter 5 will represent the conclusion of this project in the form of whether it is successful or not based on the objectives achievement and in addition of future suggestion in order to improve this project.

CHAPTER 2

LITERATURE REVIEW

Basically, this chapter provides the summary of literature reviews key points related to the domestic water system, pipe leaking, water hammer, and accumulator.

2.1 Domestic Water System

According to the statistics provided by Suruhanjaya Perkhidmatan Air Negara (SPAN) as shown in Table 2.2, domestic water consumption in Melaka is 234 consumption per capita per day in the year of 2014 and 235 consumption per capita per day in the year of 2015. Table 2.1 shows that in the year of 2014, the water consumption for domestic in Melaka is 196 million liters per day (MLD) (52.1%) and 202 MLD (52.0%) in the year o2015. This is proven that water consumption keeps increasing yearly. Therefore, total water consumption in Malaysia increases from 10,176 MLD in 2014 to 10,445 MLD in year 2015. Figure 2.1 shows the percentage of proportion of domestic and non-domestic consumption (Suruhanjaya Perkhidmatan Air Negara, 2017). Thus, this can be concluded that water is very important in our daily life either for domestic or non-domestic usage.

Table 2.1: Water Consumption 2014-2015 (Suruhanjaya Perkhidmatan Air Negara, 2017).

State	2014					2015				
	Domestic		Non-Domestic		TOTAL	Domestic		Non-Domestic		TOTAL
	MLD	%	MLD	%	MLD	MLD	%	MLD	%	MLD
Johor	823	67.8	391	32.2	**1,215**	811	64.4	448	35.6	**1,259**
Kedah	510	73.2	187	26.8	**697**	511	72.8	191	27.2	**702**
Kelantan	154	68.3	71	31.7	**225**	159	68.6	73	31.4	**231**
Labuan	17	35.8	31	64.2	**48**	17	35.2	32	64.8	**49**
Melaka	196	52.1	180	47.9	**376**	202	52.0	186	48.0	**388**
N. Sembilan	259	54.4	217	45.6	**476**	276	55.9	217	44.1	**493**
Pulau Pinang	483	59.4	330	40.6	**813**	483	59.5	329	40.5	**813**
Pahang	303	58.4	216	41.6	**520**	309	58.2	223	41.8	**532**
Perak	623	72.5	236	27.5	**858**	628	71.5	250	28.5	**878**
Perlis	81	84.5	15	15.5	**95**	81	84.2	15	15.8	**96**
Sabah	330	57.1	248	42.9	**577**	315	57.1	237	42.9	**552**
Sarawak	469	57.9	341	42.1	**810**	478	56.5	368	43.5	**846**
Selangor	1,779	58.4	1,268	41.6	**3,048**	1,862	58.6	1,316	41.4	**3,178**
Terengganu	241	57.7	176	42.3	**417**	246	57.5	182	42.5	**428**
MALAYSIA	**6,267**	**61.6**	**3,909**	**38.4**	**10,176**	**6,378**	**61.1**	**4,067**	**38.9**	**10,445**

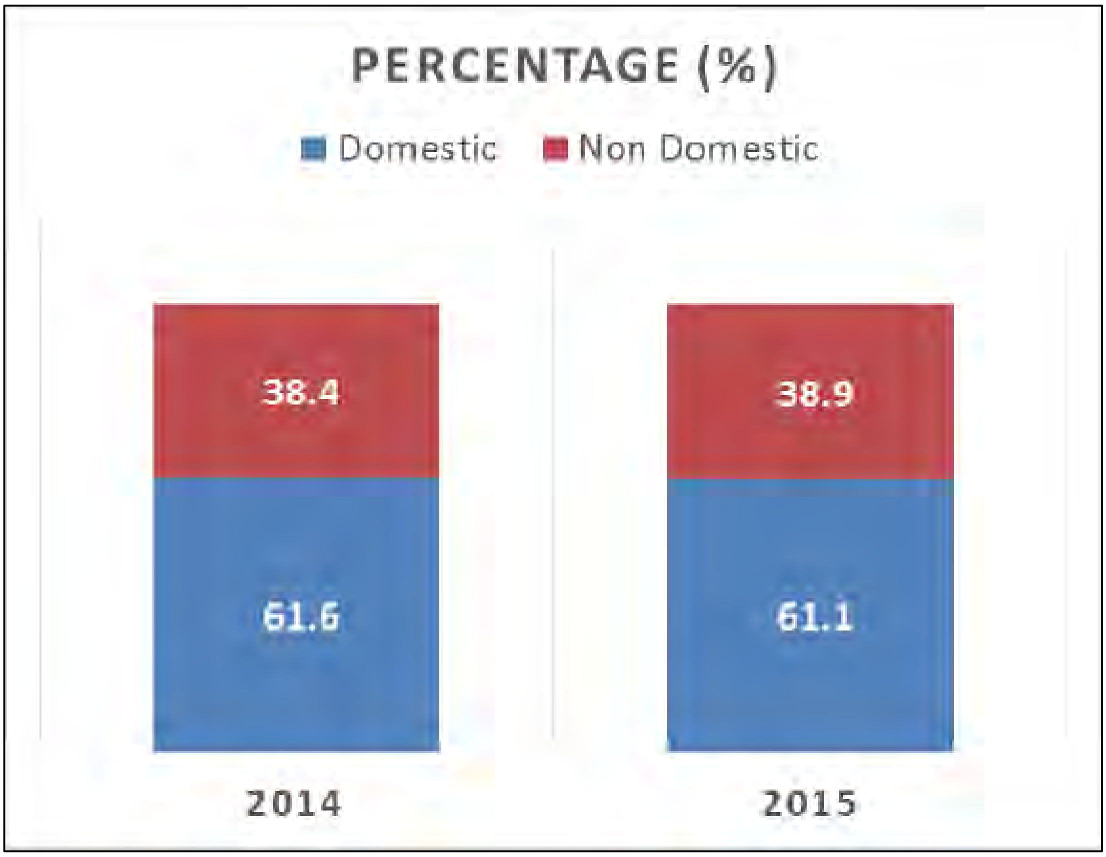

Figure 2.1 Proportion of Domestic and Non-Domestic Consumption (Suruhanjaya Perkhidmatan Air Negara, 2017).