ANALYSIS THE EFFECT OF DIFFERENT TYPE VALVE USE AT DIFFERENT PRESSURE IN PIPING SYSTEM

MUZAKKIR BIN SHUKRI

BACHELOR OF ENGINEERING

UNIVERSITI MALAYSIA PAHANG

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **THE EFFECT OF DIFFERENT TYPE VALVE USE AT DIFFERENT PRESSURE IN PIPING SYSTEM**

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Saya **MUZAKKIR BIN SHUKRI (880627-56-6613)**

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Alamat Tetap:

LOT 1536, JLN GAJAH 12,
KG.KUBU GAJAH,
47000 SG.BULOH, SELANGOR D.E

MIMINORAZEANSUHAILA BINTI LOMAN
(Nama Penyelia)

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ANALYSIS THE EFFECT OF DIFFERENT TYPE VALVE USE AT DIFFERENT PRESSURE IN PIPING SYSTEM

MUZAKKIR BIN SHUKRI

Thesis submitted in fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Automotive Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

6 DECEMBER 2010

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature

Name of Supervisor: MIMINORAZEANSUHAILA BINTI LOMAN

Position: LECTURER

Date: 6 DECEMBER 2010

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature
Name: MUZAKKIR BIN SHUKRI
ID Number: MA07077
Date: 6 DECEMBER 2010

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ABSTRACT

This project was carried out as a study of flow rate using a single channel acoustic emission (AE) technique. The objective of this project is to study the effect of ball valve, brass gate valve and brass stop cock valve to flow rate using AE technique. A test rig consists of the circumferential galvanized steel pipe, ball valve, gate valve and stop cock valve to run the experiments. The fluid used was water throughout the experiments. The pressure of water was controlled by a valve. The source of AE signal was from the valve and it was captured using AE sensor with the help of Acoustic Emission Detector 2.1.3 software. For all valve conditions, the value of hits, count and RMS (average, maximum and minimum) were recorded and analyzed. All the value recorded were compared among the ball valve, gate valve and stop cock valve. The results were gained from 10 marked points each for all type of valve. The result showed that there was no AE activity on the pipe without valve, the AE activities are greater for high pressure or full close valve. In addition from the RMS against distance graft, RMS value increased when pressure is increased. From the flow rate against RMS graf show that flow rate will decrease when RMS is increased.

ABSTRAK

Projek ini dijalan kan sebagai satu kajian tentang kesan kelajuan dengan menggunakan teknik pancaran akustik (AE) satu siaran. Objektif projek ini adalah untuk mengkaji kesan kelajuan bendalir terhadap penggunaan injap yang berbeza dengan menggunakan teknik AE. Satu rig ujikaji terdiri daripada paip besi galvani berlilitan bulat untuk menjalankan eksperimen ini. Bendalir yang digunakan sepanjang eksperimen ini ialah air. Aliran air dikawal oleh injap. Sumber isyarat AE adalah dari injap itu sendiri dan ianya dicerap dengan menggunakan penderia AE dengan bantuan paparan dari perisian Acoustic Emission Detector 2.1.3. untuk semua keadaan injap, nilai-nilai 'hits', 'counts' dan RMS (purata,maksimum dan minimum) telah direkod dan dianalisis. Semua nilai yang direkod telah dibandingkan antara injap. Keputusan diperoleh daripada 10 titik yang ditanda pada batang paip. Keputusan menunjukkan bahawa tiada aktiviti AE berlaku pada paip tanpa injap manakala aktiviti AE adalah tinggi untuk paip yang mempunyai injap dan bertutup penuh. Tambahan daripada graf RMS melawan jarak menemui bahawa nilai RMS akan meningkat apabila tekanan meningkat dan daripada graf RMS melawan kelajuan bendalir mendapati nilai kelajuan bendalir akan menurun apabila nilai RMS meningkat.

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LIST OF SYMBOLS

A	Area
C_v	Flow coefficient
d	Pipe diameter
D	Diameter
K	Resistance coefficient
l_e	Entry length
ρ	Density
Q	Flow rate
R_e	Reynolds number
μ	Fluid Viscosity
V	Flow velocity

LIST OF abbreviations

AE	Acoustic emission
A/D	Analog to digital
D/A	Digital to analog
NDE	Non destructive evaluation
NDT	Non destructive testing
PC	Personal computer
RMS	Root mean square
TFE	Teflon

Dedicated to my beloved parents and families

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The use of pipelines has a long history. For instant, more than 1000 years ago, the Romans use lead pipes in their aqueduct system to supply water to Rome. As the early as 400 B.C., the Chinese use bamboo pipes wrapped with waxed cloth to transport natural gas to their capital Beijing for lighting. Clay pipes were use as early 400 B.C for drainage purpose in Egypt and certain other countries (Henry Liu, 2003).

An important improvement of pipeline technology occurred in the 18th century when cast-iron pipes were manufacturer for use as water lines, sewers, and gas pipelines (Henry Liu, 2003). A subsequent major event was the introduction of steel pipes in the 19th century, which greatly increase the strength of pipes of all sizes. In 1979, the following the discovery of oil in Pennsylvania, the first long distance oil pipelines was build in this state. It was a 6-inch-diameter, 109-mi-long steel pipeline. Nine years latter, an 87-mi-long, 8-inch-diameter pipeline was build to transport natural gas from Kane, Pennsylvania to Buffalo, New York. The development of electric arc welding to join pipes in the late 1920s made it possible to construct leak proof, high-pressure, large-diameter pipelines. Today, virtually all high pressure piping consists of steel pipe with welded joints. Large seamless steel pipe was another major milestone achieved in the 1920s (Henry Liu, 2003).

Major innovations in pipeline technology made since 1950 include:

(i) Introduction of new pipeline material such as ductile iron and large-diameter concrete pressure pipe for water, PVC (polyvinyl chloride) pipe for sewers.
(ii) Use of pigs to clean the interior of pipelines and perform other functions.
(iii) Batching of different petroleum product in a common pipeline.
(iv) Application of cathodic protection to reduce corrosion and extend pipeline life.
(v) Use of large side booms to lay pipe, machines to drill or bore under river and road for crossing, machine to bend large pipes in the field, x-ray to detect welding flaws, and so forth.

Since 1970, major strides have been made in a new pipeline technology including trenchless construction, pipeline integrity monitoring, computer to control and operate pipelines, microwave stations and satellite to communicate between headquarters and room station, and new technologies to transport solid over long distance (e.g., slurry pipelines for transporting coal and other mineral).

Piping system is developed early since a few centuries back. No wonder the development and research will keep running to improve the system time to time. One of the current researches is towards the improvement of monitoring system for the condition of piping line and valves. There are a lot of methods that offer the good way in monitoring the pipe and valve condition such as simulation, radiographic (X-Ray), vibration method, ultrasonic test, and heat distribution test. Currently, many organizations are focused on the non-destructive test (NDT) method which is relatively low cost and time saving especially where the inspected areas are difficult and costly to be accessed.

In this project, the acoustic emission (AE) technique was used to monitor the effect of different flow rate in piping system. The technique is one of the NDT group and the application is still new in term of monitoring the flow rate and internal surface pipe condition. It is well known that this technique is widely used for geological, material behaviour and structure monitoring especially in term of crack investigation

(Hafizi, 2008). This technique was developed base on the theory of transient elastic wave that emit from rapid strain energy release inside a material that is subjected to stress. The energy is come from the changes of flaws that occur inside the material. This technique offers cost and time saving because the monitoring activity will be done without breaking any parts and also can be done online (without stopping the operation). The sensors will be located at any component and will sense the transient elastic wave known as AE signal that will further analyzed to indicate the component's condition. Although current most popular NDT method is ultrasonic testing method, the AE technique give us the alternative approach of flow rate detection and monitoring in piping systems.

1.2 OBJECTIVES

For this project, two main objectives are listed:

(i) To measure the Acoustic Emission (AE) signal in pipe line without valve.

(ii) To find the effect of flow rate by using ball valve, gate valve and stop cock valve with three different pressures.

1.3 SCOPE OF THE STUDY

For this case study, the acoustic emission technique will be used to monitor the pipe and flow condition. One pipe is used with different type of valve: ball valve, brass gate valve and stop cock valve. Practically valve is use to control the flow in the piping system. Data from the acoustic signal were then analyzed to get the acoustic characteristic in term of time domain. For this project, three tests or experiments were conducted in order to achieve the objectives. The first test was to show the effect using low flow rate with different type of valve and the procedures were the same for another two experiments except the pressure are different. In this project, we will use acoustic emission technique where the sensor will be located ten point along the pipe line. All AE parameters observed were time domain; peak amplitude, RMS and energy. Then the analysis will be done using all the data taken using acoustic emission technique.

1.4 PROJECT BACKGROUND

Piping system is one of the technologies that help to provide the quality of human life. It offers the basic need for humankind such as for washing, petrol station and cooking. Besides, piping system also important in the transportation of ‘precious’ fluid such as petroleum and natural gases. For this commercial purpose, pressure drop is vital to be avoided since it give relatively big loses to the annual profit. The lost can be the result of leakage, different flow rate and many other possible causes. The study of this project is to analyze the effect of different pressure at different type of valve use in piping system so that all the vital propose can be avoided.

1.5 DISSERTATION ORGANISATION

There are several chapters in this dissertation. The chapters are organized well to assure the well understanding for readers. The organization is as below:

Chapter 1	:	Introduction
Chapter 2	:	Literature Review
Chapter 3	:	Methodology
Chapter 4	:	Result and Analysis
Chapter 5	:	Conclusion and Recommendations

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will briefly explain about basic piping system, valves, flow analysis in a circular pipe, turbulent behaviors, acoustic emission (AE) signals, the different between AE and ultrasonic testing method and a few related studies and journals that have been done by current researchers. Besides, the information about the software that will be used also included here. All this information is important before furthering to the analysis and study later.

2.2 VALVES

Due to the various environments, system fluids, and system conditions in which flow must be controlled, a large number of valve designs have been developed. A basic understanding of the differences between the various types of valves, and how these differences affect valve function, will help ensure the proper application of each valve type during design and the proper use of each valve type during operation. Table 2.1 shows the example of valve type and its function.

Table 2.1: Example of valves and its functions

TYPE	FUNCTION
Ball valve	To control open/close
Butterfly valve	To control flow in a big diameter pipe
One way valve	Control flow to move only in one direction
Needle valve	To release high pressure flow slowly

Basically, valve is used to control the flow in a piping system. It can be operated either using manual or automatic control. Valves come with variety of sizes and also in wide range of prices. It can be used as simple as to control open and close the flow of a system. It also can very complex and specific as can be seen in many power plants. The valve that used in this study is ball valve (figure 2.2), stop cock valve (figure 2.3) and gate valve (figure 2.4).

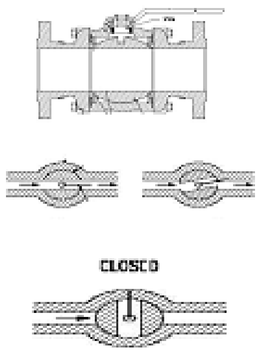


Figure 2.1: Ball valve

Source: http://www.tpub.com

The advantages of ball valve are generally the least expensive of any valve configuration and has low maintenance costs. In addition to quick, quarter turn on-off operation, ball valves are compact, require no lubrication, and give tight sealing with low torque. But the disadvantages is conventional ball valves have relatively poor throttling characteristics. In a throttling position, the partially exposed seat rapidly erodes because of the impingement of high velocity flow (Stephen, 2008).

Ball valves are available in the venture, reduced and full port pattern. The full port pattern has a ball with a bore equal to the inside diameter of the pipe.

Balls are usually metallic in metallic bodies with trim (seats) produced from elastomeric (elastic materials resembling rubber) materials. Plastic construction is also available. The resilient seats for ball valves are made from various elastomeric materials. The most common seat materials are Teflon (TFE), filled TFE, Nylon, Buna-N, Neoprene, and combinations of these materials. Because of the elastomeric materials, these valves cannot be used at elevated temperatures. Care must be used in the selection of the seat material to ensure that it is compatible with the materials being handled by the valve.

The stem in a ball valve is not fastened to the ball. It normally has a rectangular portion at the ball end which fits into a slot cut into the ball. The enlargement permits rotation of the ball as the stem is turned.

A bonnet cap fastens to the body, which holds the stem assembly and ball in place. Adjustment of the bonnet cap permits compression of the packing, which supplies the stem seal. Packing for ball valve stems is usually in the configuration of die-formed packing rings normally of TFE, TFE-filled, or TFE-impregnated material. Some ball valve stems are sealed by means of O-rings rather than packing.

Some ball valves are equipped with stops that permit only 90° rotation. Others do not have stops and may be rotated 360°. With or without stops, a 90° rotation is all that is required for closing or opening a ball valve. The handle indicates valve ball position. When the handle lies along the axis of the valve, the valve is open. When the handle lies 90° across the axis of the valve, the valve is closed. Some ball valve stems have a groove cut in the top face of the stem that shows the flow path through the ball. Observation of the groove position indicates the position of the port through the ball. This feature is particularly advantageous on multiport ball valves (Stephen, 2008).

A butterfly valve is a valve which can be used for isolating or regulating flow. The closing mechanism takes the form of a disk. Operation is similar to that of a ball valve, which allows for quick shut off. Butterfly valves are generally favored because they are lower in cost to other valve designs as well as being lighter in weight, meaning less support is required. The disc is positioned in the center of the pipe, passing through the disc is a rod connected to an actuator on the outside of the valve. Rotating the actuator turns the disc either parallel or perpendicular to the flow. Unlike a ball valve, the disc is always present within the flow, therefore a pressure drop is always induced in the flow, regardless of valve position.

A butterfly valve is from a family of valves called quarter-turn valves. The "butterfly" is a metal disc mounted on a rod. When the valve is closed, the disc is turned so that it completely blocks off the passageway. When the valve is fully open, the disc is rotated a quarter turn so that it allows an almost unrestricted passage of the fluid. The valve may also be opened incrementally to throttle flow.

There are different kinds of butterfly valves, each adapted for different pressures and different usage. The resilient butterfly valve, which uses the flexibility of rubber, has the lowest pressure rating. The high performance butterfly valve, used in slightly higher-pressure systems, features a slight offset in the way the disc is positioned, which increases the valve's sealing ability and decreases its tendency to wear. The valve best suited for high-pressure systems is the trimetric butterfly valve, which makes use of a metal seat, and is therefore able to withstand a greater amount of pressure.

Butterfly valves are valves with a circular body and a rotary motion disk closure member which is pivotally supported by its stem. A butterfly valve can appear in various styles, including eccentric and high-performance valves. These are normally a type of valve that uses a flat plate to control the flow of water. As well as this, butterfly valves are used on firefighting apparatus and typically are used on larger lines, such as front and rear suction ports and tank to pump lines. A butterfly valve is also a type of flow control device, used to make a fluid start or stop flowing through a section of pipe. The valve is similar in operation to a ball valve. Rotating the handle turns the plate either parallel or perpendicular to the flow of water, shutting off the flow. It is a very well known and well used design. But here are some general rule-of-thumbs. Any valve will work in any application for a certain period of time.

A stopcock is a valve used to restrict or isolate the flow of a liquid or gas through a pipe. In Great Britain a stopcock, not to be confused with a gate valve or a DiCiaccio branch, is used to prevent flow of water into a domestic water system. There are usually two stopcocks for a home. One is usually found just outside the property boundary and can be used to isolate the building from the water supply. The other is inside the property where the supply enters the property. These valves are provided to allow maintenance and prevent flooding if the domestic water system is pierced.

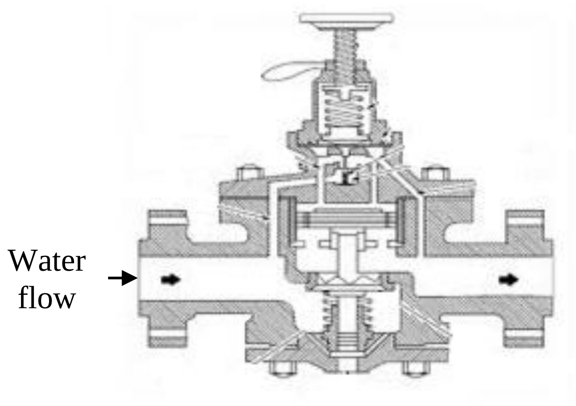


Figure 2.2: Stop cock valve

Source: http://www.tpub.com

A gate valve, also known as a sluice valve, is a valve that opens by lifting a round or rectangular gate/wedge out of the path of the fluid. The distinct feature of a gate valve is the sealing surfaces between the gate and seats are planar, so gate valves are often used when a straight-line flow of fluid and minimum restriction is desired. The gate faces can form a wedge shape or they can be parallel. Typical gate valves should never be used for regulating flow, unless they are specifically designed for that purpose. On opening the gate valve, the flow path is enlarged in a highly nonlinear manner with respect to percent of opening. This means that flow rate does not change evenly with stem travel. Also, a partially open gate disk tends to vibrate from the fluid flow. Most of the flow change occurs near shutoff with a relatively high fluid velocity causing disk and seat wear and eventual leakage if used to regulate flow. Typical gate valves are designed to be fully opened or closed. When fully open, the typical gate valve has no obstruction in the flow path, resulting in very low friction loss.

Gate valves are characterized as having either a rising or a no rising stem. Rising stems provide a visual indication of valve position because the stem is attached to the gate such that the gate and stem rise and lower together as the valve is operated. No rising stem valves may have a pointer threaded onto the upper end of the stem to indicate valve position, since the gate travels up or down the stem on the threads without raising or lowering the stem. No rising stems are used underground or where vertical space is limited.

Bonnets provide leak proof closure for the valve body. Gate valves may have a screw-in, union, or bolted bonnet. Screw-in bonnet is the simplest, offering a durable, pressure-tight seal. Union bonnet is suitable for applications requiring frequent inspection and cleaning. It also gives the body added strength. Bolted bonnet is used for larger valves and higher pressure applications.

Another type of bonnet construction in a gate valve is pressure seal bonnet. This construction is adopted for valves for high pressure service, typically in excess of 15 MPa (2250 psi). The unique feature about the pressure seal bonnet is that the body - bonnet joints seals improves as the internal pressure in the valve increases, compared to other constructions where the increase in internal pressure tends to create leaks in the body-bonnet joint.

Gate valves may have flanged ends which are drilled according to pipeline compatible flange dimensional standards. Gate valves are typically constructed from cast iron, ductile iron, cast carbon steel, gun metal, stainless steel, alloy steels, and forged steels (Stephen, 2008).

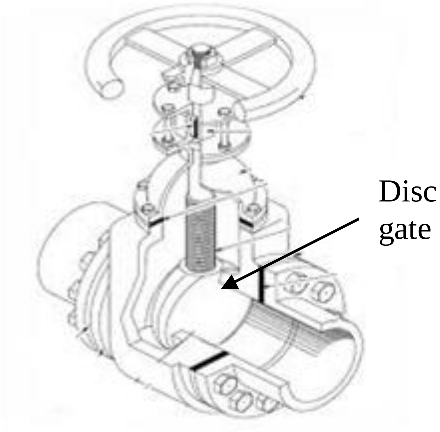


Figure 2.3: Gate valve

Source: http://www.tpub.com

For this project, the knowledge of the ball valve, stop cock valve and gate valve internal construction is important since the acoustic emission source is generated from the ball valve itself. The flow of the fluid is 'disturbed' when the valve is half closed, quarter closed or nearly closed. The continuous impact of the fluid to the ball (refer to figure 2.5) will create AE signals and propagate through the fluid and the pipe wall.

2.3 VALVE FLOW CHARACTERISTIC

The flow characteristic of a valve is the relationship between the position of its flow control element and the rate of fluid flow through the valve. It is due the changing shape and area of the opening that the flow control element produce as it moves through its travel. Therefore, the flow characteristic is determined by the type and design of the valve.

Inherent valve flow characteristic is determined by flow test that make by in which the decrees in pressure across the valve are kept constant. The test result taken from manufacture are plotted as curve on graphs in which flow control element position and flow rate are shown as percentage of their maximum. Figure 2.5 is plot of the three common valve flow characteristic: quick opening, linear, and equal percentage. The quick opening characteristic produce large changes in flow rate at the start of flow control element travel and the progressively smaller changes until the valve is completely open. The linear characteristic produce changes in flow rate that is directly proportional to flow control element position for the full range of flow control element travel. With the equal percentage characteristics, equal increments of flow control element travel produce equal percentage changes in flow rate. Stated another way; the change in flow rate is proportional to the flow rate at the start of the change.

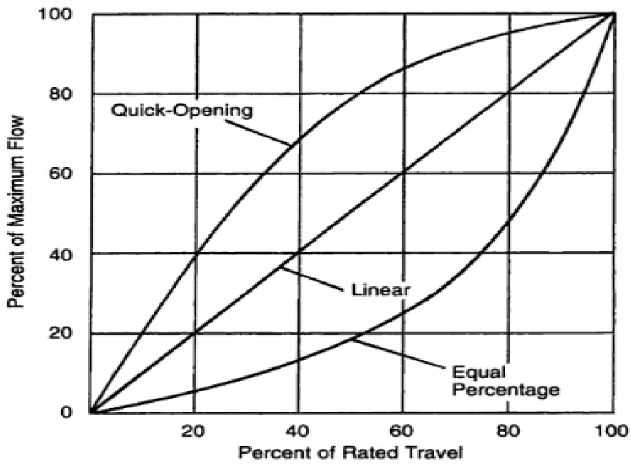


Figure 2.4: Valve flow characteristic curve

Source: The valve primer

To illustrate the equal percentage characteristic, consider the equal percentage flow characteristic curve in figure 2.4. The curve shows that changing the flow control element position from 40% open to 60% open (a 20% increment) produce a change in flow rate from 12% of maximum to 24% of maximum, a 100% increase. Changing the flow control element position from 60% open to 80% open (also 20% increment) produce a change in flow rate from 24% of maximum to 48% of maximum, again a 100% increase.

The flow characteristic exhibit by a valve when it is in a pipeline (know as installed flow characteristic) deviates somewhat from the inherent characteristic shown, because decrease in pressure across the valve varies with flow and other changes in the piping system. In general, the closer the valve is to being fully open, the less effect its flow control element position has on flow rate.

Valve exhibiting the linear flow characteristic and the equal percentage flow characteristic are preferred for use in flow regulation (called throttling) applications. With these characteristic, reasonably accurate predictions of flow rate can be made from flow control element position overall or at least for most of the entire range of flow control element travel. Of the valve used in throttling service, the globe valve has a linear characteristic, the lined butterfly valve has an equal percentage characteristic, and high performance butterfly and diaphragm valve have characteristics that fall between the linear and equal percentage characteristic.

The quick-opening flow characteristic is found on valve use primary as stop valve, such as gate and ball valve.

2.4 VALVE FLOW RESISTANCE

At the beginning of this chapter it was note that the resistance to flow of a valve is one component of the total resistance to flow in the pipeline. In this section show how such resistance to flow can be quantified and make some comparison of flow resistance between different valve types.

The fluid flowing through piping system losses energy because of following effect:

(i) Pipe friction, which is a function of the inner surface roughness of the pipe, pipe size and fluid properties.
(ii) Change in flow direction cause by elbows, returns, and tees.
(iii) Change in pipe cross-section causes by reducer.
(iv) Obstruction to flow caused by valve, strainer and so on.

Loss of energy is manifested by a decrease in fluid pressure. Fluid pressure is usually expressed as pounds per square inch (psi) or as feet of “head” and reduces the flow rate.

$$Q = AV \quad (2.1)$$

Where (A) is the flow passage area in square feet, it can be shown that valve flow coefficient and resistance coefficient are related by the equation

$$C_v = \frac{4.300d^2}{\sqrt{K}} \quad (2.2)$$

$$K = \left(\frac{4.300d^2}{C_v}\right) \quad (2.3)$$

From these equation we see that the larger the resistance coefficient, the smaller the flow coefficient, and vice versa.

Valve manufacturer conduct flow resistance tests on their product and publish the result in their catalogs. The results are presented in one of the forms discussed previously: resistance coefficient, equivalent pipe length, or flow coefficient. These data are use by piping designers when determining the best size for piping system, and by other in cases in which the flow rate or the decrease in pressure across a valve is a consideration in selecting the appropriate valve for a particular application. By using equation (2.1), (2.2) and (2.3) data from different manufacturers in the different forms can be converted to a single form to enable comparison.

Typically value of resistance coefficient, equivalent length, and flow coefficient for some of different valve types are listed in tables 2.2, 2.3 and 2.4. It should be remembered when examining these date that they are base on fully open valves.

Table 2.2: Resistance coefficient K

Type	Gate	Globe	Swing	Check Ball*	Butterfly**
K	0.2	10	1.4	0.1	1.3

*Full port

**Concentric disc and seat

Table 2.3: Equivalent feet of pipe*

Size/Type (inches)	Gate	Globe	Swing Check	Ball*	Butterfly**
1	0.6	20	4.2	0.3	-
2	1.2	60	8.4	0.6	7.8
4	2.4	120	16.8	1.2	15.6
8	4.8	240	33.6	2.4	31.2

*Base on f = 0.028 (turbulent flow) and schedule 40 pipe

Table 2.4: Flow coefficient C_v

Size/Type (inches)	Gate	Globe	Swing Check	Ball*	Butterfly**
1	34	10	22	90	-
2	260	35	95	500	190
4	1150	180	410	2500	835
8	4850	810	1750	9500	3800

Note that the value in table 2.1 to 2.3 is not exactly the same as they would be if only the equations presented above were used to calculate them. Actually manufacturer published value have been use whatever possible. Also, differences in design from one manufacturer to another can cause variations in resistance value for specific valve type. Regardless of the source of the values shown above, they are of appropriate magnitude to enable reasonable comparison between valve types (Prime, 2006).

2.5 FLOW ANALYSIS IN A CIRCULAR PIPE

The basic knowledge about flow in pipe is necessary for the project. For this case, the principle of fluid mechanics and mechanical vibration is required since it is about the fluid flow motion. There are many discussion and analysis done such by writer in fluid mechanic text book such as (Franz Durst, 2008).

Fluid flowing in pipes has two primary flow patterns. It can be either laminar when all of the fluid particles flow in parallel lines at even velocities and it can be turbulent when the fluid particles have a random motion interposed on an average flow in the general direction of flow. There is also a critical zone when the flow can be either laminar or turbulent or a mixture. It has been proved experimentally by Osborne Reynolds (Anthony Esposito, 2007) that the nature of flow depends on the mean flow velocity (v), the pipe diameter (D), the density (ρ) and the fluid viscosity Fluid Viscosity(μ). A dimensionless variable for the called the Reynolds number which is simply a ratio of the fluid dynamic forces and the fluid viscous forces, is used to determine what flow pattern will occur. The equation for the Reynolds number is

$$R_e = \frac{\rho v D}{\mu} \tag{2.4}$$

Where, ρ is fluid density, V is flow velocity, d is pipe diameter and μ is dynamic viscosity of fluid. For normal engineering calculations , the flow in pipes is considered laminar if the relevant Reynolds number is less than 2000, and it is turbulent if the Reynolds number is greater than 4000 (Franz Durst, 2008). Between these two values there is the critical zone in which the flow can be either laminar or turbulent or the flow can change between the patterns. There are few parameters that can affect a flow characteristic such as, flow velocity, diameter pipe, kinematic viscosity of fluid and the roughness parameter.

2.6 LAMINAR FLOW

Laminar flow generally happens when dealing with small pipes and low flow velocities. Laminar flow can be regarded as a series of liquid cylinders in the pipe, where the innermost parts flow the fastest, and the cylinder touching the pipe isn't moving at all.

Laminar flow, sometimes known as streamline flow, occurs when a fluid flows in parallel layers, with no disruption between the layers. In fluid dynamics, laminar flow is a flow regime characterized by high momentum diffusion, low momentum convection, pressure and velocity independent from time. It is the opposite of turbulent flow. In nonscientific terms laminar flow is "smooth," while turbulent flow is "rough."

The dimensionless Reynolds number is an important parameter in the equations that describe whether flow conditions lead to laminar or turbulent flow. Reynolds numbers of less than 2000 are generally considered to be of a laminar type. When the Reynolds number is much less than 1, creeping motion or stokes flow occurs. This is an extreme case of laminar flow where viscous (friction) effects are much greater than inertial forces.

For example, consider the flow of air over an airplane wing. The boundary layer is a very thin sheet of air lying over the surface of the wing (and all other surfaces of the airplane). Because air has viscosity, this layer of air tends to adhere to the wing. As the wing moves forward through the air, the boundary layer at first flows smoothly over the streamlined shape of the airfoil. Here the flow is called *laminar* and the boundary layer is a laminar layer (Franz Durst, 2008).

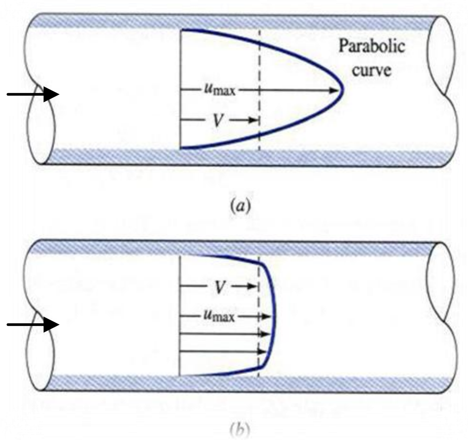


Figure 2.5: Laminar boundary layer

Source: http://images.google.com

2.7 TURBULENT FLOW

In fluid dynamics, turbulence or turbulent flow is a fluid regime characterized by chaotic, stochastic property changes. This includes low momentum diffusion, high momentum convection, and rapid variation of pressure and velocity in space and time. Flow that is not turbulent is called laminar flow. The (dimensionless) Reynolds number characterizes whether flow conditions lead to laminar or turbulent flow; e.g. for pipe flow, a Reynolds number above about 4000 (A Reynolds number between 2100 and 4000 is known as transitional flow) will be turbulent. At very low speeds the flow is laminar, i.e., the flow is smooth (though it may involve vortices on a large scale). As the speed increases, at some point the transition is made to turbulent flow. In turbulent flow, unsteady vortices appear on many scales and interact with each other. Drag due to boundary layer skin friction increases. The structure and location of boundary layer separation often changes, sometimes resulting in a reduction of overall drag. Because laminar-turbulent transition is governed by Reynolds number, the same transition occurs if the size of the object is gradually increased, or the viscosity of the fluid is decreased, or if the density of the fluid is increased.

Turbulence causes the formation of eddies of many different length scales. Most of the kinetic energy of the turbulent motion is contained in the large scale structures.

The energy "cascades" from this large scale structures to smaller scale structures by an inertial and essentially in viscid mechanism. This process continues, creating smaller and smaller structures which produces a hierarchy of eddies figure 2.7 eventually, this process creates structures that are small enough that molecular diffusion becomes important and viscous dissipation of energy finally takes place. Turbulent flow always occurs inside the piping system (Franz Durst, 2008).

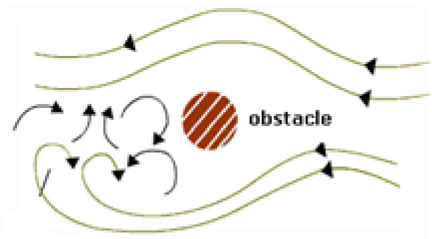


Figure 2.6: Turbulent flow inside pipe

Source: http://images.google.com

Therefore, turbulent flow is main focus for this project since laminar flow rarely happen in normal application. The knowledge of turbulent flow is important when we study about the fluid motion. For every flow that entering a pipe, it will start with laminar region, then transition region and lastly followed by turbulent region (figure 2.8).

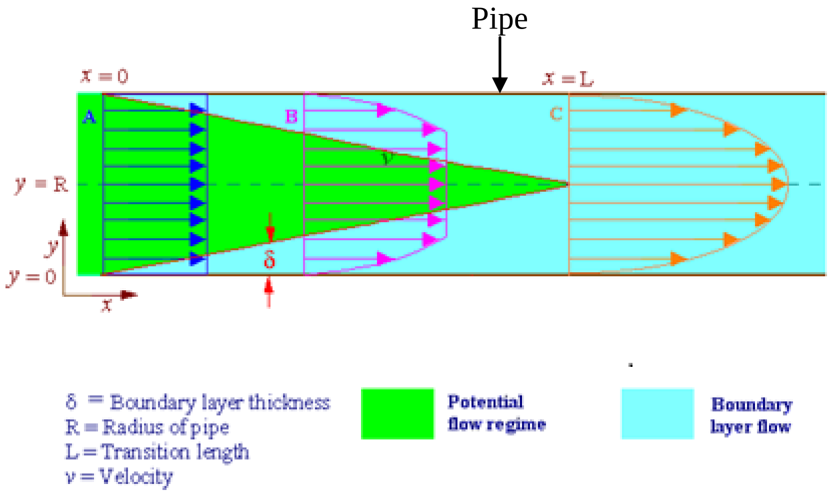


Figure 2.7: Development of boundary-layer flow in pipe

Source: http://images.google.com

There is an equation to calculate the distance or entry length, l_e for the flow to fully developed which is,

$$\frac{l_e}{D} = 4.4(Re)^{1/6} \qquad (2.5)$$

This equation will be used to calculate the length of pipe for test rig where it is necessary to do measurement of the acoustic emission signal within the fully develop turbulent flow region. Otherwise, the result will be affected by other variables such as the effect of transition region and etc.

As in the previous topic, the transition from laminar to turbulent region depends on many reasons such as wall roughness, velocity of the fluid and the fluctuations in the inlet stream. Visual analysis of course is the easiest way to detect the turbulent but since we cannot see what happen inside a close pipe or duct, there must have another way to indicate the fluid motion type. The dimensionless Reynolds number is the best 'indication' to show the fluid motion. Besides, turbulent also can be detected by using a small, sensitive instrument such as a hot-wire anemometer or a piezoelectric pressure transducer (Hafizi, 2008).

2.8 ACOUSTIC EMISSION (AE) SIGNALS

Acoustic Emission (AE) is the elastic energy that is released by a material when it undergoes deformation or fracture. AE examination is non-directional. Most AE examination sources appear to function as point source emitters that radiate energy in spherical wave fronts. Early AE systems acquired the raw radio frequency (RF) signal through analogue processing, however a rapid advancement in computer technology has lead to systems moving away from the recording of the RF signal towards acquiring smaller data files by pre-processing.

The scientific application of AE first emerged in the 1950's, but the decline of heavy industry, nuclear power and defiance spending in the 1980s, together with some poor publicity, resulted in a quiet period for AE research (Robert D. Finch, 2004). Nevertheless the technique has developed significantly and emerged as a very powerful method for numerous measurement problems, far beyond conventional non-destructive testing.

Today there is a transition to waveform-based analysis, which has opened up a new approach to AE analysis. Recent successes have been largely due to advances in high-speed digital waveform based AE instrumentation, improvements in high fidelity, high sensitivity broadband sensors and advanced PC-based signal analysis. This has given researchers an enhanced understanding of AE signal propagation, enabling a departure from traditional reliance on statistical analysis, significantly improving the monitoring capabilities of AE.

New developments have raised new problems, not least of which is sensor technology. Resonant transducers are useful in many applications but increasingly are replaced by sensors with broader frequency characteristics. Issues of flat response, sensitivity and calibration need to be addressed. Modern data transfer methods such as network techniques and wireless communication ensure that AE technology will be a field of interesting future developments and applications.

2.8.1 Detection of AE

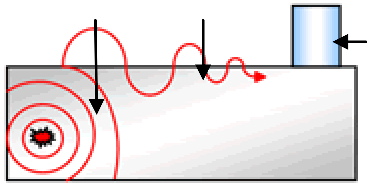


Figure 2.8: Detection of AE

Source: http://www.acousticemission.net/image.asp

Sources of AE include many different mechanisms of deformations and fracture whilst the detection process remains the same. As a crack grows a number of emissions are released. When the AE wave front arrives at the surface of a test specimen minute movements of the surface molecules occur. The function of AE sensors is to detect this mechanical movement and convert it into a useable electric signal. This process can be described as signal detection (Robert D. Finch, 2004).

2.8.2 Processing of AE Signals

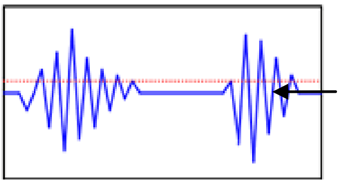


Figure 2.9: Processing of AE signals

Source: http://www.acousticemission.net/image.asp

The small voltage generated by the sensor is amplified and the raw radio frequency (RF) signal is transferred to the computer. Based on user defined characteristics such as peak definition time, hit definition time and hit lock out time, the RF signal is split into discrete waveforms. These waveforms are then prescribed by characteristics such as amplitude, rise time, absolute energy based on a user defined threshold. This process is described as signal processing (Robert D. Finch, 2004).

2.8.3 Displaying AE Signals

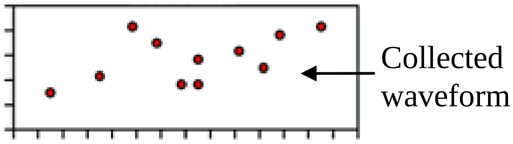


Figure 2.10: Displaying AE signals

Source: http://www.acousticemission.net/image.asp

The collected waveforms can then be displayed in two ways, either as a function of waveform parameters or as the collected waveform. Most AE tests currently only record the waveform parameters and ignore the collected waveform mainly due to the large amount of computing memory it uses (Robert D. Finch, 2004).

2.8.4 Locating AE Signals

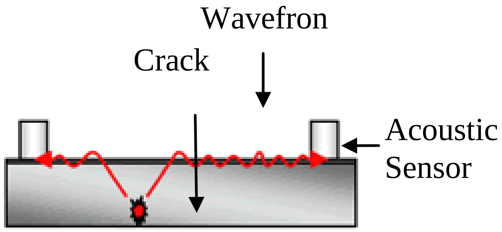


Figure 2.11: Locating AE signals

Source: http://www.acousticemission.net/image.asp

The automated source location capability of AE is perhaps its most significant attraction as a non-destructive testing (NDT) technique. The predominant method of source location is based on the measurement of time difference between the arrival of individual AE signals at different sensors in an array (Robert D. Finch, 2004).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This project was mainly about to analysis the effect of flow rate on different valve. In general, it used the same method, model, apparatus and approach as pther researchers. This is important since they already proved that the model and apparatus used were capable to give the desired result. This project had validated some data from their experiment. This project had validated some data from text book, journal and to certain extent; these data can be used as comparison for this project. With the different approach, three tests were conducted in order to get the results and achieve the objectives.

3.2 FLOW CHART METHODOLOGY

To achieve the objectives of the project, a methodology were construct base on the scope of product as a guiding principal to formulate this project successfully. The important of this project is to analyze effect of flow rate in piping system using acoustic emission technique and to measure the acoustic emission (AE) signals in pipeline with different pressure at smooth inner surface condition and to find flow rate effect of ball valve, brass gate valve and brass stop cock valve using AE technique.

The terminology of the work and planning of this projects shown in the flow chart below. This is very important to make sure that the experiment in the right direction.

3.2.1 Flow chart 1

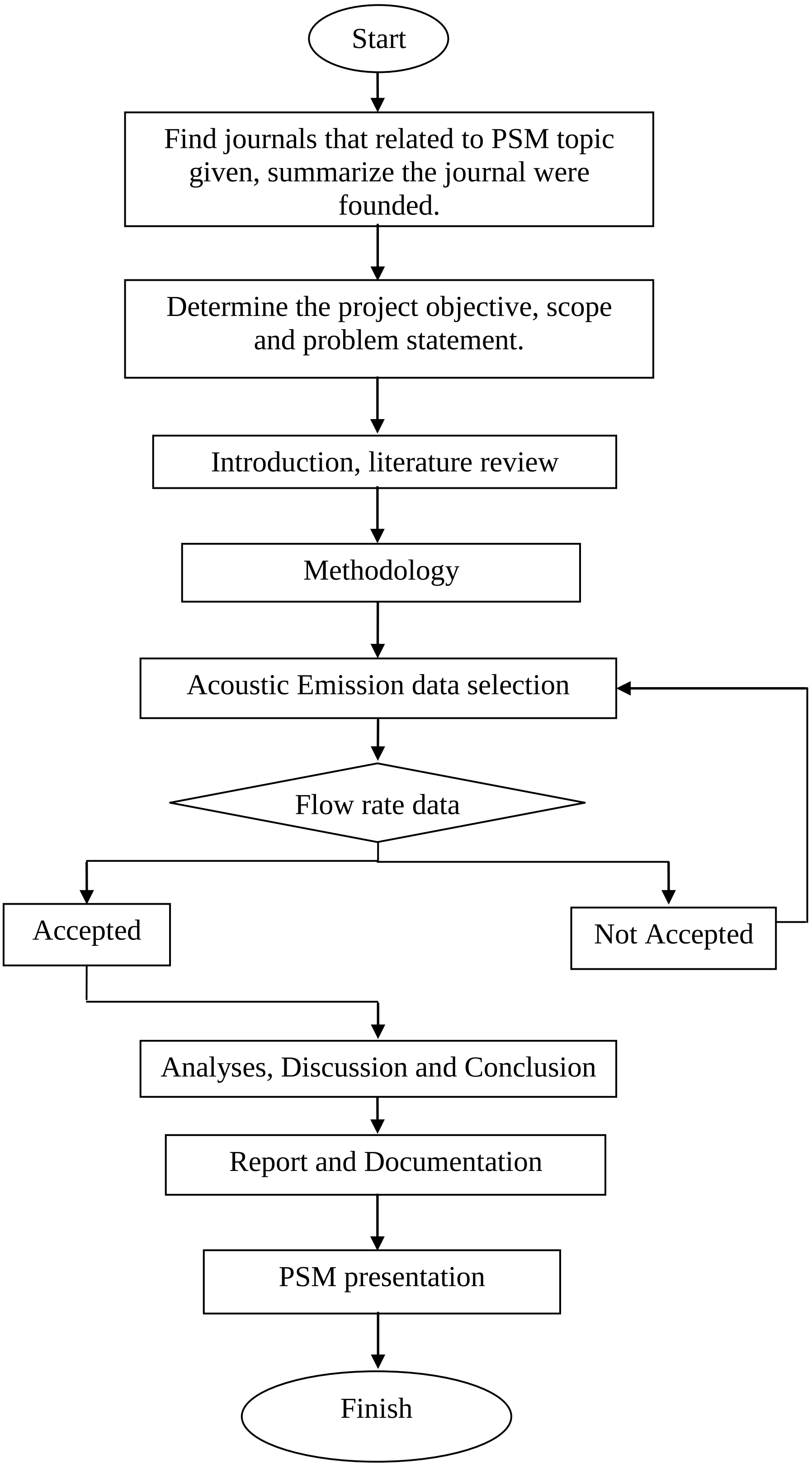
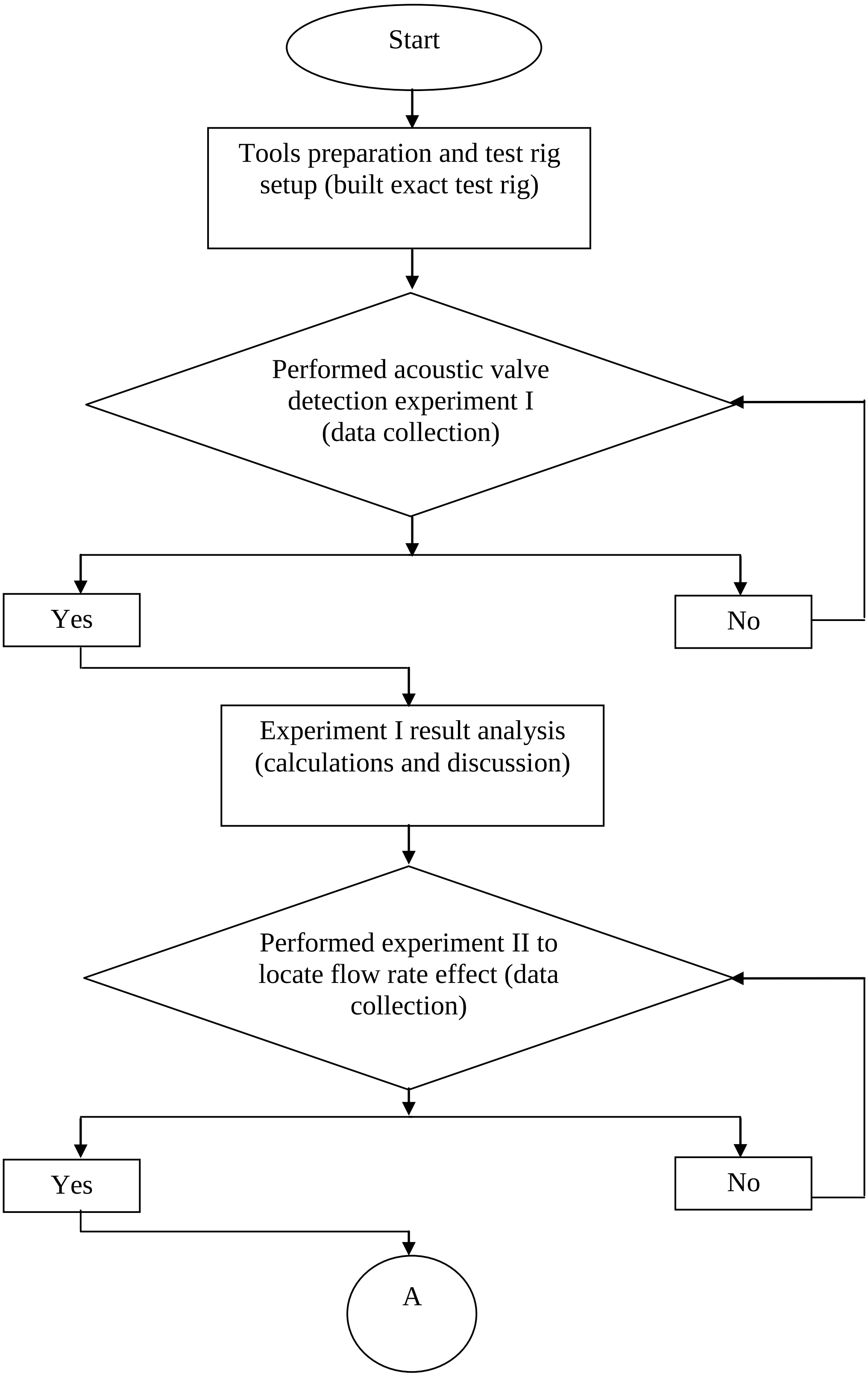


Figure 3.1: Flow chart 1

3.2.2 Flow chart 2



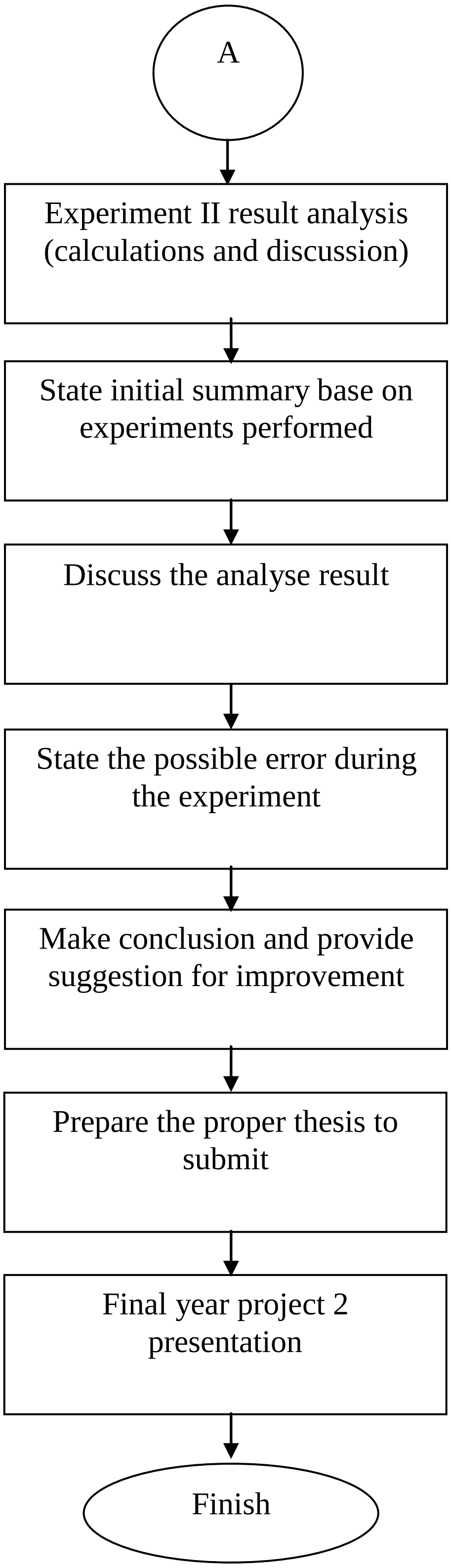


Figure 3.2: Flow chart 2

3.3 GANTT CHART

Gantt chart for FYP 1

Project Progress	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14
1) Get the project title and arrange discussion time with supervisor	■													
2) Built the basic knowledge about the project (learning the theory)	■	■	■	■	■									
3) Do research and collect the information from various resource	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4) State objective, scope and importance of the study (chapter I)			■	■	■									
5) Review study of acoustic emission journal and thesis (chapter II)					■	■	■							
6) Study of valve monitoring and its component (chapter II)						■	■	■						
7) Study of acoustic emission technique and it applications (chapter II)							■	■	■					
8) Review of primary research on acoustic emission technique (chapter II)								■	■	■				
9) Design the test rig and tools preparation (chapter III)											■	■		
10) State the overview of the experiment's procedure (chapter III)												■		
11) Provide the expected result base on previous research (chapter III)												■		
12) Submit draft thesis and log book for final year project 1													■	
13) Final year project 1 presentation														■

Gantt chart for FYP 2

Project Progress	W 15	W 16	W 17	W 18	W 19	W 20	W 21	W 22	W 23	W 24	W 25	W 26	W 27	W 28	W 29	W 30
1) Tools preparation and test rig setup (built exact test rig)	■	■	■	■	■	■										
2) Performed acoustic valve detection experiment I (data collection)							■	■								
3) Performe experiment II to locate flow rate effect (data collection)							■	■								
4) Experiment I result analysis (calculations and discussion)								■	■							
5) Experiment II result analysis (calculations and discussion)									■	■						
6) State initial summary base on experiments performed										■	■					
7) Discuss the analyse result										■	■	■				
8) State the possible error during the experiment												■	■			
9) Make conclusion and provide suggestion for improvement													■	■		
10) Final year project 2 presentation														■		
11) Prepare the proper thesis to submit														■	■	■

3.4 TEST RIG AND TOOLS PREPARATION

The experiments involved the usage of measurement tools which were acoustic sensor and pre-amplifier. The tests were done to get the acoustic signal from pipe lines with different type of valve at different pressure. Full explanation on the test procedures will be mentioned in next topic. Fluid friction measurement tool was used as test rig for this experiment. Only one diameter pipe and three type of valve in the test rig were used which are ball valve, gate valve and stop cock valve as shown in figure 3.6.

The fluid used was water (ρ = 1000 kg/m^3, μ = 0.001002 Ns/m^2). The water was pumped and let to flow through the pipe by adjusting the control valve. The water flowed back into the tank and then continues to circulate through the same path.

The flow rate of the water can be determined from the hydraulic bench where the open close of knob can be controlled. The time for the water to reach 4 liter (refer to indicator at hydraulic bench as in figure 3.3) was taken to calculate the flow rate for high, medium and low pressure. The pressure setting was done by adjusting the control valve until reading show at pressure gauge.

Figure 3.3: Pressure gauge

The sensor was located at few points on the pipe line according the tests conducted. The sensor must touch the pipe in order to measure the acoustic signal. To reach maximum detection, the grease was used between sensor and pipe. The sensor was taped at the location of interest.

Figure 3.4: Suitable locations for sensor placement for ball valve classifying test.

The location must be at least 100 cm from the bending part of the pipe line where it was assumed that the turbulent flow was fully developed at this location as shown in (figure 3.1). (Hafizi, 2008). (Mazian, 2007) calculated that the fully developed region was 52.9 cm. Equation 2.4 in chapter two was used to calculate the entry length until the flow is fully developed. The inner diameter of the pipe is 17.8 millimeters.

Figure 3.5: Hydraulic bench

The sensor that used was acoustic sensor (Figure 3.4). This sensor was made by piezoelectric material. There were several types of sensors which were classified by its operating frequency. For this project, the sensor had the frequency range from 100 kHz to 1 MHz, since in most cases acoustic emission signals appear between this ranges.

Figure3.6: Acoustic sensor

The signal obtained from the sensor need to be amplified before can be analyzed using suitable software. The pre-amplifier used was pre-amplifier AED-2000V Virtual Instrument. This pre-amplifier had two options of gain, 40 dB and 60dB. All the data used the 40dB gain. The right choice of gain was needed to make sure the optimum errors.

Figure 3.7: AED-2000V Virtual Instrument

For analysis of data from acoustic emission signal, the ADC (*Analog to Digital Converter*) card was needed to convert the analog to digital since the computer can only read the digital signal. The card was already built-in inside the computer. The software that used to analyze the obtained acoustic signal is called *Physical Acoustic AE-win 2.1.3.* The results from the software are shown in time and frequency domain.

Before the data can be taken, it is important to determine the value for threshold, sampling rate and wave length. The try and error method is used to find the optimum value until the signal appears to the required form. To get accurate data, the sample rate of 5 Mega sample per second was used. Note that all input were similar with (Hafizi, 2008) experiment.

3.5 TEST PROCEDURES

For this project, three tests or experiments were conducted in order to achieve the objectives. The first test was to show the flow rate effect using ball valve with different pressure and the procedures were the same for another two experiments except the valve is different which is stop cock valve and gate valve.

For the first test, low pressure with three different valves was used. For this stage, ten locations were selected along the pipe. For this experiment, the valve was control by refer to pressure gauge. The AE parameters observed were the average RMS, total hits and counts in 60 seconds (± 1 second).

For the second and third test, the procedure was same as the first test but using medium and high pressure. The rest is same as experiment one. All AE parameters observed were time domain; peak amplitude, RMS amplitude and energy.

3.6 BASIC COMPONENT OF PIPING SYSTEM

The basic component of a piping system is shown in the figure. The components are pipe, ball valve, stop cock valve, gate valve, pressure and pump. Pump is used to increase or decrease the energy to the flow.

Figure 3.8: Ball valve

Figure 3.9: Gate valve

Figure 3.10: Hydraulic pump

Figure 3.4 shows the basic configuration of a piping system. The fluid storage tanks maybe appear at two different positions but in some cases, the fluid is recycled where the outlet flow is going back to the same tank as the inlet. These conditions depend on the application of the piping system.

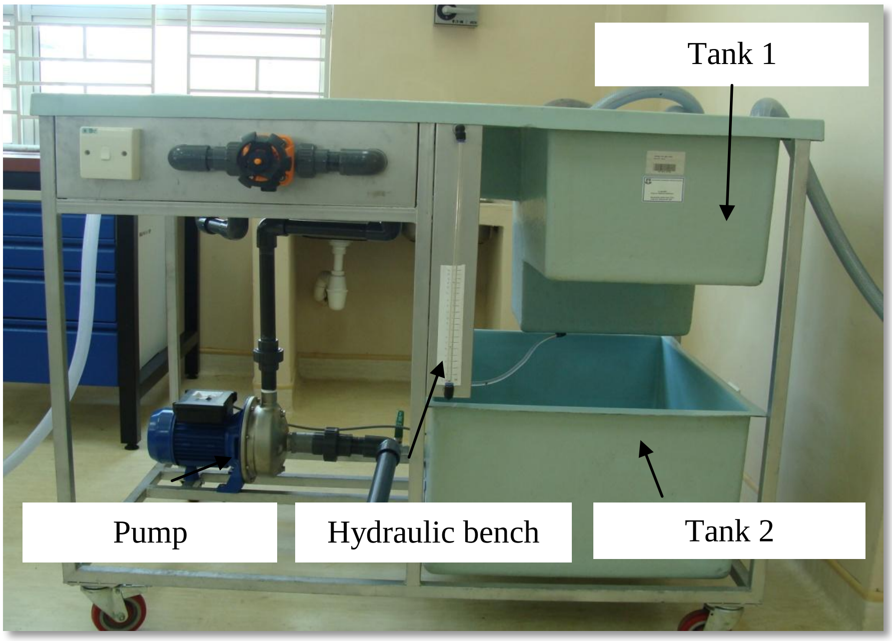


Figure 3.11: Hydraulic bench

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

As mentioned in the previous chapter, two tests were conducted to achieve the objectives for this project. Note that, some of the result from this experiment shows the same pattern as other test. Next topics show the result of all the experiments. The example of acoustic emission signals that viewed using software *Acoustic Detector2.1.3* as in the Appendix C. Acoustic emission method is one of the NDT methods where it can be done online, thus lower the cost for monitoring process. One of the important characteristic of this technique is it can be used to sense only specific defect, by recognizing the pattern of the signals appeared. Besides, this method is noise tolerant; which mean, the data is free from other unwanted signal. This has been proved by two simple tests where the sensor is placed to the pipe without any flow and without touched anything. No result shown by the recording software for both tests.

It is vital to make sure the signals were in the stable condition before 'recording' can be started. Two important precaution steps need to be applied. First, the water flow must be allowed to circulate in the test rig for several minutes each time after adjusting the valve opening to ensure the formation of stable turbulence. Second, the recording time must be started after a few seconds the sensor was placed at the specified location. The longer time is better since this step is to eliminate any unwanted vibration that may occur when placing the sensor on the pipe.

The threshold value needs to be set in the software setting before recording can be done. The proper selection of threshold is necessary to allow better form of signals to be shown. If the value is too high, no signals or hits maybe recorded. Meanwhile if the threshold value is too low, the signals may appear as continuous signal instead of burst signal. Note that, burst signal form is better in term of recognizing the pattern of the AE signals. For first experiments, the threshold value was 45 dB. In the second experiment, 50 dB was used. It is because very little signals were recorded for variable type of valve if threshold value was set to 45 dB.

4.2 EXPERIMENT I

Table 4.1, figure 4.1 and figure 4.2 show the results from the first experiment. Total hits and counts within 60 seconds (± 1 second) of signal recording time are presented. The timer started after a few seconds, before the *Acoustic Detector* software collect the data. This to ensure the signals measured are stable throughout the data collecting process. This condition applied for all the tests.

Table 4.1: Result from the measurement process

Points	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Hits	117	92	39	82	36	43	61	13	20	2
Counts	1725	846	90	189	75	222	173	21	31	3

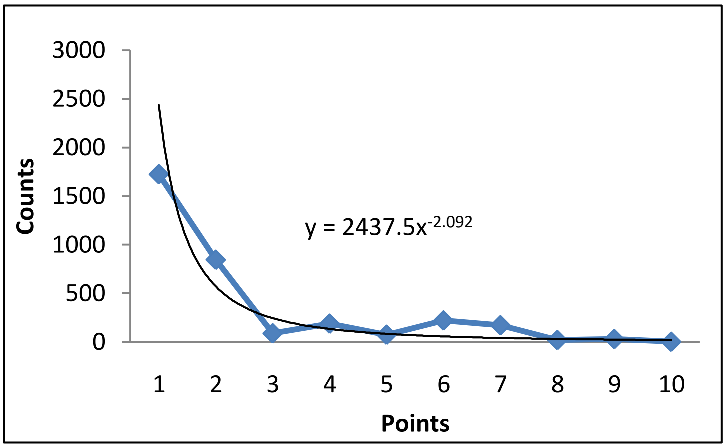


Figure 4.1: Result for *counts*

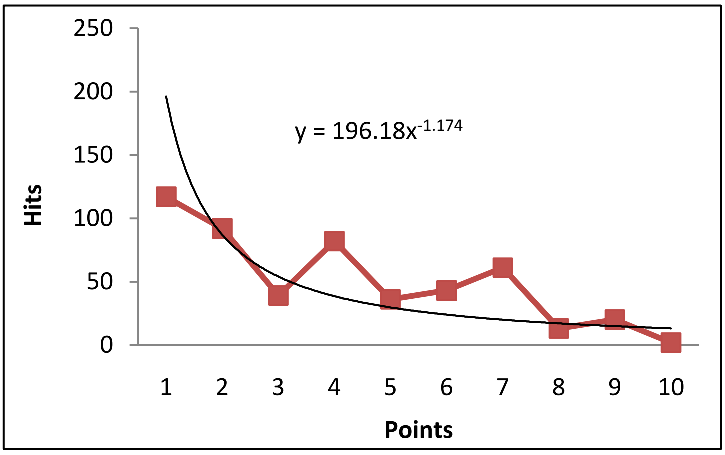


Figure 4.2: Result for *hits*

The result shows that the total hits and counts values are decreased when the distance from the valve is increased. At point number 10 (150 cm from the valve), the total hits and counts value were approaching zero and can be determine by using equation $y = 2437.5x^{-2.092}$ for total cont and $y = 196.18x^{-1.174}$ for total hits.

This condition shows that the original source of the acoustic emission signals was from the valve.

4.3 EXPERIMENT II

As mentioned earlier, this experiment is the main part for this project. For this test, AE signals were taken from fluid flow through same pipe with three kind of different valve; ball valve, stop cock valve and gate valve with different pressure; high pressure, medium pressure and low pressure by referred to pressure gauge. AE parameters measured were the peak amplitude and RMS amplitude.

Measurement is taken at ten locations as in figure 3.13. For each measurement, 60 signals were taken to be analyzed; from about 600 signals that have been recorded using the computer for each measurements. These signals were already filtered and analyzed. The filtering process was done using *Physical Acoustic AE win* software where only good data were allowed to be viewed. This process was done by the software setting as mentioned in chapter 2. Appendix D shows the data for all measurements.

4.3.1 Fluid flow through ball valve with high, medium and low pressure

The result and analysis for fluid flow through ball valve with high, medium and low pressure is presented. For average RMS, the results can be summarized as in figure 4.3, 4.4 and 4.5. All three plots give almost the same pattern where the high pressure has higher values of RMS amplitude and low flow rate compare to low pressure has low RMS amplitude and high in flow rate.

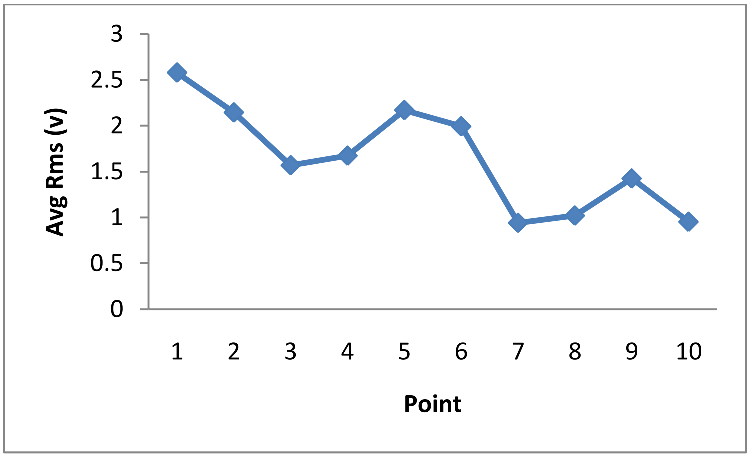


Figure 4.3: Average RMS amplitude for steel ball valve at 25 Pa

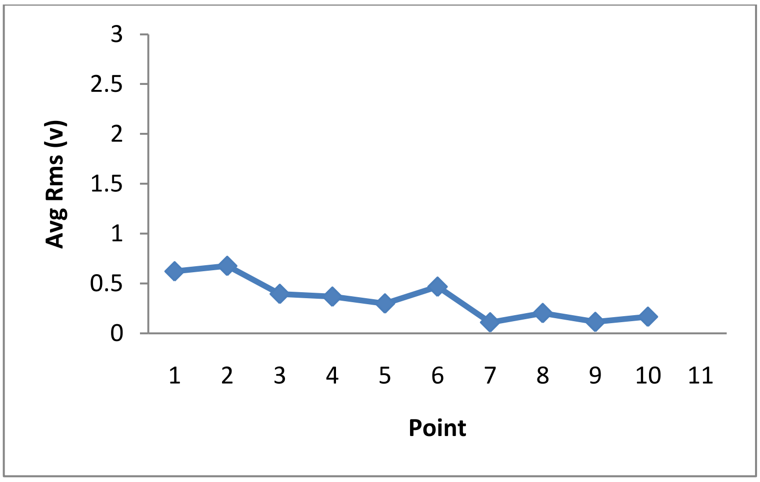


Figure 4.4: Average RMS amplitude for steel ball valve at 20 Pa

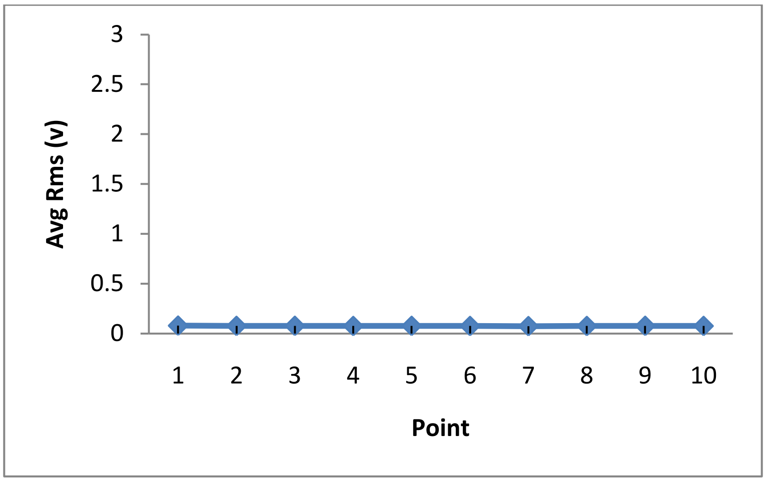


Figure 4.5: Average RMS amplitude for steel ball valve at 11 Pa

At low and high pressure, the average high flow rate value is 100% and 55.81% greater than low flow rate while for medium pressure the decrease percentage is about 27.2% and 43.1%. The average values are as stated in the figures.

Meanwhile, for PVC ball valve RMS amplitude, the results can be summarized as in figure 4.6, 4.7 and 4.8. As for the steel ball valve RMS amplitude analysis, the PVC ball valve RMS amplitude values also show the same trend but decrease in the reading. The high pressure values show greater amount than low pressure. At low and high pressure, the average high flow rate value is about 100% and 53.58% greater than average low flow rate values while for medium pressure the decrease percentage is about 41.91% and 20.1%. The average values are as stated in the figures.

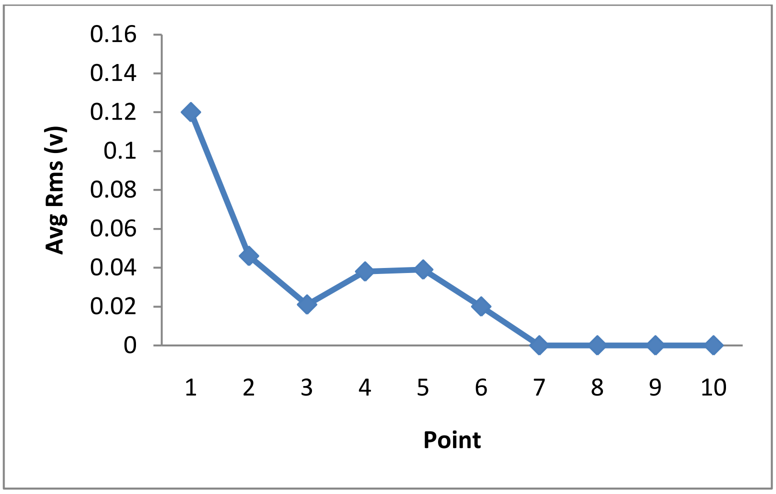


Figure 4.6: Average RMS amplitude for PVC ball valve at 25 Pa

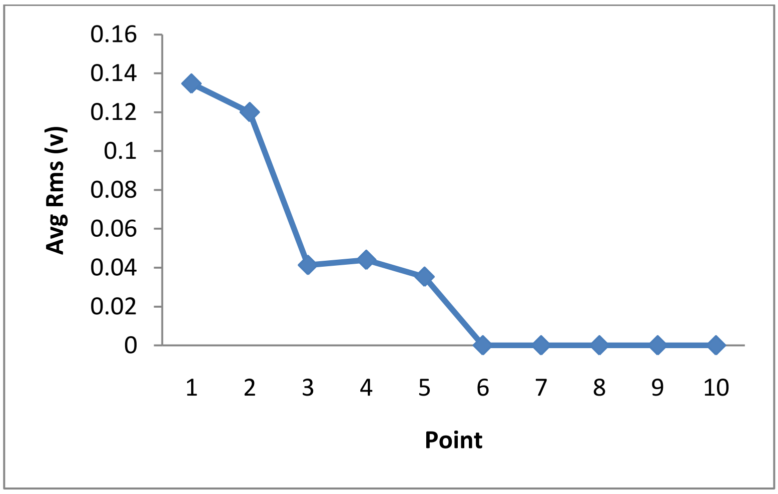


Figure 4.7: Average RMS amplitude for PVC ball valve at 20 Pa

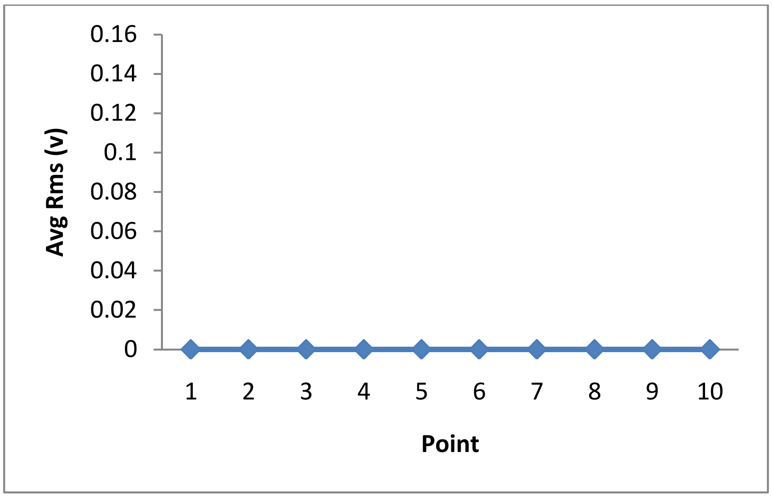


Figure 4.8: Average RMS amplitude for PVC ball valve at 11 Pa

4.3.2 Fluid flow through gate valve with high, medium and low pressure

The result and analysis for fluid flow through gate valve with high, medium and low pressure is now presented. Note that there are different pattern found in this analysis compared to fluid flow through ball valve for all AE parameters analyzed. Somehow, the values RMS for high pressure still higher than low pressure values but with very little different that the value for medium pressure is higher than high pressure because of the gate opening structure.

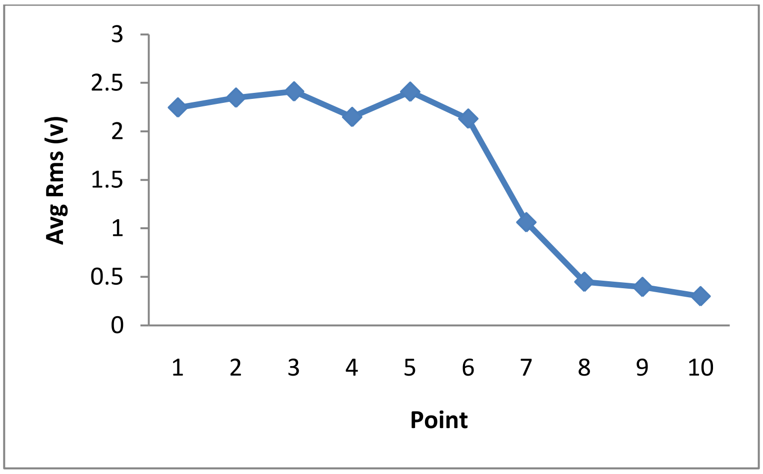


Figure 4.9: Average RMS amplitude for steel gate valve at 25 Pa

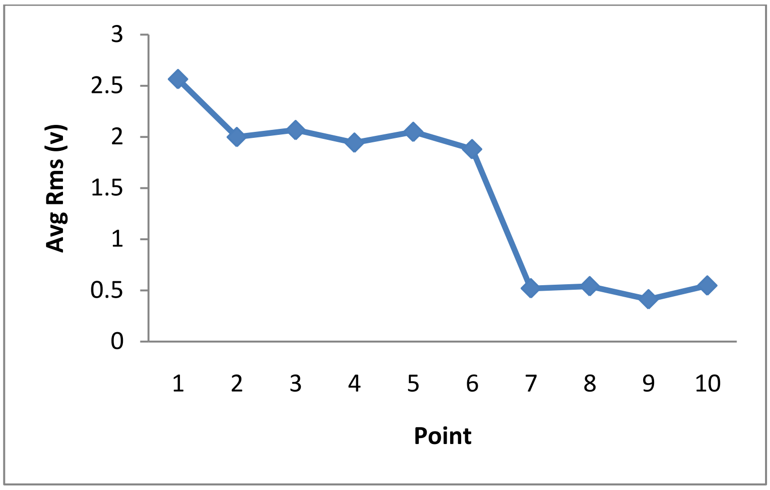


Figure 4.10: Average RMS amplitude for steel gate valve at 20 Pa

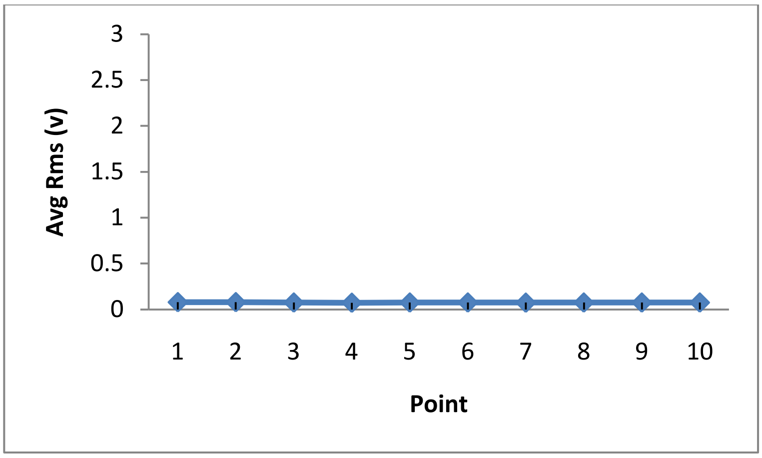


Figure 4.11: Average RMS amplitude for steel gate valve at 11 Pa

At low and high pressure, the average high flow rate value is 100% and 55.81% greater than low flow rate while for medium pressure the decrease percentage is about 36.76% and 30.12%. The average values are as stated in the figures.

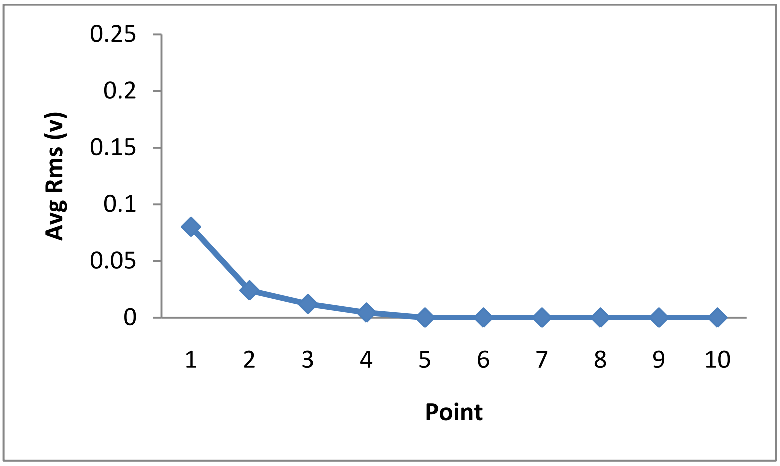


Figure 4.12: Average RMS amplitude for PVC gate valve at 25 Pa

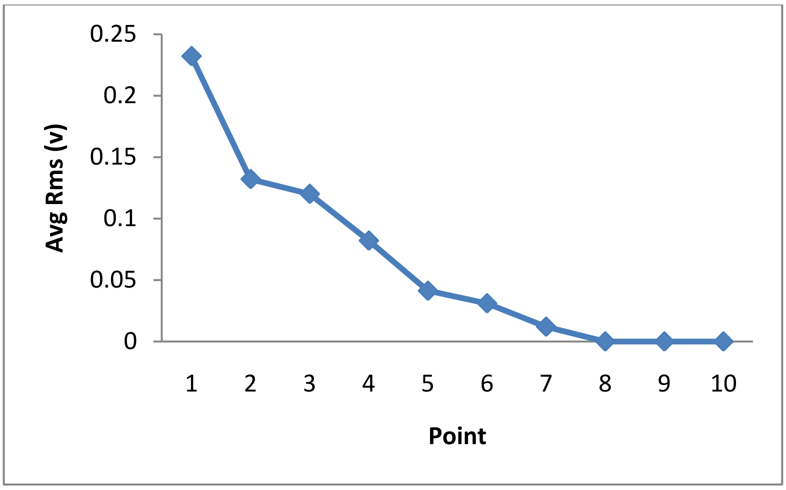


Figure 4.13: Average RMS amplitude for PVC gate valve at 20 Pa

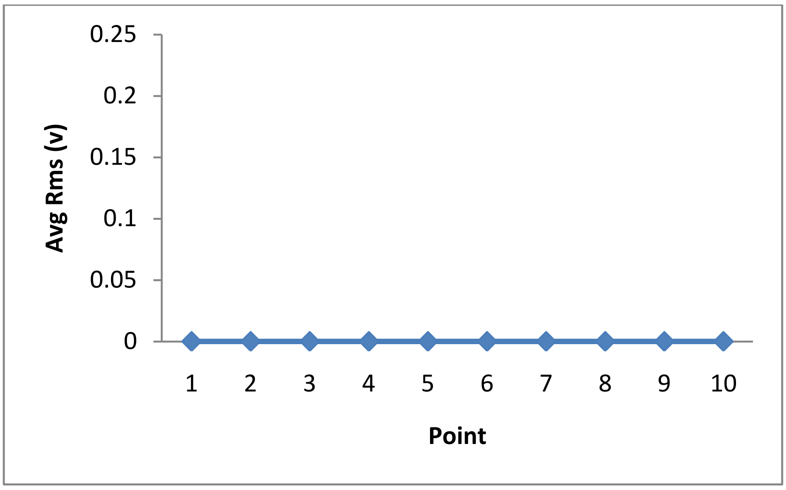


Figure 4.14: Average RMS amplitude for PVC gate valve at 11 Pa

Meanwhile, for PVC gate valve RMS amplitude, the results can be summarized as in figure 4.12, 4.13 and 4.14. As for the steel gate valve RMS amplitude analysis, the PVC gate valve RMS amplitude values also show the same trend. The high pressure values show greater amount than low pressure. At low and high pressure, the average high flow rate value is about 100% and 33.67% greater than average low flow rate values while for medium pressure the decrease percentage is about 12.80% and 33.67%. The average values are as stated in the figures.

4.3.3 Fluid flow through stop cock valve with high, medium and low pressure

The result and analysis for fluid flow through steel stop cock valve with high, medium and low pressure is now presented. Note that there are different pattern found in this analysis compared to fluid flow through ball and gate valve for all AE parameters analyzed. Somehow, the values for high pressure still higher than low pressure values but with very little different.

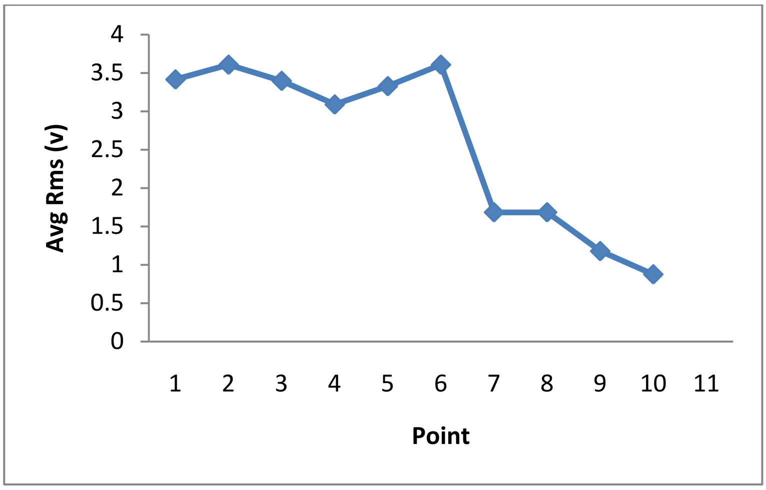


Figure 4.15: Average RMS amplitude for steel stop cock valve at 25 Pa

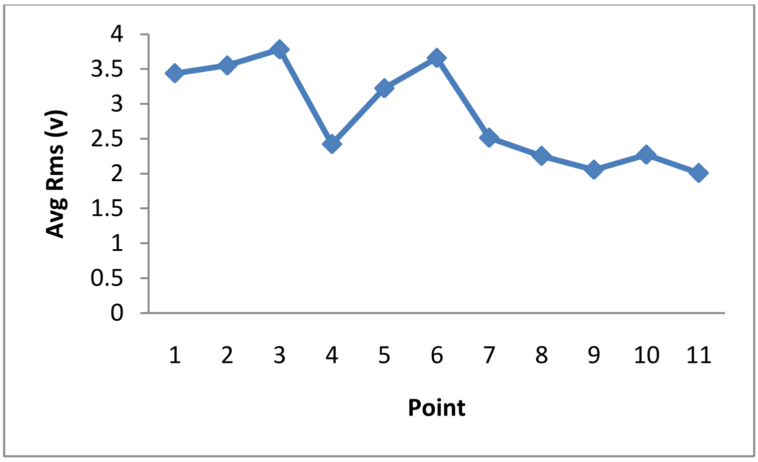


Figure 4.16: Average RMS amplitude for steel stop cock valve at 20 Pa

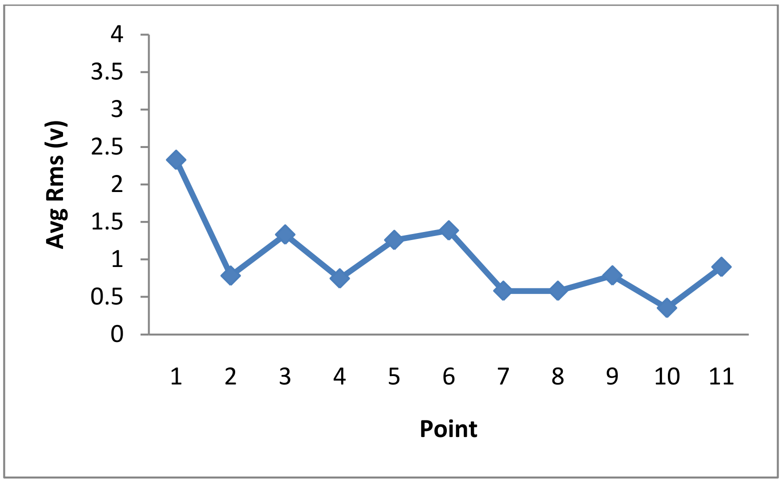


Figure 4.17: Average RMS amplitude for steel stop cock valve at 11 Pa

At low and high pressure, the average high flow rate value is 100% and 71.28% greater than low flow rate while for medium pressure the decrease percentage is about 35.34% and 55.58%. The average values are as stated in the figures.

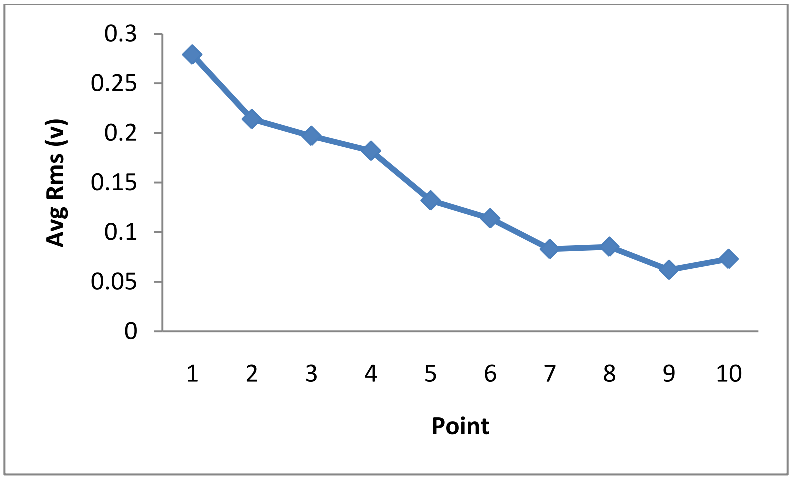


Figure 4.18: Average RMS amplitude for PVC stop cock valve at 25 Pa

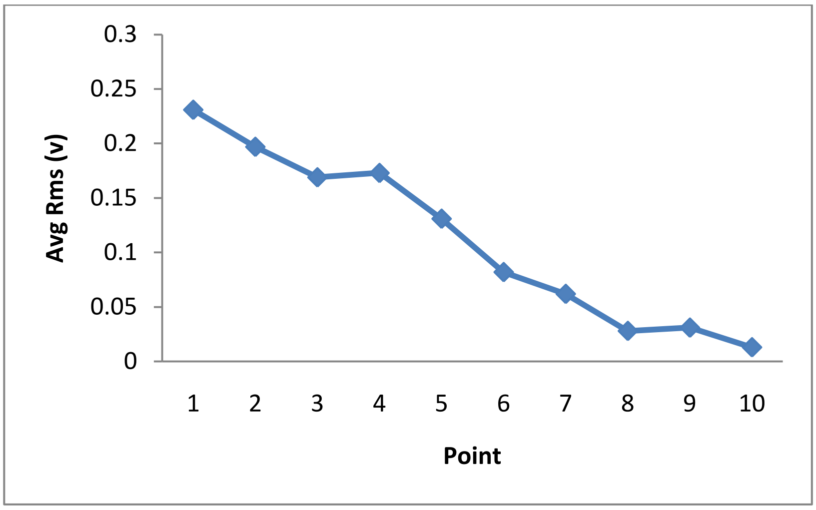


Figure 4.19: Average RMS amplitude for PVC stop cock valve at 20 Pa

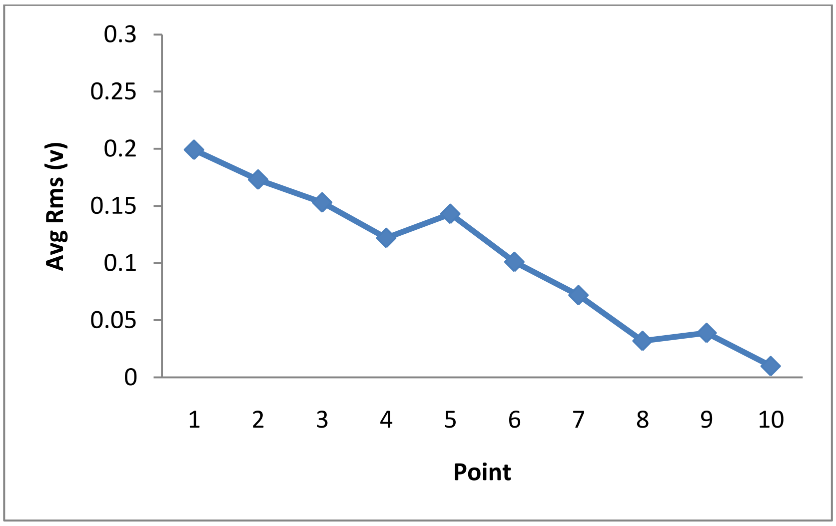


Figure 4.20: Average RMS amplitude for PVC stop cock valve at 11 Pa

Meanwhile, for PVC gate valve RMS amplitude, the results can be summarized as in figure 4.18, 4.19 and 4.20. As for the steel stop cock valve RMS amplitude analysis, the PVC stop cock valve RMS amplitude values also show the same trend. The high pressure values show greater amount than low pressure. At low and high pressure, the average high flow rate value is about 100% and 74.56% greater than average low flow rate values while for medium pressure the decrease percentage is about 45.39% and 53.41%. The average values are as stated in the figures.

4.4 Summary of average AE parameter values for ball, gate and stop cock valve

Table 4.2 and table 4.3 show the average AE parameters value for ball, gate and stop cock valve. Meanwhile figures 4.21 and 4.22 shows the plot for average value of each AE parameters versus pressure. For ball, gate and stop cock valve, there are not much different for low, medium and high pressure values. The different is at the low and high pressure value because the gap between it and high pressure value become narrow for gate valve.

Table 4.2: Average values of AE parameters for steel type of valve

Type/valve	Pressure (Nm)	RMS (Volt)	Flow rate (m3/s)
Ball	11	0.08	1.29
	20	0.34	0.82
	25	1.64	0.57
Gate	11	0.07	0.99
	20	1.45	0.96
	25	1.58	0.66
Stop cock	11	1.00	0.89
	20	2.83	0.58
	25	2.48	0.25

Table 4.3: Average values of AE parameters for PVC type of valve

Type/valve	Pressure (Nm)	RMS (Volt)	Flow rate (m3/s)
Ball	11	0.24	1.33
	20	0.34	0.79
	25	1.74	0.61
Gate	11	0.05	0.89
	20	1.66	1.20
	25	1.22	0.59
Stop cock	11	0.90	0.79
	20	2.23	0.43
	25	2.38	0.20

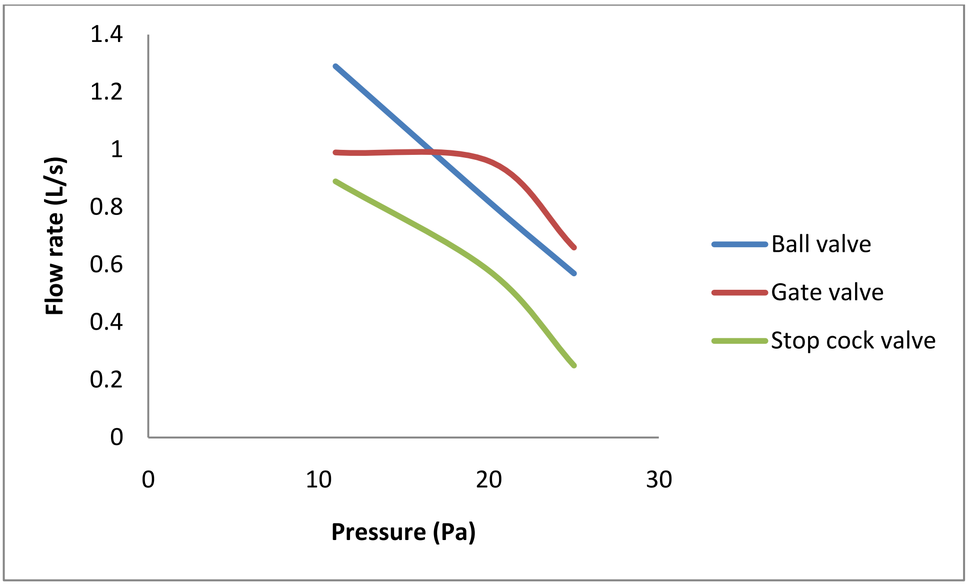


Figure 4.21: Comparison for flow rate value between steel valves

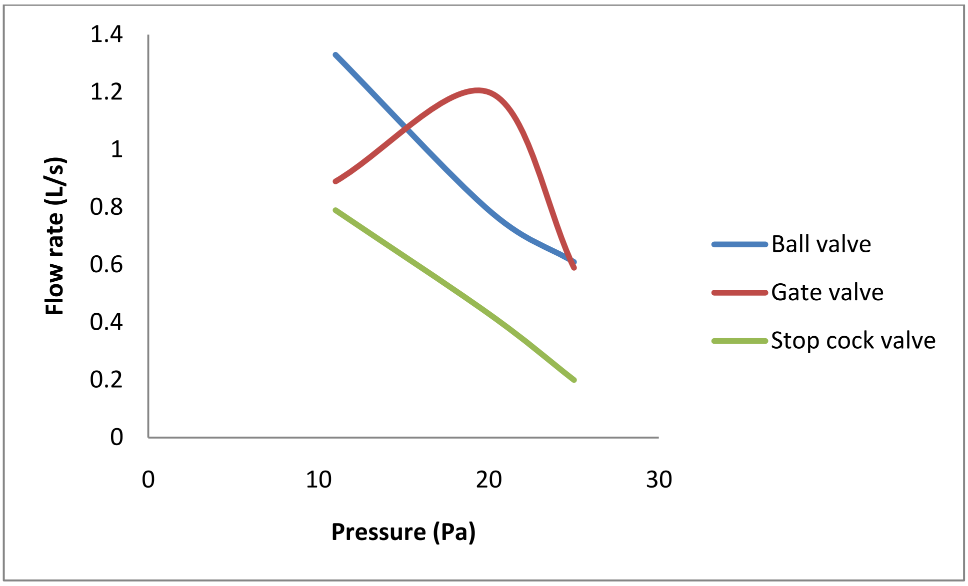


Figure 4.22: Comparison for flow rate value between PVC valves

From figure 4.21 shows that stop cock valve give the higher value of flow rate for same pressure followed by gate and ball valve but there is just slightly different at pressure 20 Pa for gate and stop cock valve. This is happen because at pressure 20 Pa the opening area for stop cock and ball valve are almost same, so the flow area between this two valve also almost same. For PVC gate and stop cock valve, there is totally different at pressure 20 Pa where gate valve give higher reading of flow rate compare to stop cock valve but ball valve is maintain as the lowest value of flow rate. From the flow rate graft, it is show that the value of flow rate is contrary with the RMS value. When the RMS reading is increase, the flow rate reading is decrease.

4.5 Reynolds Number for high and low flow rate

Although this study was focused on the acoustic signals, fluid mechanics analysis is also necessary to be done since it involves the flow of the fluid (water). Table 4.4 shows the flow rate values for high and low pressure. The values were calculated using the method that has been discussed in chapter 2.

In the same table, also include the value of Reynolds number for each flow. The value is calculated using the equation also from chapter 2 and using the information of water and the pipe from chapter 3.

Table 4.4: Flow rate for each steel valve condition

Valve	**Low flow rate (11 Pa)**			**High flow rate (25 Pa)**		
	Time (s)	Flow rate (m3/s)	Reynolds number	Time (s)	Flow rate (m3/s)	Reynolds number
Ball	6.97	0.57	1930.38	3.08	1.30	9720.81
Gate	6.01	0.67	4982.04	4.02	1.00	7447.60
Stop cock	12.51	0.26	1930.38	4.55	0.90	6720.81

4.6 DETERMINING THE LOCATION OF AE SOURCE

It is important to know the source of the AE signal before any test was conducted. The best location for sensor then can be determined in order to get better result. The intensity of AE signal will decrease as the distance from any AE source increase.

From early hypothesis, the source of AE signals was from the fluid flow itself. Turbulent flow will create a lot of small bubbles and breaks within very small period. This high frequency process theoretically will create the acoustic emission signal; as burst signal. Mazian (2007) also used the same assumption. Second hypothesis, the AE source was from the valve since fluid flow always gives impact to the valve especially when it is nearly closed.

The result from first experiment reveals that AE signals started to propagate from valve. It shows that after 150 cm distances from valve, the signals turn weak and approaching zero (figure 4.1 and 4.2). Any signal recorded after this range will give no reading. The first three points were the best place for sensor since it gave the higher AE activity to be recorded.

4.7 FLUID FLOW THROUGH VALVE

When a valve is first cracked open, fluid begins flowing through it. Further movement of it flow control element allow more fluid to flow, until the valve is completely open and the maximum fluid flow rate is achieved. The flow rate through the valve when it is completely open depends on the resistance to flow the entire pipeline in which the valve is installed, and the valve contributes to this total line resistance. Consequently, there are two distinct aspects to fluid flow through valve. First, there is the effect of the position of the flow control element on the flow rate through the valve when it is partially open. Second, there is the resistance to fluid flow of the valve when it is completely open.

4.8 VALVE EFFECT CLASSIFYING

The main objective for this study was to measure the acoustic emission signal from the pipe flow and find a flow rate effect of different type of valve using acoustic emission technique. Note that valve is used to control the flow of fluids that can cause pressure drop to pipe flow if wrong type of valve is use.

Only 60 signals were used for results over 600 signals per measurement. These data were taken, in the middle from overall data; at least seventh data and they were continuous.

Table 4.4 shows the Reynolds number for different pressure valve opening for each different type of valve. Both values for high pressure, medium and low pressure is over 4000. Thus, they are in the turbulent flow range. The high pressure values were about two times higher than low pressure for ball and gate valve and four times for stop cock valve. Note that value for ball valve, gate valve and stop cock valve flow rate was not consistent with each others. This occurs because of the different internal construction of different valve that give different flow to fluid. Ball valve for example has different opening construction compared to butterfly valve even their operational function is same which allows for quick shut off, but butterfly valves are generally favoured because they are lower in cost to other valve designs as well as being lighter in weight, meaning less support is required. The disc is positioned in the canter of the pipe, passing through the disc is a rod connected to an actuator on the outside of the valve. Because of the disc position is at the canter of pipe, pressure drop is occur, since that butterfly valve is normally use in large diameter of pipe because pressure drop doesn't much effect the flow. Somehow, the difference can be neglected since the Reynolds number for ball valve and gate valve was only 23% and 13% higher than stop cock valve for each pressure.

Table 4.5: Reynolds number values between ball and gate valve

	Ball Valve	**Gate Valve**	**Different**
High pressure (25 Pa)	9720.81	7447.60	23%
Medium pressure (20 Pa)	6147.46	7232.04	15%
Low pressure (11 Pa)	1930.38	4982.04	13%

Table 4.6: Reynolds number values between ball and stop cock valve

	Ball Valve	**Stop cock Valve**	**Different**
High pressure (25 Pa)	9720.81	6720.81	31%
Medium pressure (20 Pa)	6147.46	4345.81	30%
Low pressure (11 Pa)	4295.66	1930.38	55%

Gate and stop cock valve give just a slightly different reading where ball valve have lower RMS value than gate valve, but at the higher pressure gate valve reading is slightly lower than ball valve, this is because the internal opening structure is almost same for this two type of valve but when the gate valve is wide open, the gate is fully drawn up into the valve, leaving an opening for flow through the valve at the same size as the pipe in which the valve is installed. Therefore, there is little pressure drop or flow restriction through the valve. Gate valves are not suitable for throttling purposes since the control of flow would be difficult due to valve design and since the flow of fluid slapping against a partially open gate can cause extensive damage to the valve. Except as specifically authorized, gate valves should not be used for throttling. For stop cock valve, there is a large different reading up to 50%. These are happen because stop cock valve have a narrow opening internal structure so that it is difficult to fluid flow smoothly.

Referring to figures 4.3 throughout 4.26, a unique pattern was revealed. But the pattern cannot be seen without further analysis. In general, for ball, gate and stop cock valve, the AE parameters show the higher value RMS for high flow rate. The different between low flow rate and high flow rate value for ball and gate valve is about 10%. Meanwhile for ball and stop cock valve, the difference is about 24%.

By comparing figure 4.3, 4.9 and 4.15, there are not much different for high, medium or low pressure values. The different is at high pressure for ball and gate valve where ball valve gives higher reading than gate valve. This is happen because the ‘gap’ between it and high flow rate value become narrow for gate valve. This condition can be explained with wake interference phenomena as presented in chapter 2. This phenomenon disturbed the signal propagation or signal transfer between fluid flows to the pipe wall. As the result, the AE parameters value for gate inner surface became lower compared to the ball valve with smooth inner surface.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study proved that acoustic emission (AE) technique can be used for valve condition monitoring. The technique offers great opportunity to have new approach of lower cost and time consuming for pipe and valve monitoring.

From this project, AE signals were found to start propagate from valve. It was proved by the first experiment. Besides, it also shows that fluid can be the propagation medium for AE signals. The important key for successfulness of this method for valve classifying is the wake interference phenomena as presented in chapter 2.

Meanwhile the introduction of flow coefficient C_v can be the best indicator for the valve classifying and flow rate using AE method as well as Reynolds number for fluid flow motion and other dimensionless number. However, the selection of suitable AE parameters is necessary before applying the flow coefficient concept as the valve and flow rate indicator. The time domain parameters and RMS amplitude were used. It is suggested to use RMS amplitude rather than peak amplitude since they can represents the overall energy of the signals captured by the software of flow coefficient C_v indication for different type of valve can be shown in the table 2.2 until table 2.4. From this experiment, conclude that the value of flow rate is contrary with the RMS value. When the RMS reading is increase, the flow rate reading is decrease.

5.2 SUGGESTION

The result for different valve flow classifying experiment was based on only ten points for each type of valve. However, the result may be dissimilar if more points were used, but with little difference. Further study need to be done for more data and having more general flow coefficient value that can be used for general effect of flow and valve classification.

More points for sensor can be done if the sensor itself has smaller area of surface. Besides, the current sensor used has flat surface meanwhile the pipe is cylinder shape. The surface of the sensor doesn't fully touch the pipe and may cause inaccurate signals capturing. So, an adapter is needed to ensure all the sensor surface area can capture the AE signals from pipe.

The most important suggestion is to redesign the test rig to eliminate the constraints occur, thus getting more convincing result from the research also the new version of AE device that can collect more data. The constraints were as mentioned in discussion in chapter 5. Actually new AE rig is just having. Unexpected problem cause the new AE rig cannot be used on time. Figure 5.3 shows the new test rig that should be used for this study.

Figure 5.1: New AE rig proposed

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APPENDIX A

Gantt Chart for Final Year Project 1

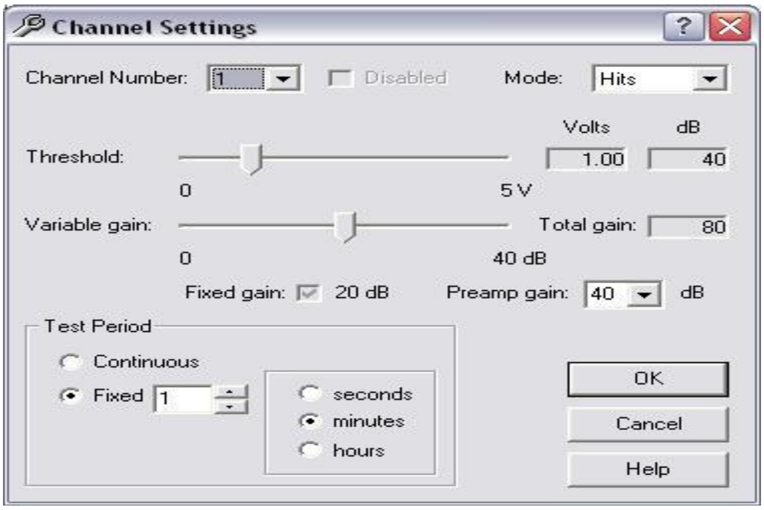
Project Progress	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14
1) Get the project title and arrange discussion time with supervisor														
2) Built the basic knowledge about the project (learning the theory)														
3) Do research and collect the information from various resource														
4) State objective, scope and importance of the study (chapter I)														
5) Review study of acoustic emission journal and thesis (chapter II)														
6) Study of valve monitoring and its component (chapter II)														
7) Study of acoustic emission technique and it applications (chapter II)														
8) Review of primary research on acoustic emission technique (chapter II)														
9) Design the test rig and tools preparation (chapter III)														
10) State the overview of the experiment's procedure (chapter III)														
11) Provide the expected result base on previous research (chapter III)														
12) Submit draft thesis and log book for final year project 1														
13) Final year project 1 presentation														

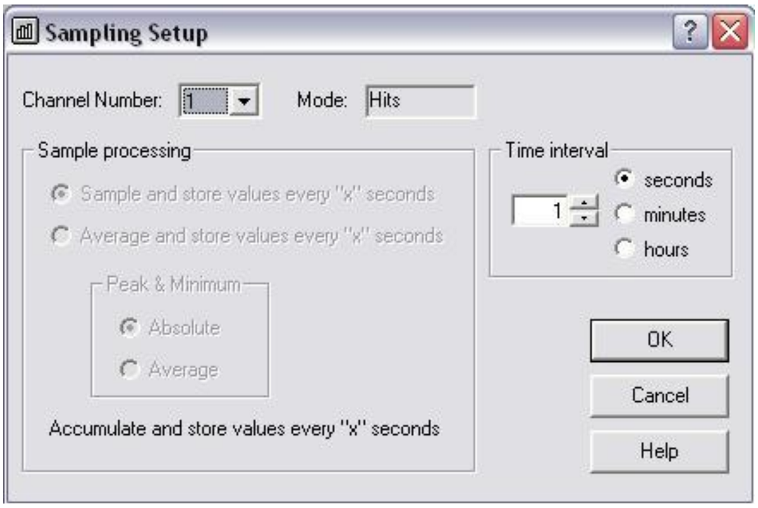
Gantt Chart for Final Year Project 2

Project Progress	W 15	W 16	W 17	W 18	W 19	W 20	W 21	W 22	W 23	W 24	W 25	W 26	W 27	W 28	W 29	W 30
1) Tools preparation and test rig setup (built exact test rig)																
2) Performed acoustic valve detection experiment I (data collection)																
3) Perfume experiment II to locate flow rate effect (data collection)																
4) Experiment I result analysis (calculations and discussion)																
5) Experiment II result analysis (calculations and discussion)																
6) State initial summary base on experiments performed																
7) Discuss the analyses result																
8) State the possible error during the experiment																
9) Make conclusion and provide suggestion for improvement																
10) Final year project 2 presentation																
11) Prepare the proper thesis to submit																

APPENDIX B

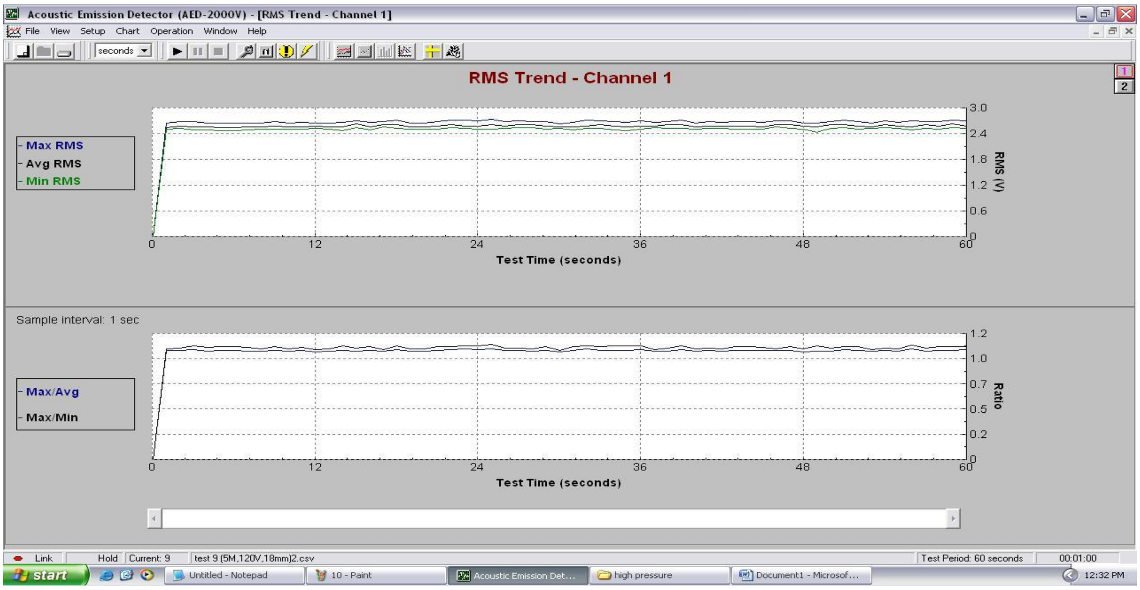
Mode setup applied for Acoustic Emission Detector 2.1.3 software

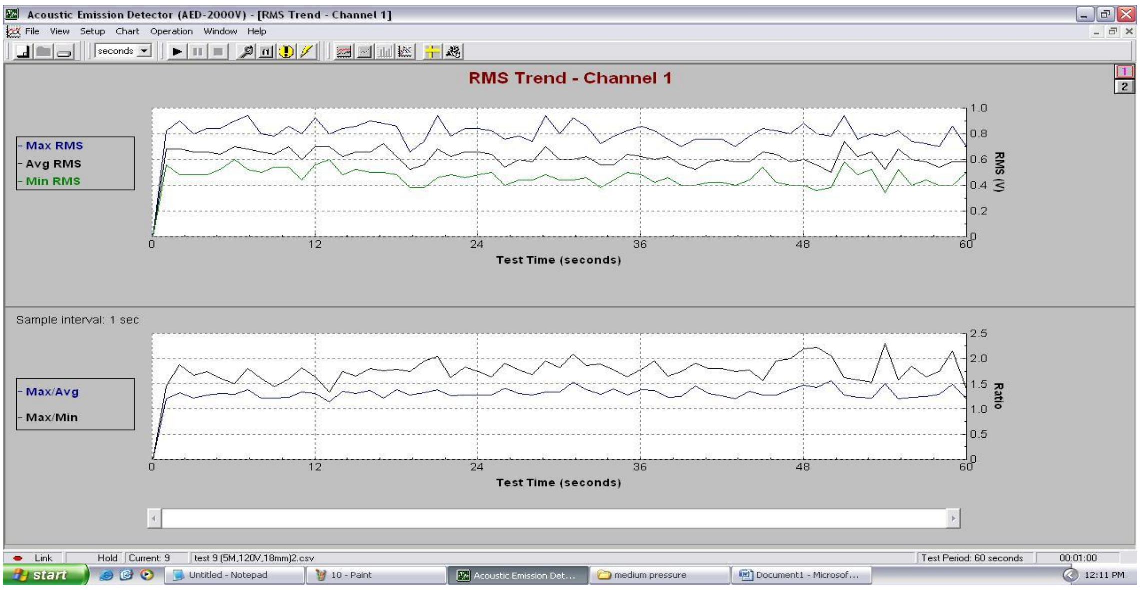


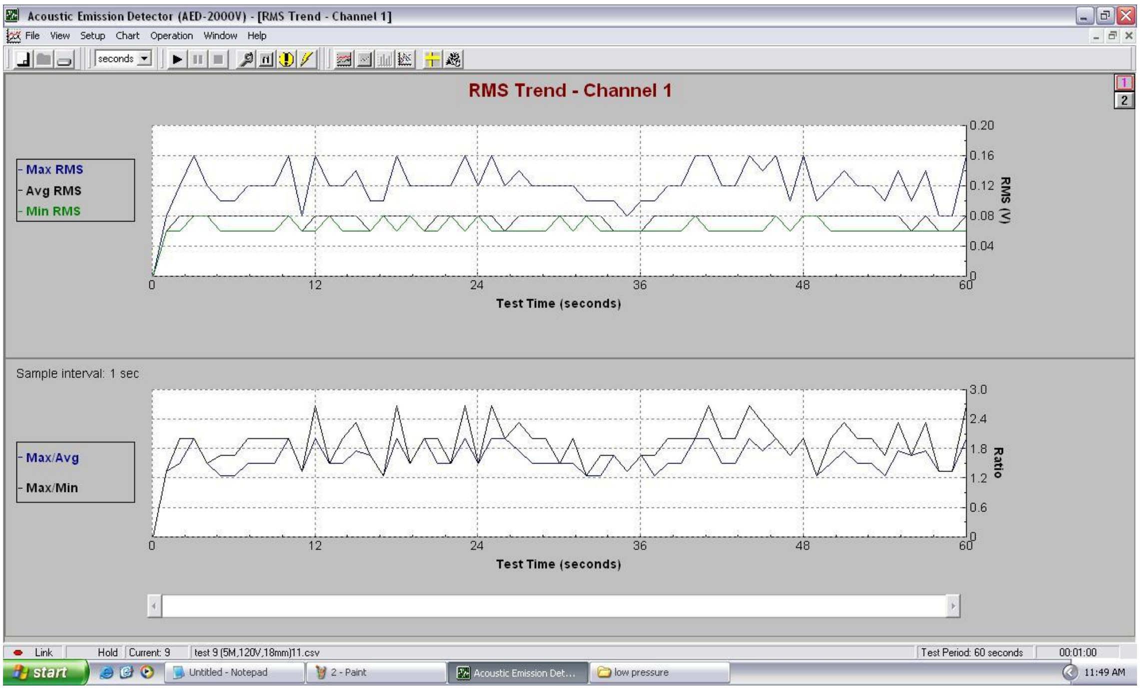


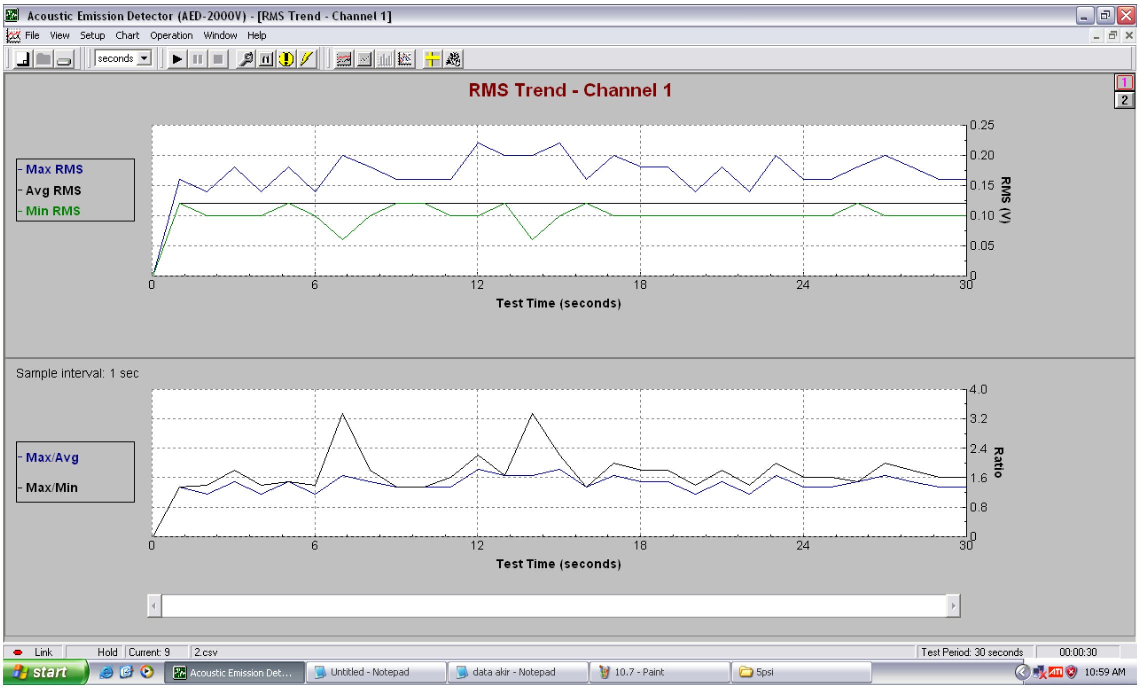
APPENDIX C

The example of AE signal that viewed using Acoustic Emission Detector 2.1.3 software






Acoustic Emission Detector (AED-2000V) - [RMS Trend - Channel 1]
RMS Trend - Channel 1
Max RMS
Avg RMS
Min RMS
RMS (V)
Test Time (seconds)
Sample interval: 1 sec
Max/Avg
Max/Min
Ratio
test 9 (5M,120V,18mm)11.csv
Test Period: 60 seconds
00:01:00


Acoustic Emission Detector (AED-2000V) - [RMS Trend - Channel 1]
RMS Trend - Channel 1
Max RMS
Avg RMS
Min RMS
RMS (V)
Test Time (seconds)
Sample interval: 1 sec
Max/Avg
Max/Min
Ratio
2.csv
Test Period: 30 seconds
00:00:30

APPENDIX D

The example of the test data gained for every pipe conditions.

Test data: Ball valve at pressure 25 Pa (Point 1)

Test	Hit mode			Count mode		
Time	Hits	Counts	RMS	Avg.RMS	Min.RMS	Max.RMS
1	0	0	2.54	2.54	2.50	2.64
2	0	0	2.58	2.58	2.52	2.68
3	0	0	2.56	2.56	2.48	2.68
4	0	0	2.56	2.56	2.48	2.64
5	0	0	2.54	2.54	2.46	2.64
6	0	0	2.54	2.54	2.46	2.64
7	0	0	2.56	2.56	2.48	2.64
8	0	0	2.56	2.56	2.50	2.64
9	0	0	2.58	2.58	2.50	2.68
10	0	0	2.56	2.56	2.50	2.64
11	0	0	2.56	2.56	2.50	2.66
12	0	0	2.58	2.58	2.52	2.64
13	0	0	2.56	2.56	2.50	2.64
14	0	0	2.56	2.56	2.46	2.66
15	0	0	2.62	2.62	2.54	2.70
16	0	0	2.56	2.56	2.48	2.66
17	0	0	2.60	2.60	2.56	2.68
18	0	0	2.60	2.60	2.52	2.72
19	0	0	2.56	2.56	2.50	2.64
20	0	0	2.56	2.56	2.50	2.64
21	0	0	2.58	2.58	2.50	2.68
22	0	0	2.60	2.60	2.54	2.72
23	0	0	2.58	2.58	2.52	2.72
24	0	0	2.58	2.58	2.50	2.70
25	0	0	2.60	2.60	2.50	2.74
26	0	0	2.58	2.58	2.52	2.68
27	0	0	2.60	2.60	2.54	2.70
28	0	0	2.60	2.60	2.54	2.68
29	0	0	2.58	2.58	2.50	2.68
30	0	0	2.56	2.56	2.52	2.62
31	0	0	2.56	2.56	2.48	2.66
32	0	0	2.58	2.58	2.52	2.72
33	0	0	2.60	2.60	2.52	2.70
34	0	0	2.58	2.58	2.48	2.68

35	0	0	2.56	2.56	2.46	2.66
36	0	0	2.58	2.58	2.50	2.70
37	0	0	2.58	2.58	2.54	2.66
38	0	0	2.60	2.60	2.52	2.68
39	0	0	2.60	2.60	2.52	2.72
40	0	0	2.56	2.56	2.50	2.64
41	0	0	2.58	2.58	2.52	2.68
42	0	0	2.58	2.58	2.52	2.66
43	0	0	2.58	2.58	2.50	2.68
44	0	0	2.58	2.58	2.50	2.68
45	0	0	2.56	2.56	2.50	2.66
46	0	0	2.60	2.60	2.56	2.70
47	0	0	2.60	2.60	2.52	2.70
48	0	0	2.58	2.58	2.50	2.64
49	0	0	2.56	2.56	2.44	2.64
50	0	0	2.60	2.60	2.52	2.68
51	0	0	2.60	2.60	2.54	2.72
52	0	0	2.58	2.58	2.50	2.68
53	0	0	2.56	2.56	2.52	2.64
54	0	0	2.60	2.60	2.54	2.70
55	0	0	2.58	2.58	2.52	2.66
56	0	0	2.56	2.56	2.48	2.70
57	0	0	2.60	2.60	2.52	2.68
58	0	0	2.58	2.58	2.50	2.68
59	0	0	2.62	2.62	2.54	2.72
60	0	0	2.58	2.58	2.52	2.70

Test data: Gate valve at pressure 25 Pa (Point 1)

Test	**Hits mode**			**Counts mode**		
Time	**Hits**	**Counts**	**RMS**	**Avg.RMS**	**Min.RMS**	**Max.RMS**
1	0	0	2.18	2.18	2.14	2.26
2	0	0	2.14	2.14	2.08	2.24
3	0	0	2.14	2.14	2.08	2.22
4	0	0	2.18	2.18	2.14	2.24
5	0	0	2.18	2.18	2.14	2.26
6	0	0	2.18	2.18	2.1	2.28
7	0	0	2.18	2.18	2.12	2.26
8	0	0	2.22	2.22	2.16	2.32
9	0	0	2.18	2.18	2.12	2.28

10	0	0	2.2	2.2	2.12	2.32
11	0	0	2.2	2.2	2.14	2.3
12	0	0	2.22	2.22	2.16	2.28
13	0	0	2.22	2.22	2.12	2.34
14	0	0	2.22	2.22	2.18	2.3
15	0	0	2.22	2.22	2.16	2.32
16	0	0	2.22	2.22	2.16	2.32
17	0	0	2.24	2.24	2.16	2.32
18	0	0	2.24	2.24	2.2	2.32
19	0	0	2.24	2.24	2.14	2.36
20	0	0	2.22	2.22	2.18	2.3
21	0	0	2.22	2.22	2.18	2.28
22	0	0	2.2	2.2	2.12	2.3
23	0	0	2.24	2.24	2.16	2.32
24	0	0	2.22	2.22	2.2	2.34
25	0	0	2.26	2.26	2.2	2.32
26	0	0	2.24	2.24	2.2	2.36
27	0	0	2.26	2.26	2.2	2.32
28	0	0	2.24	2.24	2.18	2.36
29	0	0	2.22	2.22	2.14	2.3
30	0	0	2.26	2.26	2.2	2.3
31	0	0	2.24	2.24	2.16	2.32
32	0	0	2.26	2.26	2.22	2.34
33	0	0	2.26	2.26	2.2	2.32
34	0	0	2.24	2.24	2.16	2.32
35	0	0	2.28	2.28	2.24	2.4
36	0	0	2.26	2.26	2.2	2.34
37	0	0	2.26	2.26	2.18	2.38
38	0	0	2.28	2.28	2.24	2.34
39	0	0	2.3	2.3	2.24	2.4
40	0	0	2.3	2.3	2.22	2.36
41	0	0	2.28	2.28	2.22	2.38
42	0	0	2.28	2.28	2.24	2.36
43	0	0	2.26	2.26	2.2	2.36
44	0	0	2.28	2.28	2.2	2.36
45	0	0	2.3	2.3	2.22	2.4
46	0	0	2.24	2.24	2.16	2.34
47	0	0	2.28	2.28	2.24	2.34
48	0	0	2.3	2.3	2.26	2.38
49	0	0	2.28	2.28	2.22	2.34
50	0	0	2.3	2.3	2.22	2.38
51	0	0	2.26	2.26	2.18	2.34
52	0	0	2.28	2.28	2.22	2.36
53	0	0	2.26	2.26	2.2	2.38
54	0	0	2.3	2.3	2.24	2.38

55	0	0	2.3	2.3	2.24	2.36
56	0	0	2.28	2.28	2.22	2.34
57	0	0	2.28	2.28	2.22	2.36
58	0	0	2.3	2.3	2.24	2.42
59	0	0	2.3	2.3	2.22	2.4
60	0	0	2.26	2.26	2.2	2.38

Test data: Stop cock valve at pressure 25 Pa (Point 1)

Test	**Hits mode**			**Counts mode**		
Time	**Hits**	**Counts**	**RMS**	**Avg.RMS**	**Min.RMS**	**Max.RMS**
1	0	0	3.46	3.46	3.44	3.52
2	0	0	3.46	3.46	3.44	3.52
3	0	0	3.46	3.46	3.44	3.5
4	0	0	3.42	3.42	3.4	3.44
5	0	0	3.42	3.42	3.42	3.48
6	0	0	3.42	3.42	3.4	3.44
7	0	0	3.42	3.42	3.4	3.5
8	0	0	3.42	3.42	3.4	3.44
9	0	0	3.40	3.4	3.4	3.46
10	0	0	3.40	3.4	3.4	3.44
11	0	0	3.40	3.4	3.4	3.48
12	0	0	3.40	3.4	3.4	3.44
13	0	0	3.42	3.42	3.4	3.48
14	0	0	3.42	3.42	3.4	3.46
15	0	0	3.40	3.4	3.38	3.48
16	0	0	3.40	3.4	3.38	3.44
17	0	0	3.42	3.42	3.4	3.44
18	0	0	3.40	3.4	3.4	3.5
19	0	0	3.40	3.4	3.38	3.46
20	0	0	3.42	3.42	3.4	3.48
21	0	0	3.42	3.42	3.4	3.48
22	0	0	3.44	3.44	3.4	3.48
23	0	0	3.40	3.4	3.38	3.44
24	0	0	3.38	3.38	3.36	3.44
25	0	0	3.40	3.4	3.36	3.44
26	0	0	3.38	3.38	3.36	3.42
27	0	0	3.38	3.38	3.36	3.42
28	0	0	3.38	3.38	3.36	3.44
29	0	0	3.40	3.4	3.38	3.44
30	0	0	3.40	3.4	3.38	3.48

31	0	0	3.40	3.4	3.4	3.44
32	0	0	3.40	3.4	3.38	3.46
33	0	0	3.40	3.4	3.4	3.44
34	0	0	3.40	3.4	3.4	3.44
35	0	0	3.40	3.4	3.38	3.46
36	0	0	3.40	3.4	3.4	3.46
37	0	0	3.40	3.4	3.38	3.48
38	0	0	3.40	3.4	3.38	3.5
39	0	0	3.40	3.4	3.38	3.44
40	0	0	3.40	3.4	3.38	3.44
41	0	0	3.38	3.38	3.36	3.44
42	0	0	3.40	3.4	3.38	3.46
43	0	0	3.40	3.4	3.4	3.44
44	0	0	3.40	3.4	3.4	3.46
45	0	0	3.40	3.4	3.4	3.44
46	0	0	3.42	3.42	3.4	3.48
47	0	0	3.40	3.4	3.38	3.44
48	0	0	3.42	3.42	3.4	3.44
49	0	0	3.40	3.4	3.38	3.48
50	0	0	3.42	3.42	3.38	3.48
51	0	0	3.44	3.44	3.42	3.5
52	0	0	3.44	3.44	3.44	3.48
53	0	0	3.44	3.44	3.42	3.48
54	0	0	3.44	3.44	3.42	3.5
55	0	0	3.46	3.46	3.44	3.54
56	0	0	3.44	3.44	3.44	3.5
57	0	0	3.46	3.46	3.42	3.54
58	0	0	3.46	3.46	3.44	3.5
59	0	0	3.46	3.46	3.44	3.52
60	0	0	3.44	3.44	3.42	3.52