DESIGN AND FABRICATION OF LEAD DETECTION TEST RIG

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DESIGN AND FABRICATION OF LEAD DETECTION TEST RIG

MOHAMAD SHAFIS BIN AHMAD RAMLI

Report submitted in partial fulfillment of the requirements for the award of
Diploma of
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Faculty of Mechanical Engineering
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JUNE 2013

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 Diploma of Mechanical Engineering.

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Date : ……..

STUDENT'S DECLARATION

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

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I dedicated this work to beloved parents and my family.

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ABSTRACT

Manufacturing is a process of converting raw material into product. It can be described the transformation of materials into items of greater value by means of one or more processing and/or assembly operations. The study of manufacturing was very important in order to carry out this project to ensure that students understand on what are need to do. This project is about designing and fabricating of lead detection test rig. This project involves the process of designing the piping by consider the type of pipe, and the component that involve to detect the leakage in the pipelines. From the investigated, there have many methods to detect the leak. From the investigated, the design was improved and fabricates the test rig for the analysis. The analysis were run after the fabricate is completed. After all the process had been done, these clotheslines may help us to understand the fabrication and designing process that involved in this project.

ABSTRAK

Pembuatan adalah satu proses menukarkan bahan mentah kepada produk. Ia boleh digambarkan transformasi bahan-bahan kedalam produk yang mempunya inilai yang lebih besar melalui satu atau lebih proses dan / atau operasi pemasangan. Kajian pembuatan adalah sangat penting untuk menjalankan projek ini untuk memastikan bahawa pelajar-pelajar faham mengenai apa yang perlu lakukan. Projek inia dalah mengenai reka bentuk dan plumbum pelantar ujian pengesanan. Projek ini melibatkan proses mereka bentuk paip dengan mengambil kira jenis paip, dan komponen yang melibatkan untuk mengesan kebocoran dalam saluran paip. Dari siasatan, terdapat banyak kaedah untuk mengesan kebocoran. Dari siasatan yang dilakukan, reka bentuk telah diperbaiki dan mereka bentuk pelantar ujian untuk dianalisis oleh pelajar. Analisis telah dijalankan selepas mereka bentuk selesai. Selepas semua proses itu telah dilakukan, plumbum pelantar ujian pengesanan ini boleh membantu kita untuk memahami fabrikasidan proses mereka bentuk yang terlibat dalam projek ini.

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CHAPTER 1

INTRODUCTION

1.1 Project Synopsis.

The purpose of the project is to design and fabricate of lead detection test rig structure for lead detection testing apparatus. This test rig structure should be able to stand the transducer water flow piping that will contains several parts which are leakage point, flow meter, valve, andsolenoid. In this project, a simple test rig structure has been design and fabricate. As the Diploma Final Year project allocates the duration of one semester, this project need combination of knowledge and skills to handle a several problems.

This project involves the fabrication of test rig structure with specification regarding the strength, material and cost. Tests are required on the new design and fabrication to get a perfect result.

In University Malaysia Pahang(UMP) doesn't have the test rig structure for leak detection testing apparatus. From this problem, came out an idea to design and fabricate a new test rig structure.

1.2 Project scopes.

i. Design the experimental leakage detection test rig using Solidworks software.

ii. Perform the design with upgrade the piping.

iii. Find the suitable material.

iv. Perform the experimental laborotary for the data measurement.

v. Perform the signal analysis using wavelet transform.

1.3 Project Objective

i. To fabricate the leak detection test rig.

ii. To study the practical implementation signal processing such as wavelet transform method for leakage detection in pipelines.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The test rig structure is the main structure for the leak detects testing apparatus. The leak detect testing apparatus contains of several parts that is a valve, pressure transducer, flow meter, leak, solenoid and variable speed pump. The fluid that produce by the pump will flow through this pipe and the whole component will work. The pump have a variable speed, so to make an experiment about the pressure and flow water, we just change the speed that needed.

The leak detect test rig functions are to study and experiment how the transducer and other component working together. The leak detect test rig is the simple and easiest way to study about the real leakage in the pipe system and encourage the students about the leak detect testing apparatus.

2.1 Causes Of Leakages

There are many causes which contribute to the leakage problems in pipeline system. Among the causes are:

a. **Corrosion** :

Corrosion is not only contributing to the leakage problem, it also affects the quality of water being transmitted. Corrosion can occur inside or outside and causes the pipe to become weaker in supporting the outer force exerted on it. Corrosion which happen outside of the pipe is mainly due to the environmental effect while water happens quality and corrosion protection layer are the factor affecting corrosion happens in the inside of the pipe.

b. **Material defects :**

Material of the pipeline used may not comply with the standard requirements. This means that it may not able to sustain the designed water pressure and designed traffic load. Therefore it stands a high potential to get burst and cause leakage problem.

c. **Faulty installation** :

Every pipe need to be installed properly so that they can take up the water pressure and traffic load designed. Poor workmanship on the pipes installation will greatly reduce the capability of pipes to take up loads exerted on it and eventually causes leakage problem.

d. **Excessive water pressure :**

Excessive water pressure resulting pipes with small thickness to be easily burst and causes leakage problem.

e. **Ground movement :**

Ground movement is usually caused by drought or freezing, the arrangement of pipes will differ from its original position either horizontally or vertically after ground movement and this will lead to the non uniform distributed load on the pipes. The pipes will start to crack and eventually resulting in leakage.

f. **Excessive loads and vibration from road traffic :**

Pipes are often designed to sustain certain amount of traffic loads. Pipes which have been put in used for a very long time may not have ability to sustain excessive increment of the traffic loads and therefore will crack and contribute to leakage problem.

g. **Old and poorly constructed pipelines :**

This is due to the long term usage of pipelines which is no longer sufficient in providing its service to water supply.

h. **Poorly maintained valves and mechanical damage :**

Mechanical damage usually will cause the pipelines system to not function inits optimum level which the quality of water pressure. In serious cases, it will result in the occurrence of leakage.

2.2 Impacts of Leakages

According to a research, water loss due to leakage water distribution system is generating more than just financial loss. Some leakage is generating more than just financial loss. Some of the potential impacts of uncontrolled leakages in water distribution system are:

a. **Loss of revenue**. Every state in the country spent an immense amount of cash in treating raw water and to deliver the treated water to its final consumer, which are community and the industry. Wherever leak presents is distribution system, the money spent will be lost and it is not recoverable. Observing the current leakages problem across the country, a state's government is anticipated to be able to cut its operating cost to half or double its revenue should there is an efficient water detection survey.

b. **Optimum energy consumption cannot be achieved.** Pressure need to be increased in a water distribution system in order to deliver the water in the supply network system whenever leak occurs. This is because leakages will usually cause a significant plunge in pressure and thus the delivery of this energy will not be efficient.

c. **Risk of contamination.** Water pipelines are normally laid several feet underneath the massively developed and densely populated cities. These cities are usually exposed to numerous forms of pollution. Leakages in water

network system will increase the risk of contamination to treated water supply through seepage of pollutants from environment into the piping network.

d. **Damage to infrastructure.** As in the aforementioned impact, leakages tend to overflow from underground to road surface. Water is famously known for its destructive behaviors such as damaging the road structure and also causes skidding effect of vehicle which is definitely an effect that could endanger the lives of road users.

e. **Inefficient fire-fighting capabilities.** Due to the failure to maintain optimum pressure in the water distribution system servicing hydrants, fire-fighting capabilities may be reduced and becomes inefficient. This situation is certainly going to increase the number of lives and properties lost due to the presence of leaks in water distribution systems.

f. **Jeopardizing public confidence**. Complaints from the public which is more accurately to be addressed as consumers, is inevitable whenever there is a disruption in water supply. State water authorities are expected to be bombarded with numerous complaints from end consumers. This will not only increase the work loads of state water authorities, it will also jeopardize the public relations between consumers, this will not only increase the work loads of state water authorities, it will also jeopardize the public relations

between consumers and the authorities and generate unnecessary negative image among public.

g. **Delayed capacity expansion.** Leakage problem will increase the operating cost of state water authorities to treat more water as to meet the demand, increase the amount spent in network maintenance, and reduced revenue from inefficient water supply system. The decrease in revenue will prevent the state water authorities to expend its network capacity to serve more people.

2.3 Methods Of Leaks Detection;

Various methods have been developed in order to detect pipeline leakage in a more effective way. Among all the methods being developed, acoustic method is the one gaining much popularity compared to other methods such as tracer gas, ground-penetrating radar, infrared imaging and also thermography method. The acoustic methods is popular because it is easy to adopt and effective in detecting leakage. Other than aforementioned methods, pressure point analysis, wave alert, SCADA-based system, radioactive tracing and many more techniques are also common practices. These practices are described in the following paragraphs.

1 Acoustic Methods;

Acoustic device are the principle equipments used by the water industry to locate leaks in the distribution system nowadays. The adoption of acoustic-related devices is not uncommon since 1980s. In fact, the simple to understand, easy to operate, and most importantly high accuracy nature of this method has actually accelerated the technology development and advancement of acoustic devices. Today other than simple listening device such as listening rods, sounding stick and aquaphones, sophisticated equipments that utilizing acoustic theory to locate leaks at more diversified water distribution network, for example, leak noise correlator and Sahara leak detection system, had also been developed and are tested to be able to locate leaks efficiently.

The theory used behind the acoustic methods is sound will be induced by water as it escapes from pipes under pressure. Leak sounds are transmitted through the pipe itself over significant distance(depending on the pipe size and type), and through the surrounding soil into the immediate area of leak. By utilizing simple devices to listen for this sound, leaks can be detected easily. Although acoustic methods are widely practiced by the water industry, the detection and location of leaks are not always fruitful due to the several factors that may influence the listening process.

I. Factors influencing the effectiveness of acoustic method;

Factors that are influencing the effectiveness of acoustic methods are pipe size, type and depth; soil type and water table level; leak type and size; system pressure; interfering noise; and sensitivity and frequency range of the equipment. All this factors are actually dealing with the fundamental of acoustic methods, which

is the sound or noise generated from leak in a pipeline. The significance of each factor is discussed as follows:

a. **Pipe size, type and depth.** The attenuation of leak signals in a pipe depends greatly on the pie materials and also the pipe diameter. For instance, leak signal is travelling farther in metal pipe than in plastic ones. The greater the diameter of the pipe, the greaterthe attenuation, which means the harder it is to detect the leak. Besides, the pipe material and diameter also effect the predominant frequencies of leak signals. Leak signals are more susceptible to interference from low-frequency vibration, such as from pumps and road traffic, if the diameter of the pipe is large and the pipe is less rigid, due to the lower predominant frequencies.

b. **Soil type and water table level.** In general, leak sounds are more audible on sandy soils than on clayey ones; and on asphalt or concrete surface that on grass. Besides, leak signals become weaker when the pipe is below the water table level.

c. **Location and size of leak.** Leaks occur at different part of a pipe will generate different frequency of noise. Splits and corrosion pits in pipe walls usually induce stronger leak signals and higher frequencies than leaks in joints or valves. Leaks which are to small may be too hard to induce leak signal significant enough to detected. Therefore, the larger the leak, the stronger the leak signals. But this may not true for every large leaks.

d. **Pipe pressure**. The higher the pipe pressure, the stronger the leak signals and thus the easier to locate a leak. However, increase pressure in pipe may reduce the efficiency of distribution network. The sudden increment of pipe pressure may also cause damage to piping system.

e. **Sensitivity and frequency range of equipment**.

Indeed, the more sensitive the leak sensors, the higher the signal-to-noise ratio of the equipment, which means the smaller the leaks, can be detected. Filters and amplifiers may be incorporated to make leak signals more significant.

II. Ground Surface Listening Devices;

There is several ground service listening devices as mentioned buHunaidi (200O), which have been put in use for quite sometimes. These include listening rods, aquaphones, and geophones or ground microphones. To detect leaks in pipeline system, leak detection crew first roughly bracket leaks in the system by listening on all accessible contact points in the distribution system by listening on all accessible contact points in the distribution system such as fire hydrants and valves. Whenever suspected leaks are identified, the leak detection crew will start to pinpoint the leaks by listening on the ground surface at very close intervals(usually about 1m) with the aforementioned devices. Although the operation of listening device usually straightforward, their effectiveness depends greatly on the experience of the user. If the crew was inexperienced, then it is very likely that he will miss out the possible leak location.

Besides, the noise generated is louder only when the leak is closer to the listening device. Thus, the crew may miss out a leak if he is further away from the leak.

III. Leak Noise Correlators;

Alternatively, suspected leaks can be pinpointed automatically by adopting the use of modern leak noise correlators which have become popular in recent years. Normally, leak noise correlators are the state-of-art portable computer based devices that can pinpoint leaks automatically, but it is not based on listening to the noise transmitted through the ground to the surface, like the principle adopted by listening devices. The operation of the leak noise correlator is by measuring vibration or sound at two points that bracket the location of a suspected leak. Figure shows how leak noise correlators is put into operation. In this method, acoustic leak signal are measured with vibration sensors or hydrophones are placed at two pipe contact points that bracket the location of a suspected leak. Vibration or sound signals are transmitted wirelessly from the sensors to the correlators.

The leak is in most cases located asymmetrically between measurement points and consequently there is a time lag between the measured leak signals. As to pinpoint a suspected leak, a correlator first determines the time lag between measures leak signals by calculating cross-correlation function. The location of the leak is calculated based on a algebraic relationship between the time lag, the sensor-to-sensor distance, and the propagation velocity of sound waves in the pipe. Normally, the distance

between sensors is measured on site or read from distribution system maps. Propagation velocities for various pipe types and size are usually available in most commercial devices or they can be measured easily on site.

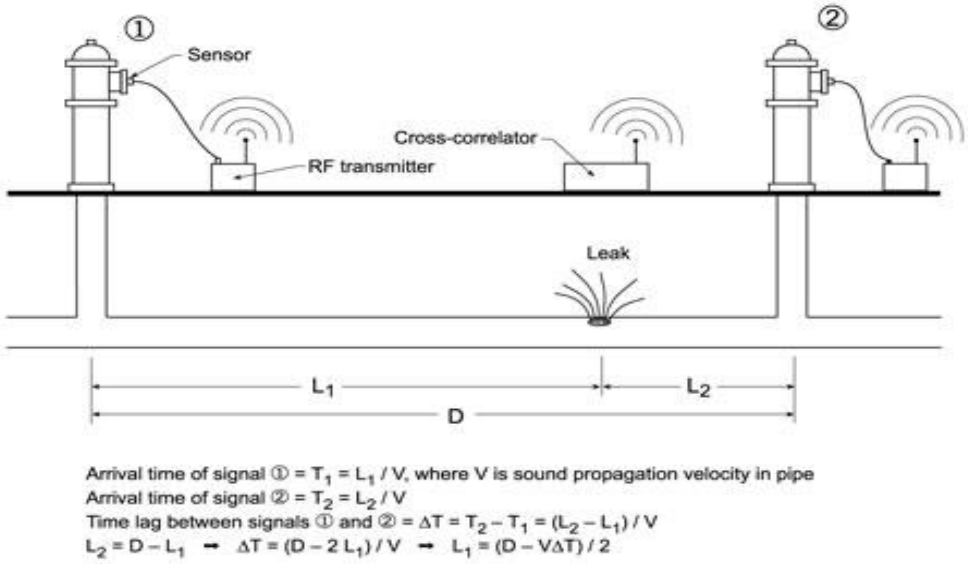


Figure 2.1:Schematic illustration of the cross- correlation method for pinpointing leaks in water pipes.

The technology of leak noise correlators is no stranger to most of the water industry around the globe. As early 1980s, the water industry in the United Kingdom had purchased correlator and in the first week of operation, they had found a leak which they suspected and had investigated for a year. The success of the operation saved the water industry 270,000 gallons of water per day. Five years later, another United Kingdom water authority operated a microprocessor correlator over a period of six weeks with a total of 48 correlation attempts, found a total of 48 leaks successfully(Halliday,1985).

In the late 1980s, water authority of Nagoya city occupied a series of water leak detection works in the city which also incorporated leak noise correlator in their operation, had successfully increased the efficiency of water supply in the city (Teruo Sanobe,1989). After years of operations, the Nagoya City water authority had summarized its operation as having less number of leakage repairs and an increased of the effective rate and accountable water rate. The overall effectiveness of water supply in the city was reported to be nearly 100%. The water authority also concluded that measures for leak preventation by mean of 'sound' should be developed more rigorously. Thus we can conclude that the utilization of leak noise correlator is capable in locating pipeline leaks and increase efficiency of water distribution.

Although leak noise correlator is capable in locating leaks in pipeline, it is not always providing accurate results, especially while being tested on plastic pipes, to the water industry for subsequent excavation and repair works. *Hunaidi et al.*(2000) had performed a test to determine the best testing methods to detect leaks in plastic pipeline. The test concluded that leaks in plastic pipe are able to be located by leak noise correlators. But several difficulties had been giving the method challenges. Professional leak detection teams in this test found out that when operated in automatic and manual mode, leak noise correlator was rarely succeed in locating leak signals as the range of frequency selected was usually too high for plastic pipe which has frequency range of mostly below 50Hz. The teams concluded that the leak noise correlators may yield a better result if the

automatic mode algorithms are revised are revised. In the test, it was found the non-acoustic methods appeared to be mo promising.

IV. Leak Detection In Large Water Transmission Mains;

a. Limitations of previously discussed devices;

When utilizing listening devices, the distance from the leak location to the listening sensor is a critical factor deciding the accuracy the detection of leak's location. In general, the deeper in the ground that the leak occurs, the harder it is to detect. The type of soil and soil conditions can also be a factor, as sound attenuation or the reduction in intensity of a sound is greater in clay soils versus sandy soils. To effectively detect a leak, listening devices need to be placed almost directly over a leak location. Thus, ground surface listening device, or even ground penetrating rods, which are historically proven to be effective in detecting leaks on distribution pipelines that are buried relative shallow are unsuitable for the detection of large diameter pipelines, due to the long distance of these pipelines and also the various uncertainties as to where the pipelines actually run underground.

Another leak detection device, the leak noise correlator, which is also widely used in leak detection, is not suitable for the leak detection carried out at large diameter transmission mains. The availability of

accessible appurtenances on which to attach the accelerometer becomes a limiting factor to the use of the noise correlator, which required accelerometers to be attached to a relatively close space. Besides, identification of leaks can be limited by the physics of acoustic attenuation and propagation of the acoustic activity in large diameter pipeline.

b. In-line acoustic based leak detection system (Sahara);

In-line acoustic based leak detection system, which also known as the Sahara system, is one of the newer non-destructive technologies developed with the aim to detect leaks in pipeline system. Sahara system not only pinpoints the location of leak, it also estimates the magnitude of leaks. The system of leak detection is used in water transmission mains. The Sahara systems uses a highly sensitive acoustic detector unit(known as drogue), which is inserted into the main at any tap point of two-inch or greater in diameter while the pipeline remains under pressure(between 3 and 200 psi or 0.3 and 13.8 bar)(Larsen et al., 2005). Other than the acoustic detector unit, the operating unit also consists of cable which incorporates with a retractable guide which protects the cable from damage as it passes into the pipe, a winch which forces the umbilical into the pipe against water pressure and withdraws the umbilical from the pipe upon completion of the survey, and cable drum which control the development and retrieval of the umbilical.

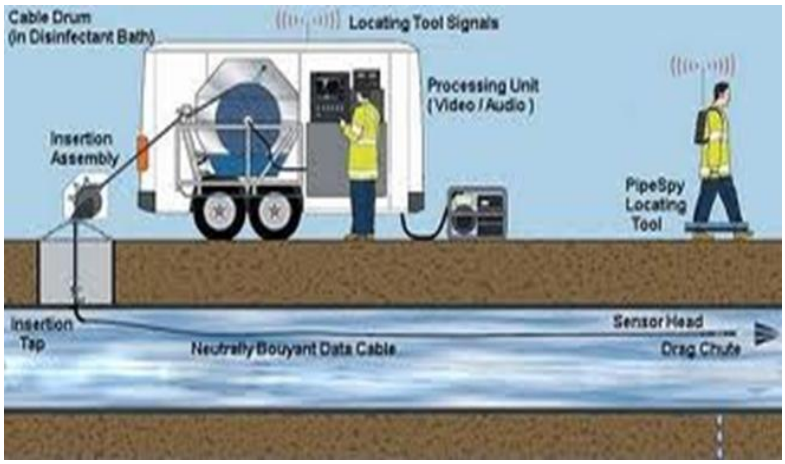


Figure 2.2: Schematic diagram of Sahara system in operation

During operation (as illustrated in **Figure 2.2**), the system is carried along the pipe by the flow water. In order to carry the system, flow rate in transmission mains must be greater than 1ft/sec or 0.3m/s. the detector head will continuously record for distinctive noise of a lead that is generated by the escape of under-pressure water as the system travels through the pipe. Once a leak is detected, the sensor head can be stopped at the precise location of the leak. An operator can then estimate the magnitude of the leak through quantification of the acoustic signal recorded by the sensor, which is then presented in visual data output through the conversion of audio data. The location of the leak is the surface located using a precision locator unit and accurately marked for subsequent excavation and repair.

Sahara system was commissioned to detect leaks in pre-commissioned pipelines in the Lake Fork Transmission Main near Dallas, Texas in the United States, when the 11.3 kilometers pipeline had failed a series of hydrostatic pressure tests (Larsin et al, 2005). Before the Sahara system is adapted, attempts werw made to locate the leak using visual inspection and correlaters. However, neither of these methods detected leaks successfully. By using the Sahara system, the contractor of the project managed to determine two leaks and four anomalies, which could be described as “leaking faucet”. The presence of the leaks was verified with the subsequent excavation and repair work. It was fond out that both main leaks were happened to be joint locations.

In the United Kingdom where the Sahara leak detection system was first developed, Themes Water Utilities Limited, which is the larger water and waste services company in the United Kingdom , concluded that the Sahara leak location system was the most accurate and cost effective way of detecting and locating system was the most accurate and cost effective way of detecting and locating trunk main leaks, after its eight years of investigation which were successfully detected and located over 960 leaks from the over 960 completed surveys(Mergelas, Bond and Laven, 2006). The organization also reported that after comparing a range of new and traditional leak detection methods with parameters included cost of operation, sensitivity of detection and accuracy of locations, the Sahara leak detection system had provided the organization sufficient

useful information to repair an average leak approximately 0.15M 1/day, with near 100% accuracy record.

Although this in-line acoustic based system is effective in detecting leaks in large diameter water transmission mains, it has a very significant shortcoming. This system is tethered by a cable during its operation. The most significant limitation of a tethered system is just like what its name suggest – it is tethered. How far can the system be extended was always the main concern of the operator. Under optimum condition, it may be stretched to amile length. However, when the inspection is to be carried out for several miles, the setting up and dismantling of the system may sound too cumbersome and time consuming and therefore could be inefficient. The presence of in-line valves, sharp bends, changes in elevation may affect the length of the tethered cable that can be deployed.

c. Free-swimming leak detection technology;

Free- swimming(non-tethered) leak detection technology is invented and designed after the recognition of the value offered by acoustic lead detection technology and the realization of the limitations associated with current leak detection technologies applicable to large diameter water transmissions mains. Free-Swimming leak detection technology is developed with the goal to enable

operators and engineers to survey pipelines which are not previously possible or logistically challenging.

Davis W. Kutz(2004) had set up a research and development programme to develop a free-swimming acoustic leak detection device targeting at large dimension transmission mains. The device was developed as a leak detection device that could be propelled with the water flow over long distances while recording signals generated by leaks as it travelled through the pipeline, the incorporation of the ability of this device to propel with water flow is due to the state of large water mains which run for long distances and do not offer much in the way of intermediated access point. One of the chief challenges in designing this device was to provide for the sensitive detection of the acoustic signal generated by a leak. The advantage of this free-swimming acoustic leak detection device is the ability of placing a sensor very near to the leak which is no further than a pipe diameter. However, the interference from noise generated by the movement of the device as it traverses along the pipeline may greatly affect the accuracy of leak detection.

In the recognition of shortcomings design, the device had finally been created as a device that provides a foam ball that envelope an aluminium, water-tight sphere containing sensitive acoustic instruments. The foam ball is inserted into pipeline and released to allow the flow to carry the ball downstream. While the ball is traversing the pipeline. Once the ball has travelled the desired pipe length, which is depending of the battery in the device, it

is retrieved with a net assembly and extracted from the pipeline, the acoustic data is then evaluated to determine the presence and location of any leaks in the pipeline.

As any other acoustic leak detection technology developed, the free-swimming technology utilizes several features in combination as to accurately locate a leak in a pipe. These include:

1. Transponders which are periodically placed along the pipeline to track the location and movement of the ball and acoustic instrument by detecting pulses.

2. Counting revolutions. The ball may roll along the bottom of the pipe without skidding or any extra revolutions. A general indication of where a leak is achieved by counting the number of times the ball has rolled. It can also be utilized to confirm other algorithms.
3. A miniature transponder placed inside the sphere emits a coded ping that allows a GPS based logger on the surface to identify the ball as it passes.

4. Internal monitoring and recording of temperature and temperature change can donate inlet/outlet along the pipeline.

The device was put in test at Tucson, Arizona and traversed a length of approximately 3.77 miles, by a two-man crew in a matter of hours (Kurtz, 2006). The result of

the test shows that the device was able to capture clearly acoustic signal generated by a one gallon per minute leak. The acoustic signal was picked up about ten to fifteen feet on either side of the leak location, as the signal built to a very well defined acoustic crescendo as it passed nearby by the leak.

Besides successfully locating the leak, the device had also reaffirmed the various tracking methods which are greatly contributing to the detection of leaks. These include counting revolutions of the ball and positioning and timing from the surface mounted transponders, as demonstrated in **Figure 2.3**

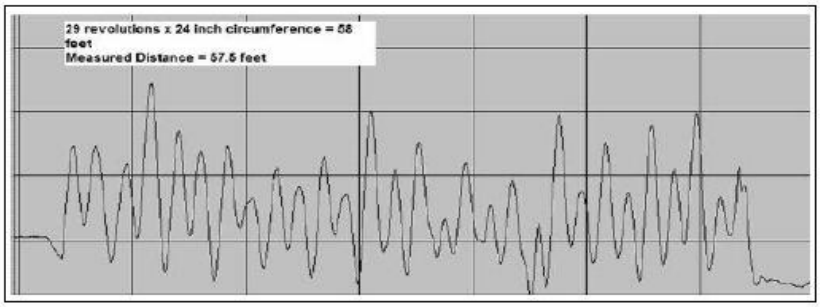


Figure 2.3: Computer display depicting revolutions of the ball and correlation to distance travelled.

Subsequent testing was performed and they had reinforced the reliability of the device to identify acoustic signals associated with a leak event in a pipeline by utilizing proven acoustic technologies. Other than leak detection accuracy, the ability of the device to travel in long distance which therefore increases the efficiency of

the testing verifies the cost effectiveness offered by it to detect leaks in large diameter.

2 Transient Pressure Method;

Over the years, many researchers had carried out researches based on the utilization of transition pressure theory. Generally, in a hydraulic system, transient pressure occur whenever there is a change in flow condition, resulting pressure waves to propagate through the system until a steady state is achived. Similarly, a leak will generate reflected waves that will continue to attenuate when a pressure wave is initiated in the system. Thus, researches use this theory to make detection of leaks possible by measuring the pressure variation between leak-presence system and water tight system.

The researches of this study carried ont simulation using computer software SURGE. The steady state of a water tight sample network was disturbed with on-off operation of valve in the network. From Figure 2.4, it is obvious that the presence of leak in a pipeline will result a different transient wave profile than a transient wave profile of a pipeline without any presence of leak. The superposition of these two profiles of a pipeline without any presence of leak. The superposition of these two profiles gives the researchers a very vivid finding that by comparing transient pressure in leak present system and water tight system, the presence of leak in pipeline system can be detected. Besides detecting leak, the researchers also carried out study on the wave profiles of different leak sizes and the results are shown as followed. From Figure 2.4, it is clearly seen that the larger the leak size, the fastest the attenuation of pressure inside a pipeline.

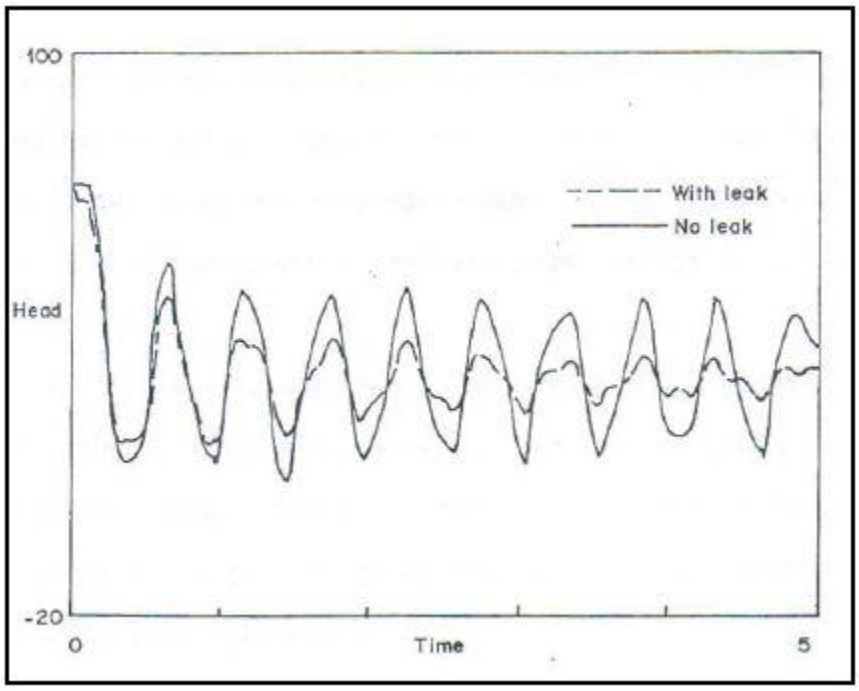


Figure 2.4: Pressure graph showing presence of leak in a water tight network

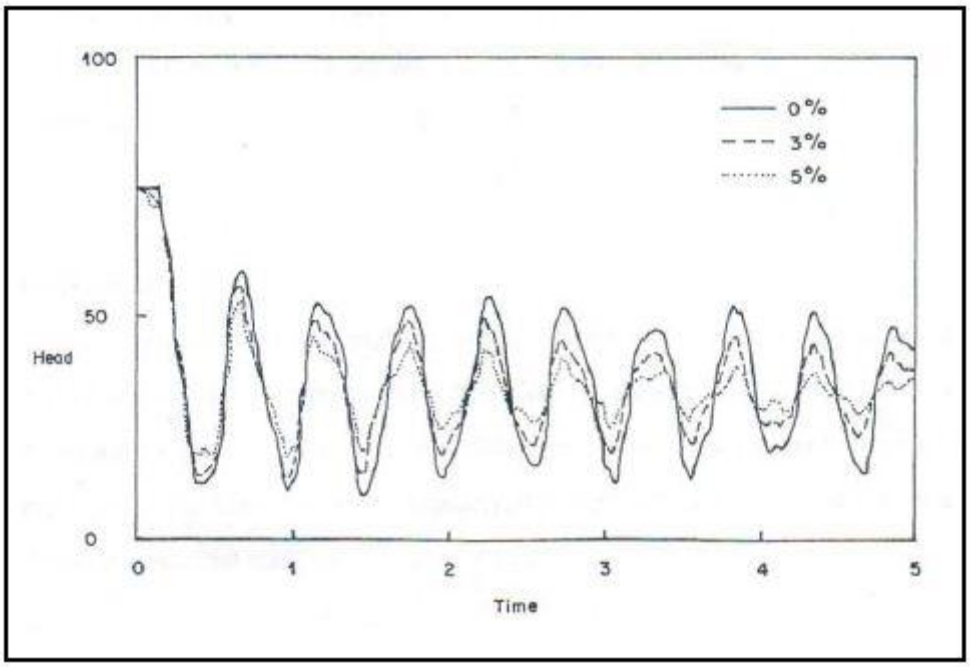


Figure 2.5: Pressure graph for different leak size representations

The previous study of the two researches was actually modified from a study by Gally and Rieutord (1985). It this study, oil is utilized instead of water. It was assumed in the study that the presence of transient pressure occurs when there is a sudden disturbance, for example, presence of a leak I the system. Two pressure recorders were installed at the upstream and downstream of the system as to record the time needs for pressure generated to reach each measurement point. After that the location is determined with the equation generated from the time difference of the arrival of pressure.

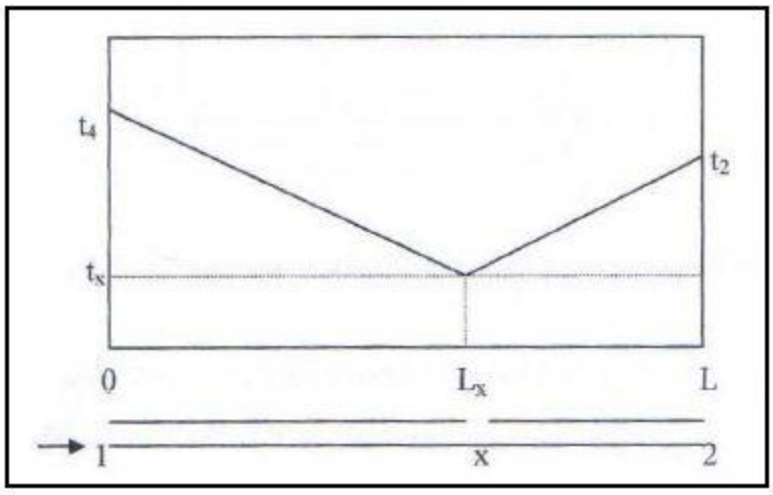


Figure 2.6: Schematic diagram for study by Gally and Rietord (1985)

$$L_x = \frac{c(t_1 - t_2) + L}{2}$$

where , c = velocity of wave

L_x = distance of leak from either one of the recorders

$(t_1 - t_2)$ = difference of time arrival

L = distance between two recorders

The estimation of leaks' location is pretty similar to the one used in a leak noise correlator. However, instead of measuring pressure, the leak noise correlator measures the propagation of noise generated by the leak. Comparing these two methods, it is seen that the utilization of acoustic method is providing a better approach to locate a leak. As mentioned, pressure yielded in a network due to an abrupt disturbance will tend to attenuate along the pipeline. The size of the leak will also greatly contribute to the attenuation of the pressure. Thus, it is generally more difficult to capture the pressure generated accurately. On another hand, noise generated from a leak can propagate through a longer stretch of pipeline and the attenuation of the noise is less important since noise travel at very high speed. Besides, it easier to distinguish a noise generated by a disturbance than to detect a difference in pressure due to presence of leak. Therefore, it can be concluded that the utilization of acoustic method is able to yield a better result in the localization of leak in a pipeline system.

3 Tracer Gas Technique;

Figure 2.7: In tracer gas method, a portable gas sensor is used to detect monotoxic gas as it escaped through leaks in pipe and rises through the surrounding soil to the ground surface

In this method, as discussed byHunaidi et al. (2000) and Stafford and William (1996), a non-toxic, water- soluble and lighter than air gas in injected into an isolated segment of a water pipe. Gases usually being used are helium and hydrogen. After the gas been injected into the isolated pipe, it will escape at a leak opening and then, being lighter than air, permeates to the surface through the soil and pavement. Therefore, wherever there is a leak in the pipelines, a higher concentration of the gas injected will accumulates around the leaks areas. By scanning the ground surface directly above the pipe with a highly sensitive gas detector, the leak can be located. Although the method is rather simple to be adopted, the minimum detectable leak level depends on upon the installation, pipeline product, and the sampling detector sensitivity.

4 Thermography;

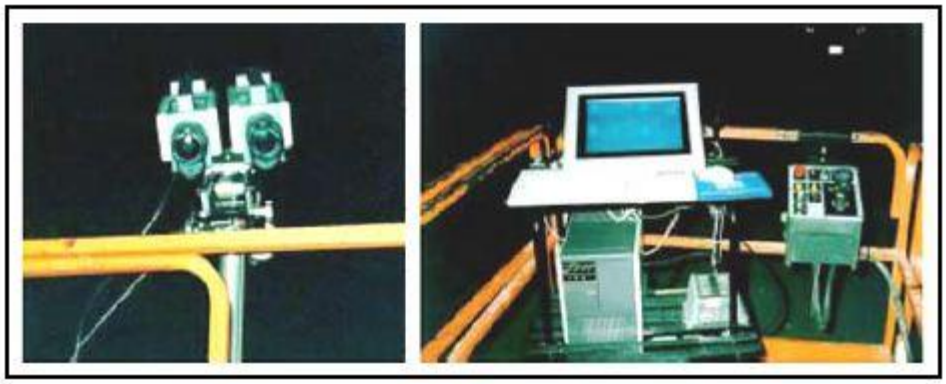


Figure 2.8: Thermography technique detect thermal infrared radiation by focusing the camera system directly above a leak and display it as visable images

Water leaking from an underground pipe changes the thermal characteristics of the adjacent soil(Hunaidi *et al*, 2000). In many situations, a pipeline will create a temperature disturbance in the environment surrounding the pipe. For example, in pressurized pipeline, the escaping water will generate a cold zone in the environment surrounding the pipe and thus making the pipe a more effective heat sink than the surrounding the pipe and thus making the pipe a more effective heat sink than the surrounding dry oil. This is the principle used behind the thermography concept or the temperature profile technique. The resulting thermal anomalies above pipes ade detected with handheld, or vehicle or airplane-mounted infrared cameras. There is also some more advance and intensive ways to detect the thermal difference by acquiring distributed temperature sensors. Two major technologies complete in the temperature sensing areas are multi sensors electrical cable and optical time domain reflectometry (OTDR) using fibre optic cable. However these two technologies are usually costly and complex. There are more common being used in detecting leaks in gas pipelines.

a. Ground penetrating radar;

To locate leaks in buried water pipes, radar can be used either by detecting voids in the soil created by leaking water as it circulates near the pipe, or by detecting segments of pipe which appear deeper than they are because of the increase in the dielectric constant of adjacent soil saturated by leaking water (Hunaidi*et al.*, 2000). Ground penetrating radar waves are partially reflected back to the ground surface when they encounter an anomaly in dielectric properties, for example, a void or pipe. The size and shape of the object is formed as an image by radar time-traces obtained by scanning the ground surface. The time lag between transmitted and reflected radar waves determines the depth of the reflecting object.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This section will show design for the test bed that made by using Solidwork software. In this section also will briefly describe the ways to make the test bed.This includes the selection and preparation of materials, equipment setting such as sensor and measuring device. This is very important to determine the best and accurate result for this study. Other than that, in this section also briefly explain the way how the study being conducted, which is by doing experiment to obtain data from test bed.

This research study was conducted based on the methodology. This methodology plays an important role in implementing this research study accordingly. The details of the methodology are explained in detail in this chapter.

3.2 Methodology Process Flow Chart

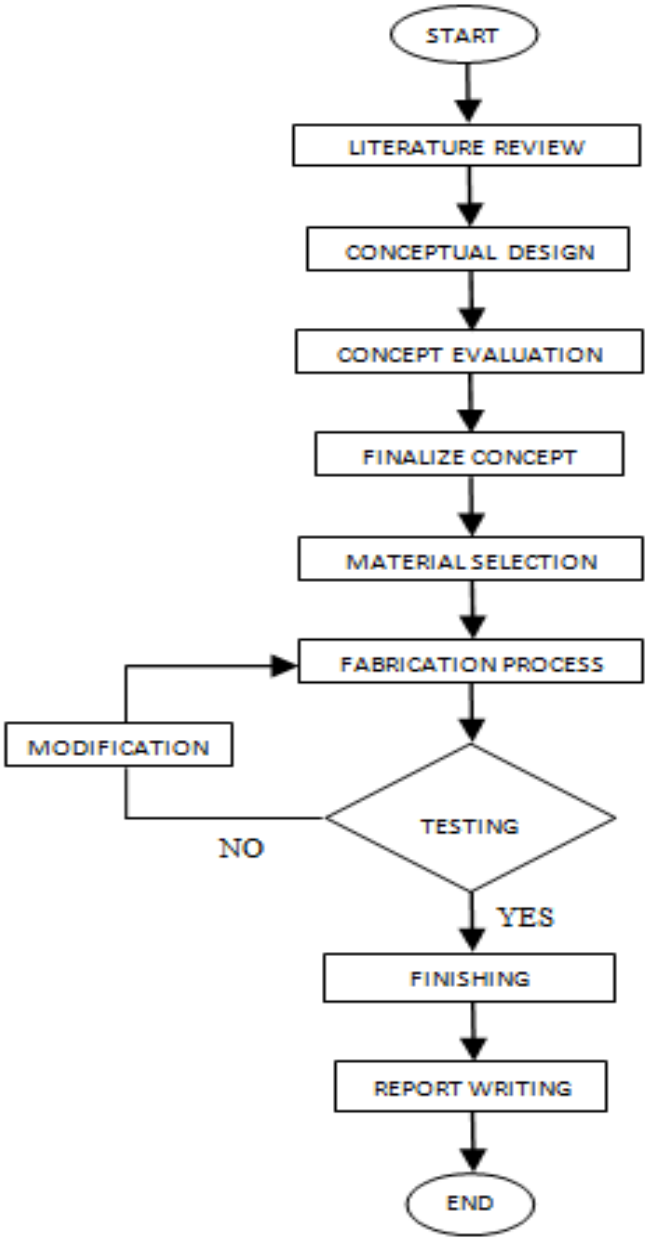
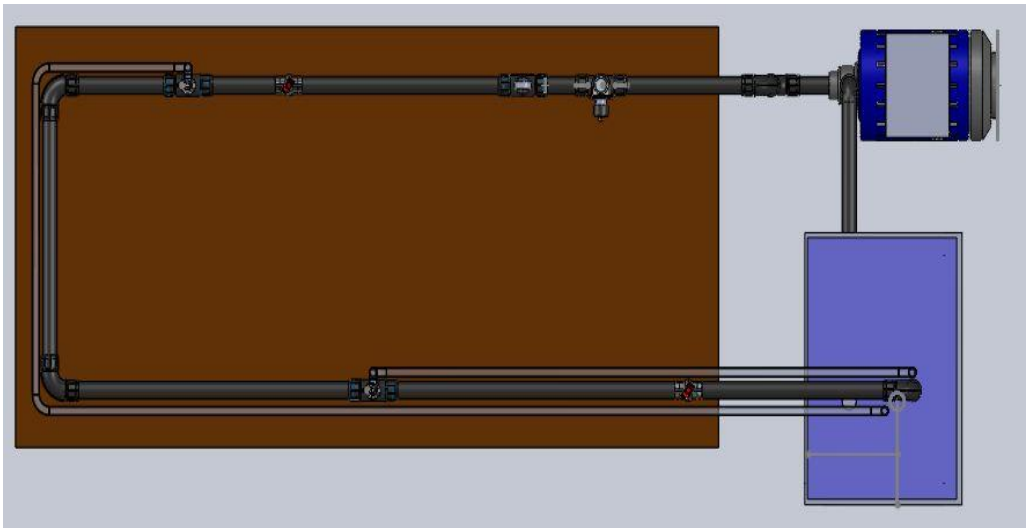


Figure 3.1:The methodology process flow chart

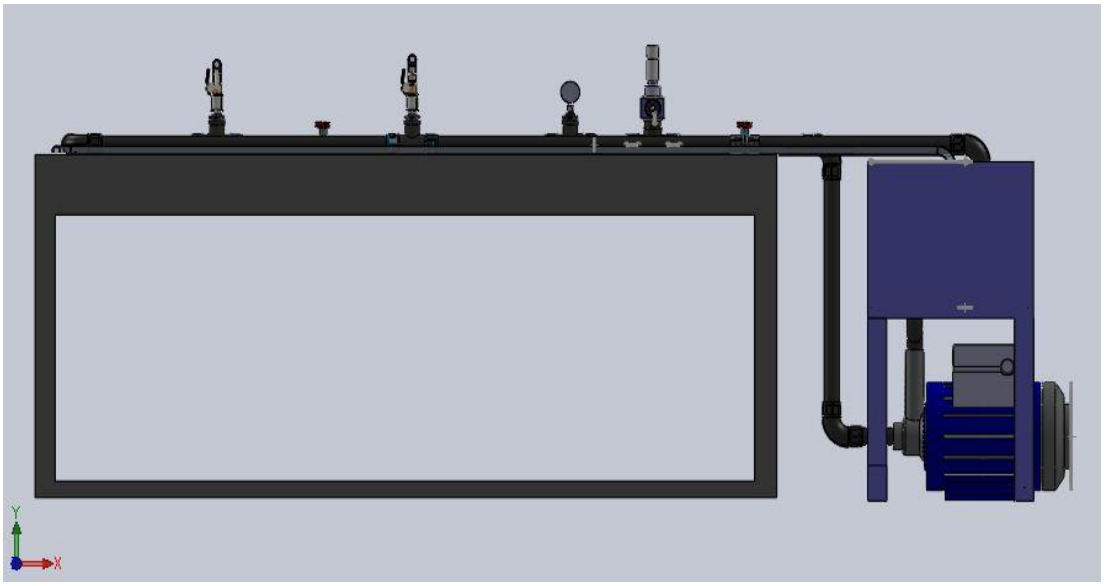
3.2 Test Rig Modelling Using Solidworks

This section will explain more details about the design of the test rig. This design is made using Solidworks. Solidworks is a 3D mechanical CAD (computer-aided design) program. SolidWorks helps mechanical engineers design products. SolidWorks does this by making it easy for the designer to visualize and communicate a 3D concept. The designer can make changes to the design, validate the design against requirements, and prepare the design for production in manufacturing. It uses a mouse-driven graphical user interface to enable engineers and designers to visualize and communicate 3D models of manufactured objects. SolidWorks works extremely well for mechanical design and similar industries requiring precise definition of 3D shapes and their design intent. It is very popular because of its unprecedented balance of power and ease-of-use.

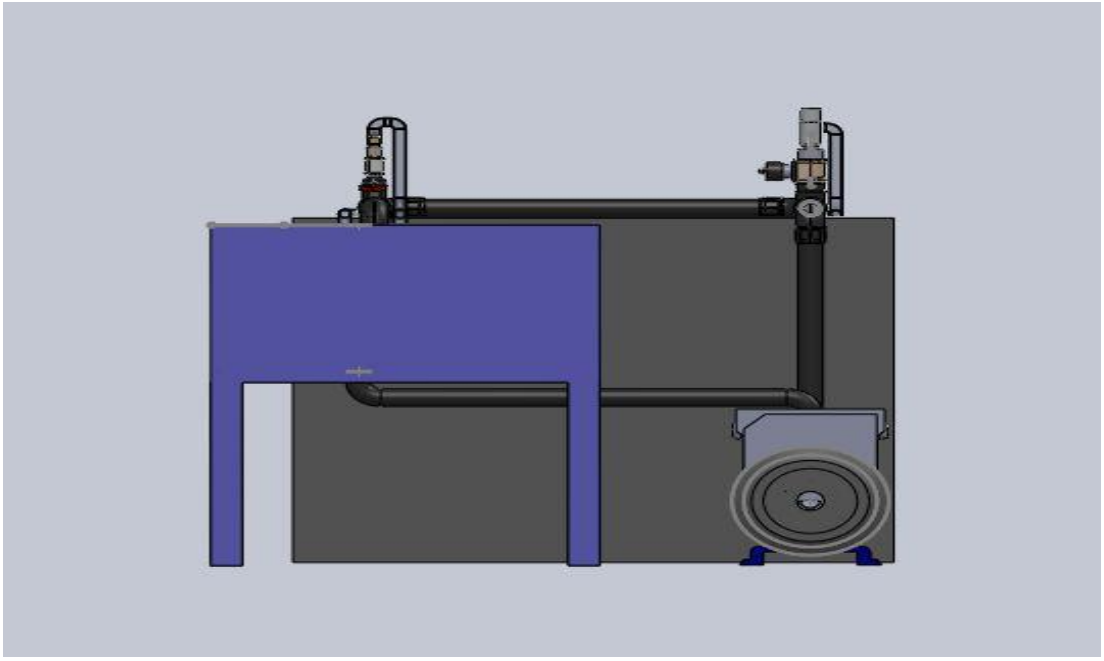
The parts of the test rig are made one by one before assembly it according to actual size. The assembly design as shown in Figure



(a) Top View



(b) Front View



(c) Side view

Figure 3.2: The test rig design by using Solidworks

(a) Top View (b) Side View (c) 3D View

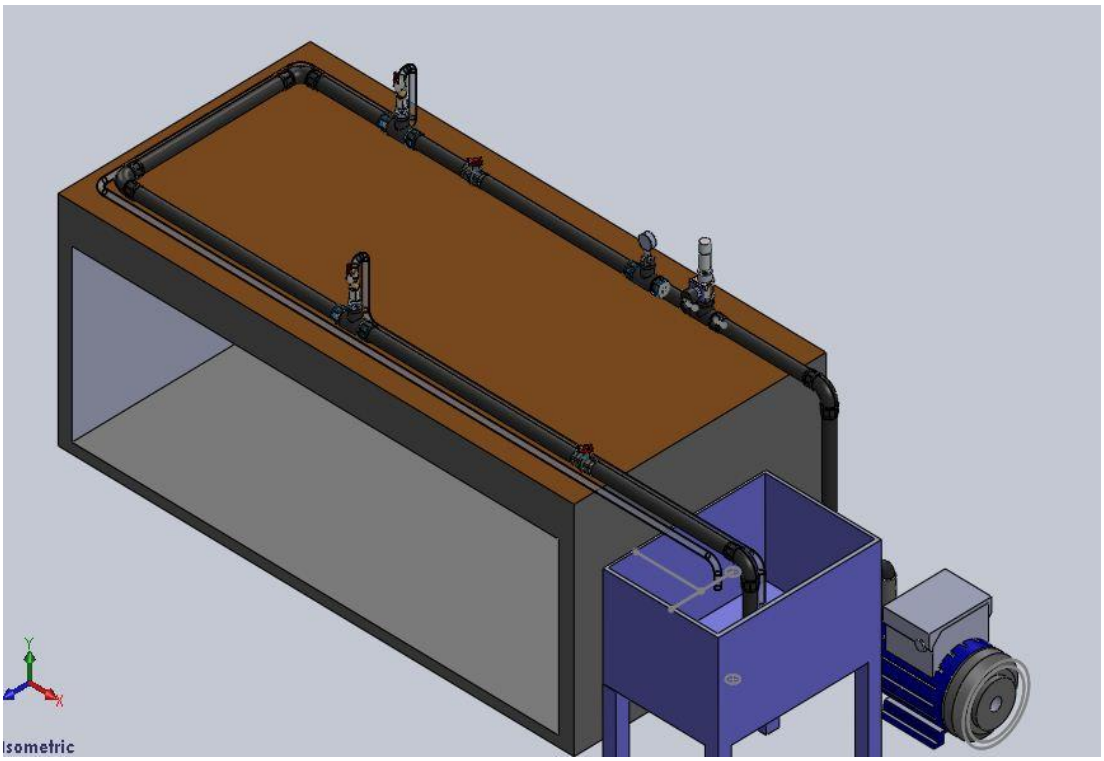


Figure 3.3: The final test rig design by using Solidworks

Figure 3.3 above is the final design of test rig by using Solidworks software. It shows the arrangement of the apparatus such as pipe, valve, flow meter, leak pipe, pump, reservoir, transducer and solenoid.

3.3 Material Selection For Test Rig

Material selection is a process which is performed to select the best materials which may have the potential to perform well both in industrially and commercially. It is important to choose the suitable materials to build the test rig because it will affect the result of the project either the measurement become inaccurate or not applicable.

3.4.1 High Density Polyethylene(HDPE)

When the flow pipeline running, the problem of speed of sound of the pipe totally affects the data. Therefore, the materials selected should have good ability in the process to analysis the data. The HDPE pipe is used for the pipeline because, HDPE speed of sound is lower than the other type of pipe. So, it make easier to analysis the data. Moreover, HDPE also have large strength to density ratio and the resistance at high pressures. By using HDPE pipe, it is easy for maintenance and the cost also in low prize then the other type of pipe.

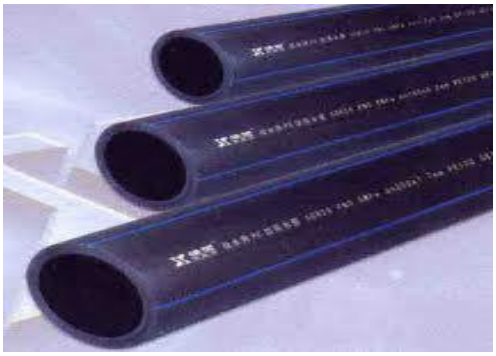


Figure 3.4:Type of pipe at the pipelines

3.4.2 Water Pump

The water pump is needed to flow the water in the pipelines.

Figure 3.5:Water pump

3.4.3 Pipe Valve

The test rig also needs to test the pressure of the pipeline. So, it needs pipe valve to hold the water to flow. When the water was hold, so it will makes the pressure to increase.

Figure 3.6:Pipe Valve

3.4.4 Flow Meter

The flow meter is used to know the pressure in the pipelines.

Figure 3.7:Flow meter

3.4.5 Leak Pipe

The leak pipe was created to make a leak in flow pipeline as a real leakage. The leak was connecting then through to the tank.

Figure 3.8:Leak pipe

3.4.6 Transducer

Transducer is the sensor to detect the leak. The pressure wascompress in the transducer, then from the pressure energy its change to electrical energy to transfer the collected of the pressure to the computer.

Figure 3.9:Transducer

3.4.7 Solenoid Valve

Solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid.

Figure 3.10:Solenoid valve

3.4 Fabrication Process

After designing phase, comes fabrication process. These processes are about the material selection and make the product base on the design and by followed the design dimension. Fabrication process is difference from manufacturing process in term of production quantity. Fabrication process is a process to make only one product compared to manufacturing process that focus to large scale production. In the project fabrication process needed to make the pipelines. Fabrication process was used at the whole system production. This was include part by part fabrication until assembly to others component.

3.5.1 Process Involve

In order to make the design come to reality, fabrication process needs to be done first. The fabrication process starts from dimensioning the raw material until it is finish as a desired product. The processes that involved are:

- Measuring: Materials are measured to desired dimensions or location.
- Marking: All measured materials need to be marked to give precise dimension.
- Cutting: Marked materials are then cut into pieces.
- Joining: Materials joined by fitting the part of pipe.
- Finishing: All joined part are recheck to make sure no leakage before running the flow of the pipelines.

3.5 Steps To Fabricate Test Rig

Firstly, after identifying items needed to fabricate the test rig then search process begins. Plywood was choosing to hold the pipeline. The type of HDPE pipe is used in the pipeline. The pipe was cut by using the dimension in the solidwork software.

Secondly, the pipe was assembling by fitting the pipe. The valve device was installed to control the flow of a fluid by opening, closing, or partially obstructing various passageways. After that, to identify the pressure in the pipelines, the flowmeter was installed.

Thirdly, for the leak part. The design is created supposed to able to make a leakage in the pipeline. So, the small valve was connected to the pipelines by

using the T-junction valve. After that, output of the small valve is connected with a small tube to flow back to the tank.

Fourthly, installed the transducer sensor. The transducer sensor was connected to the pipeline. Then the chip at the top of the transducer was connected to the device that can be read to the computer.

Lastly, in order to improve the detect of the leak, solenoid part was added to control the flow of a fluid. The solenoid switch is generated by the battery 24 volt.

3.6 Experiment Setup

After the leak test rig had been developed for testing process. The pressure transducer can be tested to analysis the performance the leakage of the pipeline. For the pressure transducer was connected to the computer to transform the pressure in the transducer to the data wave in the computer by using MATLAB software.

The solenoid is used to control the flow of the fluid by press the control button and help to improve the data. Which is, when it’s off the flow of the fluid, then on again the flow of the fluid, it can improve the high wave in the pipelines.

3.8 Summary

This chapter present on how the project is being conducted. By developing the test rig, the leak can be determined by detection of the pressure transducer. The value of the performance parameters can be obtained by using the unknown that know by apparatus and calculate it by using mathematical equations as state in Chapter 2.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

The result and discussion of the project is a fabricated test rig that capable to measure required parameters. In this chapter, the functionality of the test rig will discusses. The final fabrication of the test rig is done from only limited due to several problems occur to the project. For this part, the result is come from what is the how came after finish the test rig. Besides that, from this chapter is also discusses about the how the test rig is work. After the fabrication process is complete, the test rig should be tested of the function.

There are several parts to be fabricated to produce test rig for performance testing. Among these parts are:

i. Pipelines
ii. Leak pipe
iii. Solenoid and transducer

iv. Flow meter

4.2 Function of Parts

4.2.1 Pipelines

The pipelines are the important parts of this test rig. The purpose of this parts is to be made the base of all systems as parts of valve, flow meter, leak pipe, solenoid and transducer. Type of HDPE pipe were choose for the test rig because, this type of pipe have a strong signal to detect the leak. The strong signal means, HDPE have low reflection signal. By using the low reflection signal, it is easy to conduct the analysis of the pipelines, because it makes easy to read the graph from the analysis of the data. **Figure 4.1** shows the pipelines that were fabricate.

Figure 4.1: Fabricated test rig for MDPE pipe

4.2.2 Leak Pipe

The leak pipe is made by the small valve than assemble to the small tube through to the tank. When the valve is switch open, its means some leak is happen in the pipelines. When the valve is switch off, there is no leak in the pipeline. The leak pipe was create to learn how the function of the sensor to detect the leak when it is happen. Figure 4.2 show the leak pipe.

Figure 4.2: Leak point

4.2.3 Solenoid and Transducer

Solenoid and transducer is the most important to detect leak in the pipelines. The transducer function is collected the signal in the pipelines and the solenoid is to improve the signal. The leak can be detected when have some change of the data signal by collected from the transducer. When the flow of the

fluid was stop by the solenoid, than continue to flow again, it makes the large of virtual signal to the transducer. The transducer was connected to the computer by using the MATLAB software and the solenoid were energized by 24volts battery. Figure 4.3 show the solenoid and the transducer.

Figure 4.3: Pressure transducer and Solenoid

4.2.4 Flow Meter

The flow meter is used to determine the pressure in the pipeline. The pressure in the pipelines is most important to analysis the data to detect the leak. Figure 4.4 show the flow meter in the pipeline.

Figure 4.4: Flow meter

4.3 Problems Encounter

4.3.1 **Literature Review**: The concept and ideas review for this project are not very wide because it is not widely modified by the manufacturer.

4.3.2 **Material Preparation**: The material needs to choose and survey which is easy to conduct for the experiment because the type of pipe relatedto the result of the experiment and analysis.

4.3.3 **FabricationProcess**: The design always upgrade because of the pressure is not constant.

4.3.4 **Time Arrangement:** Actually, time provided is totally enough. But due of improper time arrangement, this project cannot finish according to plan.

CHAPTER 5

CONCLUSION

5.1 Conclusions

As the conclusion, overall perception of the project carried out was good. A test rig model had been produced base on the project title which is to design and fabricate of lead detection test rig. The project also gains student communication skill like in a presentation and meeting with supervisor.

From this project, the detail design of test rig model had been modeled by using the Solidworks software to produce the actual body of test rig model. Fabricate the product by using any kinds of facility existed in laboratory.

With the fabricate test rig, at least, it help to do some experiment of leakage in the pipelines. Next, the test rig easy to use to make the experiment and to analysis of the pipelines.

Besides that, the project will help the students in making a good knowledge before develop one a new ideas. It also learns the students about step by step how to complete the project by following guide.

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APPENDIX

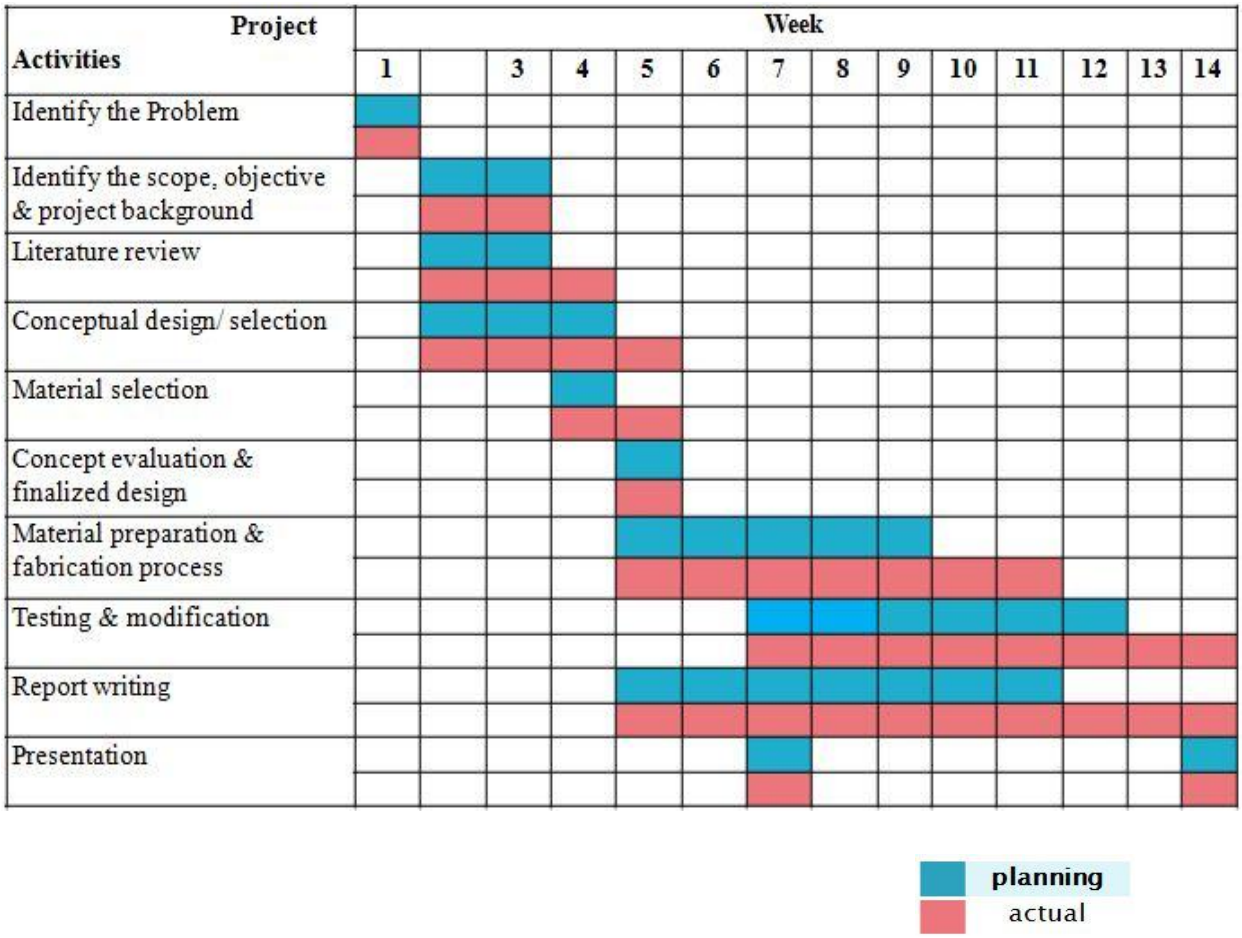

Figure : Grant Chart for This Project

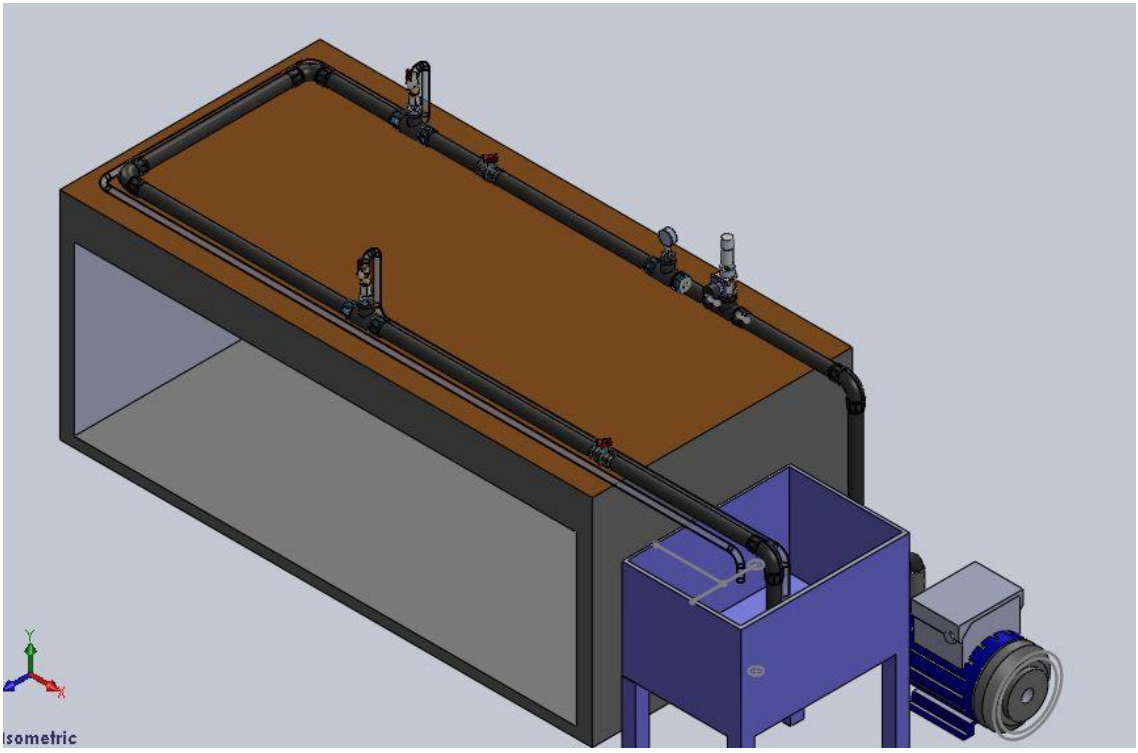

Figure : Solidwork Design

Figure : Actual Pipelines