

**MAPPING CORROSION ACTIVITIES OF VARIOUS TYPE OF ACIDIC
SOLUTION IN A PIPE USING ULTRASONIC TESTING**

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**This Thesis is Submitted to Faculty of Mechanical Engineering as Partial
Fulfillment of Requirement for the Award of the Bachelor Degree of Mechanical
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**Faculty of Mechanical Engineering
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SOLUTION IN A PIPE USING ULTRASONIC TESTING**

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LECTURER DECLARATION

“I declare that I have already read this thesis entitle “ Mapping Corrosion Activities of Various Type of Acidic Solution in a Pipe Using Ultrasonic Testing” and the point of my view that this report is quality for its scope and quality to fulfill the award for Bachelor Degree of Mechanical Engineering (Structure & Material).”

Signature :

Name of Supervisor 1 :

Date :

Signature :

Name of Supervisor 2 :

Date :

STUDENT DECLARATION

“I hereby declare that this thesis entitle “Mapping Corrosion Activities of Various Type of Acidic Solution in a Pipe Using Ultrasonic Testing” is my own work and results except for the work that had clearly stated the sources.”

Signature :

Name :

Date :

To my dearest grandma, parents and younger sister

ACKNOWLEDGEMENT

All praises to Allah S.W.T, the most merciful and gracious, and my peace and blessings of Allah be upon his messenger, Muhammad S.A.W. First of all, I would like to express my gratitude to his greatness, with whose indulgence has given me strength and convenience to complete this report successfully.

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ABSTRACT

Steel pipelines are by far the safest method of transporting oil and gas products. However, corrosion in the pipelines is always occurs and becomes a main problem. Construction or replacement costs are now of the order of RM1 000 000 per km. Given the safety and environmental concerns regarding possible pipeline rupture or leakage and the high costs of repair or replacement, accurate nondestructive inspection of these pipelines is becoming essential. In this study, Ultrasonic Testing is used to observe the corrosion activities in the pipeline models. There are three pipeline models which each of the pipeline model contains different types of acidic solution. The acidic solution is Hydrochloric Acid, Nitric Acid and Acetic Acid with concentration 70% acids and 30% distilled water. This report contains six main chapters; Introduction, Literature Review, Methodology, Result and Discussion, Conclusion and Recommendation. In Introduction Chapter, there is a brief background of the study, problem statement, problem identification, objectives and scope of the study. In Literature Review Chapter, it consist a brief background of pipelines and pipelines corrosion failures. Besides, it also contains a few previous studies about pipelines corrosion inspections. At the end of this chapter, there are included about Ultrasonic Testing and MATLAB Programming description. Chapter Three is about Methodology of this study. It contains the steps and procedures of the experiment. The important steps are preparation of the specimens/pipeline models, preparation of the acidic solution and determination of the pipeline models inspection points. Then, Chapter Four is Results and Discussion Chapter which it consist all the observation, data recorded from the experiment, MATLAB Programming, B-Scan results display and results discussion. Chapter Five is Conclusion which included the achievement of the study. Lastly, this report is ended with the Recommendation for the future study.

ABSTRAK

Paip besi telah lama digunakan sebagai kaedah pengangkutan minyak dan gas yang paling selamat. Walau bagaimanapun, pengaratn dalam paip sering berlaku dan merupakan satu masalah utama. Kos pembinaan dan penggantian paip kini telah menjangkau sehingga RM1 000 000 untuk setiap kilometer. Dalam kajian ini, Ujian Ultrasonik digunakan untuk memerhati aktiviti pengaratn di dalam model paip. Terdapat tiga jenis model paip di mana setiap model paip mengandungi jenis larutan asid yang berbeza. Larutan-larutan asid tersebut adalah Asid Hidroklorik, Asid Nitrik dan Asid Asetik dengan kepekataannya adalah 70% larutan asid dan 30% air suling. Laporan ini mengandungi enam bab utama iaitu Pengenalan, Kajian Ilmiah, Kaedah Kajian, Keputusan dan Perbincangan, Kesimpulan dan Cadangan. Dalam Bab Pengenalan, ia menerangkan secara ringkas tentang latar belakang kajian ini, pernyataan masalah, pengenalpastian masalah, objektif dan skop kajian. Dalam Bab Kajian Ilmiah, ia mengandungi penerangan ringkas tentang latar belakang paip dan kerosakan paip yang disebabkan oleh pengaratn. Selain itu, ia turut mengandungi beberapa hasil kajian-kajian yang lalu tentang pemeriksaan pengaratn paip. Pada penghujung bab ini, ia mengandungi penerangan tentang Ujian Ultrasonik dan program MATLAB. Bab Tiga adalah mengenai Kaedah Kajian projek ini. Ia mengandungi langkah-langkah dan kaedah-kaedah eksperimen. Langkah-langkah yang penting adalah penyediaan bahan kajian/model paip, penyediaan larutan asid dan menentukan titik pemeriksaan pada model paip. Kemudian, Bab Empat adalah Bab Keputusan dan Perbincangan di mana ia mengandungi kesemua pemerhatian, data direkodkan daripada eksperimen, program MATLAB, paparan keputusan dalam bentuk B-Scan dan perbincangan keputusan. Bab Lima adalah Kesimpulan di mana ia mengandungi pencapaian daripada hasil kajian ini. Akhir sekali, laporan ini diakhiri dengan cadangan untuk kajian pada masa hadapan.

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CHAPTER 1

INTRODUCTION

1.0 Background of the Study

Pipelines are used as one of the most practical and low price methods for large oil and gas transport since 1950 in United States. Pipeline installations for oil and gas transmission drastically increased in the last three decades. Consequently, pipeline failure problems increasingly occurred. Economical and environmental considerations require assessment of structural integrity and safety of oil and gas pipelines under various service conditions including the presence of defects should be evaluated.

Some pipelines deteriorate slowly, and in certain cases pipeline life has been reliably targeted at 70 years or more. However, other pipelines have been built which have exhausted their useful life even only after 1 year of operation. So as the results, it will waste too much time and money for the pipelines repair or replacement.

At the start of the 1990s there were concerns over the increasing threat of corrosion to pipeline integrity:

1. Corrosion was the major cause of pipeline failures in North America.
2. Corrosion in one pipeline in North America required over \$1 billion in repairs.

In gas and oil pipelines industries, external and internal defects, e.g., corrosion defects, gouges, foreign object scratches, and pipelines erection activities are major failure reasons in gas pipelines. However, according to Alberta Energy and Utilities Board, corrosion is one of the major reasons causing pipeline defects because corrosion alone account for 59% of pipe failures.

Many different corrosion mechanisms exist. The most common types are generally well understood and usually happen at the gas pipelines are uniform corrosion, pitting corrosion, galvanic corrosion, intergranular corrosion, erosion corrosion and stress corrosion.

1.1 Problem Statement

Corrosion may be defined as the deterioration of a material resulting from chemical attack by its environment. Since corrosion is caused by chemical reaction, the rate at which the corrosion takes place will depend to some extent on the temperature and the concentration of the reactants and products. Other factors such as mechanical stress and erosion may also contribute to corrosion.

Corrosion is usually referring to an electrochemical attacks process on metals. Metals are susceptible to this attack because they possess free electrons and can set up electrochemical cells within their structure. Most metals corroded to some extent by water and the atmosphere. Metals can also be corroded by direct chemical attack from chemical solutions and even liquid metals.

Corrosion on the internal wall of a natural gas pipeline can occur when the pipe wall is exposed to water and contaminants in the gas, such as oxygen (O_2) and carbon dioxides (CO_2), or chlorides. The nature and extent of the corrosion damage that may occur are functions of the concentration and particular combinations of these various

corrosive constituents within the pipe, as well as of the operating conditions of the pipeline. For example, gas velocity and temperature in the pipeline play a significant role in determining if and where corrosion damage may occur. In other words, a particular gas composition may cause corrosion under some operating conditions but not others. Therefore, it would be difficult to develop a precise definition of the term "corrosive gas" that would be universally applicable under all operating conditions.

Corrosion may also be caused or facilitated by the activity of microorganisms living on the pipe wall. Referred to as microbiologically influenced corrosion, or MIC, this type of corrosion can occur when microbes and nutrients are available and where water, corrosion products, deposits, etc., present on the pipe wall provide sites favorable for the colonization of microbes. Microbial activity, in turn, may create concentration cells or produce organic acids or acid-producing gases, making the environment aggressive for carbon steel. The microbes can also metabolize sulfur or sulfur compounds to produce products that are corrosive to steel or that otherwise accelerate the attack on steel.

Internal corrosion may be kept under control by establishing appropriate pipeline operating conditions and by using corrosion-mitigation techniques. One method for reducing the potential for internal corrosion to occur is to control the quality of gas entering the pipeline. Also, by periodically sampling and analyzing the gas, liquids, and solids removed from the pipeline to detect the presence and concentration of any corrosive contaminants, as well as to detect evidence of corrosion products, a pipeline operator can determine if detrimental corrosion may be occurring, identify the cause(s) of the corrosion, and develop corrosion control measures.

Therefore, from this we know that corrosion, are a destructive process as far as the engineer is concerned and represent an enormous economic loss. Thus it is not surprising that the engineer working in industry must be concerned about corrosion control and prevention.

1.2 Problem Identification

Internal corrosion in a gas pipeline may be detected by any of several methods. Ultrasonic Testing, Magnetic Particles Inspection, Penetrate Testing, Eddy Current Testing are a few examples of Non-Destructive Testing which are use widely in industries nowadays. However for this study, the best type of testing that had been chosen is by used Ultrasonic Testing. In this testing, the polarities of corrosion activities in the pipelines have been predicted by determine the thickness changes of the pipelines model.

Ultrasonic testing is a versatile NDT method which is applicable to most materials, metallic or non-metallic. By this method, surface and internal discontinuities such as laps, seams, voids, cracks, blow holes, inclusions, lack of bond etc. can be accurately evaluated from one side. Ultrasonic testing utilizes high frequencies acoustic waves generated by piezoelectric transducers. Frequencies from 1 to 10 Mega Hertz (MHz) are typically used, although lower or higher rangers are sometimes required for certain applications. The resultant acoustic wavelengths in the best material (depend on the ultrasonic wave velocity) are of the order of one to ten millimeters. A highly directional sound beam is transmitted to the test piece through a suitable couplant, usually grease or oil like material. While various types of instrumentation and display modes are feasible, the most widely employed is the pulse-echo technique, with A-scan mode.

Since acoustic waves propagate effectively through most structural materials, but are dissipated or reflected by in homogeneities or discontinuities, measurement of the transmitted and reflected energies may be related to the integrity, which is a function of the material in homogeneity thickness of the component, depth of an indicated discontinuity, size of the discontinuity etc.

Ultrasonic transit time measurements are conveniently used for determination of thickness in piping, tubing, and pressure vessels. Thickness measurement, of course, is

crucial in the prevention of failures caused by corrosion. Since the longitudinal wave speed is essentially constant for a given engineering materials, changes in material thickness may be determined quite accurately using the position of the back echo obtained from conventional normal beam inspection.

Thickness measurement is based on the transit time comparison, i.e., reference transit times are first established for known thickness of similar and the comparable travel times obtained for the item being inspected. Corrosion activities in the pipelines are most often used in the calibration of the ultrasonic instrument for thickness measurement.

Ultrasonic thickness measurement is also accomplished with digital instruments that automatically determine the transit time of the first back echo. Proper calibration is also followed in order to obtain reliable results.

1.3 Objectives of Study

There are a few objectives of this study. The objectives are:

1. To conduct experiment to study the corrosion activities in a pipe using different type of acidic solution using Ultrasonic Thickness Measurement (UTTM) method.
2. To produce a program that models a B-scan presentation of the corrosion activities in the pipe from A-scan presentation obtained from the UTTM.

1.4 Scope of Study

This study is to observe the pipelines corrosion activities under the acidic environment. It focuses on using the same types of pipes (mild steel) to model three pipelines cylinders. The length of each pipe is 250 mm, the outer diameter is 60 mm and the inner diameter is 38 mm. Different types of acidic solution had been used for each pipeline models. Two types of the acids are strong acids and one type of the acids is weak acid. The strong acids are hydrochloric acid and nitric acid, while the weak acid is acetic acid. The concentration for each type of the acidic solutions that had been used in this study is 70% acidic solution and 30% distilled water. The corrosion activities and all the observations like the thickness changes of the pipelines are fully observed by Ultrasonic Testing instrument in Universiti Teknikal Malaysia Melaka Non-Destructive Lab. From A-scan data which get from the Ultrasonic Testing, the results will be display in B-scan using MATLAB programming.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

The efficient and effective movement of gas and oil from producing regions to consumption regions requires an extensive and elaborate transportation system. In many instances, natural gas and oil produced from a particular well will have to travel a great distance to reach its point of use. The transportation system for gas and oil consists of a complex network of pipelines, designed to quickly and efficiently transport natural gas from its origin, to areas of high gas and oil demand. Transportation of gas and oil is closely linked to its storage, as well; should the gas and oil being transported not be required at that time, it can be put into storage facilities for when it is needed.

There are essentially three major types of pipelines along the transportation route: the gathering system, the interstate pipeline, and the distribution system. The gathering system consists of low pressure, low diameter pipelines that transport raw gas and oil from the wellhead to the processing plant. Should gas and oil from a particular well have high sulfur and carbon dioxide contents (sour gas), a specialized sour gas gathering pipe must be installed. Sour gas is extremely corrosive and dangerous, thus its transportation from the wellhead to the sweetening plant must be done carefully.

Pipelines can be characterized as interstate or intrastate. Interstate pipelines carry natural gas and oil across state boundaries, in some cases clear across the country. Intrastate pipelines, on the other hand, transport natural gas and oil within a particular state. Gas and oil pipelines are subject to regulatory oversight, which in many ways determines the manner in which pipeline companies must operate.

2.1 Pipelines

Pipelines can measure anywhere from 6 to 48 inches in diameter, although certain component pipe sections can consist of small diameter pipe, as small as 0.5 inches in diameter. However, this small diameter pipe is usually used only in gathering and distribution systems. Mainline pipes, the principle pipeline in a given system, are usually between 16 and 48 inches in diameter. Lateral pipelines, which deliver gas and oil to or from the mainline, are typically between 6 and 16 inches in diameter. Most major interstate pipelines are between 24 and 36 inches in diameter. The actual pipeline itself, commonly called 'line pipe', consists of a strong carbon steel material, engineered to meet standards set by the American Petroleum Institute (API).

Pipelines are produced in mild steel, which are sometimes specialized to produce only pipeline. There are two different production techniques, one for small diameter pipes and one for large diameter pipes. For large diameter pipes, from 20 to 42 inches in diameter, the pipes are produced from sheets of metal which are folded into a tube shape, with the ends welded together to form a pipe section. Small diameter pipe, on the other hand, can be produced seamlessly. This involves heating a metal bar to very high temperatures, then punching a hole through the middle of the bar to produce a hollow tube. In either case, the pipe is tested before being shipped from the mild steel, to ensure that it can meet the pressure and strength standards for transporting gas and oil.