SINGLE MODE SIGNAL ENHANCEMENT FOR DEFECT LOCATION IN PIPE USING AE

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DECLARATION

I declare that this project report entitled "Single Mode Signal Enhancement for Defect Location in Pipe Using AE" is the result of my own work except as cited in the references

Signature :

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Date : 20 JUNE 2021

APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Maintenance).

Signature : ....

Name of Supervisor : DR. NOR SALIM BIN MUHAMMAD

Date : 20 JUNE 2021

DEDICATION

Everyone needs a house to live in, but a supportive family is what builds a strong spirit. Every time I want to give up, there is always something inside telling me to just give it time. This give me an extraordinary spirit in completing this research study. I would like to thank to my beloved mother, father, my sister and my brother for their endless supports.

ABSTRACT

Acoustic Emission (AE) is very promising technique with sensors offer high sensitivity to instantly spot any corrosion defect in pipe. A research study of single mode signal enhancement for defect location in pipe using Acoustic Emission (AE) through simulation has been carried out. The straight pipe model was designed with three different defect location and equipped with five sensors on the left and right side. Considering the problem of complex wave propagation, the signal for defect location in pipe can be affected and difficult to analyse. Therefore, this research study aimed to apply linear source location through the application of multiple sensors and perform digital signal processing for enhancement of the recorded signal for defect location in pipe. The limitation of this research study is the simulation model on straight pipe with corrosion defects and digital signal processing in LabVIEW software for signal enhancement. This research study starts with input signal data of three different frequencies from SCILAB software is imported to the simulation. After simulation is finished, the data is exported in text file and inserted in LabVIEW software for signal enhancement with single mode signal enhancement algorithm. Four conditions used in this signal enhancement to improve the quality of signal level. The linear source location and the percentage error on effect of signal enhancement on data location is calculated as a result. The estimated location between the sensor and the corrosion point was calculated using the signal enhancement result. When compared with the actual location of the simulated model, the low percentage error obtained at almost all conditions when signal enhancement applied proving the efficacy of this method in precisely locating corrosion defects, thus providing an innovated solution for pipe defect location.

ABSTRAK

Emisi Akustik (EA) adalah teknik yang sangat menjanjikan dengan sensor menawarkan kepekaan yang tinggi untuk melihat pengaratan yang berlaku pada paip dengan serta-merta. Satu kajian penyelidikan tentang peningkatan isyarat mod tunggal untuk mengesan lokasi kecacatan pada paip menggunakan Emisi Akustik (EA) melalui simulasi telah dilakukan. Model paip lurus direa bentuk dengan tiga lokasi kecacatan yang berbeza dan dilengkapi dengan lima sensor di sebelah kiri dan kanan. Memandangkan masalah perambatan gelombang adalah kompleks, isyarat lokasi kecacatan pada paip dapat dipengaruhi dan sukar untuk dianalisis. Oleh itu, kajian penyelidikan ini bertujuan untuk menerapkan lokasi sumber linier melalui aplikasi beberapa sensor dan melakukan pemprosesan isyarat digital untuk peningkatan isyarat yang dirakam bagi mengesan lokasi kecacatan pada paip. Batasan kajian penyelidikan ini adalah model simulasi pada paip lurus dengan kerosakan pengaratan dan peningkatan isyarat di dalam perisian LabVIEW. Kajian penyelidikan ini dimulakan dengan isyarat yang terdiri daripada tiga frekuensi yang berbeza dari perisian SCILAB yang diimport ke dalam simulasi. Setelah simulasi selesai, data dieksport di dalam bentuk fail teks dan dimasukkan ke dalam perisian LabVIEW untuk peningkatan isyarat dengan menggunakan algoritma peningkatan isyarat mod tunggal. Empat keadaan telah digunakan dalam peningkatan isyarat untuk meningkatkan tahap kualiti isyarat. Lokasi sumber linier dan peratusan ralat kesan peningkatan isyarat pada lokasi data telah dikira sebagai hasilnya. Lokasi anggaran antara sensor dan titik pengaratan dihitung menggunakan hasil peningkatan isyarat. Jika dibandingkan dengan lokasi sebenar pada model simulasi, kesalahan peratusan yang diperoleh adalah rendah pada hampir kesemua keadaan ketika peningkatan isyarat dilakukan membuktikan keberkesanan kaedah ini dalam mengesan lokasi pengaratan adalah tepat sehingga memberikan solusi inovatif untuk lokasi kecacatan paip.

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A	-	Amplitude
D	-	Duration
d	-	Distance
d_C	-	Estimated location
E	-	Energy
kHz	-	KiloHertz
I	-	Sensor
m	-	Meter
ms	-	Millisecond
m/s	-	Meter per second
N	-	Count
P1	-	Corrosion point 1
P2	-	Corrosion point 2
P3	-	Corrosion point 3
R	-	Rise time
S	-	Source
s	-	Second
T	-	Time of Arrival
tL	-	Time of Arrival of left signal
tR	-	Time of Arrival of right signal
Δt	-	Time different
V	-	Velocity
$V_{AE,F(1,3)}$	-	Mode group velocity

LIST OF ABBREVIATIONS

AE	-	Acoustic Emission
ECT	-	Eddy Current Testing
FEM	-	Finite Element Method
NDT	-	Non-Destructive Testing
NTSB	-	National Transportation Safety Board
LabVIEW	-	Laboratory Virtual Instrument Engineering Workbench
TOA	-	Time of Arrival
VI	-	Virtual Instruments

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Pipelines is a crucial component as a transportation mechanism to buildings, factories and manufacturing facilities. Installation of pipe structures in power plants is certainly expensive. This large expenditure is expected to provide a good return by ensuring that the structure can run its operations properly without any failures. Although pipelines are designed in absolute compliance with industry standards to ensure complete safety, the operational history of structures from power plants shows that declines in structural performance in terms of unscheduled closures, extensive maintenance and operational efficiency occur most often due to failures such as corrosion, cracking, leakage and thermal stress as ordered in the technical document. For instance, in a report adopted from the National Transportation Safety Board (NTSB) stipulated that the cause of a fatal pipeline rupture in Carlsbad, New Mexico in August 2000 was a significant decrease in pipe wall thickness and severe internal corrosion.

It was stated that on Saturday, August 19, 2000, a 30 -inch -diameter natural gas delivery pipeline operated by the El Paso Natural Gas Company burst near the Pecos River near Carlsbad. The gas released is ignited and burned for 55 minutes. Twelve members of the same family who were camping under a concrete iron bridge supporting a pipeline across the river were killed and three of their vehicles destroyed. Two nearby steel suspension bridges for the gas pipeline crossing the river suffered severe damage. The erosion was caused by the failure of the El Paso Natural Gas Company to prevent, detect or control internal corrosion in the company's pipelines.

During the investigation, NTSB researchers found that the rupture was the result of severe internal corrosion that resulted in a reduction in the wall thickness of the pipe so that the remaining metal could no longer withstand the pressure in the pipe. Furthermore, corrosion is likely caused by a combination of microbes and contaminants such as moisture, chloride, oxygen, carbon dioxide and hydrogen sulphide. Considering this situation, effective monitoring techniques are required to optimize failures and aim to improve the reliability and competitiveness operation of pipe.

Corrosion can cause damaged to the pipelines and an inspection is therefore necessary to identify defect early enough to limit serious consequences. There are diverse defects inspection in pipe, as introduced which the Acoustic Emission (AE) technique is very promising. This is a Non-Destructive Testing (NDT) technique with sensors offer high sensitivity to instantly spot any abnormal state in pipelines. Accordingly, the Acoustic Emission (AE) based technique has been applied in numerous works to detect and classify defect location in pipe.

Acoustic Emission (AE) can be defined as a transient elastic wave due to the stress waves by mechanical means that the Acoustic Emission (AE) technique is produced by the detection and analysis of these stress waves on the surface of a structure. Defect from corrosion in pipe represents one in foremost problems in existing structures. Defects in pipes can be caused by corrosion due to human- made damage or exact nature of the environment such as air, soil, water and seawater. Various defects inspection in pipes for instance, Penetrant Testing, Ultrasonic Testing, Eddy Current Phased Array and Guided Waves Testing are implemented to measure the growth of corrosion. However, each defect inspection has its specific limitations. Therefore, there is an advanced approach used to track the severity of corrosion has been known as Acoustic Emission (AE) for the last two decades. (Prateepasen, A., 2012).

The application of Acoustic Emission (AE) technique has been recognized as one of the most reliable and proven techniques in Non-Destructive Testing (NDT) to detect and monitor the progression of defects in different structures. Acoustic Emission (AE) is a highly effective and efficient technology used in metals, fiberglass, wood, composites, ceramics, concrete and plastics for fracture behaviour and defect detection. It can also be used to detect defects and pressure leakage in pipes, tanks, vessels and to track the progression of welding corrosion (Gholizadeh, S., Leman, Z., and Baharudin, B.T.H.T., 2015).

Acoustic Emission (AE) is a passive technique which means does not active and the signal travels to the detecting sensors from the signal that produced by the growing defect itself. Since Acoustic Emission (AE) technique can detect signals from defect location in relatively far distances from the sensor, the strength of the signal and the accurate defect location are important. Because of this factor, signal enhancement using Acoustic Emission (AE) is needed intended to detect defect location in pipe more significantly. The main purpose of signal enhancement is to reduce the noise or any other factor from the signal so that important features of the signal become easily discernible. The defects can be detected by Acoustic Emission (AE) at an early stage as they occur or growing and can be used as a warning system before the structure is critically damaged.

The difference of Acoustic Emission (AE) with other technique are pertinent to the origin of the signal. Acoustic Emission (AE) signals revealing information about the behaviour of the structures or processes. Acoustic Emission (AE) signals can simply hear the energy released by the structure instead of supplying energy to the structure that being examined. The basic idea behind the Acoustic Emission (AE) signals is to extract data to gain some information about the defect location of the sources. Digital signal processing has been a longstanding related in Acoustic Emission (AE) studies. The appearance of powerful computer software resulted in a technique that permits effective and efficient extraction of data from the signals.

Acoustic Emission (AE) signals are also related to dynamic processes or structural changes. There is an essential ability to distinguish between developing and stagnant defects. In addition, Acoustic Emission (AE) signals usually produce an immediate indicator related to the strength or risk of defect on the structure. Other advantages of Acoustic Emission (AE) signals including the use of fast and complete volumetric inspection of multiple sensors for process control without the need to disassemble and clean the structure. (Scruby, C.B., 2000).

Finding a significant location for source of Acoustic Emission (AE) is usually the main target of an inspection. Acoustic Emission (AE) permits the usage of multiple sensors during testing and allowing the sensors to record a hit from a single signal. The source can be located by knowing the velocity of the wave propagation in the structure and the difference arrival times of hit between the sensors once hits are recorded by each sensor, as measured by computer software. It is possible to inspect an entire structure with few sensors by spacing the sensors in correct arrangement. Hence, the signal generated can be enhanced. (Alan, G.B., 2013).

1.2 Problem Statement

Propagation of acoustic wave is complex due to dispersion, multimodal and unknown occurrence of signal in structure. In some situations, the signal is present, but the signal propagates with a small size of wave propagation, background noise and reflection boundary. It is difficult to determine the signal if the location of the defect is exposed to these situations because the signal travel to the sensor might be slow or influenced by flow conditions in the pipe. Considering the problem of complex wave propagation, the signal for defect location in pipe can be affected and difficult to analyse the data from the signal. Of course, the major factor that limiting the ability to extract data from Acoustic Emission (AE) signals are the deleterious effect come from the structure. Therefore, it is needed to find a good algorithm and method to enhance the signal for better defect location in pipe so that the generated signal is more prominent compared to the problem mentioned above.

1.3 Objectives

Objective is the reason why this study is carried out. There are the objectives of this study:

1. To apply linear source location for defect detection in pipe through the application of multiple sensors.
2. To perform digital signal processing for enhancement of the recorded signal for defect location in pipe.