UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON MODE SHAPE CURVATURE IN ALUMINUM 6061 USING CUBIC POLYNOMIAL REGRESSION METHOD BASED ON EXPERIMENTAL DATA

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical and Manufacturing Engineering Technology (Maintenance Technology). The member of the supervisory is as follow:

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(Mohamad Afiq Amiruddin bin Parnon)

ABSTRAK

Kaedah melicinkan gapped (gsm) adalah kaedah ujian tidak merosakkan (ndt) yang paling popular kerana kesederhanaannya dan tidak memerlukan data asas untuk perbandingan. Walau bagaimanapun, gsm tidak tepat untuk mengesan saiz kerosakan yang besar dalam struktur dan menyebabkan pengesanan palsu. Objektif kajian ini adalah untuk mengesan saiz retak 0.5 hingga 5 inci dalam spesimen dan membina analisis berangka untuk rosak dan struktur rosak lengkung bentuk mod manakala skop kajian ini adalah menggunakan perisian microsoft excel untuk pengiraan kelengkungan bentuk rosak dan tidak rosak dan yang terakhir adalah dengan membandingkan hasil analisis berangka yang diperoleh dari kedua-dua eksperimen dan simulasi untuk kelengkungan bentuk rusak dan tidak rosak. Pengesanan kerosakan pangkalan getaran adalah satu kaedah yang merangkumi kajian kelengkungan bentuk mod, frekuensi semula jadi dan nisbah redaman. Mod kelengkungan mod akan dianalisis dengan menggunakan elemen terhingga yang berlaku tiga kaedah berbeza seperti perbezaan ke hadapan, tengah dan ke belakang, dan regresi polinomial kubik. Analisis elemen hujung (fea) pada keadaan sempadan bebas pada rasuk keluli dijalankan untuk menunjukkan kemungkinan kaedah yang dicadangkan yang menganggarkan data bentuk lengkung yang tidak rosak menggunakan analisis numerik 2 ini.

ABSTRACT

Gapped smoothing method (GSM) are the most popular non-destructive testing (NDT) method due to its simplicity and did not require baseline data for comparisons. However, GSM are less accurate to detect wide size of damage in structure and cause false detection. The objective of this study is to detect crack size of 0.5 to 5 inch in the specimen and to construct a numerical analysis for undamaged and damaged of a mode shape curvature structure while the scope of this study are using Microsoft Excel software for the calculation of damaged and undamaged mode shape curvature and the last one are by comparing the numerical analysis result that obtain from both experiment and simulation for damaged and undamaged mode shape curvature. Vibration base damage detection are a method that includes the mode shape curvature studies, natural frequency and also damping ratio. The mode shape curvature will be analyze by using finite element which occur three different method such as forward, central and backward difference, and cubic polynomial regression. Finite element analysis (FEA) on a free boundary condition on a steel beam was carried out to demonstrate the feasibility of the proposed method that estimate undamaged curvature mode shape data using this 2 numerical analysis.

DEDICATION

To my beloved mother Norliah binti Hj Ahmad, to my father Mohd Hasni bin Abd Hamid and my brother Aidil Syahir bin Mohd Hasni. A gratitude of thank you to all my lecturer that have been helping and supporting me throughout this project. Last but not least, to all my friends that have been there for me.

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mm - millimeter

LIST OF ABREVIATION

NDT	-	Non Destructive Testing
GSM	-	Gapped Smooth Method
NDI	-	Non Destructive Inspection
SHM	-	Safety Health Monitoring
VBDD	-	Vibration Based Damage Detection
MAC	-	Modal Assurance Criterion
UT	-	Ultrasonic Testing
RT	-	Radiographic Testing
FRF	-	Frequency Respond Function
FFT	-	Fast Fourier Transform
SDI	-	Standard Damage Index

CHAPTER 1

INTRODUCTION

1.1 Overview

Aluminum is a common kind of structure used in the international range. Nevertheless, due to delamination and barely seen influence damage, its applications are restrained, which lead to a better catastrophe if the damage is left undetected. Various neighborhood non-destructive inspection (NDI) techniques have been practiced to observe delamination. Nonetheless, the shape desires to be out for operation to begin the NDI operation which is labor cost, time-consuming and loads of prices required. In the study, vibration-based injury detection imposing mode structure curvature in Gapped Smooth Method (GSM) algorithm will be used and applied as the method baseline free and small injury occur, which has the potential for real-time Structural Health Monitoring (SHM) approach to limit inspection time and cost. The detection of delamination on the specimen is with the aid of using the accelerometer (piezoelectric sensor) for sensing and searching on selected parameters that are greater prone to influence the detection vary of harm size. The study is initiated from fabrication and experimenting observed by means of the simulation, a modal test using harm and undamaged aluminum beam using the unique GSM algorithm. Experiments and simulations of a structure are performed to gain the preliminary records of selected impartial and based variables that come from the cutting-edge GSM algorithm. The records from test and simulation will end up the inputs of mathematical modelling for broken and undamaged calculation, to produce an equation by way of using finite distinction technique for broken mode form curvature and using cubic polynomial regression for undamaged mode form curvature. After finishing all the calculation on both test and simulation, the received result calculation will be compared.

1.2 Background

Since historical times, the first car and infrastructure that is used in order to transport or cross peoples and goods on which the transport should transit and had to be made available. On land, the first transportation that used to be used is rudimentary slides, it came from trunks of a tree to raise heavy and large loads. The most essential aspect of the records of automobile or transportation are the wheel, barring wheel vehicle can't move and human beings cannot be transported on a daily foundation (Dixit & Lamkanfi, 2017). Transportation is a science that worries about environment friendly for movement of individuals and items that is embraced to acquire dreams or to fulfil the tasks given that required transfer something from one area to another. In engineering, transportation definitely involved about the use of scientific ideas to the planning, design, operation and administration of the transportation system.

5000 years ago, wagons and carriage that is pulled with the aid of a cow or horses used to be the most efficient transport. In 1780, the first steam engine was once constructed by way of James Watt, after that incident, it had adapted to other moving vehicles such as rails and cars. According to Motavalli (2014), bicycles, trains, motor cars, trucks, airplanes and trams had been invented in the 17th and 18th century. In 1906, the first auto used to be developed with an inside combustion engine. After the advent of interior combustion engine, many sorts of transportation machine have been primarily based on the inside combustion engine. As vehicle industry, via continuing to improve in accordance to the demand for alleviation and safer using are extended (Bierstedt et al, 2014).

Figure 1.1: Early Transportation in World History

Although the vehicle had been designed safer with a sensor that can give up the car from colliding, a catastrophe is nevertheless can't be prevented. There are many reasons that a automobile could motive a disaster to happen such as the unfocused driver in driving, and a driver being worn-out from long hours of driving at the back of the wheel. According to Reason (2017), there is lots reason of an accident, but the result is constantly the same. Whether the car injury or the driver itself is carelessly while driving.

1.3 Problem Statement

It is very necessary to make positive that all non-destructive inspection (NDI) tools to be maintained in term of integrity and safety, the maintained NDI tools are for the security towards shape such as machines, plane and civil structures too. In order to make a non-destructive inspection onto the massive structure, it may additionally be required a long time and expensively costing as the shape has to be stopped permanently or cannot method something in its operation. Hence, the usage of vibration-based damage detection (VBDD) in structural health monitoring allows giant constructions to be inspected during its operation. However, the current of vibration-based injury detection is now not that accurate for detection of an actual harm size especially in a thick aluminum structure, it will cause an incomplete repair of injury that might also lead to fatal damage. Thus, by way of the use of vibration-based harm detection imposing mode structure curvature in gapped smoothing technique algorithm can limit the time taken to check out the part and reduce the upkeep cost and additionally optimize the operation time of the transportation.

1.4 Objective

1. To detect damage and undamaged curvature from depth crack of 0.5 mm, 1.0 mm and 2.5 mm.
2. To identify damage and undamaged curvature by using cubic polynomial regression method.

1.5 Scope

1. Use of aluminum 6061 as an experiment material.
2. Use Labview and Microsoft Excel software for the calculation for damaged and undamaged mode shape curvature.
3. Compare the numerical analysis result that obtain from both experiment and simulation for damaged and undamaged mode shape curvature.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Laminated in composite buildings causes' structural failure that may additionally lead to splendid injury consequences. Structural damage in bodily properties can be changed due to the laminated takes place upon structure. The injury that alters the dynamic responses such as natural frequencies, damping and mode shapes can be extracted to estimate injury information (Pizhong et al, 2006). Natural frequencies of a shape trade the vibration-based technique and detection of harm has a benefit over conventional nondestructive checks in detecting various kinds of injury by way of using minimal dimension data.

This chapter provides an overview of preceding research that related and explains detail about all the method regarding this task research. The drift of this venture will temporarily give an explanation for about vibration, followed by vibration-based harm detection and in certain about mode form curvature through all the method that has been used with the aid of the olden researcher.

2.2 Vibration

Vibration can be considered to be the oscillation or repetitive movement of an object round an equilibrium position. The equilibrium position is the position the object will acquire when the force appearing on it is zero. The vibration happens two categories such as free vibration and compelled vibration. Free vibrations normally occur when the gadget is disturbed, then lets in it to move barring restraint (Florian Petit et. al, 2015). A generic

function of free vibration is damping. All structures are subject to frictional forces, and the electricity of the vibrations, causing the amplitude to diminish. Vibration typically takes place in the mechanical compartment, a mechanical gadget vibrate when its parts endure action which fluctuates in time.

Vibration testing is a check to decide the breaking factor of each day the usage of the item. Vibration evaluation involves many techniques such as time wave analysis, spectrum evaluation and etc. The purposes of vibration testing are covered with airplanes, structures and automotive. According to Paul E. Mix (2015), vibration trying out is a very necessary thing as it consists of and is used in many industries, from the machinery industry to the automobile industry.

2.3 Non-Destructive Testing

A nondestructive take a look at or NDT is a test the place the trying out material does no longer injury or intact. According to Gholizadeh (2016), NDT is detection of harm on the surface and interior of testing fabric except the material being cut or redoing it. NDT is a properly approach to reduce the price of manufacturing or value of maintenance, as it can detect flaws without adverse the phase being produced or checked. NDT technique additionally consists of visual inspection the place worker search for a defect with a bare eye, ultrasonic trying out the place the people can become aware of the harm inner a structure whilst eddy current was using cutting-edge to notice injury on the floor and lastly dye penetrant to notice injury on the joint phase of the structure.

2.3.1 Visual Testing

Visual checking out or visible inspection is the most basic type of NDT technique. It used to be executed by only bare eyes by looking out it on the floor of a cloth or product for flaws or damage. According to Bossi and Giurgiutiu (2015), visible inspection does no longer require any equipment, so this method can cut fee from buying a piece of equipment just for testing. Although it can help limit cost-

efficiently, it has its very own trouble such as it can solely become aware of injury on the surface of the material and damage ought to be viewed with a naked eye in any other case it cannot be detected. This approach also cannot be used to realize injury inside a structure. This method had their pros and cons, so it can solely work for harm that is big adequate to be viewed for naked eyes and the injury must be on pinnacle of the surface of a structure.

2.3.2 Ultrasonic Testing

Ultrasonic testing is a check that can be used to realize harm inner of a structure. It makes use of ultrasound to detect the damage. As the ultrasound signal hit the damage are the layout on that equipment will alternate it to point out there is injury occurred. It is the equal as sonar makes use of by using a fisherman to come across the area that has a lot of fish. If the signal reflects faster than typical means that there is something are blockading the signal. This technique can solely be used to a fabric with a good conductor of sound. Same goes as it on material, primarily based on the information carried by means of the signal, the crack place and every other characteristic should be achieved.

2.3.3 Thermography Testing

Thermography checking out or thermal imaging is a test to realize the thermal of a material. When damage occurs, it tends to produce heat. A flaw such as delamination or affect injury causes an alternate in the thermal radiation or the area. So when shape or equipment fails a test, it ought to be accomplished shortly the usage of a thermography testing as the warmth will disappear quickly. It also can become aware of injury internal of the material, but solely damage that occurs, it tends to produce less heat. The benefit of thermography trying out is that it can look at a massive surface of a structure. It additionally does not want tons time to conduct testing. The instrument is costly and it needs an especially knowledgeable and educated employee to use this method (Mulaveesalaa & Tuli, 2018).

2.3.4 Radiographic Testing

Radiographic testing is the same procedure as ultrasonic testing where it transmit signal and as the signal hit something, it displays the signal back to its origin. But an rather of a sign being display on the screen, radiography uses listening to approach to notice the damaged area. There are many kinds of radiography testing specify for specific material. As for thin material, radiography with low voltage can be used to become aware of damage. Meanwhile, for thick material, radiography that transmits a gamma-ray can be used to observe damage. It can additionally become aware of massive voids, Trans laminar cracks, non-uniform fiber distribution, small matrix cracks and removal in a sample. (Atas & Soutis, 2014).

2.3.5 Electromagnetic Testing

According to Koyama et al (2013), electromagnetic testing or additionally acknowledged as eddy modern-day checking out is a take a look at that uses electromagnetic induction to detect harm on the floor of shape and injury inside of the structure. This approach is desirable for structure with the tremendous conductive material. The concept of this approach is a coil is excited with an alternating cutting-edge that will produce an alternating magnetic field. After that, as the coil tactics a conductive material, the cloth will be precipitated with modern from the coil. This approach generally makes use of considerably in the aerospace industry. This is due to the fact this technique is very touchy and can become aware of tight cracks and it can additionally be executed on ferromagnetic and non-ferromagnetic materials.