SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis 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 (Structure and Materials)"

Signature :

Supervisor : DR. MOHD BASRI BIN ALI

Date : JUNE 2015

FINITE ELEMENT ANALYSIS OF STRAIN SIGNAL FROM CHARPY IMPACT

NABIHA BINTI PATHIL

This report submitted

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Faculty of Mechanical Engineering

Universiti Teknikal Malaysia Melaka

JUNE 2015

DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged."

Signature :

Author : NABIHA BINTI PATHIL

Date : JUNE 2015

Special for

Abah and Emak

ACKNOWLEDGEMENT

Bismillahhi-rahmani-rahim…

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ABSTRACT

Charpy impact test are inexpensive impact testing that can be used in order to measure the energy absorbed of the material. Previous studies have shown that the energy absorbed measured using the instrumented Charpy impact test is not accurate. So, new way to determine the strain energy with three different velocities by using signal processing approach need to be studied. This project uses numerical analysis based on Finite Element Analysis to simulate the Charpy impact test and the strain from the striker is obtained from the modeling of Charpy impact test. The material for the specimen is the same as standard ASTM E-23 specimen and three different velocities is used which is 5.18 m/s, 3.35 m/s and 7.00 m/s. The strain signal from these three different velocities will be compared with the experimental strain signal Charpy impact test. For the analysis purpose, the signals obtained will be converted using the Fast Fourier Time (FFT) to convert the time domain to the frequency domain. After that Power Spectrum Density (PSD) method will be used to calculate the strain energy based on the area under the graph. It was found that both the impact strain signal and strain energy are influenced by the velocity of the impact. The PSD values also influenced by the velocity of impact since the strain signal are varied with different velocities.

ABSTRAK

Ujian Charpy impak merupakan ujian impak yang murah dan digunakan untuk mengukur tenaga yang diserap oleh sesuatu bahan. Kajian lepas menunjukkan bahawa tenaga yang diserap yang diukur melalui instrumen ujian Charpy impak tidak begitu tepat. Jadi, kaedah baru untuk menentukan tenaga terikan menggunakan tiga halaju yang berbeza dengan mengunakan pendekatan pemprosesan isyarat perlu dikaji. Projek ini mengunakan analisis berangka berdasarkan Analisis Unsur Terhingga (FEA) untuk simulasi ujian Charpy impak dan juga terikan daripada hentaman yang diperolehi dari permodelan ujian Charpy impak. Bahan yang akan digunakan untuk spesimen adalah sama seperti piawaian yang ditetapkan iaitu ASTM E-23 spesimen dan tiga halaju yang berbeza yang digunakan adalah 5.18 m/s, 3.35 m/s dan 7.00 m/s. Isyarat terikan yang diperolehi dari tiga halaju ini akan dibandingkan dengan uji kaji isyarat terikan ujian Charpy impak. Untuk tujuan analisis, isyarat ini akan ditukarkan dari domain masa dan domain frekuensi mengunakan *Fast Fourier Time* (FFT). Selepas itu, kaedah *Power Spectrum Density* (PSD) digunakan untuk mengira tenaga terikan berdasarkan luas kawasan di bawah graf yang diperolehi. Hasil kajian mendapati bahawa kedua-dua isyarat tarikan dan tenaga terikan dipengaruhi oleh impak halaju. Nilai PSD juga didapati berubah apabila berlakunya perubahan impak terikan terhadap halaju yang berbeza.

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CHAPTER 1

INTRODUCTION

1.0 BACKGROUND

The Charpy impact tests have been used to determine the material toughness. This Charpy impact test are simpler testing that can be used to analyze the material toughness. The Charpy impact test is inexpensive testing, easy to conduct and the faster results are obtained based on this test. Holt M. J., 1990 state that the material toughness are obtained by measured the energy absorbed during the Charpy impact test. While Aberate,S., 2011 state that the difference between height of the pendulum release and height of the pendulum strike the specimen will consider as the energy absorbed by the specimen during the impact. The differences between the energy of the striker at the impact and the energy remaining in the striker after striking the specimen indicate the energy absorbed in the breaking specimen. (P.K. Mallick, 1993)

Even Charpy impact test have been used in the industries, during the impact the energy absorbed are assumed as estimation and not same as the calculation energy during the impact (Mahatan M. P., 2000). Based on the ISO 148, Charpy impact test machine used velocity of the striker between 3 m/s to 6 m/s for impact test. (ISO 148-

2, 2006) differenct velocity of the impact will influenced the energy absorbed of the specimen. (Chandavale R.G., 1995)

Then, many researchers focus more on using numerical analysis using Finite Element Analysis (FEA) to study more about the Charpy impact test based on the modeling of the Charpy impact test such as Chia-Lung Chang, 2009 study wheel impact test using Finite Element Analysis, the simulation of wheel impact test has been used to predict the impact failure of a wheel. Based on the numerical analysis using FEA found that the strain energy is higher than total plastic work that can lead to the failure of a wheel.

Then, the energy comes from the dial or encoder of Charpy impact test have been compared with strain energy from different velocities and thickness by signal processing approach via experimental and calculated using Power Spectrum Density (PSD). The results found that the energy absorbed influenced by the velocities of the striker and the thickness of the specimen (M B Ali, 2013)

For overall, this case study are using finite element analysis to obtained impact strain signal from Charpy impact by using three different velocities. Abaqus software are used to obtained impact strain signal from simulation of Charpy impact and using Fast Fourier Transfer (FFT) and Power Spectrum Density (PSD) as signal processing approach to convert the impact strain signal to frequency domain and get the strain energy.

1.1 PROBLEM STATEMENT

Most common method for measuring the energy absorbed for the specimen is by using Charpy impact test and Izod test. The specimen will absorbed the energy until the specimen yields and the specimen will begin to undergo plastic deformation at the notch during the impact test. This process will continuously undergo until no more energy can be absorbed by the specimen. Energy absorbed during the Charpy

impact are measured by the difference between height of pendulum before the impact and height of the pendulum after the Charpy impact test. (Abarate, 2011)

Charpy impact test give more advantages for to analyze material toughness since the material specimen used during the impact test are small, easy to conduct and also inexpensive way to determine the material toughness. But, Charpy impact has some disadvantages even these tests are widely used to determine the material toughness in the industries. The energy absorbed during the Charpy impact test have been found that are not accurate during the experimental and assume as the estimation which cannot determine precisely the material toughness for the materials. (Xu *et al*, 2006)

Other than that, the specimen used for the Charpy impact test are small so there will be limited constraint development inside the specimen and the energy absorbed or the strain energy during the impact test for the materials are still not accurate.Both strain energy gets during Charpy impact test is not same as the theoretical calculation of strain energy. So, in order to get more accurate results a new method to obtain strain energy based on the signal are need to be studied by using signal processing approach via Finite Element Analysis (FEA). By using finite element the load-displacement oscillation of Charpy impact test can be clearly explained for the full dynamic analysis. (Rossoll, A., 1999)

This project will use three different velocities for simulated the Charpy impact test to study the impact strain signal from FEA. Then based on the signal obtained from the Charpy impact test simulation from FEA, the Fast Fourier Time (FFT) will transform the signal into simpler form. Based on the signal obtained from FFT, the PSD will be used to convert the signal to determine their strain energy. This strain energy will be compared with the experimental results from the Charpy impact test.

If this method can be approve, in the future this new method can be used to determine the strain energy by using signal processing via FEA as another alternatives to find or determined the strain energy in Charpy impact test.

1.2 OBJECTIVES

Objectives for this project are:

1. To determine the impact strain signal with different velocity.
2. To calculate the energy using signals processing approach.
3. To compare the result of signal processing approach from previous studies.

1.3 SCOPES

For this project, computer software are mainly used in order to get the signal obtain by using signal processing approach via Finite Element Analysis (FEA). The specific scopes are as below:

1. Modeling of Charpy impact test by using ABAQUS software.
2. (50×10×10) mm ASTM E23 standard specimens are used for the Charpy impact test modeling.
3. Three different velocities are used 5.18m/s, 3.35 m/s and 4.27m/s respectively used for calculating impact strain signal.
4. Used Fast Fourier Time (FFT) to convert the signal obtains from the Abaqus to time domain to frequency domain signal.
5. Power Spectrum Density (PSD) method used to calculate strain energy based on the area under that get from signal converted by the FFT.

1.4 ADVANTAGES OF THIS PROJECT

These projects are focused on the Charpy impact test. So, the importance will be on the:

1. As a beginner by using signal pattern to define the characteristic of impact for different parameters such as velocity, material properties or thickness of the specimen.
2. Purpose new method to calculate the energy absorbed based on signal processing approach.
3. Using signal processing approach to calculate the energy from Charpy impact test other than used the instrumented Charpy impact test to measure the absorbed energy.

CHAPTER 2

LITERATURE REVIEW

2.1 IMPACT TEST

Impact test are important in order to know the material toughness. Impact test separates into two categories which is pendulum impact test and drop weight impact test. Based on Westmorland Mechanical Testing websites states that the most commonly testing used for the impact test are Charpy impact test and Izod test.

Charpy impact test and Izod test are commonly same based on swingging of the pendulum or striker and hit the specimen. Abrate, 2011 explained that the difference between height of the pendulum release and height of pendulum strike the specimen will be consider as the energy absorb by the specimen during the impact. While Agrawal, 1988 states that the diferences between Charpy test and Izod test are the test specimen design, method of supporting and striking the specimen

Generally, impact test are used to measure the response of a material to dynamic loading and the results obtained from a standard impact test are usually a single value of impact energy or energy spent on a single experiment. (Perez N., 2004).

Impact test yield information on the impact forces, impact velocities, displacement and also strain energy of the striker at any time during the impact test.

2.2 CHARPY IMPACT TEST

In many years, Charpy impact test have been used to test the toughness of a material. Charpy impact test was developed by S. B. Russel on 1989. On 1901, G. Charpy improved charpy test by standardize the method by giving precise specification. Because of good and reliable dynamic fracture toughness can be determined by using charpy test it imposes high strain rate to the specimen. Below are figure that shown components of charpy test:

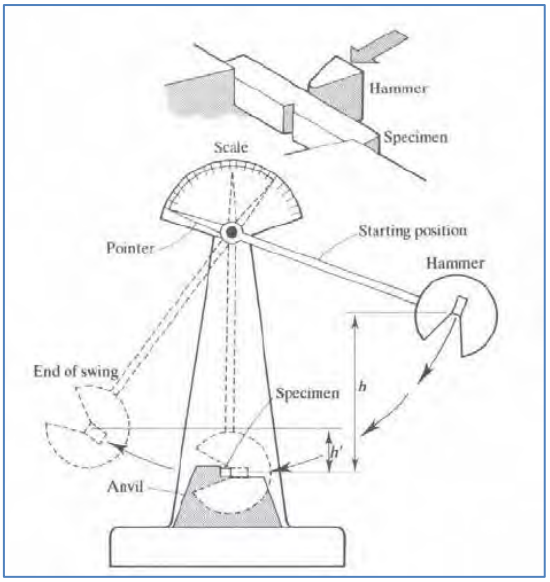

Figure 2.1: Charpy impact test.

(http://e2pro.us/home/mechtest.html)

The difference between height of the hammer and the potential energy can be relate to shows that the potential energy can be determined as absorbed energy in Charpy impact test.

$$\Delta h = h - h' \quad (1)$$

The potential energy or absorbed energy

$$PE = m \times g \times \Delta h \quad (2)$$

Where,

g is the gravitational acceleration

The potential energy are used to break the specimen during the impact (Roebben & Lamberty, 2007).

Charpy impact test have been used to measure the amount of energy absorbed during the impact. Based on the energy absorbed during the specimen break, it can determine the material toughness of the specimen.

Charpy impact test are commonly used in various industries to studies the material toughness since this test are the standardize high strain rate test and also due to the cheapest testing machine and easy to conduct. In terms of energy, during Charpy impact test as the velocity and kinetic energy of a striking mass are varied, energy is transferred and work is done on the specimen. (Abrate, S., 2011)

2.3 CHARPY SPECIMEN

Charpy impact test not only can be used for testing the metal material but it also can be used for testing the composite, polymer and ceramics materials. The are two types of the specimen can be used for Charpy impact test which is V-notch specimen or U-notch specimen. Based on standard dimension state in ISO 148-1 : 2006 (E), the dimension of Standard Charpy impact specimen used for the test are 55×10×10 mm. V-notch specimen has centre of the length 2 mm depth with 45° angle and 0.25 mm root radius. While, U-notch have 5 mm depth and 1mm root radius. Figure 2.2 below shows the standard Charpy impact test specimen that widely used in the industries: