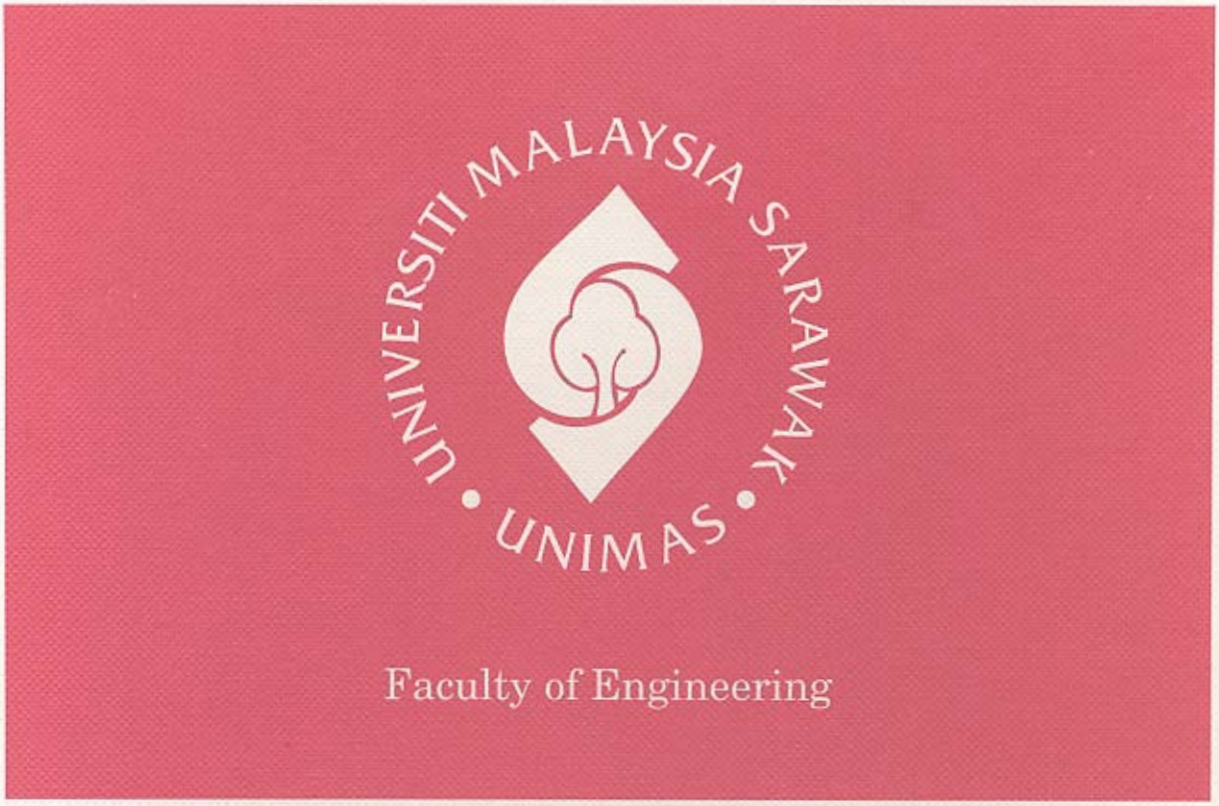

DEVELOPMENT AND CONSTRUCTION OF CONVENTIONAL IMPACT TESTING RIG

Mahathir B. Hj. Mohd Pattali

Bachelor of Engineering with Honours
(Mechanical Engineering and Manufacturing Systems)
2004

Universiti Malaysia Sarawak

BORANG PENYERAHAN TESIS

Judul: **Development and Construction of Conventional Impact Testing Rig**

SESI PENGAJIAN: 2003/2004

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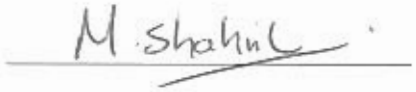
APPROVAL SHEET

This project report attached hereto, entitled "**DEVELOPMENT AND CONSTRUCTION OF CONVENTIONAL IMPACT TESTING RIG**" is prepared and submitted by Mahathir Bin Hj. Mohd Pattali in partial fulfillment of the requirement of Bachelor's Degree with Honours in Mechanical and Manufacturing System Engineering is hereby accepted.

(Assoc. Prof. Dr. Sinin Hamdan)

Project Supervisor

Date : 8/4/04



(Dr. Mohamad Shahril Osman)

Project Supervisor

Date : 8/4/04

DEVELOPMENT AND CONSTRUCTION OF CONVENTIONAL IMPACT TESTING RIG

MAHATHIR B. HJ. MOHD PATTALI

This project is submitted in partial fulfilment of
the requirements for the degree of Bachelor of Engineering with Honours
(Mechanical Engineering and Manufacturing System)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
2004

Dedicated To My Beloved Family

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ABSTRACT

This work is focused in designing a conventional impact testing rig using a drop weight technique which provide a measurement of stress and strain. The rig was designed are constructed and used a strain gauge and photodiode as a sensor to detect the impact signal. Both of the strain gauges and photodiode are connected to the oscilloscope. The oscilloscope is connected directly to the computer. The signal receive from the sensor are directly displayed in monitor in waveform manner by the oscilloscope. The signal received is analysed to get stress and strain. The project did not achieve the objective due to inability of oscilloscope to detect the single trigger mode. To achieve results, a digital camera has been used as the instrument to collect the experimental data. The usage of this camera is limited as this is only for visual inspection method. No parameters are used as an experimental data.

ABSTRAK

Kajian ini memberi tumpuan untuk merekabentuk sebuah mesin penguji impak konvensional menggunakan teknik beban jatuh yang boleh menghasilkan kadar terikan dan tegasan. Mesin ini direka menggunakan tolok terikan dan photo diode sebagai alat sensor untuk mengesan pecutan hentaman. Kedua-dua sensor ini kemudiannya disambungkan ke '*oscilloscope*'. *Oscilloscope* ini pula disambungkan terus ke komputer. Oscilloscope akan menayangkan isyarat yang dihantar oleh sensor di monitor komputer di dalam bentuk gelombang. Isyarat yang diterima ini kemudian akan dianalisa untuk mendapatkan nilai tegasan dan terikan. Ekperimen yang telah dijalankan gagal mencapai tujuan utama disebabkan oleh kerana kegagalan penggunaan '*oscilloscope*' pada mod '*single trigger*'. Digital kamera telah digunakan sebagai alternatif untuk tujuan pengambilan data ekperimen. Penggunaan kamera digital ini terhad hanya pada 'visual inspection' sahaja. Ini bermakna tiada parameter digunakan sebagai ekperimen data.

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CHAPTER 1

INTRODUCTION

Nowadays, in engineering field especially in developing or in designing a new product, the resistance of the design towards impact is an important task that needs to be determined. Impact plays an important role to determine the reliability and long lifetime of the product.

Impact is defined as a sudden application of a load confined to a localised area of a material [1]. Impact can also be defined as the action of one object hitting another or the force with which one-object hits onto one another [2]. Engineering components are often exposed to impact condition. For example, communication device such as hand phone and pager must endure dropping, and helmet and guards must not shatter when subject to impact.

Many polymers are inherently brittle compared with metals. Although polymers, as well as most materials, have some measured level of impact toughness, the overall toughness of a component is related to the selection of the materials, the fabrication processes and the design of part.

IMPACT TESTING

Impact testing can be defined as the techniques routinely used to measure the mechanical properties of materials [3]. It is applying a load to a specimen at high speed, and then measuring the response of the specimen. It is also use to give an indication of the relative toughness of a material. Impact energy and impact velocity are the two key measurements made during an impact test. Impact test is classified, as destructive tests (DT), where the test samples are subjected to be damage or destruction after the test. This also includes crash test on automobile, which is developed to test a new design of vehicle and safety equipment.

In standard testing, such as tensile and flexural testing, the materials absorb energy slowly. In real life, materials often absorb applied forces very quickly as falling object, blows, collisions, drops and etc. The purpose of impact testing is to simulate these conditions. Impact test are performed to measure the response of material to dynamic loading [4]. The most common laboratory test configuration can be divided into two types, which are Pendulum Machine and the Drop Tower.

1.1.1 PENDULUM MACHINE

Pendulum impact test machines measure the energy absorbed in fracturing a test specimen [4]. The methods are used to investigate the behaviour of specified specimens under specified impact stresses, and to estimate the brittleness or toughness of specimens. Information on a typical behaviour of a material can be

obtained by testing different types of test specimens prepared under different condition, varying notch radius and test temperatures.

The specimen is clamped in a vice where the pendulum hammer with a hardened steel striking edge with specified radius is released from predefined height, causing the specimen to shear from the sudden load. The residual energy in the pendulum hammer carries upwards where the difference in the drop height and return height represents the energy to break the test bar. The test can be carried out at room temperature, at lower temperatures to test cold-temperature embrittlement. Test bars can vary in type and in dimensions of the notches. Figure 1.1 and 1.2 shows the two types of pendulum machines.

Figure 1.1 Charpy testing machine

Figure 1.2 Izod testing machine

1.1.2 DROP TOWER

Also known as drop weight and falling weight impact testing machine. Drop tower test machines measure energy using an instrumented striker system [4]. The impact velocity is obtained using an infrared detector mounted to the test machine frame. The test results of drop tower are dependent on the geometry of both falling weight and support and should only be used to obtain relative rankings of materials.

Impact values cannot be considered absolute unless the geometry of the test equipment and specimen conform to the end-use requirement. The relative ranking of materials may be expected to be the same between two test methods if the modes of failure and impact velocities are the same.

Drop tower is a weight dropped in a vertical direction, with a tube or rails to guide it during the free fall. Once again, with the weight and height known, impact

energy can be calculated. In the early day, there was no way to measure impact velocity, so engineers had to assume no friction in the guide mechanism. Since the falling weight either stopped dead on the test specimen, or destroyed it completely in passing through, the only result that could be obtained was having a pass or fail in nature. Figure 1.3 shows a drop tower-testing machine.

Figure 1.3 Drop tower testing machine

1.2 OBJECTIVE

The main objective of this project is to develop an impact-testing rig using the free fall drop technique. The impact-testing rig used a free falling weight. The rig is attached that is guided by three vertical rods. The sensor devices i.e a photodiode and strain gauges (attach at the anvil) are used to detect the signal occurring when the weight hit the specimen.

The photodiode is use to detect the impact acceleration during the impact. This acceleration value is then converted into impact force that will give the stress value. Velocity value can be calculated by integrate the acceleration value captured by photodiode.

The strain gauges are used to measure the impact loading. When a force P, is exerted on a specimens cause the deformation and thus reduce the height. The ratio between height and transverse expansion is a specific factor for each material. The ratio between bar reduction and the original height is strain. The materials stress is the ratio between the acting force P and the cross-sectional area of the bar perpendicular to the force. If the stress and the strain measured during a load test are plotted, a typical stress-strain curve is obtained for the material concerned.

This sensor device connected to the oscilloscope. These oscilloscopes are connected directly to computer and used to receive the signal and display it in waveform manner.

CHARTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Many researches have developed impact testing method or technique. Mostly the impact testing method is used to determine the properties of the materials. This includes impact response of carbon fibre composite, impact resistance of concrete plates reinforced with a fibre reinforced plastic grid.

2.2 IMPACT RESPONSE OF CARBON FIBER COMPOSITE

Morton and Godwin [5] have done an experiment on impact response for carbon fiber composite. In this experiment, an instrumented guided falling weight has been used. This apparatus consisted of two vertical wires guiding a carriage to which was attached a strain gauge cell. A tup with a hemispherical end 6.35 mm in diameter formed the striker and was attached to the load cell. A commercial software package on a Hewlett Packard HP85B are used to displayed either on an oscilloscope or plotter, or recorded and processed the signal after captured.

2.3 IMPACT RESISTANCE OF CONCRETE PLATES REINFORCED WITH A FIBER REINFORCED PLASTIC GRID

Banthia, Yan and Sakai [6] have done an experiment on impact resistance of concrete plates reinforced with a fiber reinforced plastic grid. This test was carried out using a drop weight impact machine. The machine has a 505 kg hammer, which can be dropped from variable heights of up to 3 m. For the test, a hammer drop height of 0.5 m was chosen as it provided sufficient energy for a complete fracture of the plates. With this drop height, the hammer had a potential energy of 2470 J and an approach velocity of 2.97 m/s just before hitting the specimen. The cylindrical striking end of the hammer carries a dynamic load cell (called the "tup") which has a capacity of 1000 kN. The tup records the contact load-time pulse between the specimen and the hammer which can than be used in the data analysis. A high speed video camera was used to record the event at a high speed of 1000 frames/sec. this helped in understanding the response of the specimen during impact and in correlating the data from the various transducers mounted on the hammer and the specimen.

2.4 DEVELOPMENT OF IMPACT TESTING RIG

The main objective of this project is to develop the impact testing rig and to determine the stress and strain of the specimen. These techniques (drop weight) are chosen because this technique has many advantages. This technique will give the result in term of true stress and true strain of the specimen.

2.4.1 The advantage using the conventional drop weight technique

There are several advantages using the conventional drop weight technique:

2.4.1.1 Variable value of height

In this system, the load can be place at any height. The higher the height being placed, the higher the velocity is achieved. When the velocity increases, the displacements also increased [7].

2.4.1.2 The usage of accelerometer

In this conventional drop weight impact-testing rig, the accelerometer is employed at the weight and can be used continuously. Accelerometer can also be used at any temperature without giving any effect.

Mahazir [7] and S. Hamdan [8] have done the impact test using the conventional drop weight technique. In their system, accelerometer was used. Camera is also used to determine the changes of diameter specimen. To capture the impact signal, strain gauges has also been used.

CHARTER 3

EXPERIMENTAL WORKS

3.1 INTRODUCTION

The purpose of this study is to develop the conventional impact-testing rig by using drop weight technique. This impact-testing rig system is attached with two optional devices to detect and receive the signal when impact is occurring which is strain gauge and photodiode. Each of these devices receives different signal.

3.2 CONVENTIONAL DROP WEIGHT

3.2.1 Experimental Setup

The instrumented impact tester in this study, is functionally equivalent to that used by S. Hamdan [8]. The free fall drop weight is positioned within three guide rods, as shown in figure 3.1. A frame is built for the stability during the experimental works supports the three guide rods. The height maximum is 1.653 m. If the weight and guided rod friction are neglected, the velocity just before impact is given by:

$$v = \sqrt{2gH_d} \qquad (3.1)$$

where: **g** is the gravity acceleration taken as 9.81 ms^{-2}

$\mathbf{H_d}$ = the height of the weight from the base.

The calculated velocity is found to be **5.6ms^{-1}**.

The base is a cast iron workshop anvil of 25 kg mass resting on a concrete floor. The task of this anvil is to absorb the load or force released by the impact. The drop weight that impacted the specimenp is incorporated a hardener steel roller (figure 3.2). The total load of the weight (include hardener steel roller) is 2.2 kg and the maximum force can be calculated by using formula above:

$$F = ma \qquad (3.1)$$

where: **a** = acceleration taken as 9.81 ms^{-2}

m = weight of mass which is 2.2 kg

It was found that that the maximum force is **21.58 kN**