IMPACT PROPERTIES OF POLYMERS

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Dedicated to my beloved family and friends

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ABSTRACT

Polymer is made up from many chemically bonded parts or monomers that themselves are bonded together to form a solid. Polymeric materials such as PVC, nylon and nylatron are used as the specimen for this testing.

In this study, the drop weight testing had been conducted to the specimens under the impact loading using accelerometer. The drop weight was dropped on the specimen from the different heights. The accelerometer is functioning as a sensor to produce a voltage output which is proportional to the acceleration of the drop weight where the accelerometer is mounted on it. The data acquired from the accelerometer was then converted to acceleration, velocity and displacement. The stress-strain curves were plotted in the further steps.

The results show that the voltage produced by the accelerometer is influenced by the height of the drop weight from the specimen. At higher height, more impact energy is available for the drop weight to knock the specimen. The results of the drop weight testing also indicate that the value of modulus of elasticity is increasing from nylon → PVC → nylatron at the same strain rate. This shows that the nylatron has the highest strength among these materials.

ABSTRAK

Polimer terdiri daripada banyak monomer yang diikat secara kimia untuk membentuk pepejal. Kajian dijalankan dengan menggunakan bahan polimer sperti *PVC*, *nylon* dan *nylatron* sebagai spesimen.

Dalam kajian ini, kajian hentaman telah dijalankan dengan mengggunakan meter pecutan di mana specimen dihentam dengan penghentam. Penghentam dijatuhkan ke atas spesimen dari ketinggian yang berbeza. Meter pecutan berfungsi sebagai sensor untuk menghasilkan voltan yang akan berkadar dengan pecutan penghentam di mana meter pecutan akan dipasang di atasnya. Data yang diperoleh daripada meter pecutan ditukarkan kepada pecutan, halaju dan sesaran. Graf tegasan lawan keterikan akan diplotkan kemudian.

Keputusan menunjukkan bahawa voltan yang dihasilkan oleh meter pecutan dipengaruhi oleh ketinggian penghentam dari specimen. Pada ketinggian yang tinggi, lebih banyak tenaga hentaman digunakan untuk menghentam specimen. Keputusan juga menunjukkan bahawa nilai modulus ketegaran telah meningkat daripada nylon → PVC → nylatron pada nilai keterikan yang sama. Ini menunjukkan bahawa nylatron adalah paling kuat antara ketiga-tiga bahan tersebut.

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NOMENCLATURE

A	-	Cross-sectional area
F	-	Force
h	-	Height
l	-	Length
ε	-	Strain
Δl	-	Changes in length
σ	-	Stress
V	-	Voltage
K	-	Sensitivity of accelerometer
g	-	Gravity acceleration
t	-	Time
a	-	Acceleration
V	-	Velocity
x	-	Displacement
dv	-	Changes in velocity
dx	-	Changes in displacement
dt	-	Time interval value
v	-	Poisson's ratio

CHAPTER 1

INTRODUCTION

1.1 Impact

When the force or displacement is rapidly applied to a material, it is often found that the stress levels and deformations induced are very much larger than would be generated by the same forces or displacements applied very gradually [1]. Such rapid applied loads or displacements are usually called impact. An impact force can be defined as a high force or shock applied over a short period of time. Impact force may be generated in an object either by the collision of moving bodies or simply by the sudden application of force or motion to the object [2].

Impacts are generated in object in variety of ways. For example, the drop of a forging hammers or suddenly applied loads, such as produced during combustion in the power stroke of an internal combustion engine. Impacts also generated during the crashing of an aircraft or automobile. But, somehow impacts are generated to be used and applied in our daily activities or works such as using hammer to pound a nail with a series of impacts. These high velocity impacts prevent friction with the wood on the sides of the nail from retarding the forward motion of the nail [3]. In construction, a pile driver does the same thing, on a much larger scale.

In the selection and use of materials, it is important to determine the impact properties of the materials. This is to ensure that failure will not occur and also to prevent economic losses.

1.2 Objectives

The work will be carried on the impact properties of polymers such as PVC, nylon and nylatron which will be constructed using impact testing as well as drop weight testing by using accelerometer. In the drop weight testing, impact loading is provided on a specimen.

The main objectives of this testing is to investigate and learn the mechanical properties of the polymers specifically under impact testing. Skills in processing and analyzing the data and results from the testing is required to calculate the data of the testing and plot a graph in the computer using the PC oscilloscope together with the supplied software. With the data from the graph, the stress and strain values can be calculated.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the researches which had been done by the engineers and scientists related to the objectives of this project. It includes the knowledge and information from various aspects which is required in this testing. This is useful before proceed to the methodology part.

2.2 Impact Testing

The failure of engineering materials is always an undesirable event which can cause economic losses, unsafe condition and so on. Therefore, it is important to know how materials behave under impact loading condition, such as high speed impact. Such examples are bumper, car body panels, gasoline tanks, helicopter blades and so on. In each instance, the success of the materials in the application requires knowledge of its mechanical and chemical profile, and in particular, the characterization of its impact performance [2].

Even though the cause of failure and the behavior of the materials may be known, prevention of its failures is difficult to guarantee. The usual causes are improper material selection and processing, misuse and inadequate design of the component. It is the responsibility of engineer to make the right choice to

characterize the material properly for its use. The engineer is required to predict and plan for possible failure, access its cause in case the failure does occur and take appropriate preventive measures against future incidents [4].

2.3 Impact Testing Techniques

Impact testing is designed to measure the resistance to failure of a material to a suddenly applied force such as collision, falling object or instantaneous blow. The testing measures the impact energy, or the energy absorbed prior to fracture. The most common methods of measuring impact energy are the:

- Charpy Impact Test
- Izod Impact Test
- Drop Weight Test

2.3.1 Charpy Impact Test

The Charpy impact test was invented by Georges Augustin Albert Charpy (1865-1945). The Charpy impact test measures the energy absorbed by a standard notched test specimen while breaking under an impact load. The Charpy impact test continues to be used as an economical quality control method to determine the notch sensitivity and impact toughness in engineering materials [5]. While most commonly used on metals, it is also used on polymers, ceramics and composites.

Figure 2.1: Georges Augustin Albert Charpy (1865-1945) [5].

The standard Charpy impact test specimen consists of a bar of metal, or other material, with the dimension 55×10×10 mm, having a notch machined across one of the larger dimensions. The notches may be [6]:

- V-notch: A V-shaped notch, 2mm deep, with 45° angle and 0.25mm radius along the base.

- U-notch and keyhole notch: 5mm deep notch with 1mm radius at base of notch.

The direction of crack propagation is determined by the notch and therefore, the Charpy impact test properties will depend on the orientation of this notch.

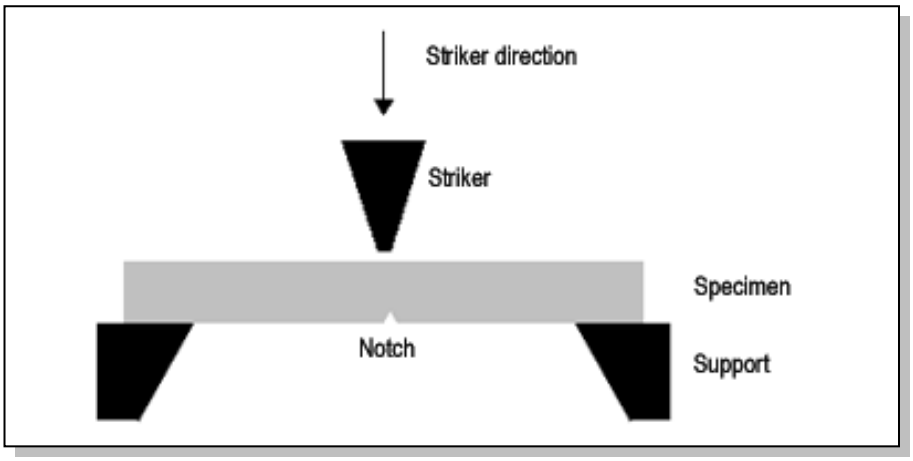

Figure 2.2: A Schematic Drawing of the Charpy Impact Test [6].

The Charpy impact test involves striking a suitable specimen with a striker, mounted at the end of a pendulum. The test specimen is fixed in place at both ends and the striker impacts the test specimen immediately behind a machined notch.

In the Charpy impact test, the falling weight is in the form of a pendulum, the weight and dimensions of the arc determine the amount of kinetic energy generated. The maximum kinetic energy is reached at the lowest point of the swing and the test specimen is placed very precisely at this point, after impact the specimen will either fracture or be severely deformed. The pendulum will continue to travel to a maximum height on the other side of the swing where a pointer records the energy lost (energy absorbed by the test specimen) in fracturing the test specimen [7].

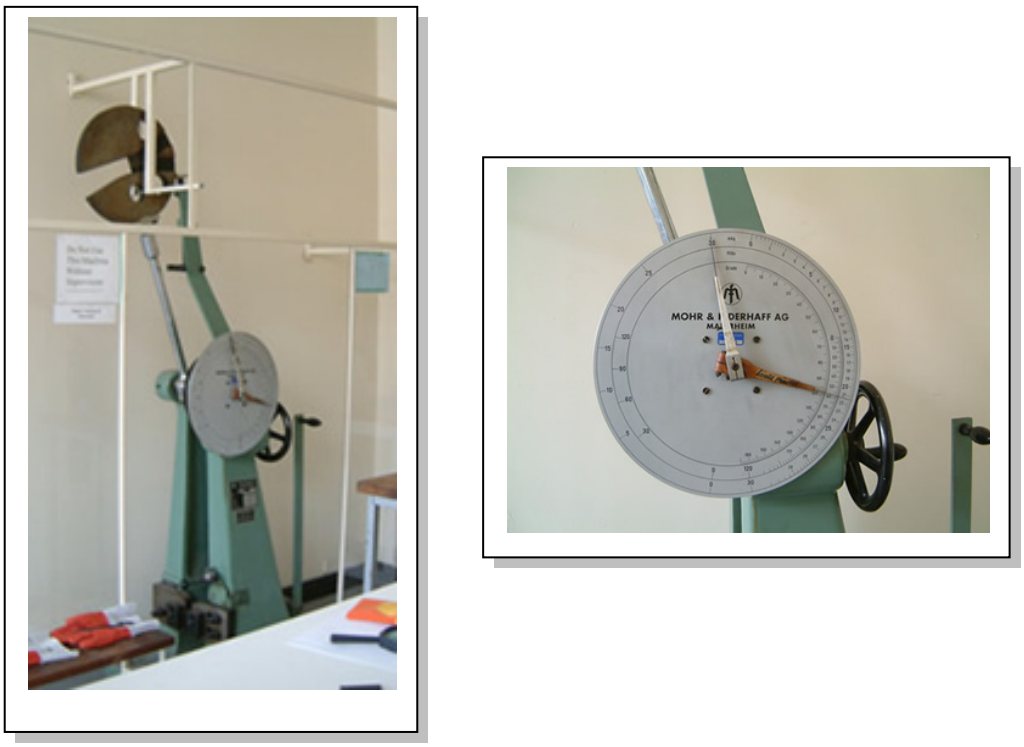

Figure 2.3: Charpy Impact Test Equipments [7].

2.3.1.1 Impact Energy

Impact energy is a measure of the work done to fracture a test specimen. When the striker impacts the specimen, the specimen will absorb energy until it yields. At the point of impact, the specimen will begin to undergo plastic deformation at the notch. The test specimen continues to absorb energy and when the specimen can absorb no more energy, fracture occurs. At the point of impact also, the amount of kinetic energy is known and the impact energy is recorded by a pointer. The impact energy is calculated based on the height to which the striker would have risen, if no test specimen was in place, and this compared to the height to which the striker actually rises. Tough materials absorb a lot of energy, whilst brittle materials tend to absorb very little energy prior to fracture [6].

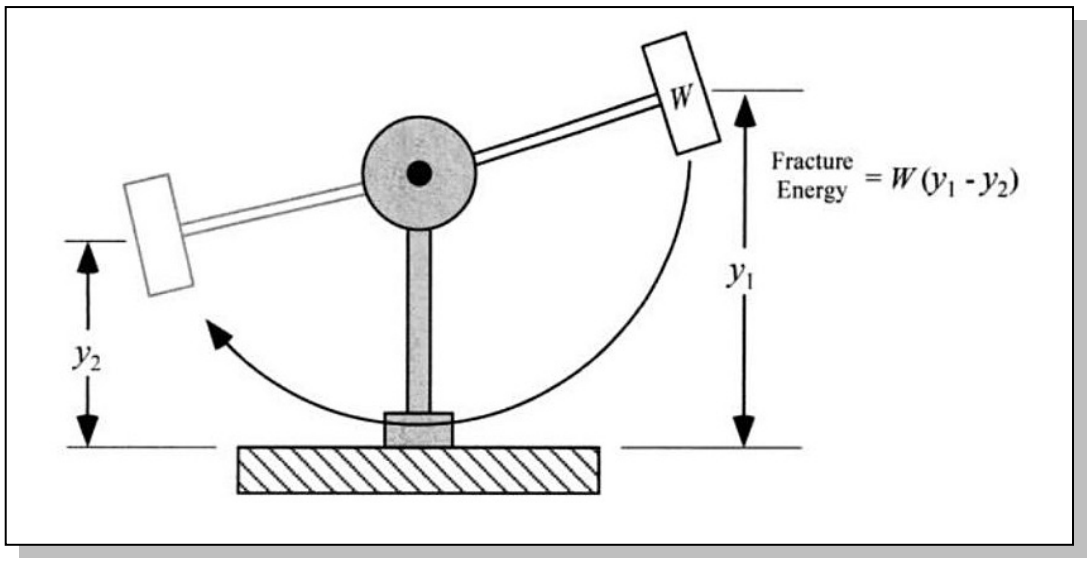

Figure 2.4: Fracture / Impact Energy Calculation [8].

2.3.1.2 Factors Affecting Impact Energy

Factors that affect impact energy of a specimen will include [6]:

- Yield strength and ductility

  For a given material if the yield strength is increased, the impact energy will be seen to decrease. For example, if the material undergoes some process that makes it more brittle and less able to undergo plastic deformation. Such processes may include cold working or precipitation hardening.

- Notches

  The notch depth and tip radius are very important. This is because the notch serves as a stress concentration zone and some materials are more sensitive towards notches than others.