# Charpy impact test of polypropylene at various temperatures

This experiment examined the impact of polypropylene at various temperatures through the Charpy test. Three different forms of specimens including unnotched ones, blunt-notched and sharp-notched were tested to measure the impact energy. Results showed that low temperature resulted in the decrease of impact energy. These results have important implications for human designed applications concerning the toughness of polymers at different temperatures.

The study of impact test has become an important aspect of toughness. Some progress has been made to understanding the mechanical characteristics of various polymers, especially toughness. Toughness, ability of a material to absorb energy and deform plastically before fracturing [1], is a concept most people have been accepted. It can be calculated by the areas under a stress-strain curve.

Impact test, which describes the response of materials to a sudden high-speed force, can be divided into two different methods. One test method uses an instrument where a pendulum of known energy strikes a sample of defined size and shape. The other one test way uses an instrument where weights or others are allowed to fall freely through known heights on to specimens. [2]

The first method mentioned above can be also separated from two kinds, which involve in cantilever (Izod) test and supported beam (Charpy) test. The illustrations of two tests are shown in Fig. 1. The distinct difference between the two methods is the fact that a specimen tested in the Izod is fixed in the horizontal direction instead of vertical direction tested in the Charpy.

Fig. 1 Izod and Charpy Impact Test

(b) Charpy

(a) Izod

Temperature has an obvious influence in the behavior of polymers, such as tensile strength, shear stress, toughness, etc, because temperature affects the micro-structure of polymers. Among the changes, the inherent toughness is definitely dependent on temperature, structural orientation, stress concentration effects and rate of loading [3]. However, there have been few published reports directly addressing the problem of the effect on polypropylene at various temperatures. This experiment was to make clear of the relationship between the impact strength of polypropylene and temperature referenced in Charpy test.

# Experimental

## Equipment

The equipment photograph is shown in Fig. 2 and the parameters of it are figured out in Table 1.

Fig. 2 Charpy impact test system

Location: S. 2. 10

Table 1. Parametres of Charpy Impact Test Equipment

Hammer Velocity

Hammer Weight

Hammer standard

2. 9m/s

1. 189kg

ISO

## 2. Specimens

A number of different rectangular-section standard polypropylene (PP) Charpy test samples including sharp notched, blunt notched and unnotched ones were tested at different temperature conditions. The different specimens are shown in Table 2. which also involves in the sizes (width and thickness) of the testing specimens. â… , â…¡, and â…¢ in Table 2 are the four different dimensions separately.

Table 2 Parameters of the specimens

## Room temperature

## Experimental Procedures:

The specimens are divided into two parts, and one of the parts was put into the freezer before being tested.

All of the data of an unnotched specimen at room temperature were input into the via keypad, and the sample was held onto the proper position of the equipment.

A pendulum was raised to a specified height and then released when the equipment was started. Then the specimen was separated by the high-velocity pendulum.

The impact energy was recorded in the Charpy impact test equipment.

Steps 2 to 4 were repeated for each of the unnotched specimens to achieve a series of data.

Steps 2 to 5 were repeated for all of the blunt-notched samples and then the sharp-notched samples.

Steps 2 to 6 were repeated for the unnotched, the blunt-notched and the sharp-notched at -20â„ ƒ.

## Results and Discussion

## 1. Tabulate the individual values and average value of impact energy absorbed by the specimens for each test temperature.

The individual data and average values of impact energy absorbed by the specimens for both two temperatures are listed in the two tables below. Table 3 illustrates the data at room temperature, and Table 4 exhibits the data at -20â„ ƒ.

## 2. Discuss the effect of temperature on impact energy for sharp notched, blunt notched and unnotched samples.

Since the impact strength is dependent on the energy absorbed, a structure that is much easier to move will respond better to the impact [4]. Therefore, the impact strength will increase with the increase of temperature and rubbery state has higher impact strength than glassy state. The higher the temperature is, the more severely the molecular chains will move. As a result, the impact energy is significantly lower at -20â„ ƒ than that at room temperature. It can also be found in Table 4.

## 3. Analyze experimental error

(a) When the parameters of specimens were measured, the apparatus error of vernier calipers could not be avoided. At the same time, the location of specimens was changeable, which was an operation error existed.

(b) The sharp-notched samples were cut artificially, thus the factitious errors could not be ignored.

(c) For the low temperature test, the frozen specimens were moved from a freezer to atmosphere, which might lead to the rising of temperature. As a result, the impact energy got a slight increase.

(d) The errors of Charpy impact test equipment could not be ignored. Movement in the clamp and energy imparted to broken fragments might be the factors of the remaining energy of the pendulum and therefore the impact energy increased. [5]

## 4. Explain the cause of the whitening observed in some of the fractured samples.

All kinds of the samples are listed in the Fig. 3.

Fig. 3 The tested samples

Through the observing of all different kinds of specimens, whitening is the most obvious in the unnotched samples. Many reasons listed lead to this phenomenon. Stress-whitening crazing usually can be observed for thermoplastics at levels of stress that below those required for large scale yielding. [6]When there is a sudden load to the sample, fracture crazes will be developed. Most of the time, it occurs in amorphous, brittle polymers and generally consist of an open network of polymer fibrils between 10 and 40nm in diameter, interspersed by void of about 10-20nm. [6]

# Conclusions

After the experiment completed, many benefits of toughness and impact test have been listed below.

There is a large variety of methods to measure impact energy of polymers and the most common used test is the Charpy test.

With the decrease of temperature, the impact energy of same shaped specimens has a significant decline.

The whitening of polymers is easier to be observed in the unnotched samples than that in sharp-notched and blunt-notched.