CHITTAGONG UNIVERSITY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

Experiment No	Experiment Name
04	Impact Test of metal specimen with Charpy Test Method

COURSE NO : **CE 212**

COURSE TITLE : **Mechanics of Materials (Sessional)**

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SECTION : A

GROUP : 03(A)

LEVEL : **02**

TERM : **01**

REMARKS

Objective :

1) To study the impact testing machine
2) To determine the energy absorbed by a material before failure at room temperature using the Charpy or Izod method of impact test.
3) To observe the failure patterns and failure surfaces.

Scope:

1) These test method describe notched-bar impact testing of metallic materials by the Charpy test and the Izod test. They give the requirements for test specimen, test procedures, test reports, test machines and determining the percent of shear fracture on the surface of broken impact specimens.

2) These test method do not address the problems associated with impact testing at temperatures below -196°C (77K).

3) The values stated in SI units are to be regarded as standard. No other units of measurements are included in this standard.

4) This standard does not purport to address all of the safety concerns, if any associated with its use. It is the responsibility of user of this standard to establish appropiate safety and health practices and determine the applicability of regulatory limitations prior to use.

Theory:

An impact test normally determines the energy absorbed in fracturing a test specimen. This absorbed energy is a measure of a given material's toughness and acts as a tool to study temperature-dependent brittle-ductile transition. It is to determine whether the material is brittle or ductile in nature. An impact test is a dynamic test in which a selected specimen which is usually notched, is struck and broken by a single blow in a specially designed machine. The energy absorbed per unit area while breaking the specimen is measured.

Impact or shock loading differs from static and cylic load in two respects:

1) Load is applied rapidly, that is with appreciable speed
2) Loading is seldom repeated, since failure often occurs on the first application, if it occurs at all.

The major factors that affect the results of impact test are:

a) Velocity of pendulum b) Specimen type c) Temperature

In impact test method the tested pieces are notched. The intension of the notch is to approximate end use conditions; the notch serves as a stress concentrator. These tests gives a value for toughness.

Types of impact Test:

i) Charpy Impact Testing ii) Izod Impact Testing

	Charpy Impact Testing	Izod Impact Testing
Material Tested	Metals	Plastics and Metals
Types of Notches	U-notch and V-notch	V-notch only
Position of the specimen	Placed horizontally on the anvil as simply supported beam; notch facing away from the pendulum	placed vertically on the anvil as cantilever beam notch facing toward the pendulum
Striking Point	Middle of the sample	Upper tip of the sample
Specimen Dimensions	55mm x 10mm x 10mm V-notch angle = 45°, Depth of notch = 2mm	75mm x10mm x 10mm V-notch angle = 45° depth of notch = 2mm

Significance and Use:

1) These test methods of impact testing relate specifically to the behaviour of metal when subjected to a single application of a force resulting in multi-axial stresses associated with a notch coupled with high rates of loading and in some cases with high or low temperature.

2) Impact test provide information on the resistance of a material to sudden fracture where a sharp stress rise or flaw is present.

3) In addition to providing information not available from any other simple mechanical test, these tests are quick, inexpensive and simple to perform. Data obtained from such impact test is frequently employed for engineering purposes.

4) These types of impact test have given way to testing methods that make use of fracture mechanics. Fracture mechanics allow analysis of materials containing cracks and sharp notches. Impact tests have thus remained popular despite their shortcomings as they serve a useful purpose in quickly comparing materials and obtaining general information on their behavior.

Test Method : ASTM E23

Apparatus :

1) Impact Testing Machine

2) Specimen :

i) For Izod Test :

Specimen size = 75 mm × 10mm × 10mm
Type of notch = V-notch
Angle of notch = 45°
Depth of notch = 2mm
Specimen is placed vertically on the anvil with the notch facing hammer

ii) For Charpy Test :

Specimen size = 55mm × 10mm × 10mm
Type of notch = V-notch
Angle of notch = 45°
Depth of notch = 2mm

- Specimen is placed horizontally on the anvil as a simply supported beam

3) Slide Calipers/Measuring scale

Procedure:

① Prepared the test specimen and measured the actual dimensions. For preparing test specimen, a v notch was created along the depth of the test specimen which was 2mm in depth. Then measured the dimension with slide callipers.

② Ensured that everybody was in safe condistance. Then released the pendulum without the sample from a certain height and read out the dial reading, which was the initial energy.

③ Then moved the pendulum up to certain height and locked it in it's position.

④ The test specimen was placed in position according to charpy test condition.

⑤ Then the pendulum was released carefully to swing and recorded the reading from the test scale after the impact.

⑥ Then calculated the energy absorbed by the fractured surface of the specimen.

⑦ Returned the pendulum to its locked position.

Experimental Data :

Vernier constant = 0.01 mm = 0.01×10^{-1} cm = 0.001 cm

Type	Main Scale (cm)	Vernier Scale (cm)	Vernier constant	Actual Reading	
				cm	mm
Length	4.2	20	0.001	4.22	42.2
Width	0.8	27		0.827	8.27
Depth	0.3	25		0.325	3.25

[Here, Actual Reading = Main Scale Reading + Vernier Constant × Vernier Scale Reading

Depth at Notch = Specimen Depth − Depth of notch

= 3.25 mm − 2 mm

= 1.25 mm

Cross sectional area at notch = Depth at notch × Specimen width

= 1.25 mm × 8.27 mm

= 10.3375 mm^2

Absorbed Energy = Initial Energy − Final Energy

= 350 − 210 = 140 J

$$\text{Impact Value} = \frac{\text{Absorbed Energy}}{\text{Cross sectional Area at notch}} = \frac{140 \text{ J}}{10.3375 \text{ mm}^2}$$

$= 13.543 \text{ J/mm}^2$

Type of Test	Specimen Length (mm)	Specimen width (mm)	Specimen Depth (mm)	Depth at notch (mm)	Cross sectional area at notch (mm^2)	Energy Absorbed (J)	Impact Value (J/mm^2)
Charpy Test	42.2	8.27	3.25	1.25	10.3375	140	13.543

The impact value of the given test specimen = 13.543 J/mm^2

Calculation:

From the Data, Verniere constant $= 0.01\ mm = \frac{0.01}{10} = 0.001\ cm$

Here, Actual Reading = Main Scale Reading + Verniere Constant × Verniere Scale Reading

$\therefore$ Actual Length $= 4.2 + 0.001 \times 20 = 4.22\ cm = 42.2\ mm$

$\therefore$ Actual Width $= 0.8 + 0.001 \times 27 = 0.827\ cm = 8.27\ mm$

$\therefore$ Actuad Depth $= 0.3 + 0.001 \times 25 = 0.325\ cm = 3.25\ mm$

Depth of notch = 2mm

Depth at notch = Specimen Depth − Depth of notch

$= 3.25\ mm - 2mm$

$= 1.25\ mm$

Cross-sectional area at notch = Depth at notch × Specimen Width

$= 1.25\ mm \times 8.27\ mm$

$= 10.3375\ mm^2$

Dimension of given test specimen $42.2\ mm \times 8.27\ mm \times 3.25\ mm$ which is nearer to charpy standard Dimension [55mm × 10mm × 10mm]. Therefore charpy test was conducted.

Given, Initial energy = 350J ; Final Energy = 210J

Absorbed Energy = Initial Energy − Final Energy

$= (350 - 210)\ J = 140J$

$$\text{Impact Value} = \frac{\text{Absorbed Energy}}{\text{Cross-sectional area at notch}}$$

$$= \frac{140\ J}{10.3375\ mm^2}$$

$$= 13.543\ J/mm^2$$

Result:

The impact value of the given test specimen by Charpy Test method was found to be 13.543 J/mm^2

Failure Pattern seems to be Britte Fracture.

Discussion:

The aim of the experiment was to determine the energy absorbed by a material before failure using the Charpy or Izod method of impact test and also to observe the failure patterns of the specimen. According to ASTM E691, the average absorbed energy for low impacting energy should be nearer to 15.9 J. The estimated impact value was found to be 13.543 J/mm^2 which is nearer to 15.9 J indicating accuracy of around 85%. Three major factor affect the impact value which are i) Temperature ii) Specimen size and type iii) Velocity of pendulum during straining. Error may occure due to temperature effect. For test performed at room temperature, a temperature of 20°C ± 5°C is recommended. The transition temperature at which brittling effect take place varies considerably with the size of the test specimen. If this temperature condition is not maintained properly, then error may occur. Moreover, error may occur due to notch effect of the specimen. The notch results in a combination of multi-axial stresses associated with restrained to deformation in directions perpendicular to major stress and a stress concentration at the base of the notch. Therefore, improper notch may affect failure pattern as well as impact value causing inaccuracy. Another source of error is the velocity straining of pendulum which may cause absorption of higher energy and results in improper impact value. However, minor error may occur if the depth of notch and width of the specimen are not measured appropiately. Otherwise, all the procedures and safety concerns were maintained properly to determine the impact value of the test specimen and observing its failure pattern.

Assignment

Q.1) What is the necessity of making a notch in impact test specimen?

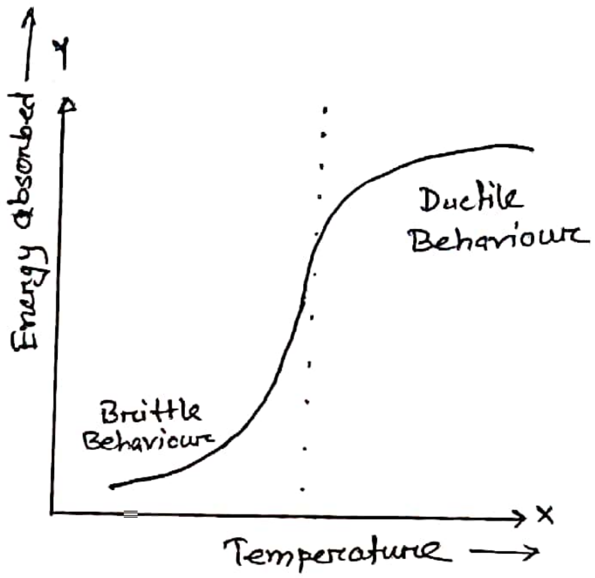
During impact test, notch in test specimen works as a stress concentrator and encourage fracture. When the striker impacts the specimen, the specimen will absorb energy until it yields and works hardens at the plastic zone at the notch. When the specimen can absorb no more energy fracture occurs. Impact tests on two steels showed that a 45° notch reduced the energy transition temperature by about 80°c. Therefore, notch is an important factor in the behaviour of structures subject to brittle fracture. Notches are commonly used in a material impact test where a morphological crack of a controlled origin is necessary to achieve standardized characterization of fracture resistance of the material.

If the notch is made sharper or more drastic, the normal stress at the root of the notch will be increased in relation to the shear stress and the bar will be more prone to brittle fracture.

The elastic behaviour terminates as soon as the shear stress exceeds the shear strength of the material and deformation or plastic yielding sets which is the condition for ductile fracture.

Q.2) Suppose same material is tested different temperatures, what will be its effect in the energy absorption?

Answer: Many materials, including metals, exhibit marked changes in impact energy with temperature. Effect of temperature is frequently made by energy absorb vs temperature graph. It can be seen that at low temperature the material is more brittle and energy absorb is low. At high temperatures the material is more ductile and energy absorb is higher. The transition temperature at which this embritling effect takes places varies considerably with the size of the test specimen and notch geometry.



Therefore, if same material is tested in different temperature, it will be seen that at lower temperature energy absorption will be lower and failure pattern will be brittle fracture. Because at lower temperature size of the specimen doesn't vary and notch geometry remain same.

At higher temperature, energy absorption will be higher and failure pattern will be ductile fracture. Because at higher temperature dimensions of specimen will be increased including notch geometry. Since cross sectional area at notch will be changed, it will absorb more energy in high temperature.