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NAME OF THE EXPERIMENT:

Mechanical testing of materials – 3(c) Impact (Charpy) test of metals

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Table of Contents

Introduction

Impact testing is one kind of mechanical testing of materials which measures a material's resistance to shock or sudden applied force and consequently plastic deformation. We can understand the amount of energy absorbed in a rapid force applied on a material, thus ‘toughness’ of a material. This measurement gets crucial while determining the mechanical behavior of a material under sudden loads. There are basic two types of impact tests based on how the specimen is placed and crafted for the test:

I. Charpy Test: Utilizes U or V notched specimens, supported at both ends and faces away from the pendulum horizontally.
II. Izod Test: Utilizes only V notched specimens, supported at one end and faces towards the pendulum vertically.

As this test is also capable of determining the resilience and durability of a material, this is used while understanding a materials assurance of safety and probable defects of it. Consequently, impact testing plays a vital role in quality control of materials.

Objective

- To understand the principle of impact testing and gain experience operating the impact testing machine to achieve the required impact properties.
- To understand ductile -brittle transition behavior of metals when subjected to impact loading at different temperatures.

Equipment

I. Impact specimens:
    a. Steel (at room temperature)
    b. Steel (at –50°C)
    c. Cast iron
II. Pendulum impact testing machine

Procedure

1. Measured the dimensions of the given specimen (cast iron and steel)
2. Reduced one steel specimen temperature to –50°C using dry ice.
3. Placed the specimen on to the impact testing machine and carried on the test for all three specimens.
4. Recorded the impact energy both in izod and charpy scale.
5. Draw a ductile brittle transition curve from the data.

Result

Primary measurements
Dimension of the specimen : 10 x 10 x 55 (mm)
Type of the notch : V- notch
Depth of the notch : 2 mm

Material	Testing Temperature (°C)	Impact Energy (J)
		Charpy
Steel	25	280
Cast Iron	25	2
Steel	-50	12

Discussion

In the impact test we conducted, there were three specimens– cast iron, steel in room temperature and steel in –50°C. The specimens used were prepared in the ASTM method. We used V notch and conducted only the charpy test.

Fig: V-shaped notch in the specimen

What general information is obtained from impact tests regarding the properties of material?

From an impact test, we get to know the 'toughness' of a material. In an impact test, a sudden load applied on the material. According to the mechanical property of a material, it changes, deforms or gets destructed. This material property is toughness. Toughness is the property of a material that defines its energy absorbing quality. The greater the toughness, the tougher to destroy.

Why do some metals become brittle at cold temperatures?

Some materials become brittle at cold temperatures depending on the material's atomic and molecular structure and its bonding. This change is known as 'ductile-to-brittle transition'. There are a few reasons for DBT:

I. Vibration of Atoms: In higher temperature, the atoms of a material vibrate more than in lower temperature. High vibration causes energy from the outside to transform into kinetic energy of the atoms. On the contrary, as in lower temperature, atoms can move easily, cracks and destructions occur in the structure to release the energy.
II. Dislocation: High temperature causes dislocations to move easily because of higher thermal energy, the opposite happens in lower temperature. Because of rigid dislocations, the material becomes brittle.

What kind of fracture has been obtained in the specimens and why?

From the experiment, we see crack fracture in brittle failures and in ductile failure the crack propagated like tearing apart. In cold steel and cast iron, the fracture had no appreciable plastic deformation, it just broke in half. The crack propagated nearly perpendicular to the applied impact.

Fig: Fracture of cast iron

Fig: Fracture of Steel (-50°C)

On the other hand, in the case of room-temperature steel, the fracture had significant plastic deformation scenes.

Fig: Fracture of Steel (room temperature)

What factors influence the ductile-to-brittle transition temperature in materials?

In the case of ductile-to-brittle transition (DBT), there are many factors that influence the transition. Some are mentioned below:

I. Composition of material: Composition of a material is heavily important in the case of DBT. For example, high carbon metals are usually brittle at lower temperatures than low carbon metals.

II. Atomic packing: Depending on types of atomic packing e.g. BCC, FCP etc., ductile-to-brittle transition varies. For example, FCC metals remain ductile even at very low temperature, BCC metals become brittle in relatively less lower temperature.
III. Microstructure: Composition and microstructure plays a vital role in DBT. At grain levels, the lower the grain boundary, the higher DBT temperature.
IV. Crack: As cold materials tend to fail along their internal crack, cold materials become easier to ductile failure.

Compare the advantages and limitations of the Charpy and Izod tests.

Both the Charpy and Izod tests are popular and used in most of the impact tests. But there are many advantages and disadvantages of both of the tests:

	Charpy Impact Test	**Izod Impact Test**
Advantages	This test is widely accepted and uses ASTM standard	Easier setup than the Charpy test
	Measures a broad range of impact energy	Takes lower cost
	More reliable toughness information	Quick assessment
Disadvantages	In this test, the setup is more complicated than other impact tests	Only one type of notch can be used
	The specimen must be created with extreme precision, otherwise, results may vary	Not broadly accepted
	Does not perfectly simulate real life impacts	Does not perfectly simulate real life impacts