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# Engineering Materials

## Module 7: Toughness and Impact Test

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PREPARED BY

**IAT Curriculum Unit**

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# Module 7: Toughness and Impact Test

## Module Objectives

After the completion of this module, the student will be able to:

- Define toughness.
- Describe in simple words the ways in which toughness of materials are measured.
- Explain the main factors that affect the toughness of materials.
- Name different methods of evaluating the toughness of materials.
- Describe and explain the pendulum impact test.
- Describe the main parts of the BROOKS Pendulum Impact Tester (Model IT50).
- Carry out the impact (toughness) test on different materials according to a written procedure and analyze the tests results.

## Module Contents

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## Introduction

Toughness is an important mechanical property of materials considered by engineers when choosing a material for a specific design or application.

It describes the material's resistance to fracture and often expressed in terms of the amount of energy a material can absorb before fracture. Tough materials can absorb a considerable amount of energy before fracture while brittle materials absorb very little.

### 1. Toughness definition

Toughness is the property of a material that it does not break under a sudden shock.

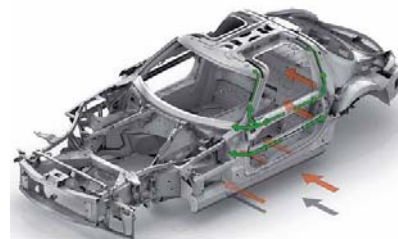
It is simply expressed as the ability of a material to withstand shock loading. Toughness property is required in many parts such as: car chassis, hammer head, connecting rod, and anvils to do the job they intended to do properly. Fig 7.1 shows some of the parts that need the toughness property.

### 2. Factors affecting toughness

1. **Temperature:** toughness decreases with decreasing temperature.
2. **Speed of loading:** toughness decreases as the rate of loading increases.
3. **Notch effect:** toughness decreases at the stress concentration points.



(a)



(b)



(c)

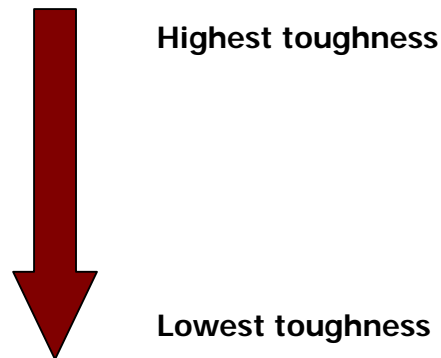


(d)

Fig.7.1: (a) Hammer. (b) Car chassis. (c) Anvil. (d) Connecting rod.

## 2.1 Examples of toughness of materials arranged in a descending order

1. Copper
2. Nickel
3. Iron
4. Aluminum
5. Lead
6. Tin
7. Cobalt



## 3. Toughness and Impact Tests

There are basically three types of impact tests for evaluating the toughness of materials:

- The Pendulum test.
- The Drop Weight test.
- The Instrumented test

In this module, we will only discuss the most commonly used impact which is the “**Pendulum Test**”.

### 3.1 How to compare toughness of different metals?

One way to compare toughness of different materials is by comparing the areas under the stress strain curves from the tensile tests of these materials as shown in Fig. 7.2. This value is simply called “material toughness” and it has units of energy per volume.

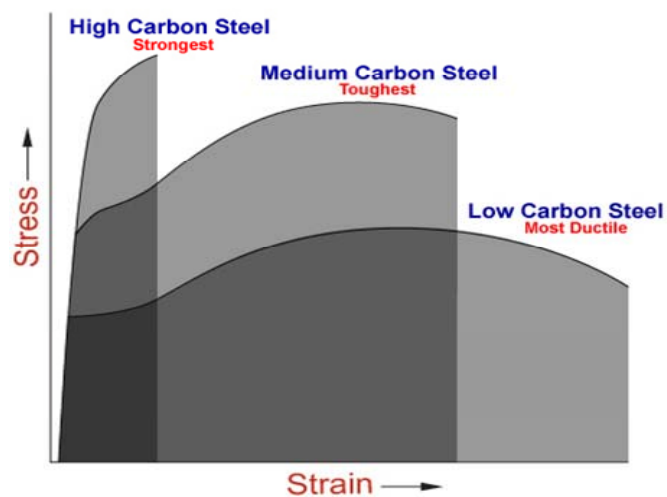


Fig. 7.2: The stress strain curve for different materials.

#### 4. The pendulum impact test

The pendulum impact test measures the kinetic energy absorbed by a material specimen of specific dimensions as it fractures by the impact of a known energy value of a special hammer mounted in a pendulum. See Fig.7.3.

The kinetic energy of the hammer at the time of impact equals to the potential energy of the hammer before its release.

The potential energy of the hammer (PE) can be calculated using the following formula:

$$PE = m \cdot g \cdot h$$

Where:

**PE** = the potential energy.

**m** = the mass of the hammer in Kilograms (Kg).

**g** = the gravity acceleration in m/s<sup>2</sup>.

**h** = the vertical height in meters (m).

The mass of the hammer and the height of fall ( $h_F$ ) determine the energy. In the elevated position, the pendulum possesses a definite potential energy which is converted to kinetic energy during its downward swing. The pendulum achieves maximum kinetic energy at the lowest swing position just before it strikes the specimen.

The impact energy absorbed by the specimen during rupture is measured as the difference between the height of the drop before fracture ( $h_F$ ) and the height of rise after fracture of the test specimen ( $h_R$ ) and is directly read on the dial scale which is calibrated to give the reading directly in joules.

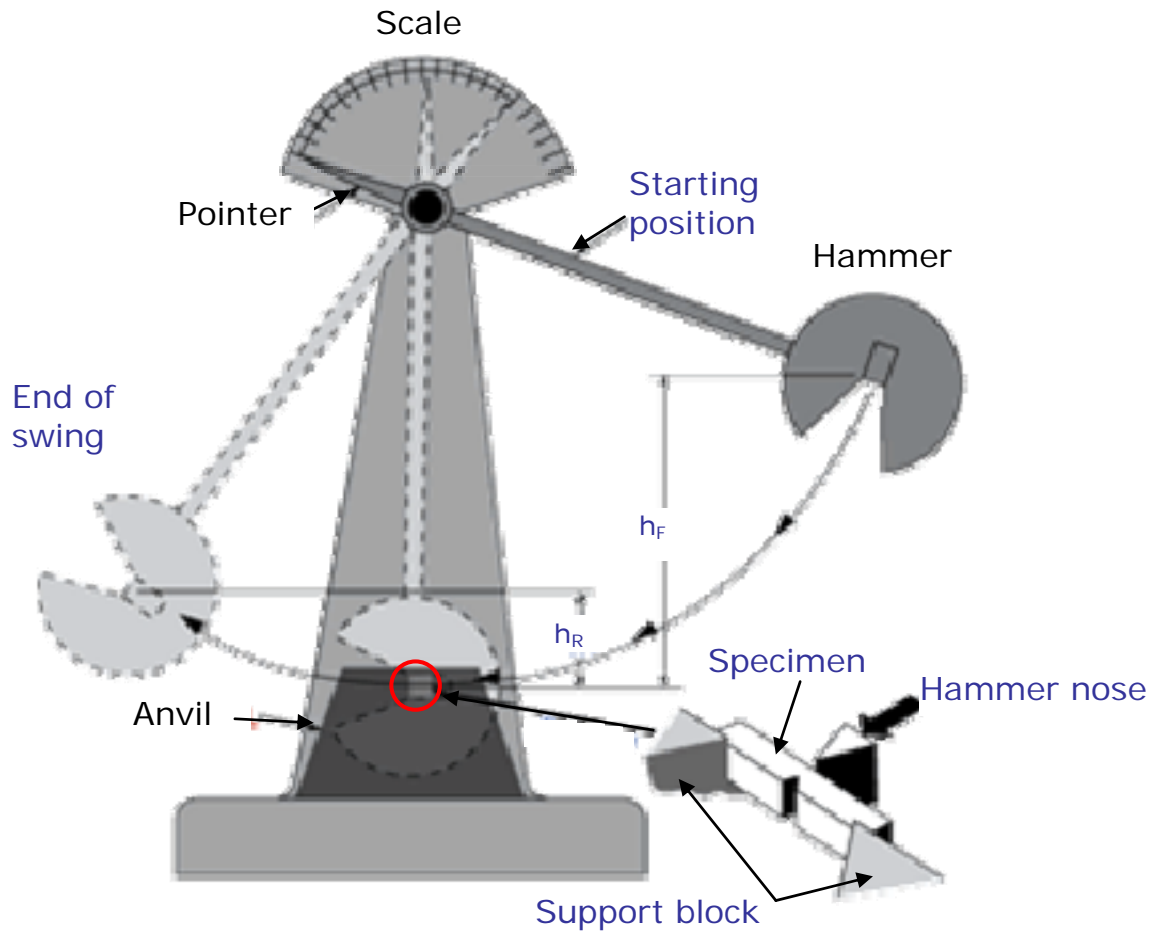


Fig.7.3 pendulum Impact test

#### 4.1. The BROOKS Pendulum Impact Tester (Model IT50)

The main parts of the BROOKS pendulum impact tester are shown in Fig. 7.4.

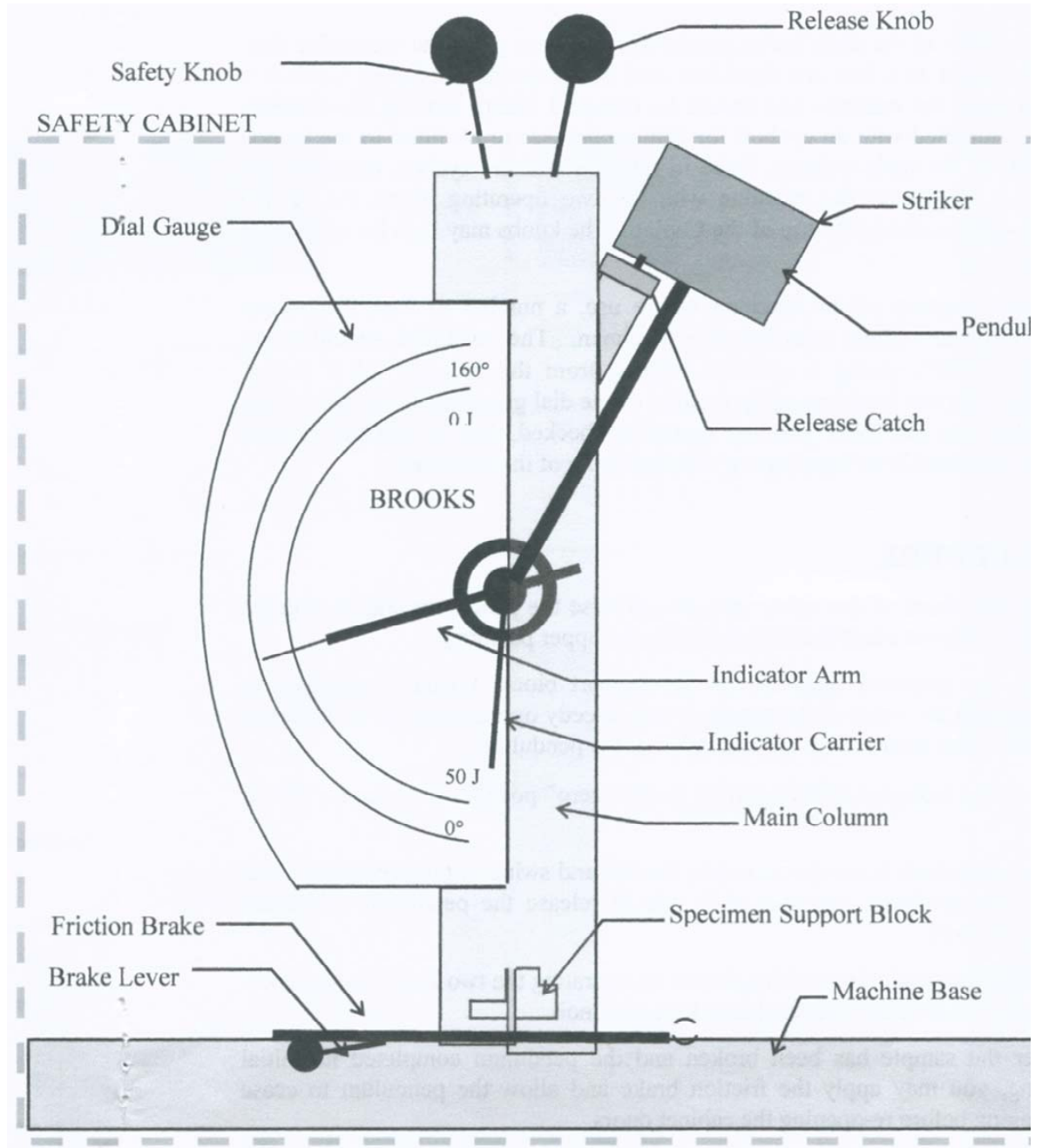


Fig. 7.4: shows the main parts of the BROOKS pendulum impact tester

#### 4.2. Test Specimen dimensions

The specimens used in this apparatus can be made of a low carbon steels as well as plastic materials and must be of the dimensions shown in Fig.7.5.

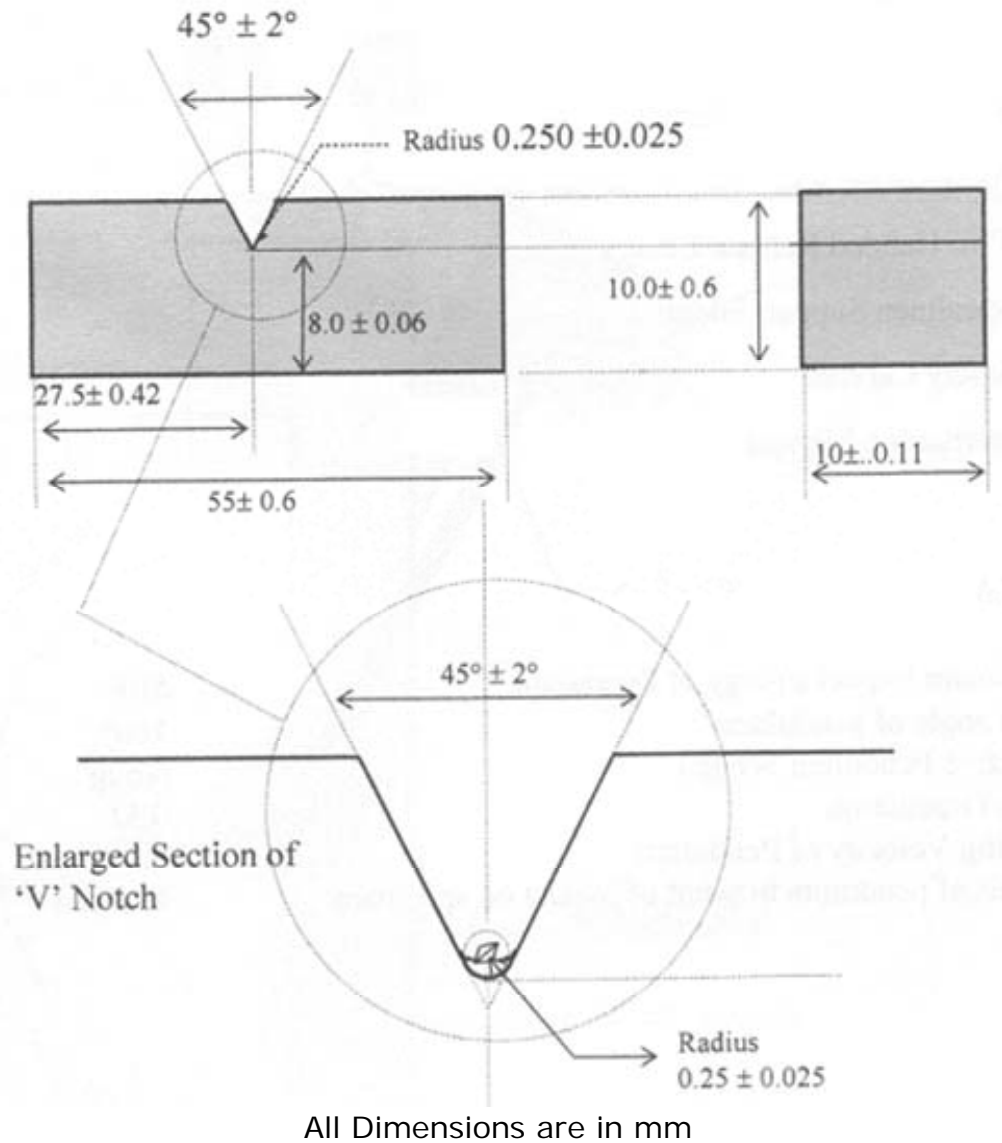


Fig. 7.5: The impact test specimen dimensions



**5.The impact test procedure:**

1. Open the safety cabinet and raise the pendulum till it engages with the release catch as shown in Fig.7.6.

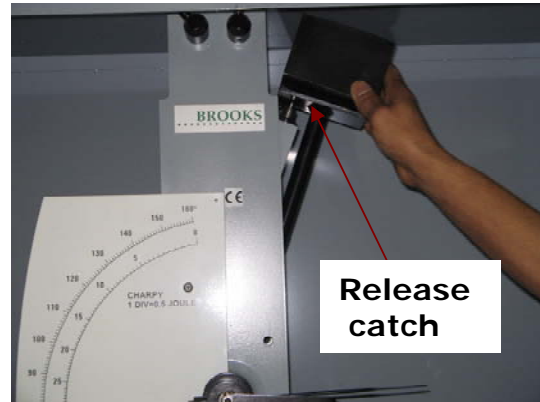
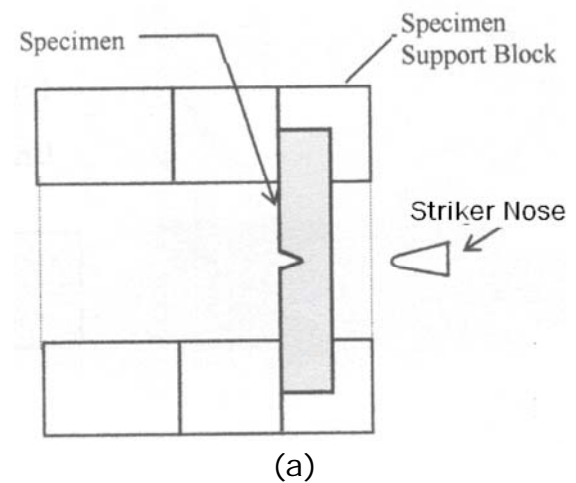


Fig. 7.6: engaging the pendulum with the release catch.

2. Place the prepared specimen on the support block and ensure that its notch is facing the opposite side of the hammer as shown in Fig.7.7a.

**N.B:** When inserting the test piece into the support, the pendulum must be supported by the safety support pin shown in Fig.7.7b.



(a)



(b)

Fig. 7.7: (a) specimen orientation on the support block.(b) Safety

- Adjust the indicator with its carrier to the “zero” position (set to zero or 50 joules) as shown in Fig.7.8.

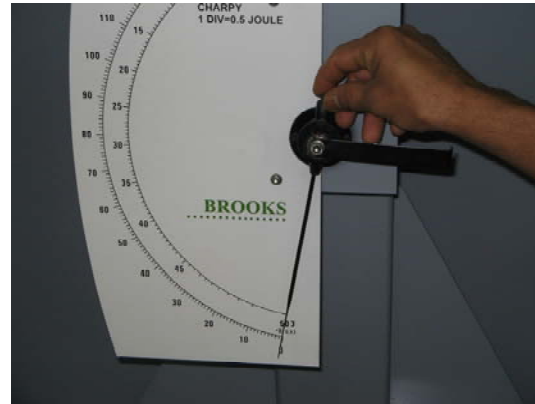


Fig.7.8: setting the indicator to zero.

- Check for safety fall and close the safety cabinet.  
N.B: When operating the equipment, the access door should be firmly closed and remains secured until the pendulum stop. See in Fig.7.9.



Fig.7.9: The access door is firmly closed.

- Release the pendulum latching device by operating the two knobs in sequence (safety knob first and then the release knob) as shown in Fig.7.10.



Fig.7.10: Starting the test.

- After the specimen breaks and the pendulum complete its initial swing, apply the friction brake to stop the pendulum and open the cabinet as shown in Fig.7.11.

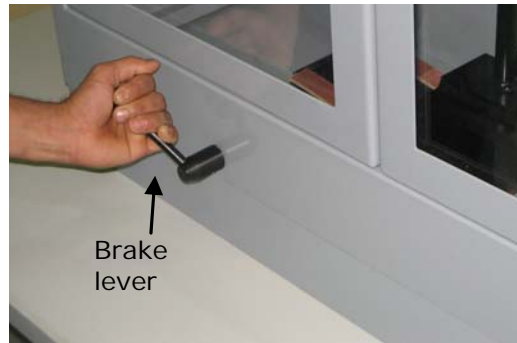


Fig.7.11: Using the brake lever to stop the pendulum.

- Read the energy absorbed by the broken specimen from the pointer on the dial See Fig.7.12.

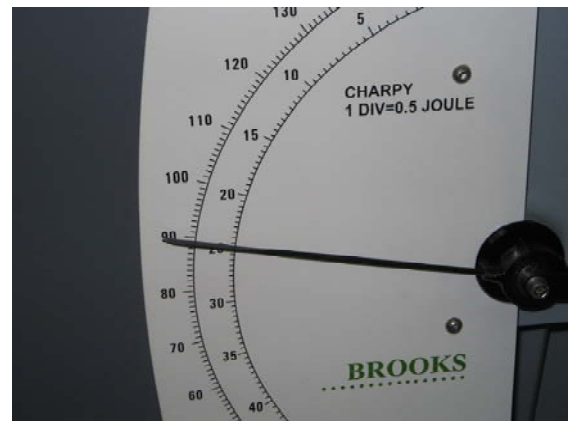


Fig.7.12: read the dial

**Activity:**

- Use the results of the four tested specimens (Aluminium, steel, copper, and brass) to fill in the following table:

Toughness order	Metal name	Fracture energy in Joules
1 <sup>st</sup> (toughest)		
2 <sup>nd</sup>		
3 <sup>rd</sup>		
4 <sup>th</sup> (least toughness)		

- Use the data obtained from the tensile tests performed in module 4 to compare the toughness of the above mentioned materials?

**For further reading, you can use the following links**

<http://www.ndt-ed.org/EducationResources/CommunityCollege/Materials/Mechanical/Toughness.htm>

**6 Supplementary recourses**

1. Mechanical and Non-destructive testing video.

**7 References**

1. The BROOKS Pendulum Impact Tester (Model IT50) instruction manual.
2. Modern engineering materials edition 1.
3. Engineering materials 1. "An introduction to Properties, Applications, and Design".
4. Different internet sites.

