FOUNDRY TECHNOLOGY II
Practical Manual

Class XII

CENTRAL BOARD OF SECONDARY EDUCATION
2, COMMUNITY CENTRE, PREET VIHAR, DELHI - 110092
## Contents

**Experiment: 1**

1.1 Visit to Foundry shop  

**Experiment: 2 Moulding practice in the Foundry**

2.1 Moulding Practice  
2.2 Inspection of Mould and Core  

**Experiment: 3 Melting Furnaces in the Foundry**

3.1 Furnace description – general  
3.2 Furnaces for production of castings – Report on  

**Experiment: 4 Laboratory Demonstration of Melting and Solidification**

4.1 Laboratory requirement  
4.2 Melting Procedure  
4.3 Melting of metals of low melting point  

**Experiment: 5 Mechanical Testing of Castings**

5.1 Hardness Testing  
5.2 Tensile Testing  
5.3 Impact Testing
PREFACE

The Indian Foundry (Metal Casting) Industry is 2nd largest globally. The industry growth in 2010-11 was more than 20% and employs approximately 500,000 people directly and another 1.5 Million indirectly.

Metal castings is the process of melting the metals of different specification and alloys and pouring in cavities (Moulds) to give desired shapes of the final component as per required application. These components are ready to use either as it is or after machining as the case may be. Castings are made in various metallurgies such as grey iron, ductile iron, steel, aluminium and its alloys, zinc, magnesium and copper alloys etc. and then heat treated and machined as required as per use and application of the component.

Government of India has ambitious plans to boost share of manufacturing in the GDP to 25% from present 15-16%, the industry is likely to be driven by huge demand from various industrial sectors which will create an additional demand for 200,000-250,000 skilled workforce in foundry industry at various levels in next five years. The foundry industry is facing acute shortage of skilled manpower and this shortage is likely to compound in next 5 years.

To address the problem of skilled manpower across various industrial sectors, CBSE has undertaken the ambitious project of introducing competency based Vocational Education in its affiliated schools. Taking cue from this need, a new course on Foundry Technology is being launched in cooperation with the Institute of Indian Foundrymen (IIF); that will help students to join the industry after Class XII or they can pursue higher education in this field.

The Board is grateful to the members of the Committee of Course for their advice, guidance and total commitment towards development of this course. We are indeed indebted to these academic advisors who have lent us the benefit of their rich and insightful experience. I would like to appreciate Vocational Education Cell, CBSE; for coordinating and successfully completing the work.

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Acknowledgements

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भारत का संविधान

उद्देश्य
हम, भारत के लोग, भारत को एक सम्पूर्ण 'प्रभुक्त-संपन' समाजवादी पंथनिरपेक्ष लोकतंत्रात्मक गणराज्य बनाने के लिए, तथा उसके समस्त नागरिकों को:

सामाजिक, आधिक और राजनीतिक न्याय,
विचार, अभिव्यक्ति, विश्वास, धर्म
और उपासना की स्वतंत्रता,
प्रतिष्ठा और अवसर की समता
प्राप्त कराने के लिए
tथा उन सब में व्यक्ति की गरिमा
'और राष्ट्र की एकता और अखंडता
सुनिश्चित करने वाली बंधुता बढ़ाने के लिए
दृढ़संकल्प होकर अपनी इस संविधान सभा में आज तारीख 26 नवंबर, 1949 को एतन्द्रश्च इस संविधान को अंगीकृत,
अधिनियमित और आयोजित करते हैं।

1. संविधान (ब्राह्मणयावसंख्य) अधिनियम, 1976 की भाषा 2 द्वारा (3.1.1977) से "प्रभुक्त-संपन लोकतंत्रावस्था गणराज्य" के लिए अपनाया गया
2. संविधान (ब्राह्मणयावसंख्य) अधिनियम, 1976 की भाषा 2 द्वारा (3.1.1977) से "राष्ट्र की एकता" के लिए अपनाया गया

भाग 4 क
मूल कर्त्तव्य

51 क. मूल कर्त्तव्य – भारत के प्रत्येक नागरिक का यह कर्त्तव्य होगा कि वह –

(क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राज्यध्वज और राष्ट्रगान का आदर करे;
(ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रतिष्ठा करने वाले उज्जवल आदर्शों को हृदय में संजोए रखें और उनका पालन करें;
(ग) भारत की प्रभुता, एकता और अखंडता की रक्षा करें और उसे अनुशंसा रखें;
(घ) देश की रक्षा करे और आह्वान किए जाने पर राष्ट्र की सेवा करें;
(ड) भारत के सभी लोगों में समानता और समान प्रतिभा की भावना का निर्माण करे जो धर्म, भाषा और प्रदेश या वर्ष पर आधारित सभी
भेदभाव से परे हों, ऐसी प्रथाओं का त्याग करे जो रित्यों के समान न विराज हैं;
(ढ) हमारी सामाजिक संस्कृति की गौरवशाली परंपरा का महत्त्व समझें और उसका परिश्रम करें;
(ज) प्राकृतिक परवरण की विज्ञान के अंतर्गत वन बीजल, तत्वी और वन्य जीव रखें, रक्षा करें और उसका संरक्षण करें तथा प्राणीमात्र के प्रति
दयाभाव रखें;
(झ) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करें;
(ञ) सामाजिक संपति की सुरक्षित रहे और हिंसा से दूर रहें;
(ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कृष्ट की और बढ़ाने का सत्ता प्रयास करें जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत
और उपलब्धि की नई उच्चायर्थों को हृदय ले;
(ट) यदि मानव-पीपल या रज्जस्तः है, छह वर्ष से चौदह वर्ष तक की आयु बाले अपने, यथास्थिति, बालक या प्रतिपाल्य के लिये शिक्षा के
अवसर प्रदान करें।

1. संविधान (ब्राह्मणयावसंख्य) अधिनियम, 2002 द्वारा अपनाया गया।
THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC and to secure to all its citizens:

- JUSTICE, social, economic and political;
- LIBERTY of thought, expression, belief, faith and worship;
- EQUALITY of status and of opportunity; and to promote among them all
- FRATERNITY assuring the dignity of the individual and the unity and integrity of the Nation;

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.

ARTICLE 51A

FUNDAMENTAL DUTIES

Fundamental Duties - It shall be the duty of every citizen of India-

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;
(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;
(c) to uphold and protect the sovereignty, unity and integrity of India;
(d) to defend the country and render national service when called upon to do so;
(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;
(f) to value and preserve the rich heritage of our composite culture;
(g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;
(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;
(i) to safeguard public property and to abjure violence;
(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement;
(k) to provide opportunities for education to his/her child or, as the case may be, ward between age of 6 and 14 years.

1. Subs. by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "unity of the Nation" (w.e.f. 3.1.1977)
# MODULE OBJECTIVES

<table>
<thead>
<tr>
<th>Exp No.</th>
<th>Experiment Name</th>
<th>Practical</th>
<th>Key Learning Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Visit to Foundry shop</td>
<td>18 Periods</td>
<td>• Understand the layout of foundry&lt;br&gt;• Identification of major machines and equipments used in foundry&lt;br&gt;• Raw materials used in the foundry&lt;br&gt;• Understand the concept of major industrial activities in the foundry&lt;br&gt;• Identification of the various casting defects</td>
</tr>
<tr>
<td>2</td>
<td>Moulding practice in the Foundry</td>
<td>12 Periods</td>
<td>• Understand the different proportions of mould ingredients&lt;br&gt;• Preparation of sand systems.&lt;br&gt;• Selection of parting line.&lt;br&gt;• Placement of pattern&lt;br&gt;• Ramming of sand around pattern.&lt;br&gt;• Preparation of mould&lt;br&gt;• Visual inspection of mould&lt;br&gt;• Hardness of mould at different locations&lt;br&gt;• Closing of mould.</td>
</tr>
<tr>
<td>3</td>
<td>Melting Furnaces in the Foundry</td>
<td>10 Periods</td>
<td>• Different kind of furnaces used in the foundry&lt;br&gt;• Fuels requirement for different kind of furnace&lt;br&gt;• Operation of different kind of furnace&lt;br&gt;• Application of each furnace&lt;br&gt;• Safety measure during operation of furnace.&lt;br&gt;• Construction of furnace</td>
</tr>
<tr>
<td>4</td>
<td>Laboratory Demonstration of Melting and Solidification</td>
<td>10 Periods</td>
<td>• Melting procedures&lt;br&gt;• Cooling of molten material&lt;br&gt;• Selection of melting furnace&lt;br&gt;• Heating rate</td>
</tr>
<tr>
<td>5</td>
<td>Mechanical Testing of Castings</td>
<td>10 Periods</td>
<td>• Preparation of test samples from the castings&lt;br&gt;• Dimension of the test specimen&lt;br&gt;• Operation of mechanical testing equipment&lt;br&gt;• Data collection during testing&lt;br&gt;• Observation and analysis of data</td>
</tr>
</tbody>
</table>
# Learning Plan

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Aim</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experiment 1</strong></td>
<td>Visit to a foundry, layout of foundry shop, report on casting quality control and diagnosis of defects in castings components</td>
<td>Literatures, industry profile, Inspection report</td>
</tr>
<tr>
<td><strong>Experiment 2</strong></td>
<td>Preparation of sand moulds using a simple pattern, selection of parting line, location of sprue, runner, ingates &amp; risers. Inspection of finished mould, determination of mould hardness</td>
<td>Simple pattern, mould making tools and accessories, Mould hardness tester</td>
</tr>
<tr>
<td><strong>Experiment 3</strong></td>
<td>Preparation of schematic sketch of cupola. Sketch of open hearth furnace, crucible furnace, Electric Arc Furnace and Induction furnace. Report on shop floor tests of liquid metal</td>
<td>Schematic diagram of cupola furnace, open hearth furnace, crucible furnace, Electric Arc Furnace and Induction furnace. Quality control reports, Charge sheets</td>
</tr>
<tr>
<td><strong>Experiment 4</strong></td>
<td>Melting of wax, melting point of metal like Pb, Sn and Al in a crucible, pouring in a sand and metal mould and observation of features of the cast item</td>
<td>Crucible furnace, Charge materials, Pyrometer, Spectrovac meter</td>
</tr>
</tbody>
</table>
EXPERIMENT: 1

VISIT TO A FOUNDRY SHOP

Introduction:

Objective: Each student should make a Report on the visit to the foundry. The date of visit and the name of foundry should be mentioned clearly on the first page.

Resource Material:

1. Principles of Foundry Technology By P. L. Jain
2. http://www.youtube.com/watch?v=4t2ddeJECZ8

Delivery schedule: 18 periods

Student expectations/learning objective:

• Understand the layout of foundry
• List major machines and equipments used in foundry
• Identify raw materials used in the foundry
• Demonstrate major industrial activities in the foundry.
• Identify various casting defects

Pre-learning required: Safety measures of foundry

Handouts/material required/equipments & tools:

Paper sheet and pencil

Procedure/methodology:

The student should observe and report the following;
1.1 Part A

1. The main products of the foundry, the metal or alloy used such as Grey iron foundry, steel foundry, non-ferrous metal foundry etc; weight of the largest casting produced

2. The Layout sketch of the foundry: Layout drawing shows in plan view (i) the enclosed area of the factory (ii) demarcation of its different sections and (iii) the arrangements of machines in the foundry workplace. A layout sketch shows the outline of the foundry shop and the location of pattern shop, raw material storage area, moulding area, melting area, pouring and knock-out (fettling) area shown as various segments within the boundary. Location of major equipment also should be indicated in the layout drawing.

3. The melting furnace and its source of heat – i) solid (coke), ii) liquid fuel plus combustion air (with or without additional oxygen) or hydro-carbon gas with air; or iii) electricity – resistance type (usually for small furnaces) or electric arc (direct or indirect).

4. Other major equipment in the foundry and their functions.

5. Pollution control devices / equipment if any

Part B:

Raw materials; Pattern shop, Moulding and Core making sections

The following information is to be reported:

B 1. The raw materials required in the foundry:
   i. Fresh sand (purchased), if any; quantity per tonne of casting
   ii. Return sand or recycled sand quantity per tonne of casting
   iii. Binders used; bentonite for example; or organic binders
   iv. Other additives, paints etc for mould and core making
   v. Refractory materials for furnace lining and repairing

B 2. Testing of raw materials, moulding sand and core sand conducted at the foundry – The student should report the names of the tests and their purpose.

Part C:

Casting Quality control - diagnosis of casting defects and remedial measures

Observation of casting defects

The student shall observe and report:

i. How the castings are inspected – visually, or with non-destructive test methods

ii. How the defects in the finished castings are detected - visually, or with non-destructive test methods
iii. The name of the defect by asking the shop floor supervisor  
iv. Possible reason for its occurrence  
v. Whether any testing (tensile, hardness, etc.) are carried out  
vi. The student should describe the appearance of the defect and its location

1.2 Classification of casting defects:
There are many ways the defects can be classified. Generally, simple ways to classify the common defects are as follows:

a) Based on Location:
   • External  
   • Internal

b) Based on Cause:
   • Raw materials  
   • Product design  
   • Process parameters  
   • Process control

c) Based on Process:
   • Moulding-related  
   • Filling-related  
   • Solidification-related

1.3 Casting defects:
(i) Sand fusion or burn: Too high pouring temperature can cause local ‘sand fusion’, particularly if the metal contains oxide impurities. The factors responsible are excessive melt temperature and impurity in the sand and slag and other oxides the melt

(ii) Mismatch: It is very gross defect and easy to detect, since the casting shape is distorted due to poor matching of the mould cavity in cope and drag. It is a moulding /assembly defect.

Fig.1.1 Casting defects – burn and mismatch
(iii) **Cold lap or Cold shut:** It appears as crack with round edges, bordering a shiny area. Cold lap arise when the metal fails to flow freely over the mould surface, mainly due to low temperature of the melt and thus low fluidity. Cold shut is more or less the same defect, but the lines of discontinuity run deeper in the casting where different streams of melt solidify without completely coalescing. This is also due to low flow rate of the melt which was poured at temperature much lower than what was required.

![Cold lap and Cold shut](image1)

![Flash/Fin](image2)

**Fig.1.2. Casting defects: Cold shut and Flash**

(iv) **Flash or Fins:** Extra metal as irregular-shaped thin sheet of cast metal usually at the parting plane. This is common for both sand mould and in die casting, where two mould halves are used. If the two halves are not closed tightly with clamps on mould box plus weights on top of the boxes for sand casting, molten metal can find its way through any gap between the mould halves as spillage. This spilled metal solidifies as fin or flash.

Some defects, such as flash and mismatch are caused due to fault in assembly of the cope and drag. Presence of gas during the last stage of solidification causes defects on the surface or just below it, which can be seen after machining. If the mould is too dry or too weak, loose sand from the mould wall can stick to the casting and cause sand inclusion or sand fusion defects.

(v) **Crack or Hot tear:** Cracks can firm in a casting during solidification. As a melt gradually solidifies in a mould, starting from the mould wall; volume contraction takes place for almost all metals – except Grey cast iron. Now, if the mould geometry is complicated, or such that there is some hindrance in contraction, the stress can cause a crack in the thin section of the metal already solidified.

Usually such cracks tend to appear in areas of the mould which freezes last, or in other words, the areas which remain hot till the last stage. These cracks are called ‘Hot tear. Alloys that freeze over a long temperature range, sharp corners or bends which causes strain in the freezing of a layer of solidified metal; too strong a core around which metal is freezing – these are the common factors. Such defects are typical in cast steels and aluminium alloys.
(vi) **Gas Defects:** Porosity, Pin hole defects – on the surface or just beneath the surface

Gases are generated from the mould additives, mould or core paint, from moisture or from fuels burnt during melting. They dissolve more at higher melt temperature and dissolved gases try to escape from the melt during solidification. If gas concentration in the melt is too high or freezing is too rapid or permeability of the mould is not adequate, some volume of gas remains in the form of porosity, or round blow holes till solidification is complete. Such gas defects, particularly in non-ferrous alloys, are observed only after machining. So, these are costly defects since machining cost is included. A special case is the presence of Pin-hole defects. As the name suggests, very small holes can appear after light machining or grinding the surface. This is a typical defect due to dissolved hydrogen gas. This defect is more common in copper and aluminium alloys and alloy steels, which can absorb hydrogen gas from many sources.

**Fig.1.3. Casting defects: Crack and Hot tear**

**Fig.1.4. Gas defects in castings**
Fig. 1.5. Shrinkage and porosity defects

(vii) Shrinkage: Since solidification shrinkage is common to all metallic melts, adequate feeding by 'risers' or 'feeders' are essential. In spite of the knowledge, shrinkage defects still appear in castings, usually below the riser, or at heavy section areas.

(viii) Inclusions and sand defects: Non-metallic inclusions are non-metallic impurities present in the melt, which were trapped by the solidifying metal.

Fig. 1.6. Sand inclusions and hot tear defects

Assessment:
1. List out the name of equipment and tools used in the visited foundry.
2. Draw the layout of that foundry.
3. Make the chart of raw materials used in foundry.
4. List the type of binders used in foundry?
5. List out the types of materials being cast in that foundry.
6. Student can draw different layout individually and discuss the advantages and disadvantages with others layout.

Individual assessment

We recognize that students have different learning styles and needs. The following will help students to assess their progress.
## Self-Assessment/ Learning Plan

<table>
<thead>
<tr>
<th>Learning objective</th>
<th>Outcome</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety measures of the foundry</td>
<td>To understand the safety norms</td>
<td></td>
</tr>
<tr>
<td>Foundry Lay out</td>
<td>To know how to design a foundry shop</td>
<td></td>
</tr>
<tr>
<td>Foundry process</td>
<td>Knowledge of casting process</td>
<td></td>
</tr>
<tr>
<td>Foundry tools</td>
<td>Use of those foundry tools</td>
<td></td>
</tr>
<tr>
<td>Equipments</td>
<td>Operation and Use of equipment</td>
<td></td>
</tr>
<tr>
<td>Casting Defects</td>
<td>Must understand causes and remedies of defects in casting</td>
<td></td>
</tr>
<tr>
<td>Raw materials used</td>
<td>Must know proportion and composition of raw materials</td>
<td></td>
</tr>
</tbody>
</table>
EXPERIMENT: 2

MOULDING PRACTICE IN THE FOUNDRY

Introduction:

Objective: To learn how to make sand mix and sand mould and the inspection of prepared sand mould.

Resource Material:

1. Principles of Foundry Technology By P. L. Jain
2. http://www.youtube.com/watch?v=4t2ddeJECZ8

Delivery schedule: 12 periods

Student expectations/learning objective:

- List different proportions of mould ingredients
- Demonstrate preparation of sand systems.
- Identify parting line.
- Demonstrate placement of pattern
- Understand ramming of sand around pattern.
- Demonstrate preparation of mould
- Identify visual inspection of mould
- Understand hardness of mould at different locations
- Demonstrate closing of mould.

Pre-learning required:

Theoretical knowledge of sand systems, must have knowledge of moulding tools, preparation of sand mix, moulding procedure and finished mould inspection.
Handouts/material required/equipments & tools:
Moulding tools, parting material, pattern, mould hardness tester

Procedure/methodology:
The student should observe and report the following;

2.1 Moulding practice:

- **Observe the pattern:** Is it symmetrical about a plane or line? If so, that plane can be a parting plane. Observe the actual practice on the shop floor for a given pattern to justify the selection of parting line. Remember that the more critical parts are to be located in the drag. Make a drawing of a simple pattern and select, giving a proper logic, the parting line.

- **Making a mould:** In the Report, List the (a) equipment used – hand moulding, pneumatic rammer or machine moulding (b) the materials required for making the moulding sand and their proportions. Report the steps in making a mould.

- **Adding the Feeding system in the mould:** The feeding system consists of the sprue, the runner and ingates and the risers. In match plate pattern or cope-and-drag pattern, the riser and gates are already attached with the pattern. There is logic in selecting the locations of the (i) Sprue – through which liquid metal enters the mould, (ii) the runner and gates. Runner, is cut in the mould, usually along the parting plane between cope and drag in such a way that the liquid metal is distributed evenly throughout the mould. The Riser(s) or the ‘feeders’ which act as reservoir of liquid metal to compensate for the shrinkage during solidification. Ingates and feeders are placed on or near such heavy sections. The Report should indicate a view of the location of the riser, runner and the ingates.

- Large castings or castings with complex shape require additional arrangements to increase the feeding distance of the riser (feeder), using ‘chill’. A ‘Chill’ is a metal block set in a mould at a location in between risers or at a junction between thin and thick sections. Report whether chills are used.

- **Mould hardness measurement:** Hardness of the mould is measured as a quick check of mould strength. A small hand held dial gauge with a spring-loaded ball at the bottom is used to measure hardness around the mould cavity. The scale on the dial is up to 100 on an arbitrary scale. The scale has no unit. Draw a sketch of the Mould hardness tester and report typical values measured on an actual mould.

<table>
<thead>
<tr>
<th>Location of hardness measurement</th>
<th>Hardness</th>
<th>Comments (whether adequate or not)</th>
</tr>
</thead>
<tbody>
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</table>

- **Mould finishing:** Report the finishing step. Usually, the mould and core are
given a coating to obtain good surface finish. The assembly step of cope and drag parts of the mould are important.

### 2.2 Inspection of mould and Core

The following points are to be noted and reported:

- For a mould with ‘core’, note how moulder, makes sure that the core is set properly. Chaplets, which are metal pieces with a stud joining flat pieces, are used to hold the core in position.

- Whether a ‘Chill’ is used to cause rapid cooling locally, so that thick sections can solidify rapidly so that the riser can feed the mould completely.

- Loose sand or dirt falling inside mould can end up as mould defect. Thorough inspection and necessary cleaning is done, either by low pressure compressed air, or bellows, just before closing the mould – i.e. putting the cope over the drag after proper alignment.

- How the cope and drag, after setting are clamped to hold tight and in addition, if there is the practice of putting weight on the mould box so that the buoyancy of the liquid metal does not shift the cope.

- Report what mould and core coating is used – whether branded (ready-made), or made in the foundry itself

- Report how venting is done and write on purpose of venting

---

**Assessment:**

1) Name of the casting (job); make a sketch.

2) Casting weight.

3) Remarks on the design or shape of the casting – simple, or complex, whether consists of thin and thick sections;

4) Metal to be cast, grade, composition and other specifications

5) Description of the pattern: type - single piece, split pattern, match plate pattern, etc; with comments on the parting line

6) Whether core is used: if yes, type of core, weight, vertical or horizontal, maximum length, length of each core print.

7) Type of mould - green sand or dry sand or skin-dried

8) What coating is used on mould and core surface and what is the drying procedure?

9) Is there any difference between the moulding practice of a large mould and a small mould? If so, state the reason.

---

**Individual assessment**

We recognise that students have different learning styles and needs. The following will help students to assess their progress
## Self-Assessment/ Learning Plan

<table>
<thead>
<tr>
<th>Learning objective</th>
<th>Outcome</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mould materials</td>
<td>Knowledge of mould materials</td>
<td></td>
</tr>
<tr>
<td>Application of tools</td>
<td>Uses of tools</td>
<td></td>
</tr>
<tr>
<td>Moulding process</td>
<td>Different moulding methods</td>
<td></td>
</tr>
<tr>
<td>Sand system</td>
<td>Different types of sand mix</td>
<td></td>
</tr>
<tr>
<td>Preparation of sand mix</td>
<td>Use of sand mixer and muller</td>
<td></td>
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<tr>
<td>Mould making</td>
<td>Steps involved in mould making</td>
<td></td>
</tr>
<tr>
<td>Mould inspection</td>
<td>Steps involved in mould making</td>
<td></td>
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<td></td>
<td>Soundness of mould</td>
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</tbody>
</table>
EXPERIMENT: 3

MELTING FURNACES IN THE FOUNDRY

Introduction:

Objective: To know use and operations of melting furnaces in the foundry.

Resource Material:

1. Principles of Foundry Technology By P. L. Jain
2. http://www.youtube.com/watch?v=4t2ddeJECZ8

Delivery schedule: 10 periods

Student expectations/learning objective:

• Identify different kind of furnaces used in the foundry
• List fuel requirement for different kind of furnace
• Understand operation of different kind of furnace
• Demonstrate application of each furnace
• List safety measure during operation of furnace.
• Understand construction of furnace

Pre-learning required:

Concept of different melting furnace used in foundry.

Handouts/material required/equipments & tools:

stationary items like paper and pencils

Procedure/methodology:

The student should observe and report the following;
Proper precautions have to be taken when visiting the melting section of the foundry.
3.1 Furnace description - general

The Report should cover the following points:

1. Detailed layout sketch of the melting section, showing the storage area for raw materials - scrap, other metallic feed material, flux etc. Position of the furnace proper and flow of the melt etc should be marked.

2. Furnace design: Describe the furnace mentioning the following points: (i) Type of the furnace and its heat source and its melting capacity (ii) schematic sketch of the furnace and sectional drawing (iii) the materials charged – name and amount charged per tonne of melt (iv) Furnace refractory lining used - acid lining (silica, fireclay) or basic lining (alumino-silicate, magnesite, chrome-magnesite, heavy duty high-alumina etc). Note the type of pouring ladle used and its capacity and give a sketch.

3. Furnace operation:
   i) Describe the preparation before beginning of charging
   ii) Describe the charging sequence, with details – initially heavy scrap or light scrap, or pigs; average size of the flux, fuel- coke size and proportion in case of cupola etc
   iii) The reactions
   iv) Chemical analysis of the melt and the slag
   v) How much slag is produced per tonne of metal and how it is disposed off
   vi) What happens to the gas generated
   vii) How the melt is tapped – ladle description and capacity, whether any holding ladle is used etc.
   viii) Whether de-oxidisers are used – ferro-silicon, ferro-manganese or aluminium (to reduce the oxygen level

4. Treatment of the melt after tapping – slag removal, removal of dissolved gas, addition of
   i) Inoculants for cast irons ii) grain refiners for non-ferrous alloys

5. Report how the ladle after pouring is cleaned and made ready for the next tapping.

6. Type of refractory is used for furnace lining and comparison of Refractories.

7. What are factors to be considered while selecting a furnace for the purpose of melting metal?

3.2 Furnaces for production of castings – Report on:

a) Cupola - for Grey cast iron
b) Crucible furnace - for non-ferrous alloys
c) Open hearth furnace - for cast iron, steel castings
d) Electric Arc Furnace - for steel castings, including alloy steels
e) Induction furnace - for non-ferrous alloys, ductile iron, and alloy cast iron

3.2.1 Sketch and description of the melting furnaces

The Report should include detailed description with schematic drawing of all the three types of furnaces.

The Report shall consist of:
a) A neat labeled sketch of the furnaces not actually seen, preferably a sectional view
b) Describe the dust removal devices and pollution control system
c) For induction furnace – indicate the frequency range
d) % loss or gain of elements such as silicon, carbon, manganese etc in cupola melting; % metal loss in slag in EAF

3.2.2 For Grey iron foundry with cupola, Report the following

<table>
<thead>
<tr>
<th>Cupola capacity, t/hr</th>
<th>No. of tuyeres</th>
<th>Coke bed height (=height of coke above the tuyeres)</th>
<th>Coke : Pig ratio (Kg coke /t melt)</th>
<th>% ash in coke, average</th>
<th>Slag rate, kg slag / t of metal</th>
</tr>
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<tbody>
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</table>

3.2.3 Cupola calculations:

i) Coke-bed charge calculation -

Example 1: i) Cupola diameter (D) = 75 cm; Height of groove above the sand bottom = h = 150 cm. Find the weight of the bed charge if the coke weighs 482 kg per m³.

Solution:

Weight of the bed charge, \( W \) = cross section area \( \left( \pi d^2 /4 \right) \times \) height of coke bed \( (h) \), \( x \) weight of Coke per cubic meter

All the units of length have to be converted to meter. \( d = (75/100) \) meter, \( h = (150/100) \) meter

Hence, Volume of coke bed = \( \left[ \pi d^2 /4 \right] \times \) height = 3.14/4 \( \times (75/100)^2 \) \( \times (150/100) \) m³ = 0.66 m³

Weight of coke bed charge = volume \( \times \) bulk density = 0.66 \( \times 482 \) kg = 320 kg

Example 2: A Cupola 110 cm in diameter (D) has a melting ratio 7:1. How much iron is melted per hour? How much coke is consumed per hour? Assume melting rate of 0.5 kg/hr/cm².
**Solution**

(a) Iron melted per hour; = cross section area \((\pi D^2/4)\) x melting rate

Given: cupola diameter \(D = 1100\) cm, Cross section area = \(\pi/4 \times (110)^2\) cm\(^2\)

(a) Iron melted per hour = \(0.5 \times 9498.5 = 4750\) kg/hr = 4.75 tonne per hour ...........

Answer

(b) Coke consumed per hour = \(4750/7\) (melting ratio 7:1) = 678 kg/hr ..........

Answer

**Assessment**

1) How the composition of the melt is analysed – If analytical equipment is used, then name of the instrument

2) Describe any shop floor test for quick estimation of quality – for example, wedge chill test for ascertaining proper carbon equivalent or graphitization for cast irons in thin sections; fluidity spiral test to have a qualitative assessment of fluidity, test to determine gas content by solidifying the melt in a cylindrical container and observing the surface - whether it swells like a cauliflower showing gas evolution, or whether the surface is flat, or has a shallow depression due to shrinkage.

3) Whether the test bar for mechanical tests and chemical analysis is cast separately or is an integral part of the casting.

**Individual assessment**

We recognise that students have different learning styles and needs. The following will help students to assess their progress

**Self-Assessment/Learning Plan**

<table>
<thead>
<tr>
<th>Learning objective</th>
<th>Outcome</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting furnaces</td>
<td>Understanding of different kind of melting furnaces</td>
<td></td>
</tr>
<tr>
<td>Charge materials of melting furnaces</td>
<td>Understanding of charge materials for different kind of furnaces</td>
<td></td>
</tr>
<tr>
<td>Construction of melting furnaces</td>
<td>Design of furnace</td>
<td></td>
</tr>
<tr>
<td>Operation of melting furnaces</td>
<td>Working procedures of furnaces</td>
<td></td>
</tr>
</tbody>
</table>
EXPERIMENT: 4

LABORATORY DEMONSTRATION OF MELTING AND SOLIDIFICATION

Introduction:

Objective: to learn melting and solidification practice of low temperature melting point materials.

Resource Material:

1. Principles of Foundry Technology By P. L. Jain
2. http://www.youtube.com/watch?v=4t2ddeJECZ8

Delivery schedule: 10 periods

Student expectations/learning objective:

- Identify melting procedures
- Demonstrate cooling of molten material
- Categorize selection of melting furnace
- Identify heating rate

Pre-learning required:

Melting point of that particular material, furnace operation, selection of melting furnace

Handouts/material required/equipment’s & tools:

Melting furnace, charge materials, ladle, temperature measurement equipment

Procedure/methodology:

The student should observe and report the following;
It may be possible in a school to demonstrate the melting and solidification of a few low-melting materials so that the students can be familiar with molten material in a small scale, without the hazardous environment of the shop floor of a running foundry.

By allowing different melts to solidify, the teacher can show:

• A simple design of a furnace – the minimum requirements of which are (i) source of heat – ‘heating element’ of resistance type in the form of wire, like that of domestic heater coil, (ii) a chamber with suitable lining that the heat cannot escape, (iii) electrical connections and (iv) some form of temperature measurement – which is a thermocouple in this case. The student should be familiar with the principle of thermocouple, based on ‘thermo-electric effects’, i.e. Seebeck effect, Peltier effect and Thompson effect

• That different metals and alloys show different amounts of solidification shrinkage.

• For the same material, the effect of variation of geometry also can be observed – for example, moulds with circular cross section and rectangular cross section

• That there can be wide difference in solidification time when the same material is cast in a sand mould or in a metal mould.

• If there is a hardness tester, then the hardness variation of the surface between sand cast and metal-mould cast specimen can be shown.

4.1 Laboratory requirement:

i. One cylindrical pot furnace, with ‘kanthal’ wire (a heating element iron-chromium-aluminium alloy, which resists oxidation and possess high electrical resistance) and winding – 300 mm depth, connected to a 15 A line with a safely fuse.

ii. Several crucibles, mage of graphite or clay-graphite – about 250 cm3 volume

iii. Steel tongs for holding the crucible – at least 2 nos,

iv. safety gloves

v. Weighing balance, max. weight 500 gm.

vi. Glass ware – i) Borosil glass beaker , 250 ml  ii) Borosil test tubes  iii) Borosil measuring cylinder – 100 ml, 200 ml

vii. Temperature indicator- cum-controller and ‘chromel – alumel’ thermocouple, 450 mm long. (Chromel = Ni 90 %, Cr 10 %; Alumel = Ni 98%, Al 2%)

viii. Moulds:

   a. Cast iron moulds – split type with dowel pins for matching the halves.

      i) Circular cross section mould with 30 mm inside diameter, 10 mm wall thickness, 150 mm height

      ii) Rectangular cross section mould with the same cross section area as circular mould:
b. 30 mm x 24 mm internal dimensions, 10 mm wall thickness

ix. Commercial grade – lead, zinc granules, pieces of aluminium sheet; commercial candle, wax or paraffin wax – 500 gm

x. Any gas burner, portable type; holding tongs etc

4.2 Melting Procedure

4.2.1 Melting wax and solidification shrinkage

1.1 Take some paraffin wax in granular form and fill up the test tube to about 3/4th its height.

1.2 Hold over the flame of the burner – the wax should melt quickly. Taking care not to burn your finger, mark the level of molten wax on the test tube with a marker pen

1.3 Put off the burner, allow the test tube to cool in air

1.4 Observe the profile of the solidified paraffin in the test tube. It should show a V-shaped depression. Mark the tip of the depression.

1.5 Measure and report the difference. Observe whether there are small bubbles or voids below the V-shaped depression.

4.2.2 Measuring the depth of shrinkage in measuring cylinder (dried)

• The same experiment can be repeated, by packing full the test tube with wax and melting

• Pour the melt carefully in the measuring cylinder, 100 ml and note the reading of level of the molten wax (say 56 ml).

• Report the profile after solidification of the wax and record the reading of the lowest point of the V-shaped depression. The difference with the previous reading gives the depth.

4.3 Melting of metals of low melting point:

Lead, zinc, aluminium are metals with relatively low melting point. They can be melted easily in clay graphite crucible in a resistance-heated furnace. For this, the student should report first the melting point and density of the metal to be melted.

i. The teacher of laboratory personnel should first set the furnace at a temperature about 150°C above the theoretical melting point of the metal.

ii. Weigh the metal pieces up to first decimal (say 114.6 gm) and press into the clay graphite crucible. Place the crucible inside the furnace.

iii. Attach the thermocouple to the temperature controller and put one end inside the furnace, close to, but not touching the top of the crucible. Close the lid of the furnace.
iv. Start the furnace, with current setting 7-8 A.

v. Clean one mould, swab with kerosene oil, then heat with portable burner for about two minutes so that then the melt is poured, the mould should be mildly hot.

vi. After a few minutes, check whether the metal has melted or not. The laboratory assistant can use a steel rod to carefully insert inside the crucible and poke through the metal layer to ensure complete melting.

vii. When the melt is ready, take out the crucible with metal tongs, using gloves. Observe and report the surface – whether fumes are coming out, whether a skin of Grey oxide layer has formed.

viii. Pour carefully in the mould the entire melt.

ix. After about 15 minutes, separate the two halves of the mould and take out the frozen solid. Measure the weight of the solidified metal. Compare with the weight of metal measured in step (b). Explain the difference.

**Assessment:**

1. How can you measure the volume of the depression of the solidified wax? Suggest a method.

2. Observe the inside of the cooled crucible. Report whether there is an oxide layer sticking to the wall or Grey oxide formed.

3. Plot cooling curve between temperature and time for Pb, Sn and Wax.

**Individual assessment**

We recognise that students have different learning styles and needs. The following will help students to assess their progress

**Self-Assessment/Learning Plan**

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<tr>
<th>Learning objective</th>
<th>Outcome</th>
<th>Yes/No</th>
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</thead>
<tbody>
<tr>
<td>Selection of melting furnaces</td>
<td>Use of furnace for a particular material</td>
<td></td>
</tr>
<tr>
<td>Melting of materials</td>
<td>Melting characteristics of particular charge material</td>
<td></td>
</tr>
<tr>
<td>Heating rate of furnace</td>
<td>Idea of amount of heat supply</td>
<td></td>
</tr>
<tr>
<td>Handling of liquid material</td>
<td>How to transfer liquid metal from furnace to ladle and ladle to mould</td>
<td></td>
</tr>
<tr>
<td>Pouring of molten material</td>
<td>Control over pouring time and rate of filling the mould</td>
<td></td>
</tr>
<tr>
<td>Pouring temperature of molten material</td>
<td>Optimum temperature to fill mould cavity</td>
<td></td>
</tr>
<tr>
<td>Cooling rate of molten materials</td>
<td>It tells time of solidification</td>
<td></td>
</tr>
<tr>
<td>Solidification of materials</td>
<td>Transformation from molten state to solid state</td>
<td></td>
</tr>
</tbody>
</table>
**EXPERIMENT: 5**

**MECHANICAL TESTING OF CASTINGS**

**Introduction:**

**Objective:** To know how to perform the mechanical test experiments to measure mechanical properties of materials like tensile test, hardness and elongation.

**Resource Material:**

1. [http://www.youtube.com/watch?v=4t2ddeJECZ8](http://www.youtube.com/watch?v=4t2ddeJECZ8)
2. Principles of Foundry Technology By P. L. Jain
3. [www.rotblattsculpture.com/Articles/safety.html](http://www.rotblattsculpture.com/Articles/safety.html)
4. [http://www.rotblattsculpture.com/Articles/safety.html](http://www.rotblattsculpture.com/Articles/safety.html)

**Delivery schedule:** 10 periods

**Student expectations/learning objective:**

- Demonstrate preparation of test samples from the castings
- Identify dimension of the test specimen
- Demonstrate operation of mechanical testing equipment
- List data collection during testing
- Analyze observation of data

**Pre-learning required:**

ASTM standards of sample size. Knowledge of sample preparation

**Handouts/material required/equipments & tools:**

Testing Equipments – Universal testing machine, Brinell and Rockwell hardness tester.

**Procedure/methodology:**

The student should observe and report the following;

Report: Standard Mechanical testing methods, particularly tensile tests, require...
standard test pieces. The student should report whether the test piece in integral with the casting or separate standard Test Block is cast – in this case, design of the test block should be sketched.

5.1 Hardness Testing

Report: Description of the Hardness test should cover the following points:

i) How the sample is cut and made ready for hardness testing. Specially mention the location of the sample – from the surface or from mid-section.

ii) What is the condition of the metal from which this sample is taken – as-cast, annealed or otherwise heat treated?

iii) Name of the Hardness tester, name and type of the indenter

iv) How the load is applied

v) How the hardness reading is obtained.

vi) Give typical hardness values for a number of tests, explaining the results. For example, difference between hardness of as-cast, annealed and quenched specimen or difference between hardness on the surface and that of the interior.

- Many shop floor practice hardness test prefer Brinell hardness test especially for cast irons. Cast irons contain metallic and non-metallic (graphite) phase. The Brinell hardness tester has larger indentation and it can detect the average hardness in a range, so the Brinell hardness tester has a higher accuracy, and smaller dispersion of hardness values

- Next most popular is the Rockwell hardness test. It is popular because it can be performed easily and rapidly, provides freedom from personal error, can distinguish small hardness differences in hardened steel, Moreover, the indentation size is small, so there is very little damage on the surface of a finished part. This test utilizes the depth of indentation, under constant load, as a measure of hardness. A minor load of 10 kg is first applied to seat the specimen. The major load is then applied, and the depth of indentation is automatically recorded on a dial gage in terms of arbitrary hardness numbers.

Principle of Hardness Testing

Hardness is the resistance of a material to localized permanent deformation. The deformation may be due to indentation, scratching, cutting or bending. In metals, ceramics and most polymers, the deformation is considered to be a plastic deformation of the surface.

If we want to create scratch mark on a piece of glass by a knife, we will fail. Because glass is a hard material and due to its hardness it will resist indentation. Diamond is harder than glass, so we can make indentation by a diamond on the surface of glass. Examples of hard material used in engineering practices are cast iron, concrete etc.

The Brinell Hardness Test is the most widely used and oldest method of hardness testing commonly used today. This test was invented in Sweden by Dr. Johan August
Brinell in 1900. This test is very often used to determine the hardness of castings and forgings. Almost all metals may be tested with the Brinell test by simply varying the ball size and test load. As long as the ball size to test load ratio remains constant, the results are considered accurate.

**The test procedure is as under:**

1. The test specimen is kept at the Brinnell Hardness Tester as shown in Fig 5.1.
2. A pre-determined test load (generally 3000 kgf) is set on the machine.
3. An indenter (generally 10 mm diameter) is chosen and affixed in the machine as shown below.
4. The test load is applied on the specimen and kept indented for a pre-determined time period and then removed.

![Fig 5.1 The Brinell Hardness Testing Machine](image)

v. The diameter of the indentation is measured in at least twice, one measurement in any direction and the other at right angle to the former. The mean of the two measurements is calculated. The Brinell hardness value is computed by using the following formula:

\[
HB = \frac{2F}{\pi \cdot D (D - \sqrt{D^2 - d^2})}
\]
In Brinell hardness test, the test load may range from 1 kgf to 3000 kgf and diameter of the indenter from 1 mm to 10 mm. A time of 10 to 15 seconds is generally specified as test standard.

5.2 Tensile Testing

This is perhaps the most important among regular mechanical tests on castings. A number of important data are available when the results of tensile test are plotted as stress-strain curve. To carry out standard tensile tests, standard test specimens are required. Such specimens can be cast, based on the desire of the customer, as integral part of the casting or as separate ‘keel block’ out of which the specimen has to machine. It is important to note that for the purpose of acceptance of results, or for comparison, special care is required in preparing standard specimen.

At the beginning of the Report, the student is to write briefly the definitions of the common terms related to the specimen and to the tensile stress-strain plot, drawing a schematic stress-strain diagram.

Fig. 5.3 Tensile Test Specimen

Tensile testing is conducted in universal testing machine. In this test, a specimen is subjected to gradual increase in load from zero till it breaks into two pieces and corresponding data on load applied and elongation suffered are noted. From the data
obtained, material properties like modulus of elasticity, yield strength, ductility, ultimate
tensile strength, breaking stress etc. are calculated. For convenience, let us consider
the test specimen (Fig 5.3) to be a mild steel piece having following dimensions:

**Fig 5.4 (a) The tensile test specimen**

- Initial gauge length = L = 50 mm
- Average initial diameter = d = 14 mm
- Original area of cross-section
  \[ A = \pi r^2 = \pi \times 7^2 = 154 \text{ mm}^2 \text{ (approx)} \]

To understand the test procedure, let us consider the following method and load values:

- The test specimen is held vertically and firmly in the jaws of Universal testing
  machine and the machine is adjusted to read zero.
- An extensometer is attached firmly to the specimen and adjusted it to read
  zero.
- The load is gradually increased to 6300 N (say) and the extensometer reading
  at each increment of loading are recorded.
- The extensometer shows a high value of extension at a point when the load is
  increased by, say 2300 N (this may not be a 6300 N increment), this point being
  the yield point.
- The extensometer is removed at this point and loading continued, the extension
  at different values of load is recorded by a vernier until fracture occurs.
- Maximum load attained by the specimen is recorded as 69000 N (say) and its
  breaking load is recorded as 61600 N (say).
The broken pieces are taken away from the machine and type of fracture is noted. By fitting the broken pieces together, final length (gauge length at failure) of the specimen is recorded (Fig 5.5). Final diameter at the neck (diameter at failure) is also recorded.

Stress, strain, yield point, ultimate stress, nominal rupture stress etc. are calculated as per the following formulae:

\[
\text{Stress} = \frac{\text{Load}}{\text{Area of cross-section of the test specimen}}
\]

\[
\text{Strain} = \frac{\text{Elastometer reading (elongation)}}{\text{Original length}}
\]

Yield strength = \( \frac{\text{Load at yield point}}{\text{Area of cross-section of the test specimen}} \)

Ultimate tensile strength = \( \frac{\text{Maximum load}}{\text{Area of cross-section of the test specimen}} \)

Modulus of elasticity = \( \frac{\text{Difference in stress between two widely spaced loads below yield point}}{\text{Corresponding change in strain}} \)

The tensile test data in the Report of the student should include

- The parameters shown in the sketch of the specimen
- The data of tensile test: tensile strength, yield strength or yield point, percent elongation at fracture, and reduction of area. The first two are strength parameters; the last two indicate ductility.
• The elastic modulus and 0.2 % Offset yield strength values also may be indicated. (Offset yield strength is the stress value, $\sigma_{0.2\%YS}$ of the intersection of a line (called the offset) constructed parallel to the elastic portion of the curve but offset to the right by a strain of 0.002. It represents the onset of plastic deformation.)

• For ductile specimen – annealed low carbon steel for example, ‘necking’ would take place. The student should report this.

• Calculate the reduction in area (RA) – Measure the cross section area after fracture

\[
\% \text{ RA} = \frac{\text{Cross section area (Original – Final, after fracture)}}{\text{Original cross sectional area}} \times 100
\]

5.3 Impact Testing

Impact test is only one method by which material property known as ‘toughness’ is measured. Toughness is the measure of the amount of energy absorbed by a material per unit volume before fracture and fail. More the energy absorbed per unit volume of the material more is its toughness.

The area under the stress/strain curve up to the UTS gives the measure of toughness of the material. However, in the context of an impact test we are looking at notch toughness, a measure of the metal’s resistance to brittle or fast fracture in the presence of a flaw or notch and fast loading conditions.

There are two types of impact test, Charpy Test and Izod Test. Both the tests involve striking a standard test specimen with a controlled weight pendulum travelling at a definite speed. The amount of energy absorbed by the test specimen before fracturing is measured and this gives an indication of the notch toughness of the test material.

From these tests we can interpret whether a material is ‘brittle’ or ‘ductile’. A brittle material will absorb small amount of energy when impact tested, ductile materials, being tougher, will absorb a large amount of energy before fracturing.

The Charpy specimen may be used (Fig 5.6) with one of three different types of notch, a ‘keyhole’, a ‘U’ and a ‘V’. The keyhole and U-notch are used for the testing of brittle materials such as cast iron. The V-notch specimen is the specimen of choice for weld testing and is the one discussed here. The standard specimen for Charpy test is generally 55mm long, 10mm square and has a 2mm deep notch with a tip radius of 0.25mm machined on one face.

![Fig 5.6 The Charpy test specimen](image)
5.3.1 The Charpy Impact Test Procedure:

i. The standard specimen is supported at its two ends on an anvil.

ii. The pendulum type hammer is set at a suitable position as shown in the Fig 5.7 at a vertical height ‘H’. Let the potential energy of the hammer at this position be E₁.

iii. The hammer is released and it strikes the test specimen (Fig 5.8). The specimen breaks into two pieces. The energy for fracture of the specimen being supplied by the striking hammer itself. Let the energy for fracture of the test specimen be ‘E’.

iv. The hammer moves through a height ‘h’ on the other side of the testing machine after breaking the test piece. This is the final position of the hammer and let energy possessed by the hammer at this position be ‘E₂’.

v. The energy required to break the test specimen is found by taking the difference between the energy possessed by the hammer in its initial and final positions (Fig 5.9).

That is, energy required to fracture the test specimen, \( E = E₁ - E₂ \).

\[ H = \text{Height through which the hammer is set before striking the test piece.} \]

The gives the measure of initial potential energy of the striking hammer.

\[ \text{Fig 5.7 Initial position of the striking hammer in a Charpy test} \]
The hammer strikes the test piece and breaks it into two pieces. A part of the energy of the hammer is used in breaking the test piece.

**Fig 5.8 The hammer strikes the test specimen**

The hammer strikes the test piece and breaks it into two pieces. A part of the energy of the hammer is used in breaking the test piece.

**Fig 5.9 The final position of the hammer after it has fractured the test specimen**

3. FINAL POSITION OF THE HAMMER

\[ h = \text{Height through which the pendulum/hammer rises after impact with the test piece and breaking it into two pieces} \]

**5.3.2 The Izod Impact Test Procedure**

The same test procedure is followed for an Izod impact test as that of Charpy impact test as shown in Fig 5.10. The test specimen is held on the anvil of the testing machine and hammer/pendulum is allowed to strike the test specimen such that it breaks into two pieces. The difference between the energy possessed by the hammer at its initial and final position gives the measure of energy required to fracture the test specimen. But the two tests differ in the following ways: (i) The dimension of the test specimen is different and the same are shown below:
Fig 5.10: Dimension of test specimen used in Charpy and Izod tests

(i) The holding arrangement of test pieces are different as shown in the figure:

Fig 5.11 Holding arrangement of test specimen in Charpy and Izod tests

In Izod Test, the test specimen is held in such a way that its one end remains fixed while the other end in free. This type of holding can be compared to a cantilever beam.

In Charpy Test, the test specimen is rigidly fixed at its both ends. This type of holding is comparable to a beam with two ends fixed.

(ii) The location of impact loads applied are different. In the Izod test, impact is against the end of the exposed cantilever; in the Charpy test, the impact is struck directly behind the test notch such that the specimen undergoes three point bending.

Fig 5.12 Application of impact loads on test specimen in Charpy and Izod tests
Assessment:
1. What are the mechanical properties of materials?
2. What is the tensile strength?
3. What is elongation?
4. What is hardness?
5. Draw the load Vs elongation curve.
6. Compare the hardness results with different materials obtained from the experiment.
7. Write down the indents shape and size for hardness tester.
8. Describe the step by step procedure for carried out the Hardness test.
9. Explain the charpy impact test procedure.
10. Discuss the Izod impact testing procedure.

Individual assessment
We recognise that students have different learning styles and needs. The following will help students to assess their progress

Self-Assessment/Learning Plan

<table>
<thead>
<tr>
<th>Learning objective</th>
<th>Outcome</th>
<th>Yes/No</th>
</tr>
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<tbody>
<tr>
<td>Mechanical properties</td>
<td>To know the mechanical properties of materials</td>
<td></td>
</tr>
<tr>
<td>Tensile test</td>
<td>Tensile strength, yield strength and elongation</td>
<td></td>
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<tr>
<td>Hardness test</td>
<td>To know the materials resistance against indentations</td>
<td></td>
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<tr>
<td>Operation of UTM</td>
<td>How to perform the experiment using UTM</td>
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<tr>
<td>Operation of Briness</td>
<td>How to do hardness test for the given specimen</td>
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<tr>
<td>Hardness testers</td>
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<td>Operation of Rockwell</td>
<td>How to do hardness test for the given specimen</td>
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<td>Hardness testers</td>
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<td>Testing</td>
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<td>Operation of Izod Impact</td>
<td>How to do Impact test for the given specimen</td>
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