



Foundry Technology - I Practical Manual

Class XI



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



Foundry Technology - I Practical Manual

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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 (Molds) 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 need 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 either 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.

Vineet Joshi
Chairman, CBSE



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भारत का संविधान

उद्देशिका

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

सामाजिक, आर्थिक और राजनैतिक न्याय,
विचार, अभिव्यक्ति, विश्वास, धर्म
और उपासना की स्वतंत्रता,
प्रतिष्ठा और अवसर की समता

प्राप्त कराने के लिए
तथा उन सब में व्यक्ति की गरिमा

²और राष्ट्र की एकता और अखंडता
सुनिश्चित करने वाली बंधुता बढ़ाने के लिए

दृढ़संकल्प होकर अपनी इस संविधान सभा में आज तारीख 26 नवम्बर, 1949 ई० को एतद्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।

1. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977) से "प्रभुत्व-संपन्न लोकतंत्रात्मक गणराज्य" के स्थान पर प्रतिस्थापित।
2. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977) से "राष्ट्र की एकता" के स्थान पर प्रतिस्थापित।

भाग 4 क

मूल कर्तव्य

51 क. मूल कर्तव्य - भारत के प्रत्येक नागरिक का यह कर्तव्य होगा कि वह -

- (क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वज और राष्ट्रगान का आदर करे;
- (ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखे और उनका पालन करे;
- (ग) भारत की प्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण रखे;
- (घ) देश की रक्षा करे और आह्वान किए जाने पर राष्ट्र की सेवा करे;
- (ङ) भारत के सभी लोगों में समरसता और समान भ्रातृत्व की भावना का निर्माण करे जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभाव से परे हों, ऐसी प्रथाओं का त्याग करे जो स्त्रियों के सम्मान के विरुद्ध हैं;
- (च) हमारी सामासिक संस्कृति की गौरवशाली परंपरा का महत्त्व समझे और उसका परिरक्षण करे;
- (छ) प्राकृतिक पर्यावरण की जिसके अंतर्गत वन, झील, नदी, और वन्य जीव हैं, रक्षा करे और उसका संवर्धन करे तथा प्राणिमात्र के प्रति दयाभाव रखे;
- (ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करे;
- (झ) सार्वजनिक संपत्ति को सुरक्षित रखे और हिंसा से दूर रहे;
- (ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कर्ष की ओर बढ़ने का सतत प्रयास करे जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई उंचाइयों को छू ले;
- ¹(ट) यदि माता-पिता या संरक्षक है, छह वर्ष से चौदह वर्ष तक की आयु वाले अपने, यथास्थिति, बालक या प्रतिपाल्य के लिये शिक्षा के अवसर प्रदान करे।

1. संविधान (छयासीवां संशोधन) अधिनियम, 2002 द्वारा प्रतिस्थापित।

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a ¹**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 the² 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.**

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)

THE CONSTITUTION OF INDIA

Chapter IV A

FUNDAMENTAL DUTIES

ARTICLE 51A

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;
- ¹(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 (Eighty-Sixth Amendment) Act. 2002.

Class XI : Foundry Technology I

Practical

Practical: 60 periods, 40 marks

Exercise No. Assignment	Periods	Marks
Exercise 1. ➤ Safety norms of the foundry ➤ Introduction to foundry tools ➤ Layout sketch of the foundry	10	05
Exercise 2. ➤ Pattern layout ➤ Calculation of shrinkage allowances ➤ Location of sprue, runner and riser, riser	15	10
Exercise 3 ➤ Sand testing – Shape and size of sand, AFS Sieve analysis of sand, clay content. ➤ Preparation of molding sand and standard specimen, Permeability, Hardness determination, tests for Green strength, Dry strength, moisture content. ➤ Optimisation of binder and water content by variation of binder and water level.	30	20
Exercise 4 ➤ Preparation of a green sand mold with a simple pattern, use of mold coating, Measurement of mold hardness	05	05

MODULE OBJECTIVES

S. No.	Experiment Name	Duration	Key Learning outcomes The students will be able to understand:
1	Safety norms in foundry industry /laboratory	2 hrs	<ul style="list-style-type: none"> • Demonstrate safety norms in foundry shop • List foundry shop hazards • Identify Personal protective equipment • Categorize general precautionary norms.
2	Introduction to foundry tools and equipments	4 hrs	<ul style="list-style-type: none"> • List foundry tools • Categorize major machines and equipments • Demonstrate use tools and equipments • List raw materials used in the foundry
3	Draw sketch of Lay out of foundry shop	4 hrs	<ul style="list-style-type: none"> • Identify foundry shop • list major machines and equipment's and demonstrate placement in shop • Identify design of a foundry industry
4	Pattern layout, Location of sprue, runner and riser	15 hrs	<ul style="list-style-type: none"> • Demonstrate designing of a pattern from component drawing • List major allowances to the pattern • Identify placement of sprue, runner and riser
5	Sand testing – Shape and size of sand, AFS Sieve analysis of sand, clay content. Preparation of molding sand and standard specimen, Permeability, Hardness determination, tests for Green strength, Dry strength, moisture content. Optimisation of binder and water content by variation of binder and water level.	30 hrs	<ul style="list-style-type: none"> • Identify sand grains/particles morphology • Demonstrate moisture content of sand grains • Demonstrate preparation of sand mix • List importance of variation of sand size • Identify clay content of sand particle • Demonstrate testing of sand system for making mold • Identify permeability of sand mix

6	Preparation of a green sand mold with a simple pattern, use of mold coating, Measurement of mold hardness	5 hrs	<ul style="list-style-type: none"> • Demonstrate preparation of green sand mold • Application of mold wash over mold surface • Calculate measurement of mold
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Learning Plan

Experiment	Aim	Resources
Experiment 1	<ul style="list-style-type: none"> ➤ Safety ➤ Introduction to foundry tools ➤ Layout sketch of the foundry 	Literatures, Foundry tools available in foundry laboratory, A3 size drawing sheet, pencil, scale
Experiment 2	<ul style="list-style-type: none"> ➤ Pattern layout ➤ Location of sprue, runner and riser, riser 	Engineering drawing of casting, Mini Drafter, Drawing Board, Instrument box, A3 size of drawing sheet, pencil and instrument box
Experiment 3	<ul style="list-style-type: none"> ➤ Sand testing – Shape and size of sand, AFS Sieve analysis of sand, clay content. ➤ Preparation of molding sand and standard specimen, Permeability, Hardness determination, tests for Green strength, Dry strength, moisture content. ➤ Optimization of binder and water content by variation of binder and water level. 	Sand samples, Electronic Balance, Oven, Sieve shaker, Sand Muller, Sand rammer, Sand Universal testing machine, hardness tester, Sand clay washer
Experiment 4	<ul style="list-style-type: none"> ➤ Preparation of a green sand mold with a simple pattern, use of mold coating, Measurement of mold hardness 	Foundry tools, pattern, sand system (Sand, water, binder), mold wash, hardness tester, mold boxes.



EXERCISE 1

Experiment: 1.1

Title : Safety norms in foundry industry/laboratory

Introduction:

Objective: To recognize the importance of safety in a foundry and execute proper safety measures in carrying out casting processes.

Resource Material:

1. Principles of Foundry Technology By P. L. Jain
2. <http://www.youtube.com/watch?v=4t2ddeJECZ8>
3. www.rotblattsculpture.com/Articles/safety.html<http://www.youtube.com/watch?v=v4i2INpJnVM>
4. <http://www.rotblattsculpture.com/Articles/safety.html>
5. <http://www.homemodelenginemachinist.com/f36/15-hot-work-safety-rules-foundry-14397/>
6. <http://chestofbooks.com/crafts/machinery/Shop-Practice-V2/Safety-in-Foundry.html#.UPOUufJ0rFw>
7. <http://www.astmnewsroom.org/default.aspx?pageid=976>

Delivery schedule: 02 hrs

Student expectations/learning objective:

- Demonstrate safety norms in foundry shop
- List foundry shop hazards
- Identify Personal protective equipment
- Categorize general precautionary norms.

Pre-learning required: Introduction to foundry.

Handouts/material required/equipment's & tools: Paper sheet and pen to note down the instruction.

Procedure/methodology:

A. Safety norms of the foundry:

Purpose

The purpose of this compliance code is to provide practical guidance on how employers who undertake foundry work can meet their duties under the Occupational Health and Safety Act 2004 (the OHS Act) and Occupational Health and Safety Regulations 2007 (the Regulations).

Scope

This code covers foundry work that predominantly involves the casting of molten metal into a mold. It can be done manually (static casting) or automatically (injection, die or continuous casting). A typical process includes preparing a mold casting, melting and pouring metal into the mold, and removing and finishing the casting.

Because of the diverse and hazardous nature of the work environment, foundries present a range of risks, including:

- explosion and burns from molten metal
- respiratory disorders from exposure to gases, vapours, fumes and dusts
- effects on skin from contact with corrosive chemicals
- eye injuries from light radiation, metal fragments or chemical splashes
- heat stress, heat stroke and fatigue from hot working conditions
- slips, trips and falls
- joint and muscle sprains and strains
- mechanical hazards from machinery and equipment (such as entanglement or crushing)
- non-mechanical hazards from machinery and equipment (such as vibration and noise).

The code provides practical guidance on foundry specific hazards but also refers to other hazards related to foundry work. Risk controls set out in the code are considered to be a means of meeting a duty holder's obligations so far as is reasonably practicable. If the risk controls are not appropriate to the particular circumstances in a foundry, a duty holder is expected to implement equally effective controls.

B. Foundry hazards :

Molten metal explosions

Steam explosions are caused by the introduction of moisture into molten metal.

Chemical explosions

Chemical explosions occur through the introduction of reactive chemical substances to molten metal directly or as a contaminant in charge material.

Heat stress

Working in hot conditions is hazardous. Health effects range from discomfort or heat rash to heat exhaustion or heat stroke resulting in permanent damage or death. Heat stress can harm without the worker being aware of the degree of effect until it is almost too late. It affects concentration, perception and decision making, so heat stress is also dangerous in less obvious ways.

Burns

Burns are one of the major types of injuries in molten metal foundries and are generally caused by contact with hot surfaces, radiation or molten metal splashing.

Light radiation

Eye disorders and skin burns may be caused by intense ultraviolet and infrared radiation from molten metal in furnaces, particularly around pouring areas and in welding operations. Bystanders and passersby also need to be protected, preferably by exclusion.

Hazardous substances

Hazardous substances such as lead, amines, formaldehyde, toluene, phenol, furfuryl alcohol and isocyanates are substances that can harm the health of people exposed to them. They can be inhaled, swallowed or absorbed through the skin, and employees can suffer immediate or long-term health effects.

Exposure may cause irritation, chemical burns, cancer, birth defects or diseases of certain organs such as the lungs, liver, kidneys and nervous system.

Hazardous wastes

Legislative controls exist for the safe transport, storage and disposal of hazardous waste. Where no legislative controls apply, a safe means of transport and disposal (having regard to the nature of the hazard) needs to be employed (eg sealed, marked containers suitably protected from possible damage and able to be handled safely).

Dangerous goods

Dangerous goods such as carbon dioxide, formaldehyde, oxygen, sulphur dioxide and xylene are hazardous for a variety of reasons – they may be highly flammable, explosive, corrosive, acutely toxic, asphyxiant or highly reactive according to class. They are readily identifiable by class diamonds on the labels.

Slips, trips and falls

Slips, trips and falls are a common hazard in most workplaces, with consequences ranging from mild (such as scrapes) to severe (such as fractures or fatalities).

Manual handling

Manual handling tasks are those where force is exerted by a person to lift, lower, push, pull, carry or otherwise move, hold or restrain any object. These occur during pattern and core making, loading furnaces, molding, fettling, dispatch, inspection and surface coating.

Machinery and equipment (plant)

Machinery and equipment are used in pattern and core making as well as casting and molding. Plant such as cranes, hoists, forklifts and conveyors are also used as mechanical handling devices within foundries.

Mechanical hazards

Mechanical hazards include hard surfaces coming together and scissoring action. Risks include entanglement, crushing, severing, cutting and slips, trips and falls.

C. Non-mechanical hazards

Noise

Noise levels in excess of 85 decibels (dB(A)) averaged over eight hours, or a C weighted peak hold sound pressure reading of 140 dB(C) can result in hearing loss. Pattern and core making, molding, knockout and cleaning operations, fettling and some furnaces are among the equipment and processes that produce noise levels in excess of the acceptable standard. Regular exposure to excessive noise can damage the inner ear and cause tinnitus leading to difficulties in communications.

Vibration

Whole body (1–80 Hz) vibration takes place during shake out, sand-slinging, on forklifts, cranes and during pneumatic ramming operations. The adverse effects of whole body vibration include increased blood pressure and heart problems, nervous disorders, stomach problems as well as joint and spine injuries.

Electricity

Electric shock causes injury or death. A shock can be received through direct contact with live parts, through contact with a medium such as an unearthed tool or when it arcs across a gap. The risk is increased by excessive sweating, as wet skin is more conductive than dry skin.

Machinery that may cause non-mechanical injury

Abrasive blasting and rumbling present hazards to employees from airborne contaminants and noise.



Access hazards



Access hazards are often complex, involving several risks at the same time, such as chemical dosing in confined spaces or working at height.

D. Personal protective equipment (PPE) in the foundry

- Primary protective clothing is used for specific hazardous tasks then removed. It provides protection from hazards such as metal splash and radiant heat. The garments need to be made from inherently fire-retardant fabrics to ensure their protective properties are intact as long as the garment is intact. They need to be comfortable to wear and breathable in very extreme work conditions. Leather options offer some durability and protective benefits but can compromise comfort and add to heat stress in certain situations.
- Secondary protective clothing is all-day/everyday clothing. The clothing needs to be fire-retardant and the choice of inherent or treated can take comfort and cost into account, but these garments are the last defence for the body if primary protection fails. A cotton fabric is the minimum requirement, but specially treated cotton or wool fabric is recommended

Primary and secondary PPE

Primary PPE	Secondary PPE
for molten metal work (in addition to secondary PPE)	for general foundry work
<p>HEAD Use helmets where there is potential for items to fall from height or where work takes place above head height (eg on a mezzanine). Industrial safety helmets should be considered. Where tasks result in dust or particulates, a head covering should be considered.</p>	
<p>EARS The factors that need to be taken into account when selecting hearing protectors need to include compliance with AS 1270, level of noise, the wearer (eg personal characteristics, comfort), communication requirements, and compatibility with the job/workplace. Guidance on hearing protectors is provided in AS/NZS 1269.3.</p>	
<p>EYES AND FACE Face shields with neck protection.</p>	<p>EYES AND FACE Industrial safety glasses with side shields are the minimum.</p>
	
<p>RESPIRATORY Respiratory protective devices (RPD) used need to comply with AS/NZS 1716. The type of respirator selected needs to take into account the operator (ie facial hair, physiological and psychological factors), the task (ie how the job is done, duration, frequency) and the substance (ie type of contaminant, concentration). The standard AS/NZS 1715 provides guidance on the selection, use and maintenance of respiratory protective devices. Guidance can also be obtained from suppliers of respiratory protective equipment.</p>	

<p>TRUNK AND ARMS</p> <p>A jacket of leather or other suitably resistant material must be worn outside all other clothing. It must be free of features such as cuffs and pockets that may trap molten metal. It must be worn properly and fastened at all times.</p>	<p>TRUNK AND ARMS</p> <p>Long-sleeved shirt made from flame-resistant fabric such as wool, heavy cotton drill, Firewear, TuffWeld and Indura, or fabrics with flame-retardant coatings such as FlameShield, aramid or Trevira CS. Employers must provide reflective clothing where there is a risk radiation and heat may affect health. Garments need to fasten at the neck and wrists to prevent molten metal splashes, dust, chemicals and other substances from entering through the collar and cuffs.</p>
<p>HANDS</p> <p>Heat-resistant Kevlar or heavy leather gauntlets that cover the lower part of arm.</p> 	<p>HANDS</p> <p>Gloves selected need to take into account the hazard (eg-burns, abrasion, chemicals, cuts), the work environment and the wearer (eg fit, comfort, dexterity).</p> 
<p>LEGS</p> <p>Where risk of molten metal spills or splashes exists, trousers of leather or other suitably resistant materials must be worn. The trousers need to cover the top of the footwear and be free of features such as cuffs and pockets that may trap molten metal.</p>	<p>LEGS</p> <p>Heat-resistant trousers.</p>
<p>FEET</p> <p>Employees must wear safety footwear at all times in the workplace unless a legally qualified medical practitioner certifies that wearing safety footwear would injure the wearer. In such cases, the reason for such an opinion must be given and the most appropriate alternative protective equipment sought.</p>	



PPE commonly used in foundry; from left to right: heat resistant glove, safety shoe, leather apron, faces shields.



Storage and care of protective equipment

For foundry purposes, compliance is demonstrated by employers ensuring that:

- all protective equipment and clothing provided is maintained in sound condition, tested routinely and capable of performing the protective functions for which it was provided.
- employees are trained in the need for, effective use and care of, and means of testing the fit of protective equipment (when trained employees must cooperate in the care and maintenance of the equipment).
- equipment and clothing is only worn by the employee to whom it was issued, and is marked with the name of that employee.
- clean storage is provided for all protective equipment and clothing.
- maintenance of clothing and equipment is conducted when required.

<p>Helmet with face shield and neck protection worn with safety glasses</p> <p>Casting jacket worn over secondary protective clothing</p> <p>Heat resistant Kevlar or heavy leather gauntlets</p> <p>Safety boots</p> 	<p>Safety glasses</p> <p>Long-sleeved shirt</p> <p>Gloves</p> <p>Long pants</p> <p>Safety boots</p> 
<p>Primary protective clothing the manner prescribed by the manufacturer or supplier. (Molten metal work)</p>	<p>Secondary protective clothing (General foundry work)</p>

E. Following safety norms of foundry must be followed:

- Always wear safety glasses, or face shields designed for the type of the work operating any machine
- Wear safety shoes if heavy work is being done.

- Wear clothing suited for the job, wear shoes with thick soles.
- Don't wear rings, watches, bracelets or other jewelry that could get caught in moving machinery.
- Don't wear neck ties or loose turn clothing of any kind.
- Wear shirts or uppers with sleeves cut off or rolled above the elbows.
- Always remove gloves before turning on or operating a machine. If material is rough and sharp then gloves must be of work place or handle material with machine turned off.
- Keeping floor free of oil, grease or any other liquid. Clean up spilled liquid immediately they are sleeping hazards.
- Aisle should be clear, at all time to avoid tripping of other accident.
- Store materials in such a way that they cannot become tripping hazards.
- Don't leave tools or work on the table of a machine even if the machine in not turning. Tools or work may fall off and cause an injury.
- Put tools always when not in use.
- Place the scrap box.
- Even trace amounts of Moisture and Molten Metal don't mix!!! Steam explosions are the cause of death in foundries.
- Wear safety gear!! This includes, but is not limited to, leather shoes, leather apron, proper gloves, wire mesh face shield, safety glasses and a helmet. A leather foundry hat is the best choice.
- Have a DRY pile of sand and a shovel ready to put out fires or to control metal spills. NEVER put water on a metal fire. This can cause a HUGH EXPLOSION!
- Have a sand bed under all areas. The sand bed should be at least 3 inches thick. This will help in containing metal spills and will help protect flooring.
- Never pour over wet ground. Remember, even TRACE AMOUNTS of MOISTURE can cause EXPLOSIONS.
- Molten metal spilled on concrete will cause the concrete to explode. Use a thick sand bed over concrete.
- Always use clean metal as feedstock. Combustion residues from some lubricants and paints can be very toxic.
- Always operate in a well ventilated area. Fumes and dusts from combustion and other foundry chemicals, processes and metals can be toxic.
- Always use a dust mask. Dusts from sand, parting dusts and chemicals can be hazardous or cancer causing. Protect your lungs!
- Always use safety glasses. Even minor mishaps can cause blindness.
- Never use a crucible that has been damaged or dropped. It's just not worth the risk. Imagine what would happen if a white hot crucible of brass crumbled as you were carrying it!
- Always charge crucibles when cold. Adding metal to a hot crucible is really dangerous. If there is moisture on the metal, even just a haze, the metal can cause the entire contents of the crucible to explode.
- Spilled molten metal can travel for a great distance. Operate in a clear work area.
- Think about what you are doing at all times. Focus on the job at hand and the next step. Have all moves planned and rehearsed prior to any operation.

Educate yourself beforehand and always be careful of your own and bystander safety

Assessment:

1. List the name of personal protective equipment(PPE) in tabular as given below:

Sl. No.	PPE	Drawing of PPE	Uses of PPE

2. What is purpose safety in foundry?

3. What are hazards in a foundry industry?

Activity

1. Draw the photographs of 1st aid on A3 sheet paper.

2. Make a colorful photograph of PPE on an A3 sheet.

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

Learning objective	Outcome	Yes/No
Purpose of safety in Foundry industry	To understand the need of safety	
Foundry hazards	To understand the cause of different types of foundry hazards	
Personal Protective Equipment	Knowledge of PPE	

Experiment: 1.2

Title : Introduction to foundry tools and equipments

Introduction:

Objective: Each student should get introduced with foundry tools and make a report on the list of foundry tools, their drawing and uses in foundry.

Resource Material:

1. Principles of Foundry Technology By P. L. Jain.
2. Introduction To Basic Manufacturing Process & Workshop Technology, By Rajender Singh, New Age International Publisher, 1st addition - 2006.
3. <http://www.scribd.com/doc/54115008/10/FOUNDRY-TOOLS-AND-EQUIPMENTS>
4. <http://www.themetalcasting.com/foundry-equipment.html>
5. <http://www.technofabengineersjpr.com/foundry-equipment.htm>

Delivery schedule: 4 hrs

Student expectations/learning objective:

- List foundry tools
- Categorize major machines and equipments
- Demonstrate use tools and equipments
- List raw materials used in the foundry

Pre-learning required: Safety measures of foundry.

Handouts/material required/equipment's & tools: Paper sheet and pencil

Procedure/methodology:

Part A: Introduction to foundry tools

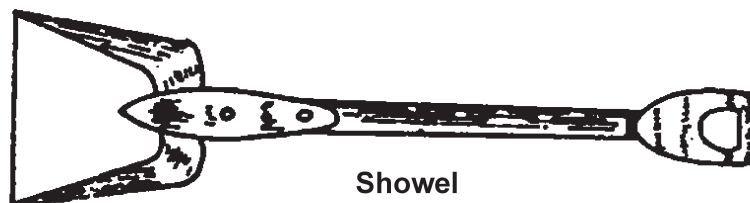
Students will be introduced by class teacher about the available foundry tools and equipments.

Student will take all tools.

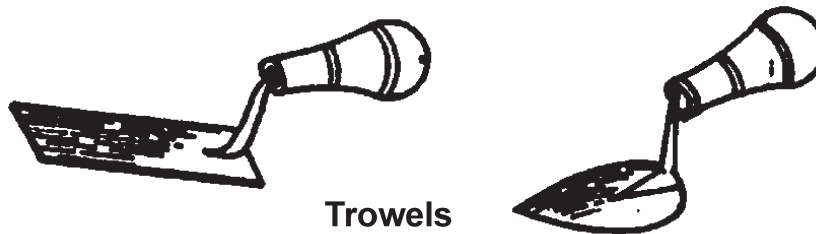
They will draw the schematic sketch of tools against name of individual tool, its application in foundry process.

Some important tools used in foundry are given below:

1. **Showel:** It consists of iron pan with a wooden handle. It can be used for mixing and conditioning the sand.



2. **Trowels:** These are used for finishing flat surfaces and comers inside a mold. Common shapes of trowels are shown as under. They are made of iron with a wooden handle.



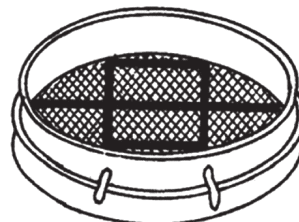
Trowels

3. **Lifter:** A lifter is a finishing tool used for repairing the mold and finishing the mold sand. Lifter is also used for removing loose sand from mold.



LIFTER

4. **Hand riddle:** It is used for ridding of sand to remove foreign material from it. It consists of a wooden frame fitted with a screen of standard wire mesh at the bottom.



Riddle

5. **Strike off bar:** It is a flat bar, made of wood or iron to strike off the excess sand from the top of a box after ramming. Its one edge made beveled and the surface perfectly smooth and plane.



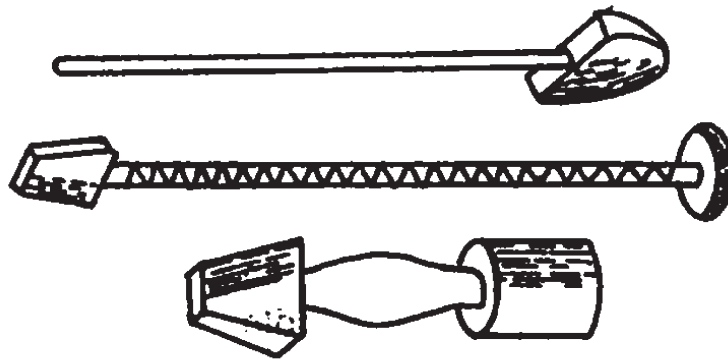
A strike off bar

6. **Vent wire:** It is a thin steel rod or wire carrying a pointed edge at one end and a wooden handle or a bent loop at the other. After ramming and striking off the excess sand it is used to make small holes, called vents, in the sand mold to allow the exit of gases and steam during casting.



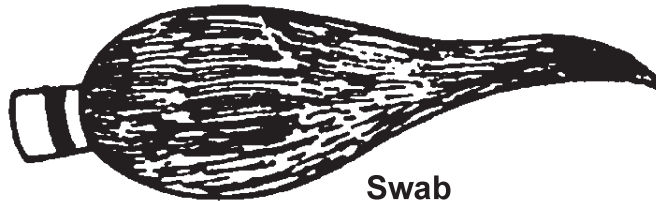
Vent Wire

7. **Rammers:** Rammers are used for striking the sand mass in the molding box to pack it closely around one pattern. Common types of rammers are shown as under.



Rammers

8. **Swab:** It is a hemp fiber brush used for moistening the edges of sand mold, which are in contact with the pattern surface, before withdrawing the pattern. It is also used for coating the liquid blacking on the mold faces in dry sand molds.



Swab

9. **Sprue pin:** It is a tapered rod of wood or iron, which is embedded in the sand and later withdrawn to produce a hole, called runner, through which the molten metal is poured into the mold.
10. **Sprue cutter:** It is also used for the same purpose as a sprue pin, but there is a marked difference between their use in that the cutter is used to produce the hole after ramming the mold. It is in the form of a tapered hollow tube, which is inserted in the sand to produce the hole.



Sprue Cutter

Equipment:

Some common equipments used in foundry are given below:

- (i) **Sand Muller:** To bind the sand particles together binder such bentonite, water and

other additives are needed to be added. All of the ingredients are required to be mixed again if the mixture has been used or new additives to be refilled. For mass production, sand muller is employed to prepare green sand mixture whereas sand mixer is used for small scale production. Figure 1 shows a typical configuration of industrial used sand muller.

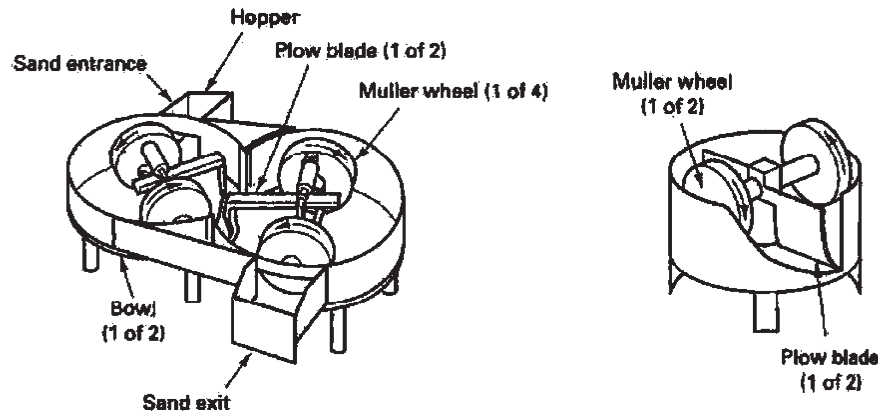


Fig.1: Schematics of continuous (left) and batch-type (right) sand muller. Plow blades move the sand and the muller wheels mix the components

(ii) Molding Machine: Molding machine uses high static squeeze force and high dynamic squeeze force to make the mold uniformly. It can make full use of sand and maintain the quality of mold. Therefore, the mold preparation costs can be reduced when large production of casting is needed. Figure 2 shows a typical molding machine and a set of core pattern.

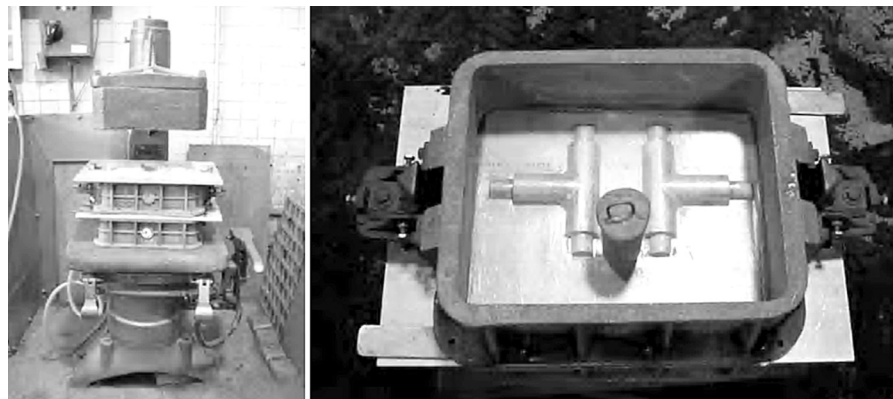


Fig.2: Left; semi-automatic Machine, Right; core pattern plate

Assessment:

1. List the name of foundry tools in tabular form available in foundry shop

Sl. No.	Name of tools	Drawing of tools	Uses of tool

2. What is use of lifter in molding?
 3. What is use of venting rod?
 4. What is use of a sand muller?

Activity

1. Put the photographs of hand tools over an A3 sheet.
 2. Draw the sketch of sand mixing equipment.

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

Learning objective	Outcome	Yes/No
Foundry tools	To understand the application of foundry	
Foundry Equipment	To understand the uses of foundry	

Experiment :1.3

Title : Draw sketch of Lay out of foundry shop

Introduction:

Objective: Student must have knowledge about the layout which includes placement of equipment, different shop floor and entry of all inputs to final dispatch of finished items.

Resource Material:

1. Principles of Foundry Technology By P. L. Jain
2. <http://www.youtube.com/watch?v=v4i2INpJnVM>
3. http://www.wiley.com/college/dec/meredith298298/resources/cases/cases_s_06c.html
4. http://infohouse.p2ric.org/ref/01/text/00778/figure3_metalcasting.gif

Delivery schedule: 4 hrs

Student expectations/learning objective:

- Identify foundry shop
- list major machines and equipment's and demonstrate placement in shop
- Identify design of a foundry industry

Pre-learning required: Safety measures of foundry and introduction about foundry tools and equipments.

Handouts/material required/equipment's & tools: Paper sheet and pencil

Procedure/methodology:

Draw the layout of foundry shop or laboratory. Most important thing is to take care that there should not be interruption in between the process movement. There should be proper utilization of space and easy handling of materials and other foundry related process. A sample of foundry layout is Figure 3.

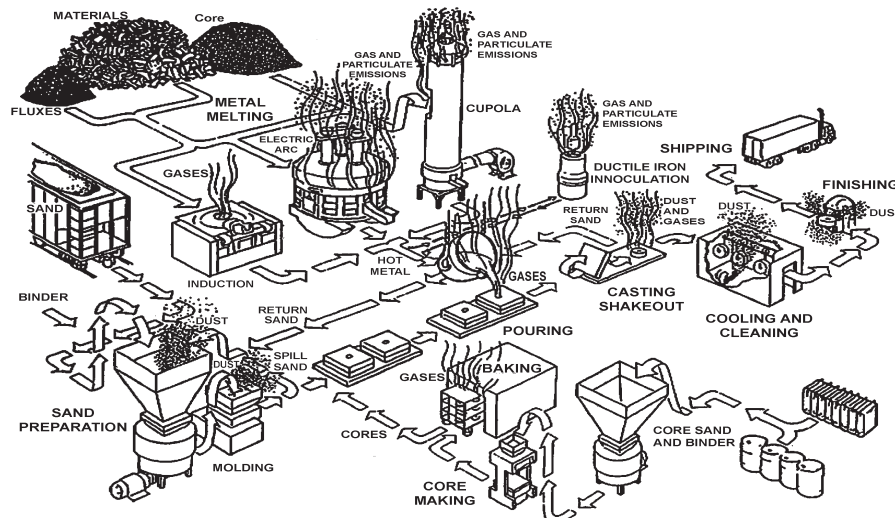


Fig. 3: Schematic sketch of a foundry Layout

Assessment:

1. What is importance of Foundry layout?
2. Prepare a specific foundry lay out on a A3 sheet.

Activity

1. Purchase A3 sheet and paste photographs of Cupola, Induction Furnace and Electric Arc Furnace.
2. Use thermocoal to make the model of foundry layout.

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

Learning objective	Outcome	Yes/No
Foundry Equipment	To understand the uses of equipments in foundry	
Foundry Layout	Knowledge of design of a foundry plant	

EXERCISE 2

Experiment : 2

Title : Pattern layout, Location of sprue, runner and riser

Introduction:

Objective: Design of pattern and the understanding of location of gating and risering system.

Resource Material:

1. Principle of Foundry Technology, by P. L. Jain
2. [http://en.wikipedia.org/wiki/Pattern_\(casting\)](http://en.wikipedia.org/wiki/Pattern_(casting))
3. http://web.iitd.ac.in/~suniljha/MEL120/L5_Metal_Casting2012.pdf
4. <http://www.themetalcasting.com/casting-pattern-design.html>
5. <http://www.custompartnet.com/wu/SandCasting>

Delivery schedule: 15 hrs

Student expectations/learning objective:

- Demonstrate designing of a pattern from component drawing
- List major allowances to the pattern
- Identify placement of sprue, runner and riser

Pre-learning required: Pattern material, shrinkage allowances for different materials, draft allowances etc.

Handouts/material required/equipment's & tools: component drawing, A3 drawing sheet, minidrafter, scale, instrument box, pencils and scale etc.

Procedure/methodology:

2.1: Pattern layout

Steps involved:

1. Get the working drawing of the part for which the pattern is to be made.
2. Make two views of the part drawing on a sheet, using a shrink rule. A shrink rule is modified form of an ordinary scale which has already taken care of shrinkage allowance for a particular metal to be cast. Shrinkage allowances for different metals are given in Table 1.

Table 1: Shrinkage Allowance for different metals

S. No.	Metals / Alloys	Shrinkage Allowance (mm/meter)
1.	Grey cast iron	7 to 10.5
2.	White cast iron	21

3.	Malleable iron	15
4.	Steel	20
5.	Copper	16
6.	Brass	16
7.	Bronze	10.5 - 21
8.	Zinc	24
9.	Lead	24
10.	Aluminium	16
11.	Magnesium	18

3. The contraction of metals/alloys is always volumetric, but the contraction allowances are always expressed in linear measures.
4. Add machining allowances as per the requirements.

I Machining Allowance:

A Casting is given an allowance for machining, because:

- i. Castings get oxidized in the mold during heat treatment; scales etc., thus formed need to be removed.
- ii. It is the intended to remove surface roughness and other imperfections from the castings.
- iii. It is required to achieve exact casting dimensions.
- iv. Surface finish is required on the casting.

Machining allowances of various metals are given in Table 2:

Table 2: Machining allowance for Various Metals

Material	Dimensions (in mm)	Machining allowance (in mm)
Cast Iron	Up to 300	2.5
	300 to 600	4.0
Aluminium	Up to 300	1.5
	300 to 600	3.0
Cast Steel	Up to 300	3.0
	300 to 600	4.5

5. Depending upon the method of molding, provide the draft allowance.

II Draft or Taper Allowance:

- It is given to all surfaces perpendicular to parting line.
- Draft allowance is given so that the pattern can be easily removed from the molding material tightly packed around it with out damaging the mold cavity.
- The amount of taper depends upon:

- i. Shape and size of pattern in the depth direction in contact with the mold cavity.
- ii. Molding methods.
- iii. Mold materials.
- iv. Draft allowance is imparted on internal as well as external surfaces; of course it is more on internal surfaces.

The taper provided by the pattern maker on all vertical surfaces of the pattern so that it can be removed from the sand without tearing away the sides of the sand mold and without excessive rapping by the molder.

Figure 4(a) shows a pattern having no draft allowance being removed from the pattern. In this case, till the pattern is completely lifted out, its sides will remain in contact with the walls of the mold, thus tending to break it.

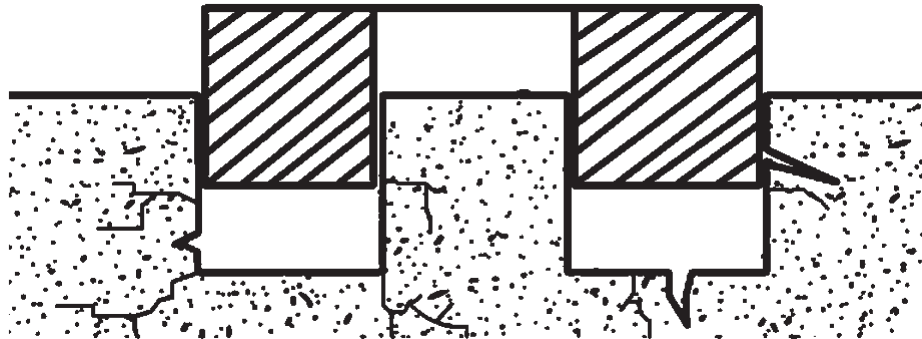


Fig. 4 (a): Pattern having no draft on vertical edges

Figure 4 (b) is an illustration of a pattern having proper draft allowance. Here, the moment the pattern lifting commences, all of its surfaces are well away from the sand surface. Thus the pattern can be removed without damaging the mold cavity.

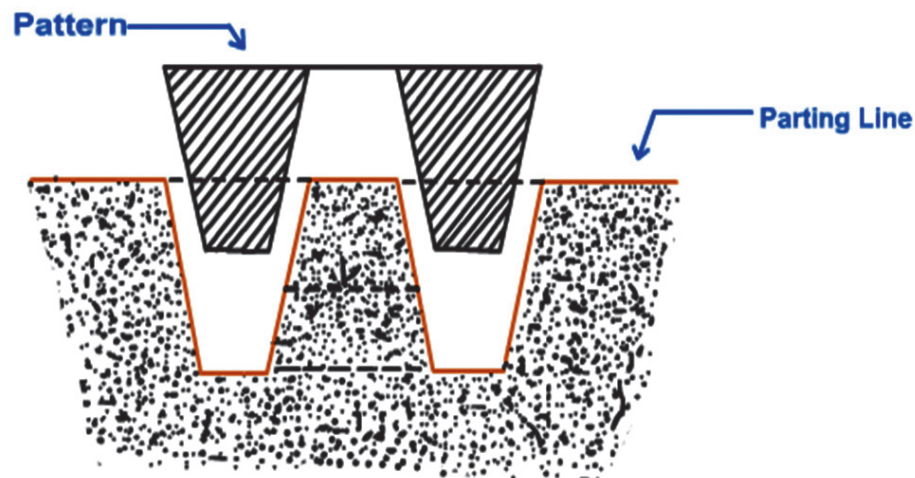


Fig. 4(b): Pattern having draft on vertical edges

Table 3: Suggested draft values for patterns

Pattern material	Height of the given surface, (in mm)	Draft angle of surface, degrees	
		External Surface	Internal surface
Wood	Up to 20	3.00	3.00
	21 – 50	1.50	2.50
	51 – 100	1.00	1.50
	101 – 200	0.75	1.00
	201 – 300	0.50	1.00
	301 – 800	0.50	0.75
	801 – 2000	0.35	0.50
	Over 2000	-	0.25
Metal and plastic	Up to 20	1.50	3.00
	21 – 50	1.00	2.00
	51 – 100	0.75	1.00
	101 – 200	0.50	0.75
	201 – 300	0.50	0.75
	301 – 800	0.35	0.50

2.2: Location of sprue, runner and riser

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 a logic in selecting the locations of the (i) Sprue – through which liquid metal enters the mold, (ii) the runner and gates. Runner, is cut in the mold, usually along the parting plane between cope and drag in such a way that the liquid metal is distributed evenly throughout the mold. The Riser or feeder which acts 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. Figure 5 illustrates a typical pattern and mold configuration.

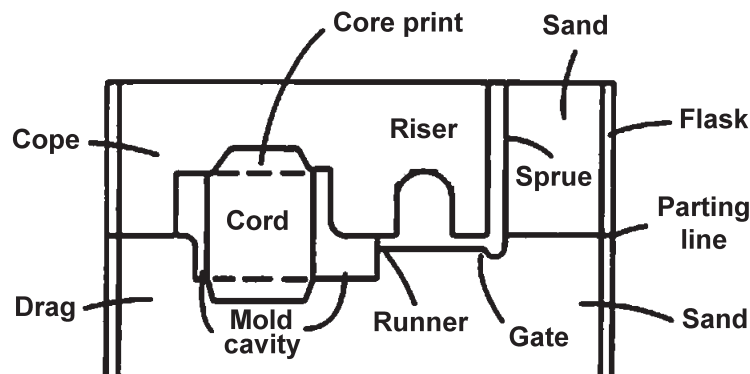


Fig.5: Schematic of a sand mold. The pattern is used to form the mold cavity, the core print for locating the core, the gate, the runner, the riser, and the sprue. A separate core box is used to make the sand core that is inserted into the parted mold before pouring.

Assessment:

1. What is shrinkage allowance?
2. Write down the list of pattern materials.
3. What is necessary of draft in pattern?
4. Necessary requirement of placement of riser and runner.

Activity

1. Make a model of pattern using thermo-coal block.
2. Make a model of pattern along with runner and riser with thermo-coal block.
3. Use different color over thermo-coal model to indicate different types of allowances.

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

Learning objective	Outcome	Yes/No
Pattern materials	Materials required for manufacturing of pattern	
Pattern design	How to draw pattern from component drawing	
Shrinkage allowance	Knowledge of solid shrinkage of metal from freezing point to room temperature	
Draft allowance	Necessary allowances for ejection of pattern from mold	
Placement of runner and riser	It will helpful in design of gating and feeding system	

EXERCISE 3

Experiment: 3

Title : Sand testing – Shape and size of sand, AFS Sieve analysis of sand, clay content. Preparation of molding sand and standard specimen, Permeability, Hardness determination, tests for Green strength, Dry strength, moisture content. Optimisation of binder and water content by variation of binder and water level.

Introduction:

Objective:

1. To know morphology to sand grains by optical microscopy.
2. Variation of sand grains by sieve analysis.
3. Determination of moisture content in sand grains
4. Determination of clay content in sand
5. Preparation of sand system
6. Preparation of standard sample
7. Determination of harness of standard sand sample
8. Determination of permeability of sand mix
9. Determination of compressive and shear strength of sand mix
10. Optimization of water and binder content.

Resource Material:

1. Principle of Foundry Technology, by P. L. Jain
2. Metal casting by Heine and Rosenthal
3. http://en.wikipedia.org/wiki/Foundry_sand_testing
4. <http://www.sandtesting.com/>
5. Indian Standards IS1918:1966 Physical testing of foundry sands
6. Mold & Core Test Handbook, published by the American Foundry Society, ISBN 0-87433-228-1

Delivery schedule: 30 hrs

Student expectations/learning objective:

- Identify sand grains/particles morphology
- Demonstrate moisture content of sand grains
- Demonstrate preparation of sand mix
- List importance of variation of sand size
- Identify clay content of sand particle
- Demonstrate testing of sand system for making mold
- Identify permeability of sand mix

Pre-learning required: preparation of sand mix

Handouts/material required/equipment's & tools: sand, binder, sand muller, clay washer, oven to dry the sand particles, electronic balance, sand rammer, permeability tester, sieve shaker, optical microscope or magnifying glass, hardness tester, sand universal testing machine etc.

Procedure/methodology:

3.1: Pattern layout

Shape Evolution of sand particle

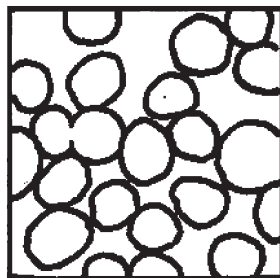
Steps:

1. Take few grams of sand from different source.
2. Observe the shape under magnifying glass or optical microscope.

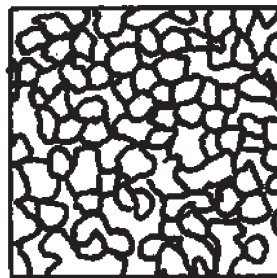


Fig.6: Optical microscope

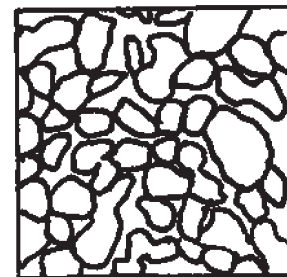
3. Draw the shape on paper.



ROUNDED



ANGULAR



SUBANGULAR

Fig. 7: Schematic sketch of different types of Sand Grain Shape

Part B

3.2: AFS Sieve analysis of sand

The test of determining the AFS grain fineness number is performed on a dried

sand sample from which all clay substances have been removed. A set of standard testing sieve is used to screen the sand as shown in the Figure 8. These sieves are stacked in sequence with the coarsest sieve at the top and placed in a sieve shaker. About 100 g sand is placed at the top sieve and, after 15 minutes of vibration, the weight of the sand retained in each sieve is obtained. The AFS grain fineness number of the sand tested can then be determined by taking the percentage of sand retained on each screen, multiplying each by a multiplier (which is simply the next available sieve old mesh number greater than the one being weighed out), adding the total, and then dividing by the total percentage of sand retained on the sieves. Typical calculation of the AFS fineness number, which includes the multiplier factor, is given in Table 4.



Fig. 8: Sieve Shaker

Data Sheet for Sieve Analysis:

Weight of sample taken = _____ grams

Table 4. Typical calculation of AFS grain fineness number.

USA sieve series No.	Sand retained on each sieve, g	Percentage of sand retained (A)	Multiplier (B)	Product (A x B)
6			3	
12			5	
20			10	

30			20	
40			30	
50			40	
70			50	
100			70	
140			100	
200			140	
270			200	
Pan			300	
Total				

$$\text{AFS grain fineness number} = \frac{\text{Total Product}}{\text{Total Percent of Sand Retained}}$$

3.3: Tests for Moisture Content

The most accurate method of moisture determination is to dry out the sand and to note weights before and after. The percentage of moisture can be calculated from the difference in the weights, of the original moist and the consequently dried sand samples.

$$\text{Percentage of moisture content} = (W1-W2)/ (W1) \%$$

Where, W1 = Weight of the sand before drying,

W2 = Weight of the sand after drying.

Fifty grams of tempered sand, accurately weighed and placed in the pan. The timer for the blower of the moisture teller is set for the required time to dry the sand (approximately 5 min) and air at 110°C is blown over and through the sand. The sand is dried after this and weighed again. Note the difference in the initial and final readings and determine the percentage of moisture in the sand.

Data Sheet for Moisture Content

Sample Description	Reading Number	Moisture Content	Average %
		%	
	1		
	2		
	3		

3.4: Tests for Clay Content

The equipment necessary for determining the percentage of clay in molding sand consists of a drying oven, a balance and weights, and a sand washer. Sand clay washer is shown in Figure 9. Clay content test is carried out as follows:

A portion of sand sample is thoroughly dried out at 110°C until constant weight is attained. 50 g of this dried sand is placed in a wash bottle. To this sand, 475 c.c. of distilled water and 25 c.c. of 3.0 % caustic soda solution are added. The mixture is stirred for 5 min in a rapid sand washer. Sufficient water is added up to the level line marked on the bottle. The liquid is then siphoned off after 10 min. The bottle is refilled twice more and siphoned the liquid off. The sand is placed in the oven for drying. The sand is weighed when it is completely dried and the percentage of clay is determined by the difference in the initial and final weights of the sample.



Fig.9: Sand clay washer

The clay content can be determined from the difference in weights of the initial and final sand samples.

$$\text{Percentage of clay content} = (W1-W2)/(W1) \times 100$$

Where, W1-Weight of the sand before drying,

W2-Weight of the sand after drying.

Data Sheet for Clay Content

Sample Description	Reading Number	Clay Content	Average %
		%	
	1		
	2		
	3		

3.5: Specimen Preparation for permeability test, hardness test, strength test of sand mix:

Since the permeability of sand is dependent to a great extent, on the degree of

ramming, it is necessary that the specimen be prepared under standard conditions. To get reproducible ramming conditions, a laboratory sand rammer is used along with a specimen tube. Figure 10 shows the set up of laboratory sand rammer. The measured amount of sand is filled in the specimen tube, and a fixed weight of 6.35 to 7.25 Kg is allowed to fall on the sand three times from a height of 50.8 ± 0.125 mm. The specimen thus produced should have a height of 50.8 ± 0.8 mm. To produce this size of specimen usually sand of 145 to 175 g would be required. After preparing a test sample of sand as described, 2000 cm³ of air are passed through the sample and time taken by it to completely pass through the specimen is noted.



Fig.10: Sand rammer for specimen preparation

Measurement of strength of molding sands can be carried out on the universal sand strength testing machine. The strength can be measured in compression, shear and tension. The sands that could be tested are green sand, dry sand or core sand. The compression and shear test involve the standard cylindrical specimen that was used for the permeability test.

3.6: Permeability Test

Permeability is defined as that physical property of the molded mass of sand mixture which allows gas to pass through it. It is determined by measuring the quantity of air that passes through a given sample of sand in a prescribed time and under standard condition.

Permeability of molding sand depends on several factors including shape of sand grains, fineness, degree of packing, moisture content and amount of binder present. Hence, coarse grained sands are more permeable than finer ones.

To determine permeability the AFS Standard sand specimen of 5.08 cm (2 inches)

diameter and 5.08 cm in height is prepared by ramming the required quantity of sand in a smooth surface tube with three blows of standard rammer. This sand specimen is placed in the mercury cup of the permeability meter. The air drum is raised to take 2000 cm³ of air in to the air drum which will be indicated by the graduation on it. The whole air is then allowed to escape through the sand specimen with a pressure of about 10 g/cm³ and the time is recorded. Figure 11 shows the schematic sketch of permeability tester.

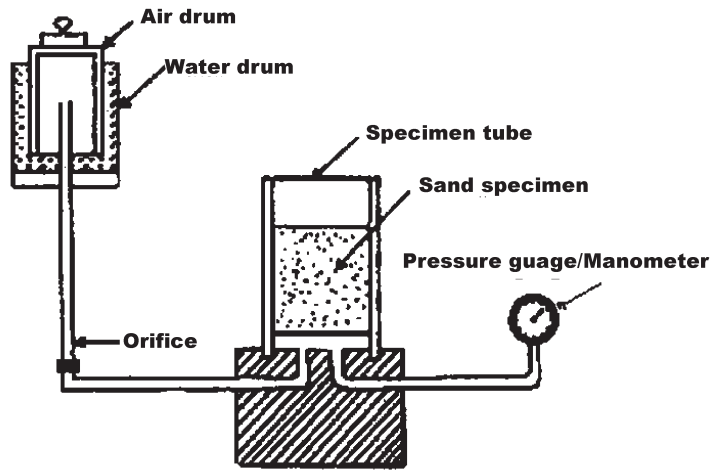


Fig. 11: Permeability measuring set up

Then, the permeability number, P is obtained by

$$P = \frac{V \times H}{A \times P \times T}$$

Where V = volume of air = 2000 cm³

H = height of the sand specimen = 5.08 cm, P = air pressure, g/cm²

A = cross sectional area of sand specimen = 20.268 cm²

T = time in minutes for the complete air to pass through.

Inserting the above standard values into the expression, we get

$$P = \frac{501.28}{T}$$

Data Sheet for Permeability

Sample Description	Clay Content	Moisture Content	Time in Second	Permeability	
				Reading	Average

3.7: Sand Hardness Test

The hardness achieved by ramming the molding sand mixture can be measured by using an indentation-type mold hardness tester where a spring-loaded 1/2 inch diameter steel ball is pressed into the AFS Standard sand sample and the hardness number is read directly from a dial gauge which reads from 100 to 0. If no penetration occurs, the hardness reading is set arbitrarily to 100. If the ball sinks completely into the sand up to the limiting surface of the tester, the reading is set to 0; i.e. the sand is very soft. A “hard rammed” mold generally reads 90, while a “soft” mold reads 50 to 60. Severe penetration by the liquid metal and washing of the sand occur when the hardness reading is below 50. A hardness tester is shown in the Figure 12.

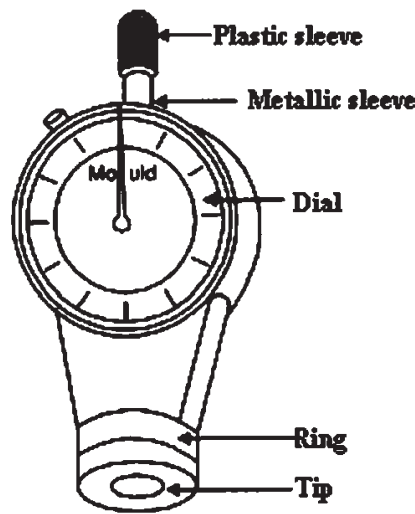


Fig.12: Mold Hardness Tester

Data Sheet for Mold Hardness

Sample Description	Clay Content	Moisture Content	Mold Hardness			
			Top	Bottom	Average	Difference

3.8: Sand Strength Test

Sand strength test is the measure of holding power of various bonding materials in green and dry sand. It determines the cohesiveness or natural binding capacity of the sand grains. There are three types of test for sand strength: (1) compression, (2) shear, and (3) tensile test. Of these tests, the compression test and shear test are by far most widely used and are very convenient for routine testing of all types of natural bonded and synthetic molding sand.

Measurements of strength of molding sands can be carried out on the universal sand strength testing machine. Figure 13 shows the hydraulic universal testing machine. The strength can be measured in compression, shear and tension by changing the holder in same tester. Compression and shear test holders are shown in Fig. 14 and Fig.15 respectively.

The sands that could be tested are green sand and dry sand. The compression and shear test involve the standard cylindrical specimen that was used for the permeability test.

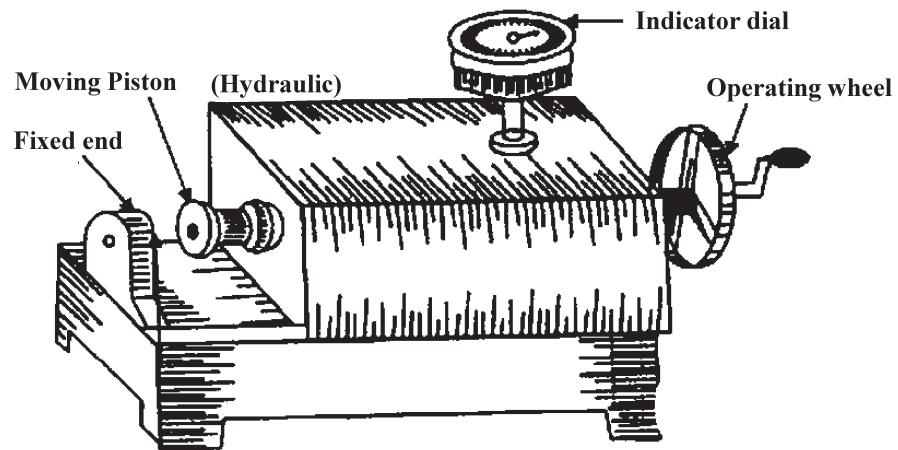


Fig. 13: Universal Sand Strength Testing Machine (Hydraulic)

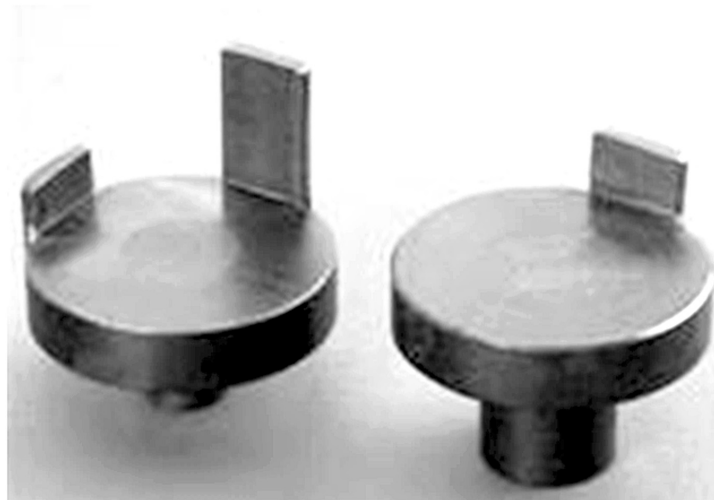


Fig. 14: Holders for Compression Strength Test

(a) Green compression strength(GCS):

Green compression strength or simply green strength generally refers to the stress required to rupture the sand specimen under compressive loading. The sand specimen is taken out of the specimen tube and is immediately (any delay causes the drying of

the sample which increases the strength) put on the strength testing machine and the force required to cause the compression failure is determined. The green strength of sands is generally in the range of 30 to 160 KPa.

(b) Green shear strength(GSS):

With a sand sample similar to the above test, a different adapter is fitted in the universal machine so that the loading now be made for the shearing of the sand sample. The stress required to shear the specimen along the axis is then represented as the green shear strength. It may vary from 10 to 50 KPa.

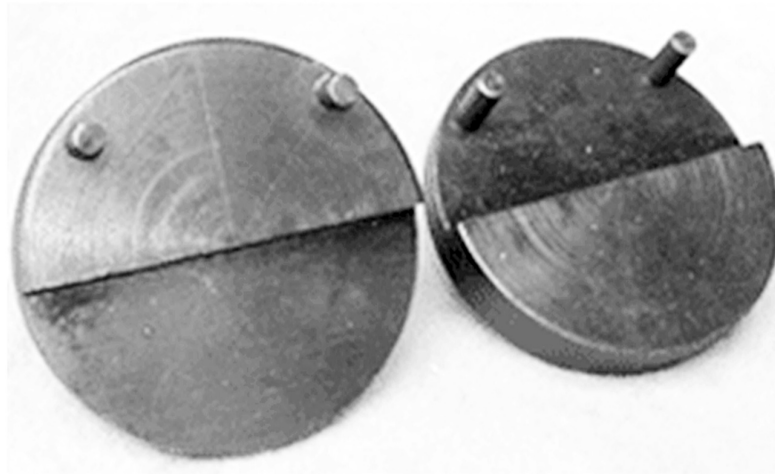


Fig. 15: Holders for shear Strength Test

(c) Dry strength:

This test uses the standard specimens dried between 105 and 110°C for 2 hours. Since the strength increases with drying, it may be necessary to apply larger stresses than the previous tests. The range of dry compression strengths found in molding sands is from 140 to 1800 KPa, depending on the sand sample.

Steps involved are:

1. Specimen is held between the grips
2. Apply the hydraulic pressure by rotating the hand wheel
3. Taking the deformation use of the indicators.

Data Sheet for Green and Dry Compressive Strength, shear strength

Sample Description	Clay content	Moisture content	GCS (g/cm ²)		DCS (g/cm ²)		Shear Strength (g/cm ²)	
			Reading	Average	Reading	Average	Reading	Average

3.9: Optimizations of binder and water content by variation of binder and water level.

(a) Optimizations of binder content by variation of binder level

Optimization of binder content is carried out by varying the level of binder and keeping the moisture fixed in the sand mix.

Steps:

1. Make the sand samples using different % of binder like 2%, 4%, 5%, 6% and 8% etc. by keeping the moisture content fixed.
2. Take the data of permeability number, hardness number and green compressive strength (GCS)
3. Plot the permeability number, hardness number and GCS with binder content.
4. Optimize binder content to achieve better permeability, hardness and compressive strength of sand

COMPLETE DATA SHEET FOR EXPT. 3.9 (a)

Sample No.	Moisture Content (%)	Binder Content (%)	Permeability Reading	Hardness Number	GCS (g/cm ²)
1		2			
2		4			
3		5			
4		6			
5		8			

(b) Optimization of water content by variation of water level

Optimization of binder content is carried out by varying the level of binder and keeping the moisture fixed in the sand mix.

Steps:

1. Make the sand samples using different % of water like 3%, 5%, 6%, 7% and 8% etc. by keeping the binder content fixed.
2. Take the data of permeability number, hardness number and green compressive strength (GCS)
3. Plot the permeability number, hardness number and GCS with water content.
4. Optimize water content to achieve better permeability, hardness and compressive strength of sand

COMPLETE DATA SHEET FOR EXPT. 3.9 (b)

Sample No.	Moisture Content (%)	Binder Content (%)	Permeability Reading	Hardness Number	GCS (g/cm ²)
1	3				
2	5				

3	6				
4	7				
5	8				

Assessment:

1. What is sand mix?
2. Draw the sand shape on paper.
3. What is size distribution of sand grains.
4. What do you understand by permeability?
5. How can you make a standard sand specimen for permeability and strength testing?
6. Write down the formula for determination of moisture content.
7. Write down the formula of permeability number?
8. What is mold coating?

Activity

1. Student can make ASTM standard specimen using thermo-coal.
2. Student can collect different source of sand like river bank sand, beach sand and other source to see morphology of sand.

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

Learning objective	Outcome	Yes/No
Sand morphology	Understand the packing of sand in the mold	
Sand size distribution	Variation of sand size and applicability for foundry practice	
Sand sample preparation	For different testing of sand systems	
Moisture content determination	To determine how much moisture further require for sand system	
Permeability number determination	Ability of sand mix to pass the air/gas through sand mix after ramming	

EXERCISE 4

Experiment: 4

Title : Preparation of a green sand mold with a simple pattern, use of mold coating, Measurement of mold hardness

Introduction:

Objective:

1. Preparation of green sand mold
2. Application of mold coating
3. Determination of mold hardness

Resource Material:

1. Principle of Foundry Technology, by P. L. Jain
2. Metal casting by Heine and Rosenthal
3. <http://afsosu.org.ohio-state.edu/resources/Foundry%20Doc3C%20Green%20Sand%20Molding%20Procedure.pdf>
4. <http://www.simpsongroup.com/tech/rpt-sales-Fundamentals%20of%20Sand%20Control.pdf>
5. http://www.foundry101.com/new_page_7.htm
6. <http://www.youtube.com/watch?v=TSLZQU64F-I>
7. http://www.foseco.com.tr/tr/downloads/FoundryPractice/237-01_Coatings_for_the_green_sand_molding.pdf
8. <http://www.js McCormick.com/coremold.php>
9. <http://www.thaifoundryequipment.com/index.php?lay=show&ac=article&Id=233169>

Delivery schedule: 5 hrs

Student expectations/learning objective:

- Demonstrate preparation of green sand mold
- Application of mold wash over mold surface
- Calculate measurement of mold

Pre-learning required: preparation of green sand mix

Handouts/material required/equipment's & tools: sand, binder, sand muller, foundry tools, hardness tester, brush to apply coating over mold surface, coating material etc.

Procedure/methodology:

Experiment Steps:

Step I: Preparation of green sand mold using a simple pattern

1. Take any simple pattern
2. Select mold box as per the pattern



3. Make the sand mix using a definite amount of moisture and binder.
4. Identify which side of pattern should be on the cope or drag side. Flasks are always tapered upward and cope is usually taller than drag.
5. Assemble the flasks and pattern. Make sure that the flasks are firmly locked.
6. Flip the assembly upside down (cope is at the bottom, drag is at the top).
7. Apply adequate mold release powder all over pattern surface



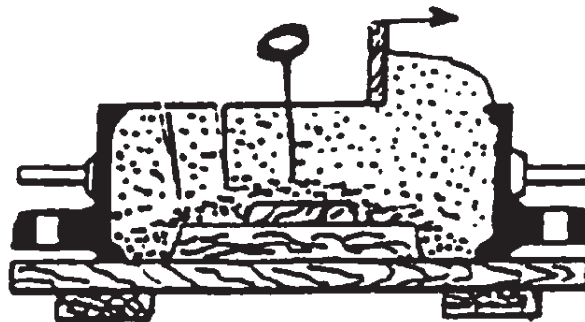
Ram sand down firmly and systematically, start from edges and corners using smaller side of bench rammer and the center of the mold with larger side.



8. Add more sand and ram it down until the top surface has been reached.
9. Scrape the top surface using scraper. The scraped sand should not be used again.



10. Place an aluminum plate on the top of assembly. Flip the flasks over and redo step 5 – 8 for the cope. Note: the aluminum plate is now at the bottom of the assembly.
11. In case of venting is needed, use the vent wire to poke the cope few times. The vent does not have to go all the way through pattern. Venting has to be done after scraping as scraped sand could block the vents.



12. Locate and cut the sprue with appropriate size of sprue cutter. Leave the sprue cutter in the sand mold and craft pouring basin if needed.
13. Separate the cope and drag, pull out the pattern and sprue cutter, blow any loose sand out of the mold cavity.
14. Reassemble the cope and drag. Now Green sand mold is ready

Step II: Use of mold coating or mold wash

1. Prepare mold wash

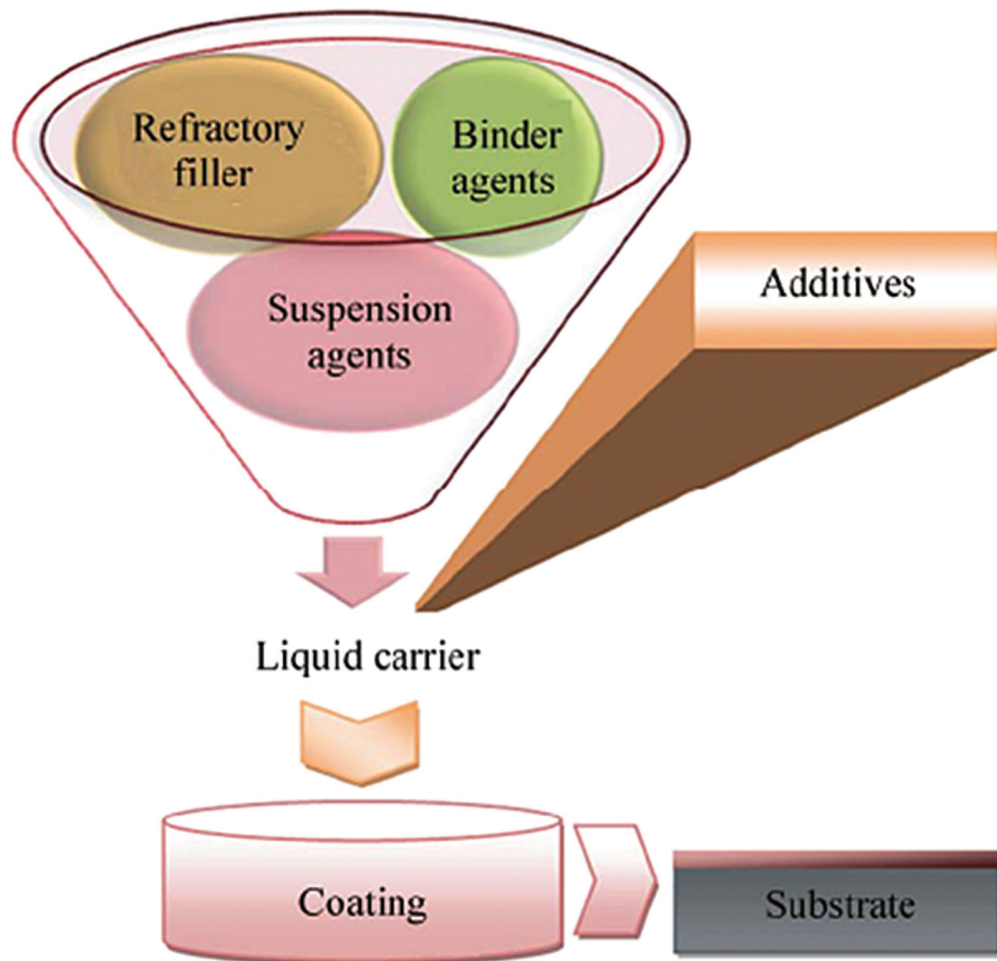


Fig. 16: coating components

2. Separate the cope and drag, pull out the pattern and sprue cutter, blow any loose sand out of the mold cavity.
3. Use brush for coating the mold surface
4. Dry the coating by using some flame or torch.
5. After drying reassemble the cope and drag.

Step III: Measurement of mold hardness

1. Separate cope and drag and remove the pattern.
2. Use hardness tester to measure hardness at different locations of cope and drag part of mold cavity.
3. Apply sufficient pressure to allow the indenter to move slowly into the mold surface. Record the dial reading when the indenter has penetrated the mold surface to the depth recommended by the equipment manufacturer.
4. Take hardness before coating as well as after drying of the coating.
5. Compare the harness reading after coating and without coating
6. Discuss the variation of hardness of mold at different locations of mold

7. Also discuss the effect of coating on mold harness.
8. Compare the results in tabular form.

COMPLETE DATA SHEET FOR EXPT. 4

Sample No.	Moisture Content (%)	Binder Content (%)	Hardness number (with-out coating)	Hardness Number(after Coating)
1	3			
2	5			
3	6			
4	7			
5	8			

Assessment:

1. What is green sand?
2. Write down the name of different mold wash material.
3. Write down the name of method of application of mold wash over mold surface.
4. What is necessity of determination of mold hardness?

Activity

1. Make a green sand mold of your foot hand only. Do not use any foundry tools.
2. Make a different numbers of molds by varying different percentage of binder and measure average hardness of molds and discuss the results with variation of binder.

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

Learning objective	Outcome	Yes/No
Green sand molding	Method and steps of green mold preparation.	
Proportion of green sand ingredients	Composition of sand system	
Mold wash	Mold wash materials, it uses to the mold	
Mold hardness	Erosion resistance, rammingness of sand mix	