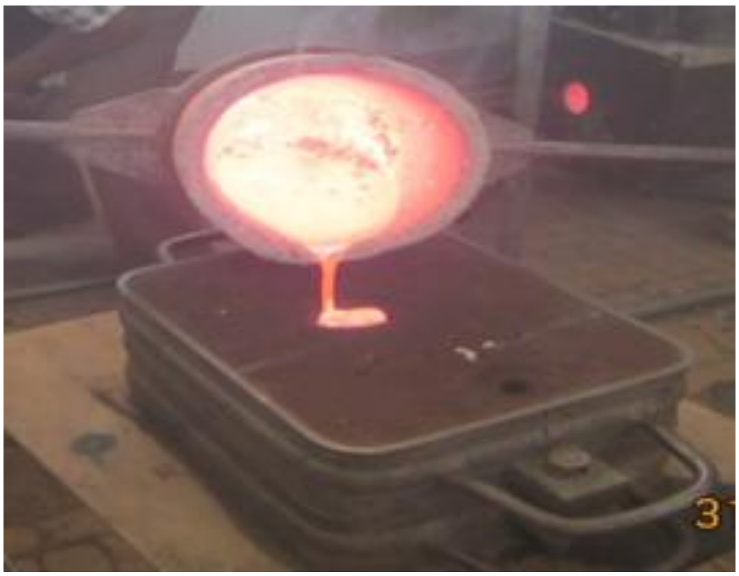
Foundry Works

Level-I

Based on March, 2022 Curriculum Version 1



Module Title: Performing Basic Foundry Works

Module Code: IND FDW1 M05 0322

Nominal Duration: 140 Hours

Prepared by: Ministry of Labor and Skill

August 2022

Addis Ababa, Ethiopia

Table of Contents

Contents

Acknowledgments

Ministry of Labor and Skills wishes to extend thanks and appreciation to the many representatives of TVT instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronyms

CP	Core print
LAP	Learning activities performance
PPE	Personal protective equipment
TTLM	Teaching training and learning materials
TVT	Technical and vocational institute
UC	Unit of competency
LO	Learning outcome
IND	Industrial
FDW1	Foundry work level 1
M05	Fifth module

Introduction to the Module

This training module is intended to equip students with the knowledge, skills, and attitudes necessary to complete basic foundry work within the allotted 140 hours. The trainees will comprehend the applications of basic casting processes and increase the significance of foundry technology, which supports the growth of foundries, in this module. On the completion of theoretical training and through the hands-on practice given, they will acquire some of the basic skills and techniques of foundry processes in details. To this end, the module focuses on the fundamental aspects and practices in foundry works including safety practices, pattern making, mold making, and selecting of metals to be melted, pouring, based on the required theoretical and practical parts to perform basic metal foundry operations. Individual/group project works should be given in order to improve the skills of trainees in metal casting operations.

In the foundry field; performing basic foundry works project helps to get the net shape of the intended products from simple to complex shapes.Foundries are one of the largest contributors to the manufacturing sector including recycling old and new materials, and melting and recasting millions of tons of scrap metal every time to create new products. The foundry process is suitable for both small and large components. It gives a high rate of production, small dimensional tolerances, and good surface finish. Due to these properties, it can be used to produce intricate parts. Moreover, many foundries use sand in their molding process, and others apply permanent molds.This module is designed to meet the industry requirement under the foundry works based on the occupational standards, particularly for the unit of competency; ***Performing Basic Foundry Works***to achievethe expectedoutcomes inthe level-I.

This module covers the following units including:

- Job requirements
- Sequence of operation
- pattern preparation
- Mold and core making
- Clean and restore work area

Learning Objectives of the Module which lets the trainees to:

- Identify job requirements
- Determine sequence of operation
- Pattern preparation
- Perform mold and core makings
- Clean and restore work area

Module Instructions

For effective use of this module, trainees are expected to follow the module instructions including:

1. Read the information written in each unit.
2. Accomplish the Self-checks at the end of each unit.
3. Perform operation sheets which were provided at the end of units.
4. Do the learning activity performance (LAP) test giver at the end of each unit and
5. Read the identified reference books to get more knowledge as well as to do examples and exercise.

Unit one: Job Requirements

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Reading drawings, instructions and specifications.
- Foundry safe work practices and procedures.
- Selecting foundry materials.

This unit will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Identify drawings, instructions and specifications.
- Appy foundry safe work practices and procedures.
- Select Material.

1.1 Reading drawings, instructions and specifications

Reading drawing is the preliminary condition in the manufacturing and engineering fields. It is a graphical language which helps to communicate the designers, readers and foundry workers.

1.1.1 Introduction

In the foundry works, reading drawing, instructions and specifications are crucial to understand the process of casting. Foundry is a workshop or factory for casting metal. The process of casting involves melting an alloy of metal, forcing the molten metal into a chamber commonly referred to as a mold or die, letting it cool, and then removing the casting from the mold. Casting is used to produce metal components that are close to specified shapes. Even though it only involves a few steps, casting is a complex manufacturing process that needs careful planning, execution, and inspection to guarantee not only the physical features but also the metallurgical integrity of the casting, which is typically used in engineering structures that need to withstand high static or cyclic load bearing temperatures, pressures, or mechanical forces.Casting job is required for several reasons to produce variety of size, snape having complicate internal details. A large number of metal components in designs we use every day are made by casting. The reasons for this include:

(a) Casting can produce very complex geometry parts with internal cavities and hollow sections.
(b) It can be used to make small (few hundred grams) to very large size parts (thousands of kilograms)
(c) It is economical, with very little wastage: the extra metal in each casting is re-melted and re-used.

Understanding drawings is essential for understanding detailed product design instructions and specifications. Before casting operations, the quality of the surface finish and various allowances, including pattern and machining, including other specifications must be understood.

1.2 Foundry safe work practices and procedures

All foundry workers and trainees must be made aware of the life-saving precautions that must always be taken whenever metal is melted. Be sure that students have apply safety thoroughly and wear appropriate personal protective equipment (PPE). Safety in the foundry workshop is very crucial to protect oneself, other individuals and equipment. To achieve safety following work procedures is very necessary to ensure safety. The potential hazard areas in the foundry shop arerelated to pattern making, mold making, melting, pouring. During pattern making related to wood lathe and grinding operations, wood dust. noise from woodworking and metal machining; electric shock, pattern falling, fire etc. You should wear appropriate safety equipment (PPE – personal protective equipment) which includes safety glasses, ear protection, and safety shoes at all times when working on your die casting. Appropriate safety must be worn when casting metals. Aprons, gloves and leggings should be leather as this offers the most protection is a spillage of molten aluminum occurs. Normal textile material burns through very quickly and should not be used for the casting process.

1.2.1 General Safety for Foundries

The methods and materials involved in any form of metal casting operation are VERY hazardous. Educate yourself on the proper safety precautions before attempting any metal casting. Think about safety precautions, things to keep in mind are:

1. Even trace amounts of moisture and molten metal don't mix!!!
2. Never put water on a metal fire. This can cause a huge explosion!
3. Have a dry pile of sand and a shovel ready to put out fires or to control metal spills.
4. 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.
5. Never pour over wet ground. Remember, even trace amounts of moisture can cause explosions.
6. Molten metal spilled on concrete will cause the concrete to explode. Use a thick sand bed over concrete.
7. Always use clean metal as feedstock. Combustion residues from some lubricants

and paints can be very toxic.

8. Always operate in a well-ventilated area. Fumes and dusts from combustion and other foundry chemicals, processes and metals can be toxic.
9. Use a niosh rated dusk mask. Dusts from sand, parting dusts and chemicals can be hazardous or cancer causing. Protect your lungs!
10. Always use safety glasses. Even minor mishaps can cause blindness.
11. 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!
12. 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.
13. Spilled molten metal can travel for a great distance. Operate in a clear work area.
14. 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.
15. Educate yourself beforehand and always be careful of your own and bystander safety.

1.3 Required foundry materials

All the materials needed for casting should be selected before the time of casting. These include variety of sands, clay, additives, and water. As practically as possible, ensure that all the materials you need to complete the casting are ready prior to the casting date including foundry tools and equipment. Factors affecting the selection of required casting materials are pattern materials, cost effectiveness, melting temperature, cooling time, weight and volume of casting, surface finish and dimensional accuracy required.

1.3.1 Types of sand and their bonding systems

Sand casting uses natural or synthetic sand (lake sand) which is mostly a refractory material called silica (SiO_2). The sand grains must be small enough so that it can be packed densely; however, the grains must be large enough to allow gasses formed during the metal pouring to escape through the pores. Larger sized molds use green sand (mixture of sand, clay and some water). Sand can be re-used, and excess metal poured is cutoff and re-used also. There are variety of sands used for foundry works. Each type of sand has its specific function to make mold. Silica sand is the main compound found in sand. It contains silicon and oxygen atoms. All the atoms in its structure are linked to each other and creates strong bonding system. Clay (bentonite) is common type of binder. Binders used in molding sands to get the following properties:

- Binders are added to give cohesion to molding sands.
- Binders provide strength to the molding sand and enable it to retain its shape as mold cavity.
- Binders should be added in optimum quantity as they reduce refractoriness and permeability.

1.3.1.1 Sands

The refractory molds used in casting consist of a particulate refractory material (sand) that is bonded together to hold its shape during pouring. Although various sands can be used, the following basic requirements apply to select the best sand for the project.

- Dimensional and thermal stability at elevated temperatures
- Suitable particle size and shape
- Chemically not reactive with molten metals
- Not readily wetted by molten metals
- Freedom from volatiles that produce gas upon heating
- Economical availability
- Compatibility with binder systems

Green sand mold is produced with an aggregate consisting of refractory materials and binders. The basic ingredients are silica sand, the aggregate and refractory clay on the binder. Two types of green sand are commonly used: (1) natural bonded molding sand and (2) Synthetic sand. Molding sand must possess several characteristics. First, it must be cohesive so that the individual grains stick together while the pattern is being removed, otherwise the mold will break apart. Second, it must be porous enough so that gases and water vapor can scope when molten metal is poured in to the mold. Molding sand must also refractory to withstand high temperature of molten metal. Most green sand molds consist of silica sands bonded with a betonies-water mixture. (The term green means that the mold, which is tempered with water, is not dried or baked). The composition, size, distribution, purity, and shape of the sand are important to the success of the mold making operation.

Natural sand

Natural sand is directly used for molding and contains 5-20% of clay as binding material. It needs 5-8% water for mixing before making the mold. Many natural sands possess a wide working range of moisture and are capable of retaining moisture content for a long time. Its main drawback is that it is less refractory as compared to synthetic sand.Many natural sands have weak molding properties. Natural sands can be reconditioned by mixing small amounts of binding materials like bentonite to improve their properties and are known as semi-synthetic sand.

Synthetic sands

Synthetic sands have been washed to remove clay and other impurities, carefully screened and classified to give a desired size distribution, and then re blended with clays and other materials to produce an optimized sand for the casting being produced. Synthetic sand consists of silica sand with or without clay, binder or moisture. It is a formulated sand i.e., sand formed by adding different ingredients. Sand formulationsare done to get certain desired properties not possessed by natural sand. These sands have better casting properties like permeability and refractoriness and aresuitable for casting ferrous and non-ferrous materials. These properties can be controlled by mixing different ingredients. Synthetic sands are used for making heavy castings.

Sand composition

Foundry sands are composed almost entirely of silica (SiO_2) in the form of quartz. Some impurities may be present, such as limonite (FeO-TiO_2), magnetite (Fe_3O_4), or olivine, which is composed of magnesium and ferrous orthosilicate [$(MgFe)\ SiO_4$]. Silica sand is used primarily because it is readily available and inexpensive. However, its various shortcomings as a foundry sand necessitate the addition of other materials to the sand mix to produce satisfactory castings, as described later in this article.

1.3.1.2 Shape and distribution of sand grains

In determining the size, shape, and distribution of the sand grains, it is important to realize that the grain shape contributes to the amount of sand surface area and that the grain size distribution controls the permeability of the mold. As the sand surface area increases, the amount of bonding material (normally clay and water) must increase if the sand is to be properly bonded. Rounded grains have a low surface-area-to-volume ratio and are therefore preferred for making cores because they require the least amount of binder. However, when they are recycled into the molding sand system, their shape can be a disadvantage if the molding system normally uses a high percentage of clay and water to facilitate rapid, automatic molding. This is because rounded grains require less binder than the rest of the system sand.

Angular sands have the greatest surface area (except for sands that fracture easily and produce a large percentage of small grains and fines) and therefore require more mulling, bond, and moisture. The angularity of a sand increases with use because the sand is broken down by thermal and mechanical shock. The sub angular-to-round classification is most commonly used, and it affords a compromise if shape than control of grain shape. The grain size distribution, which includes the base sand size distribution plus the distribution of broken grains and fines from both molding sand and core sands, controls both the surface area and the packing density or porosity of the mold.

The porosity of the mold controls its permeability, which is the ability of the mold to allow gases generated during pouring to escape through the mold. The highest porosity will result from grains that are all approximately the same size. As the size distribution broadens, there are more grains that are small enough to fill the spaces between large grains. As grains break down through repeated recycling, there are more and more of the smaller grains, and the porosity of the mold decreases. However, if the porosity of the mold is too great, metal may penetrate the sand grains and cause a burn-in defect. Therefore, it is necessary to balance the base sand distribution and continue to screen the sand and use dust collectors during recycling to remove fines and to determine the proper bond addition.

There are different of molding sand including green sand, dry sand, loam sand, facing sand, backing sand, system sand, parting sand and core sand which are explained below.

Green sand. It is also known as tempered or natural sand just prepared mixture of silica sand with 18 to 30 percent clay, having moisture content from 6 to 8%. The clay and water furnish the bond for green sand is fine, soft, light, and porous. Green sand is damp, when squeezed in the hand and it retains the shape and the impression to give to it under pressure.

Dry sand. When green sand that has been dried or baked in suitable oven after the making mold and cores is called dry sand. It possesses more strength, rigidity and thermal stability. It is mainly suitable for larger castings. Mold prepared in this sand are known as dry sand molds.

Loam sand. Loam is mixture of sand and clay with water to a thin plastic paste. Loam sand possesses high clay as much as 30-50% and 18% water.

Core sand. Core sand is used for making cores and it is sometimes also known as oil sand. This is highly rich silica sand mixed with oil binders. After reconditioned, molding and core sands have the basic properties as shown in Table 1.

Table 1. Properties of sand

Sand property	Description
1) Refractoriness	Refractoriness is defined as the ability of molding sand to withstand high temperatures without breaking down or fusing thus facilitating to get sound casting.
2) Permeability	It is also termed as porosity of the molding sand in order to allow the escape of any air, gases or moisture present or generated in the mold when the molten metal is poured into it.
3) Cohesiveness	It is property of molding sand by virtue which the sand grain particles interact and attract each other within the molding sand.
4) Green strength	The green sand after water has been mixed into it, must have sufficient strength and toughness to permit the making and handling of the mold.
5) Dry strength	As soon as the molten metal is poured into the mold, the moisture in the sand layer adjacent to the hot metal gets evaporated and this dry sand layer must have sufficient strength to its shape in order to avoid erosion of mold wall during the flow of molten metal.

6) Flowability or plasticity	It is the ability of the sand to get compacted and behave like a fluid. It will flow uniformly to all portions of pattern when rammed and distribute the ramming pressure evenly all around in all directions.
7) Adhesiveness	It is property of molding sand to get stick or adhere with foreign material such sticking of molding sand with inner wall of molding box.
8) Collapsibility	After the molten metal in the mold gets solidified, the sand mold must be collapsible so that free contraction of the metal occurs and this would naturally avoid the tearing or cracking of the contracting metal.
9) Miscellaneous properties	In addition to above requirements, the molding sand should not stick to the casting and should not chemically react with the metal.

Facing sand. Facing sand is just prepared and forms the face of the mold. Initial coating around the pattern and hence for mold surface is given by this sand. This sand is subjected severest conditions and must possess, therefore, high strength refractoriness.

Backing sand. Backing sand or floor sand is used to back up the facing sand and is used to fill the whole volume of the molding flask. The backing sand is sometimes called black sand because that old, repeatedly used molding sand is black in color due to addition of coal dust and burning on coming in contact with the molten metal.

Parting sand. Facing sand without binder and moisture is used to keep the green sand not to stick to the pattern and also to allow the sand on the parting surface the cope and drag to separate without

clinging. This is clean clay-free silica sand which serves the same purpose as parting dust.

1.3.1.3 Bonding Materials

The binders are categorized as either inorganic or organic substance. The inorganic groupincludes clay sodium silicate and port land cement etc. In foundry shop, the clay acts as binderwhich may be Kaolinite, Ball Clay, Fire Clay, Limonite, Fuller’s earth and Bentonite. Bindersincluded in the organic group are dextrin, molasses, cereal binders, linseed oil and resins likephenol formaldehyde, urea formaldehyde etc. Organic binders are mostly used for core making.Among all the above binders, the bentonite variety of clay is the most common. Bonding materials are important to get bond strength and able to get the shape of pattern. There are variety of bonding materials such as clay. charcoal dust, cereals, wood dust, corn flour etc. are also known as additives.

Clays. Bonds in green sand molds are produced by the interaction of clay and water. Each of the various clays has different properties, as described below. The most common clays used in bonding green sand molds are betonies, which are forms of montmorillonite or hydrated aluminum silicate. This is a layered structure, and it produces clay particles that are flat plates. Water is adsorbed on the surfaces of these plates, and this causes betonies to expand in the presence of water and to contract when dried.

Cereals. Theseinclude corn flour, dextrin, and other starches, are adhesive when wetted and therefore act as a binder.They stiffen the sand and improve its ability to draw deep pockets. However, use of cereals makes shakeout more difficult, and excessive quantities make the sand tough and can cause the sand to form balls in the Muller. Because cereals are volatile, they can cause gas defects in castings if used improperly.

1.3.2 Pattern materials

There are variety of pattern materials including wood, metal such as aluminum and metals, plastic, wax, and foam. Casting materials are usually metals or various time setting materials that cure after mixing two or more components together. The selection of pattern material depends on the size, complexity of pattern, dimensional accuracy required and number of the casting need to be made from one pattern.

i. The properties of pattern material should be:
ii. It should be easily worked and formed in existing shape.
iii. Always pattern materials weight should be light.
iv. It should be strong and hard.
v. It has capable to resist wear and abrasion.
vi. It has the capability to resist corrosion as well as any type of chemical reaction.
vii. It should be unaffected by variation in temperature as well as humidity.
viii. It should be dimensionally stable as well as available at a low price.

1.3.2.1 Common pattern materials

There are various pattern materials including wood, metal, plastic and others for specific types of casting process applications.

Wood. Wood patterns are used where the number of castings to be produced is small and the size of the pattern is large.

Advantages of Wood Materials

It is a common material for making patterns as it has the following advantages.

1. It is cheap and available in abundance.
2. It can be easily shaped into various forms and intricate designs.
3. Due to its lightness in weight, it is easy to change it.
4. A good surface can be easily achieved only by planning and sawing.
5. It can be preserved for a long time by applying appropriate preservatives like shellac varnish.

Disadvantages of Wood Materials

1. It wears out quickly due to its low resistance to abrasion of sand that is why a wooden pattern cannot be used continuously for a long time.
2. It is susceptible to moisture, due to which it may crack or split.
3. Its life, due to the above reasons, is shorter than that of other pattern materials.

Metal pattern. A metal pattern is used where only the number of castings is large and near dimensional accuracy is desired. Commonly used metal patterns are aluminum or its alloy, brass, white metal, steel, etc.

Advantages of Metal pattern

Metals are used with the following advantages.

1. The life of the metal pattern is much longer than that of the wood pattern and largely eliminates the natural damage of wood.
2. Do not absorb moisture.
3. Stronger.
4. Get longer life.
5. Precise and smooth surface finish.
6. Good machinability.

Disadvantages of Metal pattern

1. They are expensive as compared to wood, so it is used less, where less number of castings have to be done, it is not used.
2. It requires machining to obtain different shapes and finer surfaces and again it takes a separate cost.
3. Most of these are very heavy patterns and in the case of large castings, the weight of the pattern always becomes a problem in its manipulation.
4. It has a tendency to rust in large numbers.

Self-check-1

Part 1. Choose the best answer

1. Which of the following is the best patterns making material due to itslight weight and serving long time with good dimensional accuracy?

a) Wood b) Aluminum c) Steel

2. Which one of the following pattern materials are affected by moisture?

a) Aluminum b) Steel a) Wood

3. What is the most common metallic material used for patterns?

b) Wood c) Aluminum d) Foam

4. The _______ pattern could have the entire assembly of runner and gates integrate in it.

a) Single piece c) Two pieces
b) Match plate e) Gated pattern

5. Two-piece patterns are used for manufacturing of the intricate castings.

a) True b) False

6. Cope and drag pattern use separate wooden plates and alignment pins.

a. True b. False

7. Which of the following factor is not considered while selecting a kind of pattern?

a) Quantity of castingb) Types of molding method

c) Shape of the castingd) Nature of molding process

8. In the molding sands, which of the following are the major required properties?

a) Sand grainsb) permeabilityc) sand grain size d) All of the above

9. The strength of dry sand mold depends onthe ___.

b) Binders b) Sand grain c) Additives d) Sand quality

Part 2. Give short answer

1) What materials are for making the pattern during investment casting and why?
2) Can Aluminum be used for making patterns?
3) List the types of sand and describe their purposes.
4) Mention the types of pattern materials and explain their advantages and disadvantages.
5) What are the advantages of sand casting?
6) What kinds of materials are used in sand casting?
7) Explain the use of understanding drawings, specifications and instruction before the job starts.

Part 3. Match column "A" with "B"

"A"	"B"
1) Green sand	a. The sand used directly on the surface of the pattern and mold
2) Facing sand	b. A workshop or factory used for casting metal.
3) Foundry	c. Wet state of sand
4) Metal pattern	d. used where the number of castings to be produced is small quantity
5) Wood pattern	e. used when large number of castings with dimensional accuracy required

Part 4. Fill in the blank space

1. _____________ is the replica of object to be casted.
2. __________ is made up of silicon dioxide (SiO_2).
3. ____________ pattern is single piece pattern.
4. The ability of sand property withstand high temperature is ____________.
5. ____________ is mostly used binder in the green sand mold making.

Answer key

Multiple choice (Part 1)

1. b 2. c 3. b 4. d 5. a 6. a 7. d 8. d 9. b

Answer key for short answer (part 2)

1) For making the pattern in the investment casting process wax materials are used because in wax pattern materials there is no chance of the mold cavity being damaged while removing the pattern.
2) Yes, Aluminum is the most common metal which is used for making patterns.
3) There are variety of sands including green sand, dry sand, loam sand, facing sand, backing sand, system sand, parting sand and core sand.
4) Some of the types of patterns are wood, metal plastic, wax, etc.
5) Sand is particularly useful for detailed parts with complex geometries and internal passageway, resist high temperature and cost effective.
6) Sand casting can be used with a wide range of metals, including iron, aluminum, steel, zinc, brass, and bronze alloys.
7) Reading drawing helps to understand details of a product and to plan the process.

Operation sheet-1	**Identifying, selection types of sand and patterns**

Title: Identifying of types of sand and pattern.

Purpose. Selecting foundry materials, patterns and sand types

Supplies and materials: wood, plastic, metal, sand, clay, water, binder, drawings

Required Tools:

- Balance
- Foundry hand tools
- Drawings
- Caliper
- Try square
- Tape rule

Procedures.

1. Apply safety and hazard identification in the foundry shop.
2. Select the pattern materials which are available in the shop.
3. Select type of sand
4. Select foundry tools
5. Measure sand, water and clay as per mixing ratio using volume calculation and direct measuring.
6. Clean the work area

7. Return all tools, used sands and materials in their proper place

Precautions:

- Follow safe working procedures.
- Follow instructions.

Criteria- each tool must be used for the required operations.

Oral questions related with procedures of operation sheet 1.

1) How did you select pattern materials?
2) What are the types of sand?
3) What are the possible hazards in the foundry shop?
4) Why is sand used in metal casting?
5) What is the difference pattern and mold?

Answerkey for the oral questions of operation sheet 1.

1) Pattern materials can be selected based on the number of castings to be produced, quantity of production, dimension accuracy and surface finish, nature of molding process like sand casting, permanent mold casting, types of molding etc.
2) The types of sand are green sand, facing sand, backing sand, etc.
3) The possible hazards of foundry are burns, dust, chemical attack, etc.
4) Sand resist when exposed to high temperature which makes it desirable in metal casting and cost advantage.
5) Patterns are a model for the object to be cast. A pattern makes an impression on the mold, liquid metal is poured into the mold, and the metal solidifies in the shape of the original pattern.

LAP Test-1	Foundry materials selection and preparation

Name: ___________________________ Date: _____________

Time started: ____________________ Time finished: _______________

Instruction I: Given the necessary tools, types of sand and pattern, select the following identification and collecting material tasks within 4 hours.

Task 1: After selecting, collect sand binders and additives which are used for mold making.

Task 2: Collect variety of sand and identify them by their purposes.

Task 3: Collect variety of patterns and identify their differences and decide when to use them.

Unit two: Sequences of casting operation

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- casting operating procedures

This unit will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Determine sand casting operating procedures.

2.1 Sandcasting operating procedures

Casting is a manufacturing process in which a liquid metal is poured into a mold cavity of the desired shape and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods. The production of shaped manufacturing products is achieved by pouring molten metal into molds.

Sand casting is highly versatile and may be used to create custom designs in nearly any shape and size. It is particularly useful for detailed parts with complex geometries and internal passageways. The casting manufacturing process is more efficient and less expensive than other manufacturing methods, and excess material is recyclable.The sand-casting process follows the following basic steps:

Create a pattern. A reusable pattern is designed to fit the specifications of the required product. The pattern can be used to make multiple molds for sand casting.

Prepare sprue and riser. These passages in the design allow for the free flow of molten alloy into the finished mold. The sprue, gates and riser ensure that the mold is filled completely by facilitating the release of gases and mitigating thermal contraction.

Form the mold. Using the prototype pattern, sand is formed into a highly detailed, breakable mold.

Melting. Melt different scraps to the required temperature in the suitable furnace.

Pour the casting. Molten metal is poured into the mold using a specialized delivery system and allow it to cool.

Shakeout process. The molten metal cools and hardens into the required shape. Once cooled, the mold is broken to reveal the fully formed part.

Finishing process. Fettling/finishing operations including cleaning work area and returning tools and used sand on their provided location.

Inspection of cast product and suggest remedies in lab report form on how to minimize defects for the nest casting work. The inspection and testing of castings includes casting finish, dimensional accuracy, mechanical testing, chemical composition and casting soundness. Some of the defects to be identified are shrinkage, scabs, voids, fusion, flash of metal, metal penetration, pin hole, etc.Finishing processes require removing casted gateways and risers and smooth the part surface. Detail sequences of sand-casting process is shown in Figure 2.1.

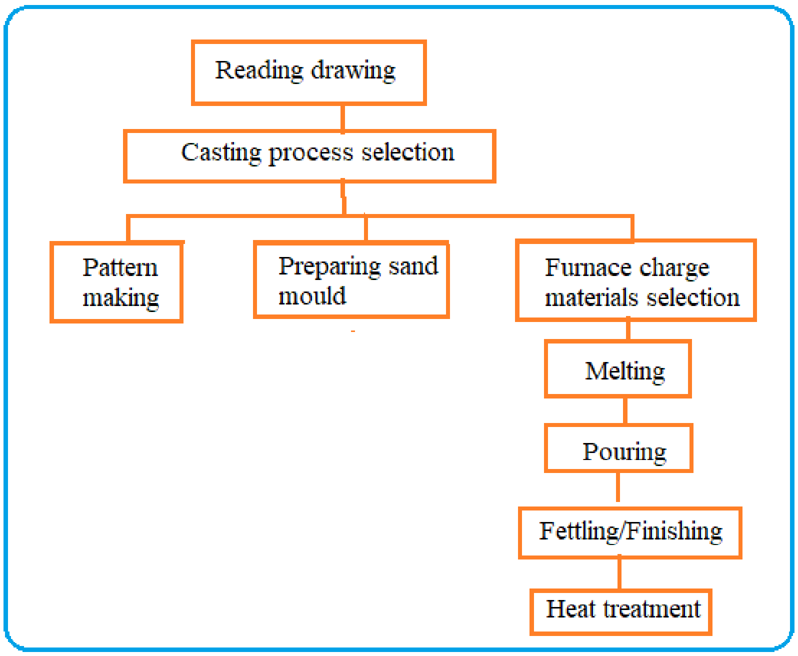


Figure 2.1 Sand casting process sequences

Following each step of casting is crucial to achieve product quality in the casting process. Due to the presence of several parameters including pattern allowance, composition of melting materials, mold factors, sand preparation, melting, cooling time and pouring stepsare all affect the quality of casting. From the previous casting practices, certain improved experiences and steps need to be followed to get quality products. Sand mold making sequence shown in Figure 2.2.

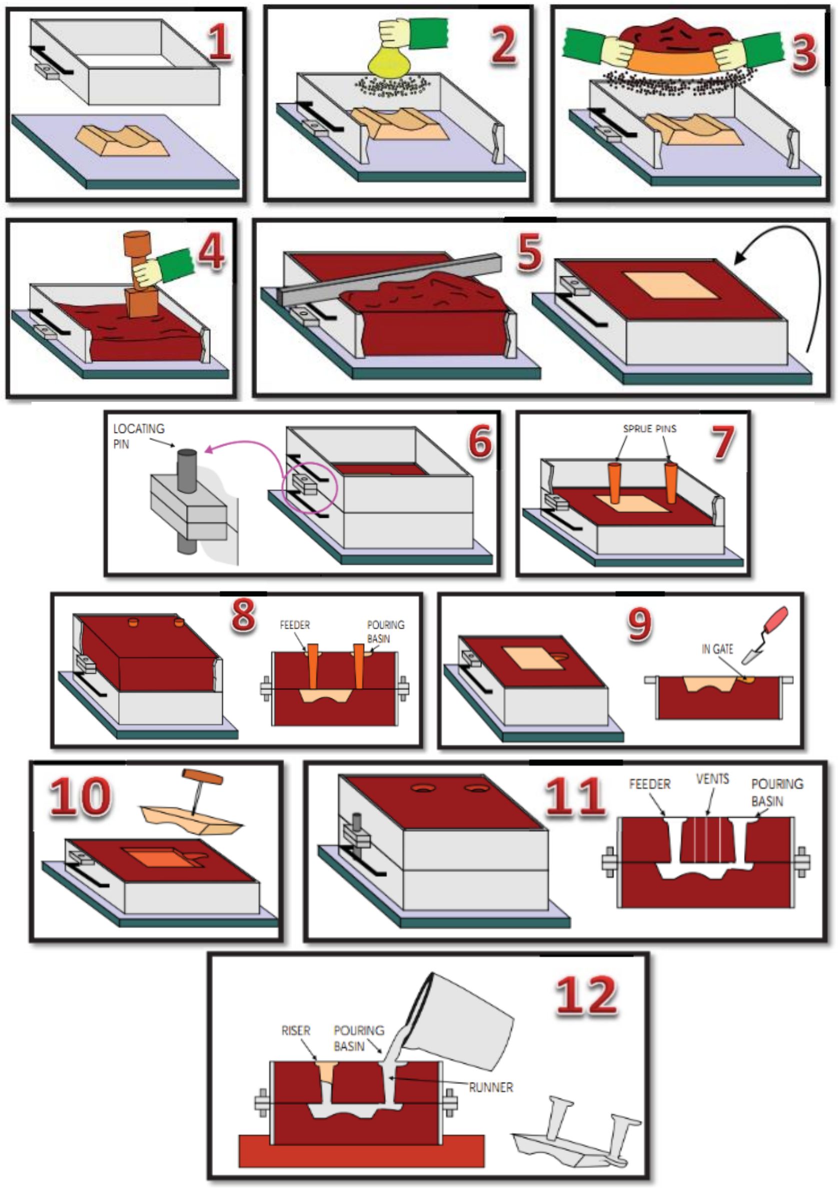


Figure 2.2. Schematic steps of sand-casting process

Self-check-2	Questions related to sequences of sand mold making

Part 1. Give short answer according to the question type.

1. The solidified part is also known as _________.
2. What are the advantages of casting over other manufacturing methods?
3. Write basic considerations of casting operations.
4. List the sequences of the sand-casting mold preparation process in detail.
5. What is the first step of sand-casting mold preparation?

Part 2. Match column "A" with column "B"

"A"	"B"
1) Cast	a) cavity
2) Melting	b) Multi-purpose
3) Pouring	**c)** Procedures
4) Shakeout	d) Solidified part
5) Fettling	e) Filling mold cavity with molten metal
6) Furnace charge	f) Furnace
7) Choosing the type of cast	g) Melting materials
8) Mold	h) Casting process selection
9) Casting sequence	i) Monitoring
10) Versatile	j) fitting of pattern parts

Unit three: Pattern preparation

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Identifying Pattern
- Identifying variety of pattern types.
- Assembling Patterns.
- Inspecting Pattern
- Inspecting finished component.

This unit will also assist you to attain the learning outcomes stated in the cover page.
Specifically, upon completion of this learning guide, you will be able to:

- Identify Pattern equipment.
- Identify variety of pattern types.
- Assemble Patterns.
- Inspect Pattern equipment.
- Inspect finished component.

3.1 Pattern equipment

The pattern is essentially a replica of the object about to be cast. Usually made out of wood, metal or model board, patterns are used to create cavities in molds. It is through pouring molten metal into these molds that aluminum castings are created. There are large number of tools and equipment used in foundry shop for carrying out different operations. The different types of patterns are considered as pattern equipment whereas the way equipment used to make patters is called pattern making tools and equipment. Identifying the right type of pattern is the basic condition for making mold cavity which is the copy of intended cast product.

3.1.1 Wood pattern making equipment

Wooden patterns are made in the woodworking shops from wood. The wooden patterns required skills how to operate woodworking machines and tools. The metal foundries usually use wooden patterns to make cast in the foundry processes.

3.1.2 Mold preparation equipment

There are variety of molding tools and equipment including hand sieve, rammers, flasks, molding board, strike off bar, etc. Sand preparation tools are basically used for preparing the various types of molding sands and core sand.

Melting and pouring equipment

Metal melting equipment includes various types of melting furnaces such as cupola, pit furnace, crucible furnaces, induction furnace etc.

3.2Variety of pattern types

A pattern is a form made of wood, metal, plastic, or composite materials around which a molding material (usually prepared sand) is formed to shape the casting cavity of a mold. Most patterns are removed from the completed mold halves and used repeatedly to make many duplicate molds. Expendable patterns of such materials as wax or expanded polystyrene are made in quantity and are used only once to produce an individual mold. There are variety of patterns utilizing for a specific product and some of the common types of patterns are shown below. Accurate measurement and cutting using the proper cutters, such as a band saw and jig saw, are required during making patterns and other wood materials. When measuring and cutting, different allowances including machining, draft, and shrinkage should be taken into account.

3.2.1 Types of Patterns in Casting

Casting pattern shapes casting mold, and the mold creates metal parts, so the casting pattern is very crucial to the final parts. Therefore, the casting parts designer should consider more product details during the pattern design phrase. Here are bellow common types of patterns used in the foundry shop.

i) **Single Piece Pattern.** Single piece pattern, also called solid pattern is the lowest cost casting pattern. The single piece patterns are perfect for simple and large size casting.

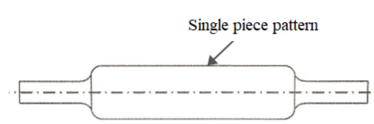


Figure 3. 1Typical single piece pattern

ii) Multi Piece Pattern. Multi piece pattern is a good solution for complex designs. Some castings have difficult shapes, and it is difficult to get the exact mold by using a single piece pattern. So, in such cases, the pattern is slitted into different pieces so that it becomes easy to remove each part of pattern from the mold cavity. This type of pattern is known as multi piece pattern. Generally, threeand above molding boxes are required to make a multi piece pattern.

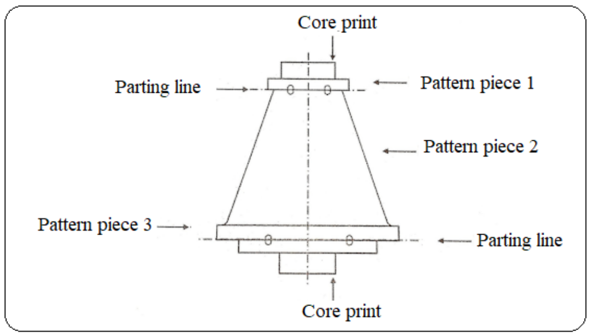


Figure 3.2. Multi piece pattern

iii) Match plate pattern. The match plate patterns are made up of metal and are generally used for mass production of small size castings.Match plate patterns are made in two pieces, like split patterns and to consist of a metallic plate known as match plate.As shown in the diagram, the patterns are mounted on both sides of the match plate.

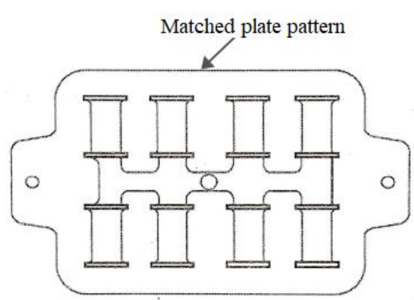


Figure 3.3. Matched plate pattern

iv) Cope and drag pattern. Cope and drag pattern are a split pattern. This pattern has cope and drag on separate plate. Cope and drag pattern have two parts which are separately molded on molding box. After molding parts, these two separate parts are combined to form the entire cavity. Some castings are heavy and large. For such castings, the complete pattern also becomes heavy and it becomes difficult to handle such heavy patterns. So, for such castings, the patterns are made into two parts which are separately molded in different molding boxes.As the molds are prepared, both the boxes are assembled which forms the complete cavity.One of the parts of the mold cavity is called cope and the other part is called drag.In cope and drag pattern, the entire casting is done in an assembled position (as a single piece). While in a two-piece pattern, the casting is done into two pieces.

v) Loose piece pattern.

In order to get some difficult shapes of casting, some patterns are made with loose piece which can be removed later when the mold cavity is formed.The loose pieces are the integral parts of the pattern only, but they are withdrawn back from the mold cavity after removal of the pattern. (See above image).It is little difficult to make a mold cavity using a loose piece pattern and it requires skilled labor.

vi) Gated pattern

In gated pattern, the pattern is used to make multiple cavities, and these mold cavities are connected with each other using gates or runners. The molten metal when poured, gets distributed in each mold cavities and the desired casting is obtained in all the mold cavities. Gated pattern is used for mass production of castings.

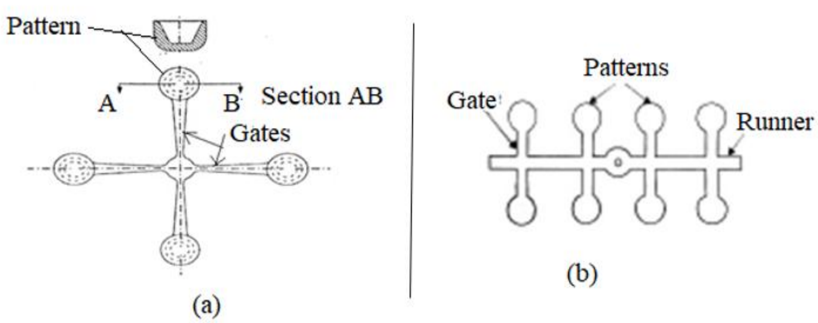


Figure 3.4. Gated patterns

vii) Follow board pattern

There are some patterns which have weak portions and these weak portions even break due to ramming force. In such cases, it is essential to support these weak patterns.So, for supporting these patterns, a special type of pattern is used known as the follow board pattern. In a follow board pattern, the wooden board is used to support the weak pattern, so that it does not break due to ramming force. In simple words, the follow board acts as a seat for the pattern.

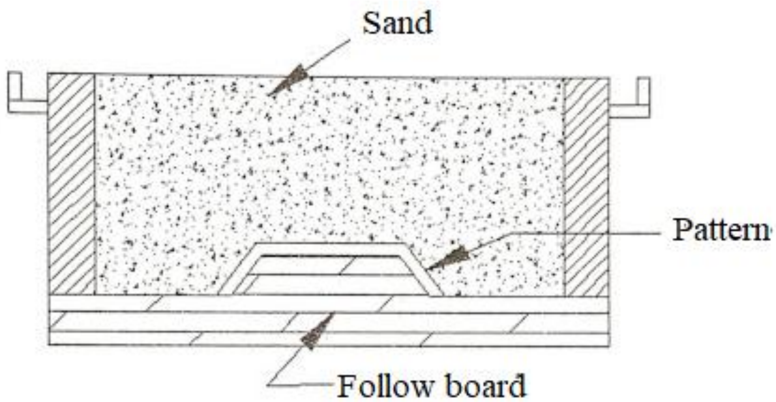


Figure 3.5. Follow board pattern

3.3 Assembling Patterns

When a pattern has many parts, it is necessary to assemble as per the design specifications. At this stage keeping the positions of parting lines and following the general approach of assembling patterns are very important. The pattern should ideally, therefore, be made with full knowledge of the intended production method. It requires molding taper and must incorporate contraction allowances specific to the alloy these may be supplemented by allowances based on the characteristic behavior of certain types of casting design.

3.4 Inspecting pattern

Inspection is made in every stage of pattern making. Inspection of pattern also perform after the final work to ensure quality of the pattern. Visual inspection is commonly utilized to identify the defects of pattern. When the patten has defects, it will appear on the cast product. Hence, a careful inspection is important before trying to utilize the pattern directly for cavity making.

3.5 Inspecting finished casting components

Castings inspection allows foundry products inspected using different mechanisms including visual inspection and microstructural analyses to ensure quality of casted product. Casting inspection methods are in place to ensure any hidden defects are identified during the manufacturing process. Some common casting defects include porosity, shrinkage, cavity, sand inclusion, and shape distortions.

Self-check-3

Part 1. Choose the best answer

1. Mold is a _____.
   a) vertical passage
   b) horizontal passage
   c) connecting passage
   d) cavity
2. Riser is a _____.
   a) vertical passage
   b) horizontal passage
   c) connecting passage
   d) cavity
3. Runner is a ______
   a) the path through which hot molten material comes out of the mold
   b) the path through which hot molten material is poured
   c) connecting passage between mold and riser
   d) none of these
4. Strike off bar is used to_______.
   a) mix the sand
   b) compact the sand
   c) remove the excess sand from the work zone
   d) none of these
5. Sprue pins are tapered so that _______.
   a) pattern can be removed easily
   b) surface can be smoothened easily
   c) the pins can be removed easily
   d) none of these.
6. many small holes are made on the upper surface of the cope box so that _______.
   a) gasses can come out
   b) work zone becomes smooth
   c) for pouring the hot molten metal
   d) none of these

7. The sand used here is known as green sand because_____.
   a) it is green in color
   b) it contains zircon
   c) it contains moisture
   d) none of these
8. Sieve is used for _______.
   a) plaining the surface
   b) for making holes on the surface
   c) for removing the foreign particles
   d) none of these
9. Sprue pins are used for ______.
   a) making the mold
   b) making the cavity
   c) making the vertical passages
   d) none of the above
10. The upper foundry box is known as _____.
    a) drag
    b) cope
    c) none of these
11. The lower foundry box is known as _____.
    a) drag
    b) cope
    c) none of these
12. The swab is used so that _____.
    a) sprue pins can be removed easily
    b) pattern can be removed easily
    c) gate can be made easily
    d) none of these
13. Rammer is used to ____.
    a) compact the surface
    b) mix water with the sand
    c) to make the holes
    d) none of these
14. Vent rods are used for ____.
    a) making cavity
    b) making riser and runner
    c) making small holes on the upper surface of the cope box
    d) none of these
15. The tapper provided to the pattern for its removal is ____.
    a) machining allowance
    b) draft allowance
    c) distortion allowance
    d) none of these

Part 2. Give short answer

1. What is a pattern in metal casting?
2. What is the use of pattern inspection?
3. Mention wood and a pattern pattern-making equipment?
4. List the types of patterns.
5. What is the difference between solid pattern and split pattern.
6. Prepare action plan on how to make a pattern from wood.

Answer key for multiple choiceof self-check-3 (part 1)

1. d	2. a	3. b	4. c	5. c
6. a	7. c	8. c	9. c	10. b
11. a	12. b	13. a	14. c	15. b

Part 3 Match column "A" with column "B"

"A"	"B"
1) Pattern	a) Having multiple cavities
2) Pattern equipment	b) Split pattern
3) Solid pattern	**c)** Single piece pattern
4) Cope and drag pattern	d) pattern material
5) Gated pattern	e) Replica of an object
6) Inspection	f) a casting defect showing reduced size
7) Match plate pattern	g) Used for compensation of shrinkage
8) Assembling pattern	h) used for mass production
9) Shrinkage	i) Monitoring
10) Pattern allowances	j) fitting of pattern parts

Operation sheet-3	Questions related to pattern making

Title: Single piece/solid pattern making

Purpose. Pattern making, assembling and inspecting

Supplies and materials: wood, drawings

Required Tools: vernier caliper, wood lathe, sand paper, jig saw, wood cutters

Procedures:

(1) Reading drawing and instructions
(2) Apply safety and hazard identification in the foundry shop.
(3) Select the wood for pattern making.
(4) Measuring and cutting considering machining allowances
(5) Mount the wood on the wood lathe
(6) Select cutting speed
(7) Select wood cutters
(8) Turn the woodpattern to the size.
(9) Use sand paper for finishing
(10) Clean the work area
(11) Return all tools, and materials in their proper place

Precautions:

- Follow safe working procedures.
- Follow instructions how to use wood machines.
- Consider all pattern allowances.

Criteria- each hand tool and machine must be used for the required operations.

Check sheet

Give short answer for the following questions; (these can be oral question).

1. What are the possible hazards during pattern making in the woodworking shop?
2. How do you select wood pattern?
3. Explain measuring and cutting wood operations considering different allowances.
4. How did you mount the wood on the wood lathe?
5. How did you select cutting speed?
6. Describe wood turning processes during pattern making.
7. Explain how did you turn the wood pattern to the size?
8. What is the purpose of sand paper during pattern making?
9. Discuss the procedures of split pattern making.
10. Describe how you made the alignment pins and holes on the pattern piece that was utilized to put the two parts of the patterns together.
11. Discuss you did you assemble and inspect the pattern.
12. Explain the use of cleaning the work area and returning tools to their places.

LAP Test-3	Split pattern making

Name: ___________________________ Date: _____________

Time started: ______________________ Time finished: ________________

Instruction I: Given the necessary tools, machines and wood material, perform the following task within 4 hours using work standard procedures.

Task 1: After selecting, tools and wood materials, perform different cylindrical shapes of **split pattern** based on the recommended dimensions given by the trainer.

Unit four: Mold and core making

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Core making.
- Closing and checking molds.
- moldingmedia/material.
- molding boxes.
- Manufacturing and positioning Pouringbasins.
- Utilizing,parting and stripping systems
- Positioning and securing vents, risers and runners.
- Removing pattern and loose pieces from mold in a safe manner.
- Cleaning and painting Molds and cores.

This unit will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Measure and cutting wooden components.
- Perform core making.
- Close and checking molds.
- Select appropriate moldingmedia/material.
- Select molding boxes.
- Manufacture and position pouringbasins.
- Utilize,part and strip systems
- Position and secure vents, risers and runners.
- Removepattern and loose pieces from mold in a safe manner.
- Clean and paint molds and cores.

4.1. Performing core making

Core making is the process which forms the interior part of the casting. The mold provides a space for the molten metal to go, while the core keeps the metal from filling the entire space. Cores can be used to extend mold projections to create extra mold sections, or to block out and create negative drafts. Cores are produced by ramming sand into a core box. The finished cores, which can be half, solid or hollow, are inserted into the mold to provide the internal cavities of the casting before the mold halves are joined. A core is a preformed, bonded, sand insert placed into the mold to shape the interior of a casting or a part of the casting that cannot be shaped by the pattern. Cores are frequently used to create hollow sections or cavities in a casting.

Core sand. Core sand is used for making cores and it is sometimes also known as oil sand. This is highly rich silica sand mixed with oil binders such as core oil which composed of linseed oil, resin, light mineral oil and other bind materials. Pitch or flours and water may also be used in largecores for the sake of economy. Cores are compact mass of core sand (special kind of molding sand) prepared separately that when placed in mold cavity at required location with proper alignment does not allow the molten metal to occupy space for solidification in that portion and hence help to produce hollowness in the casting. The environment in which the core is placed is much different from that of the mold. In fact, the core has to withstand the severe action of hot metal whichcompletely surrounds it. They may be of the type of green sand core and dry sand core.

4.1.1 Procedure for core making in metal casting

Core needs its own sand type and core box to get quality core. It has the following detail procedures while manufacturing core.

- Prepare core box according to the design specification to create hollow section.
- Mixing of core sand
- Ramming of core sand
- Venting of core
- Reinforcing of core
- Baking of core
- Cleaning and finishing of core
- Sizing of cores

- Joining of cores

4.2. Closing and checking molds

Mold should be closed safely without affecting the shape and strength of cavity. Mold also needs closing properly to avoid misalignment of mold fittings. It should be closed tightly to control the pressure of molten metal. Thus, closing and checking mold alignment is a preliminary condition before pouring molten metal.

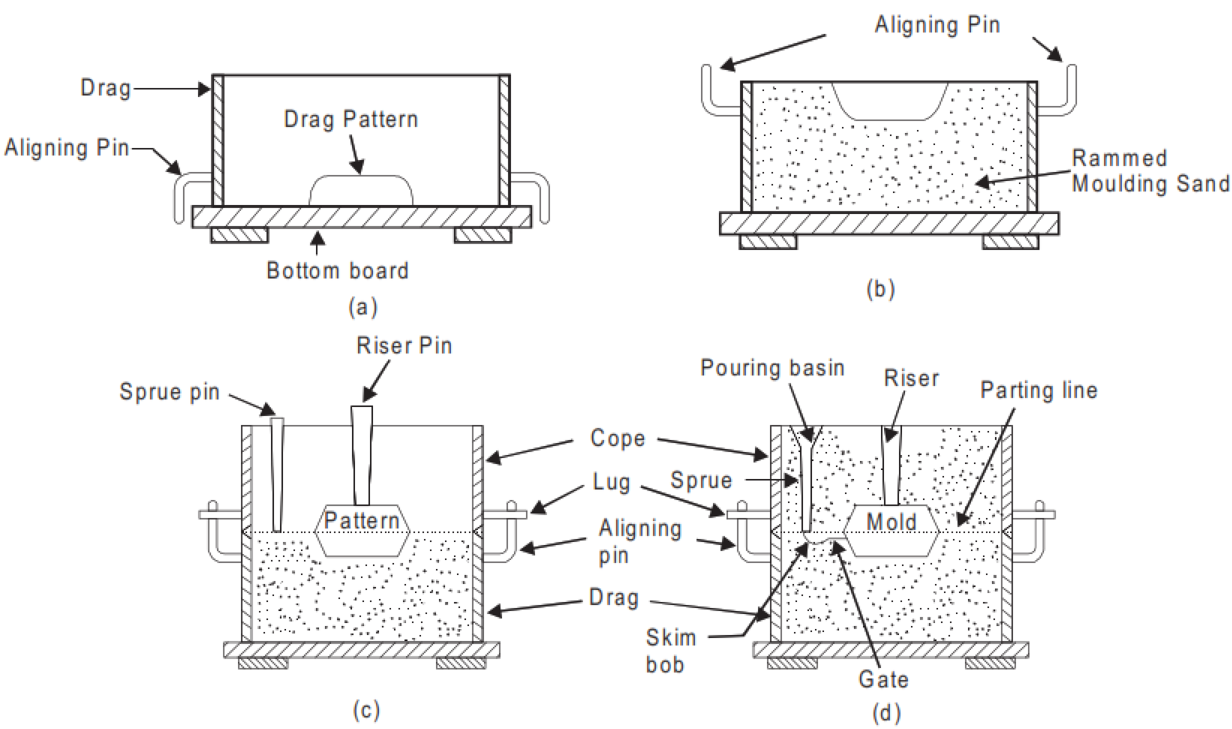


Figure 4.1. Mold making and closing

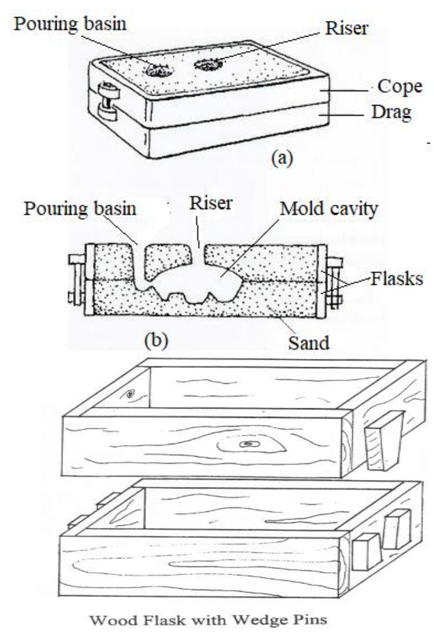
4.3. Selecting appropriate moldingmedia/material.

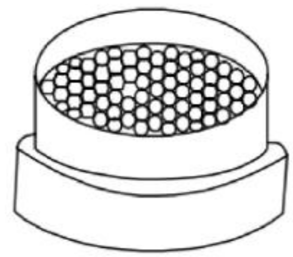
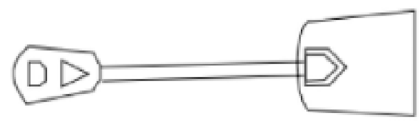
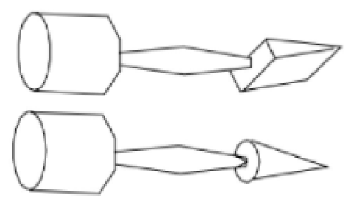
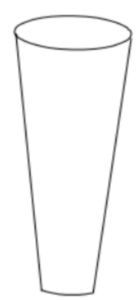
Selecting appropriate mold materials are very important to create the designed mold cavity. Sand, clay, additives and water moisture are basic materials in the process of sand-casting method. There are also alternative mold materials including, foam, wax and other expendable materials. Molding media may include use of a wide range of sands including green sand, shell sand and chemically bonded media. These sand materials/media molded by using different mold making tools.

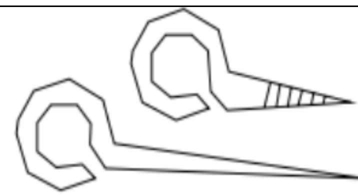
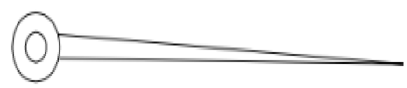
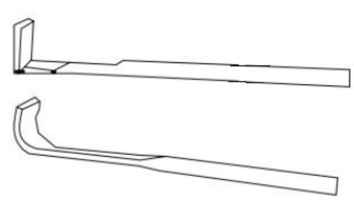
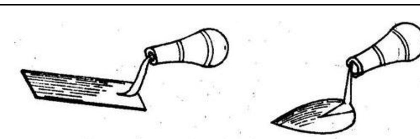
4.3.1Hand tools used in the foundry shop

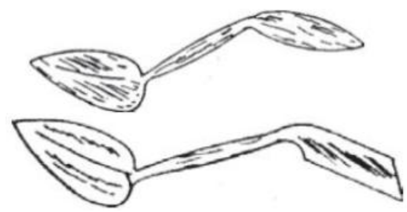
There are variety of hand tools commonly used in the foundry shop including hand riddle, shovel, rammers, hand rammer, pneumatic rammer, sprue pin, strike off bar, mallet, draw spike, vent wire, lifters, trowels, slicks, smoothers, swab, spirit level, gate cutter, bellows, clamps, cotters and wedges etc.General tools and equipment used in sand casting foundry works are discussed as under in Table 4.2.

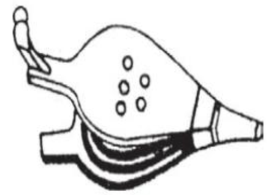
Table 4.2. Foundry tools

Hand tool description	Image of molding tools
1. Flasks Sand molds used in metal casting are called flasks. They are open metal frames that can be held together with pins and guides. They separated during the mold preparation process and placed back together for pouring without losing the original basic Flask. The top frame of the flask is called the cope and the bottom is drag.	 Figure 4.2. Metal and wood flasks
2. Molding board **The molding board-** is a smooth board on which rest the pattern and flask when starting to make a mold. The board should be as large as the outside of the flask and stiff enough to support the sand and pattern without springing when the sand is rammer.	 Figure 4.3. Molding board

3. Hand riddle It used to sieve sand and remove unwanted materials such as stone, iron and wood scrap. Its function also used to riddle the first sand over the pattern before filling the mold with the shovel and ramming.	 Figure 4.4. Riddle
4. Shovel It used to collect, mix and transfer sand**.**	 Figure 4.5. Shovel
5. Rammers They are used to ram the sand into the flask tightly around the pattern.	 Figure 4.6. Rammer
6. Sprue pin Sprue pin is shown in Fig. It is a tapered rod of wood or iron which is placed or pushed in cope to join mold cavity while the molding sand in the cope is being rammed. Later its withdrawal from cope produces a vertical hole in molding sand, called sprue through which the molten metal is poured into the mold using gating system. It helps to make a passage for pouring molten metal in mold throughgating system	 Figure 4.7. Sprue pin

7. Strike off bar Strike off bar is a flat bar having straight edge and is made ofwood or iron. It is used to strike off or remove the excess sand from the top of a molding box after completion of ramming thereby making its surface plane and smooth.	 Figure 4.8. Strike off bar
8. Draw spike It is a tapered steel rod having a loop or ring atits one end and a sharp point at the other. It is used for driven into pattern and with draw from mold cavity.	 Figure 4.9. Draw spike
9. Vent rod/wire Ventingis done prior to the pattern removal. The series of pierced small holes are called vents holes which allow the exit or escape of steam and gases during pouring mold and solidifying of the molten metal for getting a sound casting.	 Figure 4.10. Vent rod/wire
10. Lifters They are used for cleaning, repairing and finishing the bottom and sides of deep and narrow openings in mold cavity after withdrawal of pattern. They are also used for removing loose sand from mold cavity.	 Figure 4.11. Lifters
11. **Trowels.** They are utilized for finishing flat surfaces and joints and partings lines of the mold. They consist of metal blademade of iron and are	 Figure

equipped with a wooden handle.	4.12. Trowels
12. Slicks They are also recognized as small double ended mold finishing tool which are generally used for repairing and finishing the mold surfaces and their edges after withdrawal of the pattern.	 Figure 4.13. Slicks
13. Swab It is a small fiber brush used for moistening the edges of sand mold, which are in contact with the pattern surface before withdrawing the pattern. It is used for sweeping away the molding sand from the mold surface and pattern. It is also used for coating the liquid blacking on the mold faces in dry sand molds.	 Figure 4.14. Swab
14. Spirt level Spirit level is used by molder to check whether the sand bed or molding box is horizontal or not	 Figure 4.15. Spirt level
15. Gate cutter Gate cutter is a small shaped piece of sheet metal commonly used to cut • runners and feeding gates for connecting sprue hole with the mold cavity.	 Figure 4.16. Gate cutter

16. Bellows It is hand operated leather made device equipped with compressed air jet to blow or pump air when operated. It isused to blow away the loose or unwanted sand from the surfaces of mold cavities.	 Figure 4.17. Bellows
17. Clamps, cotters and wedges They are made of steel and are used for clamping the molding boxes firmly together during pouring.	
18. Gate cutter It used to cut a gate or runner in green sand.Gate cutter is a small shaped piece of sheet metal commonly used to cut runners and feeding gates for connecting sprue hole with the mold cavity.	

4.4. Selecting molding boxes

The selection of mold box is depending on the size of the part to be casted. Selection of molding box is important to match the pattern and box sizes which avoids unnecessary mold size utilization. If we use too big mold size for small casting purpose, it takes much volume of sand and consumes time of mold preparation. Thus, the size of mold and the part to be casted must be proportional. It can be achieved by the calculations of the volume of mold and the pattern.

4.5. Manufacturing and positioning pouringbasins

Pouring basin is a reservoir in the top part of a mold into which molten metal is poured. It is important to pour the molten metal in it. It has different size and shape depending on the design of gating system. Pouring basin receives molten metal and lets the molten metal to the sprue without turbulent flow. It reduces the flow of slag into the sprue and supplies uniform amount of liquid metal (see figure below).

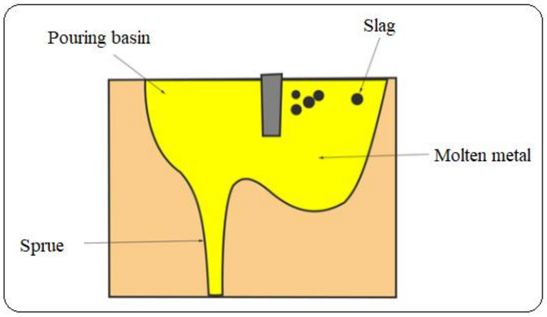


Figure 4.18. Pouring basin sectional view

4.5.1 Gating system

Gating system is very important in the foundry works. Designing a gating system requires careful consideration according to the technology, materials, and castings. This system determines the flow rate of metal to the mold cavity. If the flow rate is too fast, there is a risk of corrosion while if the speed is too slow it can cause the metal to be cool before filling the chamber, which directly affects the quality of the casting. The shape and size of the gating system in casting are properly arranged when making the mold. If the gating system is not designed properly, it can cause severe casting defects.

1. Pouring basin

It is the conical hollow element or tapered hollow vertical portion of the gating system which helps to feed the molten metal initially through the path of gating system to mold cavity. It may be made out of core sand or it may be cut in cope portion of the sand mold. It makes easier for the ladle operator to direct the flow of molten metal from crucible to pouring basin and sprue. It helps in maintaining the required rate of liquid metal flow. It reduces turbulence and vertexing at the sprue entrance. It also helps in separating dross, slag and foreign element etc. from molten metal before it enters the sprue.

2. Sprue. It is a vertical passage made generally in the cope using tapered sprue pin. It is connected at bottom of pouring basin. It is tapered with its bigger end at to receive the molten metal the smaller end is connected to the runner. It helps to feed molten metal without turbulence to the runner which in turn reaches the mold cavity through gate.

3. Gate

It is a small passage or channel being cut by gate cutter which connect runner with the mold cavity and through which molten metal flows to fill the mold cavity. It feeds the liquid metal to the casting at the rate consistent with the rate of solidification.

4. Choke

It is that part of the gating system which possesses smallest cross-section area. In chokedsystem, gate serves as a choke, but in free gating system sprue serves as a choke.

5. Runner. It is a channel which connects the sprue to the gate for avoiding turbulence and gas entrapment.

6. Riser

It is a passage in molding sand made in the cope portion of the mold. Molten metal rises in it after filling the mold cavity completely. The molten metal in the riser compensates the shrinkage during solidification of the casting thus avoiding the shrinkage defect in the casting. It also permits the escape of air and mold gases. It promotes directional solidification too and helps in bringing the soundness in the casting.

7. Chaplets

Chaplets are metal distance pieces inserted in a mold either to prevent shifting of mold or locate core surfaces. The distances pieces in form of chaplets are made of parent metal of which the casting is. These are placed in mold cavity suitably which positions core and to give extra support to core and mold surfaces. Various types of chaplets are shown in the figure below.

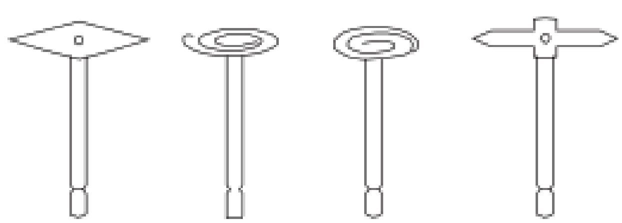


Figure 4.19. Chaplets

Pouring basin can be manufactured depending on the features of cast material. It has variety of size and shape and determined during in the design of gating system (see Figure below).

Optimum mold filling time with molten metal

The mold filling time is extremely crucial since it affects the final quality of the output. A slow fill leads to mis-runs and cold shuts, whereas a quick fill can bring about gaseous and solid inclusions. The optical mold filling time can be computed. The final function of the product, the pouring temperature die casters use, the weight and minimum section thickness of the casting, as well as the velocity of the molten metal play a role in determining the filling time.

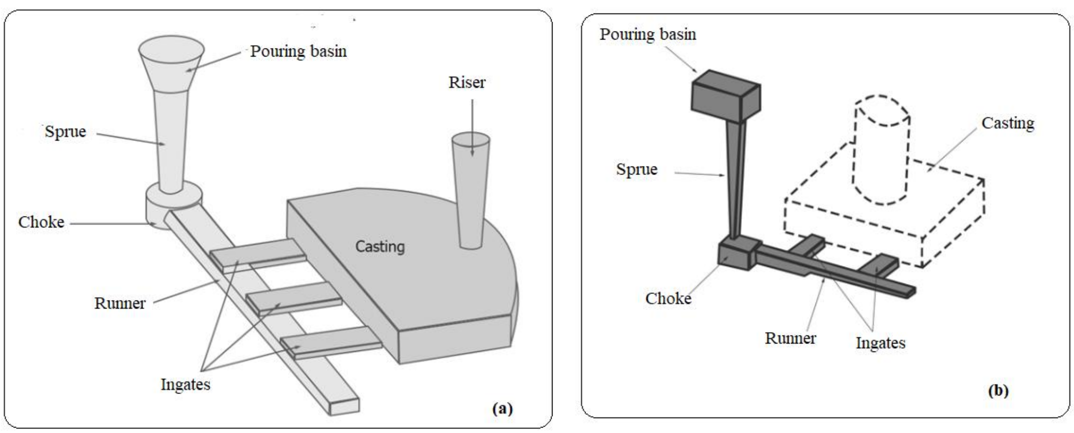


Figure 4.20. Variety shapes of pouring basin and arrangements of gating system elements

In sand casting, the metal pouring system is extremely crucial because its layout affects the quality of the casting and reduces metal wastage on the pouring system.In the above figure, the gating system in casting is designed to get the following functions:

- Fill the mold cavity with enough metal in the shortest time without having to increase the metal temperature.
- The metal flows smoothly, minimizing turbulence that causes air trapping during casting.
- The gating system sets the appropriate temperature range so that during the metal cooling process, shrinkage will occur in the gating system, not in the casting parts.

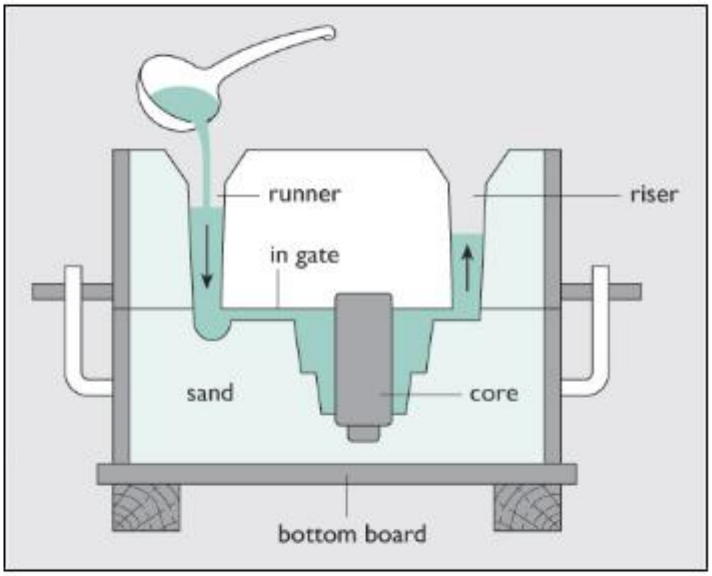


Figure 4.21 Sand mold casting having core

4.6. Parting and stripping systems

The parting line is the boundary where the cope, drag and the part meet. If the surface of the cope and drag are planar, then the parting line is the outline of the cross-section of the part along that plane. You can easily see the parting line for many cast and molded parts that you commonly use. It is conventional that the parting line should be planar, if possible.

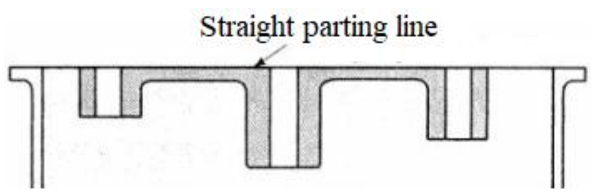


Figure 4.22. Parting line

A very small of metal will always "leak" outside the mold between the cope and the drag in any casting. This is called the "flash". If the flash is along an external surface, it must be machined away by some finishing operation. If the parting line is along an edge of the part, it is less visible this is preferred.

A parting line, metal casting using molds, is the border line in which draft angles change direction. One can check the parting line in the mold or product which divides the two halves, i.e.; the core and the cavity of a molded part. It is sometimes a starting point for the mold parting surface. Parting line is important to separate upper and lower molds after mold preparation has finished. It protects the two molds not to stick together while ramming. Parting sand is utilized to protect molds not to stick together. After the lower part of mold is filled and strike off unnecessary sand, the parting sand is usedto cover the mold and pattern with a thin layer. Stripping is using thin flat section used for making parting line in the process of mold assembling. Stripping is a physical separation process of molds.

4.7. Positioning and securing vents, risers and runners

Positioning gating system components including pouring basin, sprue, runners, gate and risers are important factors in the production of quality castings and should be fully considered in the design and construction of patterns. Gating provides for the efficient flow of the molten metal into the mold cavity. Risers are large reservoirs of molten metal attached to the casting. They provide sufficient liquid metal to the casting as it solidifies to prevent internal shrinkage cavities or shrinkage defects in the casting.

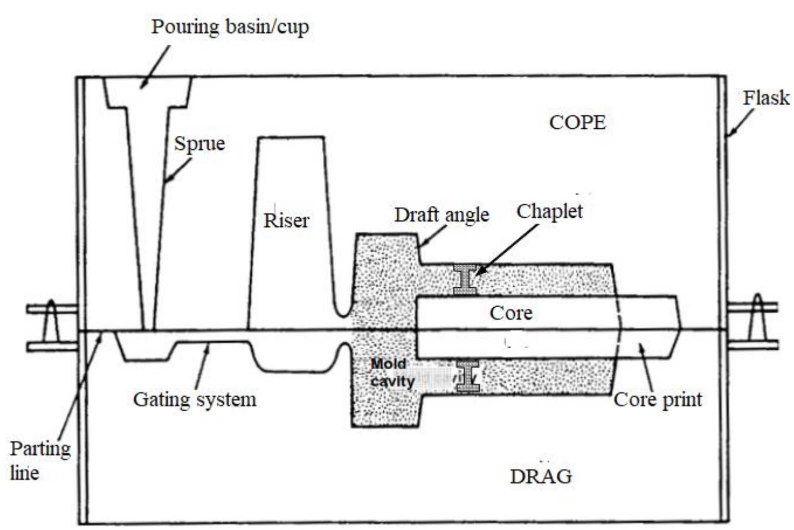


Figure 4.24. Positioning riser, sprue and core

Vents. These are used after the mold is filled with the sand. The function of venting is to allow the gas to escape from the mold. It protects the mold from blowing while pouring molten metal into the cavity and allows for colling of the cast.

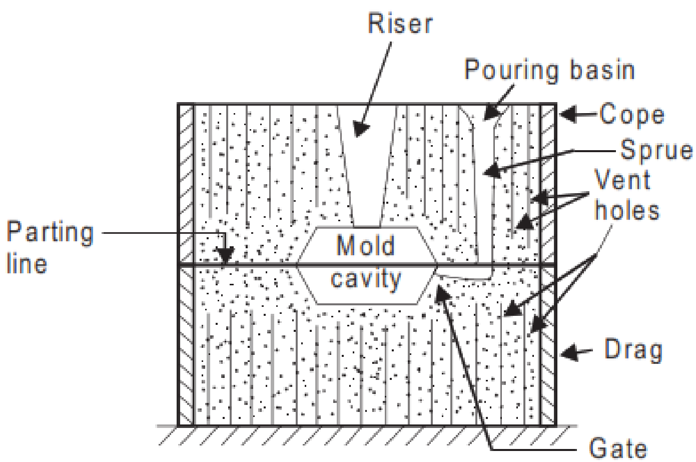


Figure 4.25 Venting of holes in the mold

Riser. The function of riser is to ensure the filling of mold cavity with molten metal and compensates the size of cast to protects shrinkage.

Runner. It controls the flow of molten metal and lets to the gate minimizing turbulent flow**.**

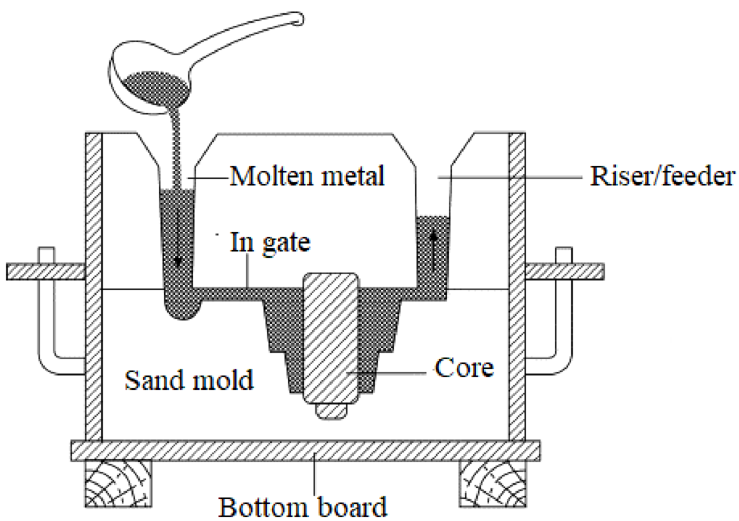


Figure 4.26. Sand casting process

4.8. Removing pattern and loose pieces from mold

After the mold has filled with the sand and all the sequences of molding have well done, pattern and loose pieces are necessary to remove safely from the mold. It requires a careful attention while removing patters from the mold. Using appropriate pattern removing tools and procedure are important while taking out the pattern without damaging the mold cavity.

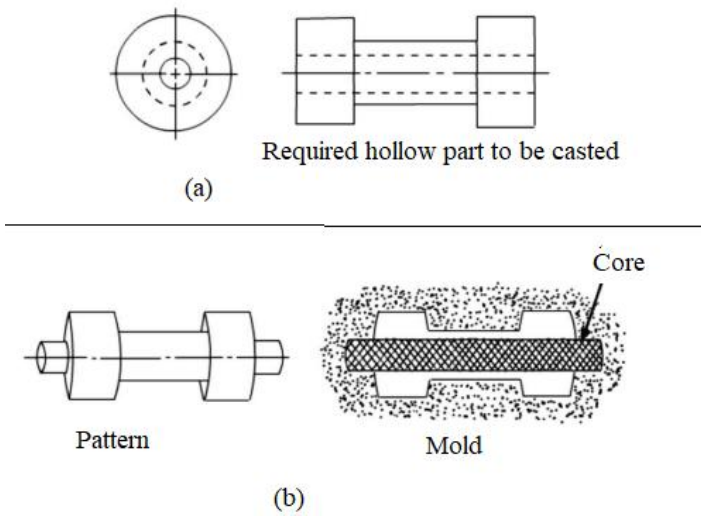


Figure 4.23. Pattern and core arrangement in the mold

A separate sand core is set in place if the casting is to be hollow, such as a thin-walled cylinder, so that the melt cannot fill the casting's open space (e.g., the inside of the cylinder). These sand cores perform a similar function in sand casting as side cavities and side cores do in injection molding and die casting, namely, they provide geometric elements that are difficult to achieve with a traditional two-piece mold or pattern. Once the core or cores are in position, the other half of the mold box is then placed on top as the component geometry grows more intricate and additional cores are needed to produce the geometric shape.

4.9. Cleaning and painting Molds and cores

After patterns are safely removed from the mold, cleaning the mold and painting mold and cores is very important to get smooth surface cast product. Non-stick paint, including mullite-corundum fireclay, electro-corundum, zircon concentrate, clay, kaolin, etc. can be used for painting of mold and core to produce smooth surface. Core is manufactured by using core box. The issues of assembly positioning and precision must be taken into account because when the sand molds (cores) are made from sand, they are frequently separated into many sections to be processed separately and the sand cores are, respectively, pulled out to be assembled.

Sand casting is a process in which a sand mold is formed by packing a mixture of sand, a clay binder, and water around a wood or metal pattern that has the same external shape as the part to be cast. A pattern can come in two halves: a top half (called a cope) and a bottom half (called a drag). Each half is placed in a molding box, and the sand mixture is then poured all around the pattern. After the sand is packed, holes, which are used to pour the molten metal into the mold (sprue) and to be used as a reservoir of molten metal (risers), are formed in the sand. Vents are also created in order to allow the escape of gases from the melt. Then the pattern is removed and a runner system or small passageway is created inside the die through which the melt can flow and be distributed. Gates are the sections where the melt enters the impression. Thus, sprues feed the runners, and the runners feed the gates.

The main reasons for using coatings are 1) to eliminate metal penetration and burned-on sand; and 2) to improve as-cast surfaces, particularly on molds and cores made with no-bake systems. The improved as-cast surface achieved by the use of coating is often destroyed by rough handling and shotblasting during the cleaning process; an indication that future improvement in coating composition and practice must go hand-in-hand with improvement in cleaning methods and handling practice. Coatings as used are composed of two distinct components: a refractory powder and a liquid, with minor additions of binders, suspending agents and preservatives. Coating a core or mold entails the deposit of refractory powder on the surface of the sand in the form of a dense continuous film. The paint-like application of the film is derived from the liquid and is the only function it serves. Once the refractory is transported and deposited on the sand surface, the liquid has accomplished its function and must be totally re-moved or it will cause casting defects

The selection available for suspending and binding refractory powders is endless; each manufacturer favors and selects a few that in his opinion enhance various desirable properties, such as suspension, hardness of the coating film, wetting of the core surface, etc. In the interest of consistency and reproducibility, it is this writer's opinion that a minimum of non-refractory materials should be used. When a coating is applied to a sand surface, the aim is to form a continuous thick dense refractory film that is well-anchored to the sand. This film will act as a barrier to the hot penetrating metal. Thickness, density and pore size are factors that determine the ability of this film to prevent penetration. Obviously, the higher the solids content, the more solids will be deposited on the surface of the sand upon drying. In addition, shrinkage is reduced and packing of the refractory powder is at its maximum.

Self-check 4.1

Give short answer part 1

1) List the procedures of core making.
2) What is the function of core?
3) Explain the procedures of core sand preparation?
4) What is the difference core sand and molding sand?
5) Write core making processes with their types.
6) Discuss how to remove patterns and cores from the mold without affecting the cavity.
7) What is the use of venting during sand mold making?
8) Enlist foundry tools and write their functions.
9) Write sand mold making processes.
10) What is the function of riser?
11) Differentiate casting and forging.
12) Discuss pattern materials with reasons.

13) Discuss properties of molding sand.
14) Discuss types of cores used in Foundry.
15) Explain gating system with its elements.
16) Discuss casting defects with causes and remedies.
17) Explain investment casting procedure in detail.
18) Describe the green sand molding-making process in detail.
19) Describe various types of sands used in mold making.
20) Write a brief note on pattern materials.
21) Dictate any four required properties of molding sand.
22) Discuss some of the functions of a sprue.
23) Define pattern. State the functions of a pattern.

Choose the best answer part 2

1. ______ forms a sear in mold on which the sand cores rests during pouring.
   A. Pattern B. sand C. core D. core print
2. Which of the following is a property of core material used in a foundry?
   B. Appropriate for long production B. low weight C. reusable D. core print
3. The use of cire is always dependent on the type of sand used.
   C. True B. false
4. The _____ is responsible for cavities in casting in the foundry.
   D. Pattern B. sand C. cores D. riser
5. A core is a dispensable item but it can be reused from time to time.
   E. True B. false
6. __________ cores cannot make long narrow features.
   F. Green sand B. dry sand C. metallic D. lost
7. Binders are added to increase the strength of the core.

A. True B. false

8. Sand casting is one of the following types:

   (a) expendable mold (b) permanent mold?

9. The upper half of a sand-casting mold is called which of the following:

   (a) cope or (b) drag?

10. In foundry work, a runner is one of the following:

    (a) a channel in the mold leading from the down sprue to the main mold cavity,

    (b) a foundry man who moves the molten metal to the mold,

    (c) the vertical channel into which molten metal is poured into the mold?

11. Turbulence during the pouring of the molten metal is undesirable for which of the following reasons (two best answers):

    (a) it causes discoloration of the mold surfaces,

    (b) it dissolves the binder used to hold together the sand mold,

    (c) it increases erosion of the mold surfaces,

    (d) it increases the formation of metallic oxides that can become entrapped during solidification,

    (e) it increases the mold filling time, and

    (f) it increases total solidification time?

12. Used sand can be utilized again for another casting by reclaiming the sand.

    (a) True (b) False

Part 3 Match column "A" with column "B"

"A"	"B"
1) Sprue	a) unwanted occurrences on the cast
2) Riser	b) used to make hole
3) core	**c)** horizontal passage of molten metal
4) Mold	d) Cavity
5) Casting defects	e) Vertical passage of molten metal
6) Binder	f) used to ram sand
7) Rammer	g) Bentonite

8) Cope	h) used for finishing of mold.
9) Drag	i) upper flask
10) Trowels	j) lower flask
11) Gate	k)Hollow vertical portion of gating system
12) Pouring basin	l) small channel of molten metal
13) bellows	**m)** used for repairing and finishing the mold cavity
14) slicks	n) blow away the loose sand from cavity
15) Draw spike	o) sand compositions
16) Molding media	p) used for with draw pattern
17) Closing mold	q) used to make small holes in the mold for gas escaping
18) Core sand	r) used for making core
19) Vent rod/wire	s) aligning mold flasks

Operation sheet 4.1	Core Making

Purpose. Making core to create internal hole

Supplies and materials: core sand, clay, water, binder, drawings

Required Tools:

- Balance
- Foundry hand tools
- Drawings
- Caliper
- Core box

Procedures of core making:

1. Select the type of core sand.
2. Select foundry tools
3. Apply safety and hazard identification in the foundry shop.
4. Select type of core sand

5. Measure the amount sand, water and clay as per mixing ratio using volume calculation and direct measuring.
6. Make a core in the core box.
7. Clean the work area
8. Return all tools, used sands and materials in their proper place

Precautions:

- Follow safe working procedures.
- Follow instructions.

Criteria- each tool must be used for the required operations.

Check sheet

Give short answer for the following questions; (these can be oral questions).

1. How did you elect the type of core sand?
2. List all the required foundry tools.
3. What are the possible hazards in the foundry?
4. How did you select type of core sand?
5. Explain the way how to prepare core sand?
6. List the procedures how to make a core in the core box?
7. What are the purposed of cleaning the work area?
8. What are the purposes of returning all tools, used sands and materials in their proper place.

Operation sheet 4.2	Mold Making

Title: Mold making

Purpose: Making sand mold cavity using different patterns following standard procedures.

Supplies and materials: sand types, clay, water, binder, drawings

Required Tools:

- Balance for measuring mass, and percentage weight calculation
- All foundry tools used for sand mold making
- Muller
- Variety of patterns
- Gloves
- Goggles

Procedures:

The following steps indicating detail sand casting mold preparation procedures.

- Selecting pattern

- Getting materials sand materials.
- Sieve the sand.
- Mix the sand, clay, additives and water.
- Checking the green sand strength by hand squeezing and when it is divided into two halves without fraying, the required sand strength is obtained. Now the sand is ready for use.
- Put the molding board on the table.
- Put the drag upside dawn on the board.
- Put the half pattern of rod is putting down.
- Put the parting compound on the board and as well as on the patterns.
- Using sieve, cover the patterns by facing sand up to 20 mm.
- Ram by hand carefully to position the patterns and fill the drag using molding sand with proper ramming.
- Remove the excessive sand from the drag using strip of metal.
- Put the bottom board on the drag and turn it upside down (normal drag position)
- Put the cope on the drag and align the half pattern of the rod using dowel pin.
- Determine the sprue and riser locations. Here, you can used common sprue, riser and gate so as to cast the two pieces at the same time.
- Spray parting compound over the pattern, sprue and riser as well as the whole surface of the mold.
- Locate the riser at the thick position that is near to the block.
- Using the sieve cover the surface of the pattern with facing sand up to 20 mm this helps to get smooth surface cavity.
- Ram this sand by hand carefully.
- Fill the remaining part with molding sand and ram properly.
- Remove excessive sand from the cope using metal strip.
  - Cut sprue basin and venting the mold with vent wire for the purpose of gas escaping.
  - Remove sprue and riser safely.
  - Making vent for the evolution of gas

1. Separate the cope and drag with great care not to damage the cavity

2. Cut the runners
3. Remove patterns
4. Remove loose sand from cavity.
5. By using blower clean cavities
6. Coat mold and/or core
7. Allow the mold to dry.
8. Close the cope to drag with care
9. Align and tight the cope to the drag
10. Clean work area

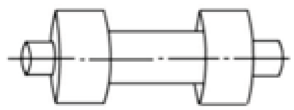
LAP Test-4.1	Core& Mold making

Name: ___________________________ Date: _____________

Time started: _____________________ Time finished: ________________

Instruction I: Given the necessary tools, machines and wood material, perform the following task within 4 hours using standard work procedures.

Task 1: After selecting, tools and wood materials, perform half core based on the recommended dimensions given by the trainer.



Pattern

Figure 4.27 Split pattern when assembled

Task 2: Perform cylindrical core using core-print/core box based on the dimensions given by the trainer

Instruction II: Given the necessary tools, machines and wood material, perform the following task within 4 hours.

Task 1: After selecting, sand, additives, tools and pattern materials, and all other necessary equipment, perform mold cavity based on the recommended pattern dimensions given by the trainer.

Unit five: Clean and restore work area

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Clearing all materials/debris and work site
- Disposing of unwanted treated sand.
- Checking foundry of safe work practices.

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Clear all materials/debris and work site
- Dispose of Unwanted treated sand.
- Check foundry of safe work practices.

5.1 Clearing all materials/debris and work site

After all thecasting operations havedone, work area should be cleared at the end of processcasting activities. The used sand, and other remains materials should be kept properly for recycling purpose and removed the unnecessary materials from workshop.

5.2 Disposing of unwanted treated sand

The quality of sand decreases when used several times for casting purpose. The used sand must be disposed to the selected area in order not to affect the environment. It needs proper site for disposing of used sand. The best approach to getting rid of sand is to get in touch with the relevant government body, related to environmental and health safety. They'll make sure to set the sand in a safe and secure manner.

5.3 Checking foundry of safe work practices.

After all the necessary casting procedures have done properly, checking safe work practice is important to get good experiences from the previous works and corrections to be undertaken. Safety includes on pattern preparation, mold preparation, mold alignment during closing, melting and pouring stages. This can help to improvequality for the next casting operations.

Self-check 5	Cleaning and restoring work area

Part 1. Give short answer

1) write a paragraph about the use of clearing all materials/debris from work area.

2) Discuss the ways how to dispose of unwanted treated sand. Where to dispose.

3) How do you check safe work practices in the foundry shop.

4) write a report containing minimum 6 pages about basic foundry operations. Include sand types,

pattern types, advantage of molding tools, core making, mold making, safety, etc. in your report.

5) Is that possible to reuse the used sand? How? Explain in detail.

Part 2. Match column "A" with column "B"

"A"	**"B"**
1) Disposing sand	a) Working foundry processes considering safety
2) Foundry safe work practice	b) Inspecting
3) Checking	**c) G**etting rid of sand
4) Debris	d) Reusing materials
5) Recycling materials	e) Factory
6) Foundry man	f) Scrap remains in the workshop
7) Foundry	g) Person who works casting
8) Mold preparation	h) Preparing the area for work
9) Restoring work area	i) Mold making

Part 3. Choose the best answer

1. In working at the foundry, the risk of getting injuries is inversely proportional to the frequency of exposure to the worker.

   a) True b) False

2. Improper controlling of hazards in the foundry can lead to the occurrence of serious health problems to the workers.

   a) True b) False

   3. Which of the following hazards presence in the foundry is responsible for lung disease to the workers?

   a) Noise c) Heat

   b) Metal splashes d) Dust

4. To control dust in the foundry during casting processes, it is dumped or mixed with water to reuse it for the preparation of mold.

   a) True b) False

5. Which of the following processes is used for recycling of silica sand or dust in foundry during the casting process?

a) Radiography c) Abrasive blasting process

b) UV method d) Finn method

6. In the foundry during casting processes, carbon monoxide gas is produced only by the furnaces.

a) True b) False

7. Which of the following operations in the production of castings gives rise to excessive noise in the foundry?

a) Pouring c) Coating

b) Shakeout d) Melting

Answer key

1) b 2) a 3) d 4) a 5) c 6) b 7) b

Reference

[1] R. Ganesh Narayanan, "Manufacturing Technology-I (3-0-0-6) Introduction to manufacturing processes," 2007.

[2] C. Making, "Mold and core making. 2005.

[3] A. Bührig-Polaczek and H. Träger, "Foundry Technology," Ullmann's Encycl. Ind. Chem., 2012,

[4] H. Träger and A. Bührig-Polaczek, "Foundry Technology," Ullmann's Encycl. Ind. Chem., 2000,

[5] Stephen D. Chastain, "Metal casting: A Sand Casting Manual for the Small Foundry, Vol. 1." 2004.

[6] P. L. Jain, Principles of Foundry Technology. 2003.

የሥራ እና ክህሎት ሚኒስቴር
MINISTRY OF LABOR AND SKILLS

The trainers who Prepared TTLM of Foundry works for L-I

TTLM	ስም	የትምህርትደረጃ (A,B or C)	የተመረቁበትየሙያዓይነት	የመጡበትክልል	የተቋም/የኢንዱስትሪስም	ሀላፊነት	ስልክቁጥ
Level 1	1. Zerihun Negash	A	Manufacturing Technology Mgt	Dire Dawa	Ethio-Italy PTC	Dept Head	9137986
	2. Abebe Mamo	B	Manufacturing Technology Mgt	Harari	Harar PTC	Dept Head	9855439
	3. Dessalegn Ahimed	A	Manufacturing Technology Mgt	Addis Ababa	Federal TVT Institute	Trainer	9245499