RQF LEVEL 3

MATBC301

MANUFACTURING TECHNOLOGY

Basic Sand Casting

TRAINEE'S MANUAL

October, 2024

BASIC SAND CASTING

KOICA Korea International Cooperation Agency

TQUM TVET Quality Management Project

2024

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TABLE OF CONTENT

ACRONYMS

Cm: Centimeter

°C: Degree Celsius

IC: Indicative Content

°F: Degree Fahrenheit

g/cm³: Grams per Cubic Centimeter

Hrs: Hours

MATBC: Manufacturing – Basic casting.

mm: Millimeter

PPE: Personal Protective Equipment.

PH: Potential of Hydrogen.

PVC: Polyvinyl Chloride

Ltd: Limited

RTB: Rwanda TVET Board

SOP: Standard Operating Procedure.

SiO2: Silicate

TQUM: TVET Quality Management Project

INTRODUCTION

This trainee's manual includes all the knowledge and skills required in manufacturing process specifically for the module of **"Basic Sand Casting ".** Trainees enrolled in this module will engage in practical activities designed to develop and enhance their competencies. The development of this training manual followed the Competency-Based Training and Assessment (CBT/A) approach, offering sample practical opportunities that mirror real-life situations.

The trainee's manual is organized into Learning Outcomes, which is broken down into indicative contents that includes both theoretical and practical activities. It provides detailed information on the key competencies required for each learning outcome, along with the objectives to be achieved.

As a trainee, you will start by addressing questions related to the activities, which are designed to foster critical thinking and guide you towards practical applications in the labor market. The manual also provides essential information, including learning hours, required materials, and key tasks to complete throughout the learning process.

All activities included in this training manual are designed to facilitate both individual and group work. After completing the activities, you will conduct a formative assessment, referred to as the end learning outcome assessment. Ensure that you thoroughly review the key readings and the 'Points to Remember' section.

MODULE CODE AND TITLE: MATBC301 BASIC SAND CASTING

Learning Outcome 1: Prepare for casting process.
Learning Outcome 2: Carryout Aluminium with its alloys casting.
Learning Outcome 3: Perform post-casting activities.

Indicative contents

1.1 Introduction to Casting.

1.2 Identification of Safety and Security Measures.

1.3 Identification of Materials, Tools, and Equipment

1.4 Pre-casting activities.

Key Competencies for Learning Outcome 1: Prepare for casting process.

Knowledge	Skills	Attitudes
• Definition of casting key terms used in casting • Identification of workplace hazard types • Identification of hazards preventions • Identification of workplace signs and symbols • Description of casting materials, tools, and equipment.	• Applying of safety signs and symbols. • Applying casting principles. • Cleaning of casting tools and equipment. • Lubricating casting equipment • Adjusting casting tools, and equipment	• Being attentive in safety sign and symbols application • Being obedient during hazard identification • Having Integrity in cleaning technics • Having Teamwork spirit during casting process • Being Flexible in casting tools and equipment adjustment • Having Self-improvement in casting preparation

Duration: 10 hrs.

Learning outcome 1 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Describe clearly the casting terminologies used in the manufacturing process.
2. Identify correctly safety measures applied at workplace during the casting process.
3. Identify correctly hazards prevention methods used during sand casting process.
4. Identify properly workplace signs and symbols to be use in sand casting
5. Apply correctly safety measures at workplace during casting process.
6. Identify properly the types of materials, tools and equipment used during the casting process.
7. Select correctly casting materials, tools and equipment used in casting process
8. Adjust effectively tools and equipment used in sand casting process.
9. Lubricate appropriately casting tools and equipment to be used in casting process preparation

Resources

Equipment	Tools	Materials
• PPEs • Sand Mixer • Fire fitting equipment's • Furnace • First aid kit • Pattern, • Moulding box	• Tape measure • Vernier calliper • Spirit level, Knife • Diagonal clamps • Shovel, mallet • Strike off bar. • Blowers / aspirator	• Sand • Aluminium ingots • Additives • Cloth rags

Indicative content 1.1: Introduction to Casting.

Duration: 2hrs

Theoretical Activity 1.1.1 Definition of key terms used in casting process and its working principles

Tasks:

1: Answer the following questions:

i. What do you understand about the key terms used in casting?
   - ✓ Metal casting process
   - ✓ Foundry
   - ✓ Casting
   - ✓ Mould
   - ✓ Pattern
   - ✓ Moulding material
   - ✓ Flask
   - ✓ Mould cavity

ii. Describe the working principle and application of sand casting?

iii. State the advantages and disadvantages of sand casting?

2: Provide the answers for the asked questions and write them on your papers.

3: Present your findings/answers to the whole class.

4: Take notes on trainer clarifications and ask questions if any.

5: Read the key readings 1.1.1.

Key readings 1.1.1: Definition of key terms used in casting process and its working principles

- **Definitions of key terms used in casting process:**

✓ **Casting:** is a traditional manufacturing process. It involves **pouring molten material into a pre-designed mold to create solid objects**. The mold is usually made of materials like sand, metal, or ceramic.

✓ **Casting process:** is a basic manufacturing procedure that entails molding molten material into the desired shape inside of a mold. There are different types of casting processes, including **sand casting**, **die casting**, and **investment casting**.

✓ **Metal casting process:** is a process in which hot liquid metal is poured into a mould that contains a hollow cut out or cavity of the desired finished shape and

the liquid metal is then left to solidify, which is removed from the mould, revealing the product, or the **"Casting Form".**

- ✓ **Foundry:** is a factory/workshop where casting produced by melting metal, pouring liquid metal into a mould, and then allowing it to solidify. There are different types of foundries, such as **sand, investment, die, and centrifugal foundries**, depending on the moulding material and method used.

- ✓ **Mould:** is a hollow form that is used to shape a liquid material, usually metal, into a desired product by letting it solidify. There are different types of casting mould, such as permanent, flexible, and evaporative.

- ✓ **Pattern:** is a model of the object that is cast used to form the mould cavity where the molten metal is poured. The pattern must account for various factors, such as shrinkage, distortion, draft, and machining allowance. The pattern can be made of different materials, such as wood, metal, plastic, or wax.

- ✓ **Molding material:** is the substance that is used to create the mold cavity where the molten metal is poured to form the casting. There are different types of casting molding materials, such as **sand, plaster, metal, and silicone**.
- ✓ **Flask:** is a frame that holds the mold cavity in place during metal casting. It usually consists of two parts: the cope (upper part) and the drag (lower part). The flask

can have different shapes and sizes, depending on the casting method and the product.

Casting cope: is the upper part of a two-part casting flask, used in sand casting. The cope contains the sprue and one or more risers, which are the channels through which the molten metal flows into the mold cavity. The cope is aligned with the drag, which is the lower part of the flask, by using dowel pins.

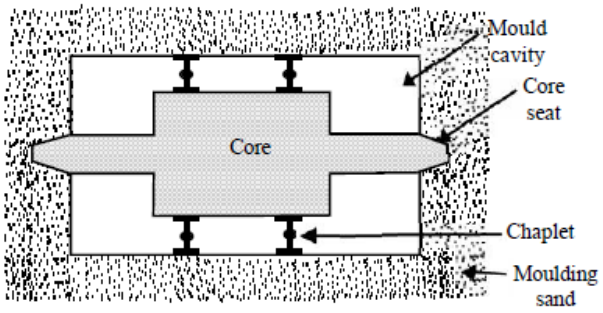
Cheek: A casting cheek is an additional part of a three-part casting flask, used in sand casting. The cheek is used to create a core print in the mold, which is a recess that holds the core in place. The cheek is placed between the cope and the drag and has a hole for the core to pass through.

Drag: is the bottom half of the pattern.

Core is sand or metal shape that is inserted into the mould to create internal features.

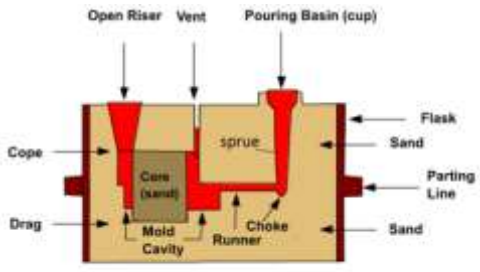
- ✓ **Mould cavity**: is combination of the mould material and cores.Riser is an additional void in the mould that provides additional metal to compensate for shrinkage.
- ✓ **Gating system**: is a network of channels that delivers the molten metal to the mould.
  - ✓ **Pouring cup** is portion of the gating system that controls the delivery of the metal.
  - ✓ **Sprue** is vertical portion of the gating system.

- ✓ **Runners** are horizontal channels.
- ✓ **Gates** is controlled entrances.
- ✓ **Facing sand** is the small amount of carbonaceous material sprinkled on the inner surface of the mould cavity to give a better surface finish to the castings.
- ✓ **Moulding sand** is sand, which binds strongly without losing its permeability to air or gases. It is a mixture of silica sand, clay, and has moisture in appropriate proportions.
- ✓ A **pouring basin** is a small funnel shaped cavity at the top of the mould into which the molten metal is poured.
- ✓ **Chaplets** are used to support the cores inside the mould cavity to take care of its own weight and overcome the met allostatic force.

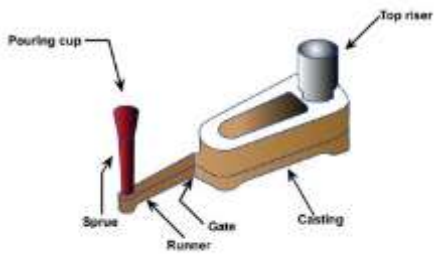


- **Working principles of casting as casting process**

The metal casting process begins by creating a mould, which is the 'reverse' shape of the part we need. The mould is made from a refractory material, for example, sand. The metal is heated in an oven until it melts, and the molten metal is poured into the mould cavity. The liquid takes the shape of a cavity, which is the shape of the part. It is cooled until it solidifies. Finally, the solidified metal part is removed from the mould.



Mould Section and casting nomenclature



Pattern attached with risering and gating system

- **Applications of Metal Casting**

Castings are used virtually in every industrial manufacturing process were. Such as, automobile and heavy equipment manufacturing is the predominant sector, taking up more than 50 percent of castings applications.

Below are sector-by-sectors application of metal casting:

- ✓ **Transport:** This includes automobile manufacturing, the aerospace industry, railways, and shipping.
- ✓ **Heavy Equipment:** Notable applications include farming, construction, and mining.
    - o **Industrial Machine Tools:** Casting is commonly used in making machining materials, plastics moulding, forging, extrusion, and forming.
- ✓ **Electrical Equipment Machines:** It is used for making electrical motors, pumps, and generators.
    - o Plant Machinery: Casting is also applicable in chemicals, petroleum, paper, sugar, textile, steel, and thermal plants.
- ✓ **Defence Equipment:** Casting finds application in military vehicles, artillery, and munitions.
- ✓ **Household Appliances:** Kitchen cutlery, gardening equipment, and some furniture.
- ✓ **Hardware:** is used to make pipes for the plumbing industry, as well as joints, valves, and fittings.
- ✓ **Art Objects:** Casting plays a critical role in making sculptures and several decorative items.

- **Advantages and disadvantages of Casting in prepare for casting process:**

- ✓ Allows for the making of intricate shapes since molten material can flow into very small sections.
- ✓ This eliminates the need for other operations like machining, forging, and welding.
- ✓ The process allows for the casting of any material that is ferrous or non-ferrous.
- ✓ It supports large savings in weight, as the metal can be placed exactly where it is needed.
- ✓ The tools required for casting moulds are simple to use and relatively inexpensive.
- ✓ The casting process is not limited by the size and weight of the product.
- ✓ Metal casting is the only method for producing certain parts made from metals and alloys.

Disadvantages of casting

Along with its advantages, the metal casting process also has disadvantages, including:

- ✓ The relatively more involved production operations make casting processes more challenging to be fully controlled.
- ✓ The casting work pieces are more prone to take with casting defects.
- ✓ Relatively poor dimensional consistency and accuracy.
- ✓ Compared with forgings of the same size and shape, the intrinsic quality of castings is weaker, and the load-bearing capacity is less than that of forgings.
- ✓ Poor working environment with high temperature, dust, and high labour intensity
- ✓ Initial cost is high.
- ✓ Specialized equipment is required.
- ✓ Resin binder is an expensive material.

Points to Remember

- The sand casting terminologies are including: Casting, Foundry , Casting , Mould , Pattern , cavity, Moulding material, Flask, and mould are the commonly terms must be focused in sand casting process
- Prepare for casting process have manly applications such in industrial and home used products
- During working principle of sand casting always pay attention to pattern Making, mold Creation, Core Placement, Metal Pouring, mold removal, cooling and solidification must be focused as steps of casting process

Indicative content 1.2: Identification of Safety and Security Measures.

Duration: 3 hrs

Theoretical Activity 1.2.1: Identification of safety and security measures used casting process.

Tasks:

1: Answer the following questions:

i. What do you understand by the term "**Hazard**"?
ii. Identify the types of hazards found in manufacturing casting processes.
iii. State safety precautions required in casting process

2: Provide the answer for asked questions on papers.

3: Present the findings/answers to the whole class

4: Read the key readings 1.2.1.

Key readings 1.2.1: Identification of hazards types and safety precautions used casting process.

- **Definition of term hazard:** is a source or a situation with the potential for harm in terms of human injury or ill-health, damage to property, damage to the environment, or a combination of these.
- **Types of hazards find in manufacturing process:**
  - ✓ **Physical hazard:** A physical hazard is an agent, factor or circumstance that can cause harm with or without contact. They can be classified as a type of occupational hazard or environmental hazard. Physical hazards include ergonomic hazards, radiation, heat and cold stress, vibration hazards, and noise hazards.

- ✓ **Chemical hazards:** A chemical hazard is a type of occupational hazard caused by exposure to chemicals at the workplace. Exposure to chemicals in the workplace can cause acute or long-term detrimental health effects. These hazards include reactive, toxins, corrosives, flammables

- ✓ **Biological hazards:** Biological hazards, also known as biohazards, refer to biological substances that pose a threat to the health of living organisms, primarily that of humans. This can include samples of a microorganism, virus or toxin that can affect human health. It can also include substances harmful to other animals**.**

- ✓ **Electrical hazards:** is a dangerous condition where a worker can or does make electrical contact with energized equipment or a conductor. Dynamic electricity is the uniform motion of electrons through condition (electric current).

Note: From all the above types of hazards are associated with casting as major hazards in the foundry industry are: Working in heat; hazardous chemicals (incorporating hazardous substances and dangerous goods); airborne contaminants; manual tasks; noise; vibration; molten metal; plant and machinery and electricity.

- **Safety precautions:** Safety precautions are measures and steps taken to prevent accidents, injuries, and other potential hazards in various works. To prevent or reduce these risks, here are some safety precautions must be respect as listed below:

- ✓ **Wear appropriate personal protective equipment** (PPE) such as gloves, goggles, masks, safety shoes, and clothing that cover the skin (overall).

Eye and Face Protection:

- **Safety Glasses:** Wear safety glasses with side shields or goggles to protect your eyes from flying debris, blowing dust, blowing particles, metal shavings, or sparks generated during fastening operations. Ensure they fit securely and provide proper coverage.
- **Face Shield:** For additional protection, especially when using high-impact fastening tools, consider wearing a face shield in combination with safety glasses. Face shields provide full-face coverage and protect against larger projectiles.

Hand Protection:

- **Work Gloves:** Choose gloves that are suitable for the specific fastening task. Depending on the hazards involved, opt for gloves that offer cut resistance, impact protection, or dexterity, as required. Ensure they fit properly and allow for proper grip and finger movement.

Hand Gloves

Hearing Protection:

- **Earplugs or Earmuffs:** When working with loud mechanical fastening tools, such as impact wrenches or nail guns, wear hearing protection to prevent hearing damage. Use disposable earplugs or earmuffs that provide sufficient noise reduction. Ensure they fit well and seal the ears properly.

PVC Earplugs Earmuffs

Skin and Legs protection (Clothing):

Wear overall and safety boot to protect your foot and body from potential scratches, abrasions, or contact with sharp fasteners. Choose clothing made of durable and non-flammable materials that can withstand the hazards of the work environment.

- Use proper ventilation and exhaust systems to remove dust, fumes, and gases from the work area.
- Inspect and maintain all equipment and tools before use and follow the manufacturer's instructions.
- Keep the work area clean and free of moisture, debris, and flammable materials.
- Follow the standard operating procedures (SOPs) for casting and report any accidents or incidents to the supervisor.

- **Educate yourself on the proper safety precautions before attempting any metal casting**:
  - ✓ Do not mix molten metal even with trace amounts of moisture, Steam explosions are the number one cause of death in foundries.
  - ✓ Never put water on a metal fire. This can cause a huge explosion!
  - ✓ Have a dry pile of sand and a shovel ready to put out fires or to control metal spills.
  - ✓ 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 dust from combustion and other foundry chemicals, processes and metals can be toxic.
  - ✓ Use a rated dust mask. Dust 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 have been damaged, it is just not worth the risk.
- ✓ Always charge crucibles when cold. Adding metal to a hot crucible is 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 a great distance. Operate in a clear work area.
- ✓ Think about what you are always doing. Focus on the job at hand and the next step.
- ✓ Have all personal protective equipment planned to any operation
- ✓ Always be careful of your own and stand safety.

Practical Activity 1.2.2: Applying safety precaution, security measures in casting process.

Task:

You are requested to go to the workshop/store and apply safety and security measures applied in sand casting process.

1: Wear appropriate PPEs for safety.

2: Apply individually safety signs and security measures refer to work instructions

3: Present your work to the trainer and whole class

4: Read the key readings 1.2.2

5: Perform the task provided in application of learning 1.2

Key readings 1.2.2: Applying safety precaution, security measures in casting process.

- **Safety and security measures:** refer to the practices, procedures, and technologies implemented to protect people and property and to prevent accidents, injuries, and health hazards in various environments, such as workplaces**.**
- **Safety signs and symbols used** to communicate important safety information and warnings to individuals in various settings. These signs typically use a combination of colors, symbols, and text to convey their messages. There are several types of safety signs, including:

Warning Signs (Yellow or Amber): Yellow equilateral triangle with black boundary

- **Prohibition Signs** (Red)

- **Mandatory Signs**

- **Emergency Signs:** provide information about emergency exits, first aid stations, and safety equipment.
  - Examples include "Emergency Exit," "Fire Extinguisher," and "First Aid."
  - **Fire Safety Signs**

- **Safety signs and symbols**

Safety signs and symbols are easily recognizable graphic labels that represent the general protocol and safety instructions in either workplaces, establishments, or public spaces.

- **Before attempting any metal casting you will go over proper safety precautions, things to keep in mind are:**

Step 1: Do not mix molten metal even with trace amounts of moisture, Steam explosions are the number one cause of death in foundries.

Step 2: Never put water on a metal fire. This can cause a huge explosion!

Step 3: Have a dry pile of sand and a shovel ready to put out fires or to control metal spills.

Step 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.

Step 5: Never pour over wet ground. Remember, even trace amounts of moisture can cause explosions.

Step 6: Molten metal spilled on concrete will cause the concrete to explode. Use a thick sand bed over concrete.

Step 7: Always use clean metal as feedstock. Combustion residues from some lubricants and paints can be very toxic.

Step 8: Always operate in a well-ventilated area. Fumes and dust from combustion and other foundry chemicals, processes and metals can be toxic.

Step 9: Use a rated dust mask to avoid dust from sand, particle dusts and chemicals can

be hazardous

To control hazards at workplace you have to use correctly the PPES, fire extinguishers, sign and symbols as indicated on the steps below:

Step 1: Selecting appropriate PPEs

Step 2: Wearing PPEs correctly

Step 3: Selecting appropriate type of fire extinguisher based on the identified class of fire.

Step 4: Selecting the safety sign and symbols and fix it in the appropriate location

Step 5: During a pour only the pouring crew is permitted in the foundry area

Step 6: Only one hour will take place at a time, the large furnace has priority.

Step 7: Do not participate or go near pores if you are not wearing safe

Step 8: No running or goofing around in the foundry

Step 9: Cleaning workplace after casting process.

Points to Remember

- Before starting casting process always, wear safety equipment for minimising hazard
- Make sure that you have a filled fire extinguisher in your workplace room that can y ou help in case of fire emergency
- Make sure that general safety measures are applied in any environment including ind ustrial like sand casting, to protect personnel, equipment, and the environment.
- When preparing for casting process, it is important to apply safety signs and security measures to ensure that incident is well-being avoided during casting process**.**

Application of learning 1.2.

Suppose that, the chief of TMC manufacturing workshop request your school a support of training his workers about the appropriate application of safety and security measures in the workshop. You are asked to train workers of TMC manufacturing workshop how to apply safety and security measures reflecting on:

i. Use of personal protective equipment in casting process

ii. Use of fire extinguishers
iii. Safety signs and symbols identification
iv. First aid toolkit concepts identification
v.
vi. Hazard prevention methods

This task is individually based

Indicative content 1.3: Identification of Materials, Tools, and Equipment.

Duration: 3 hrs.

Theoretical Activity 1.3.1: Description of Materials, Tools, and Equipment used in casting process.

Tasks:

1: Answer the following questions:

i. What are the materials, tools and equipment used in casting process?
ii. State the types of materials, tools, and equipment used in casting process.
iii. Enumerate four properties of materials used in casting process.

2: Provide the answer for the asked questions and write them on papers.

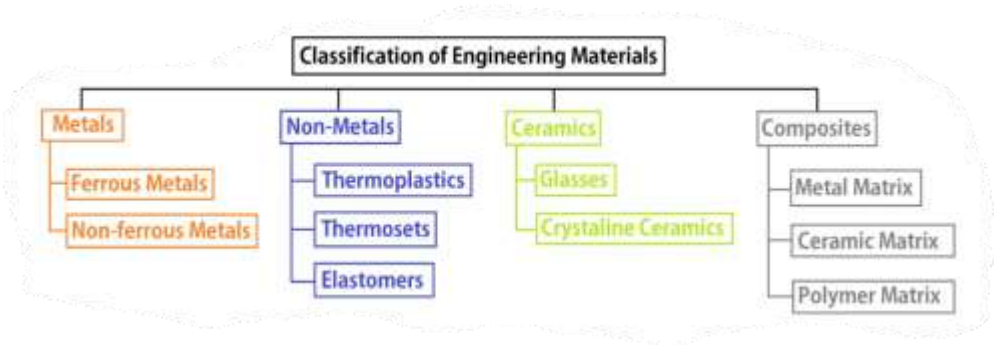
3: Present the findings/answers to the whole class

4: Listen to the trainer clarifications and ask questions if any

4: For more clarification, read the key readings 1.3.1**.**

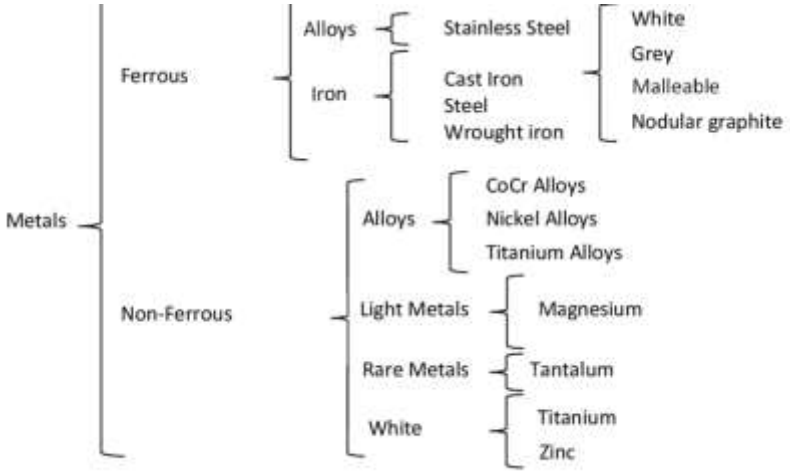
Key readings:1.3.1: Description of Materials, Tools, and Equipment used in casting process

- **Materials:** Refers to a thing that something else is made from, it can also be used to describe something that is made of matter and exists in the physical world. Nearly anything could be a material, if it is possible to use it to make something else. Many engineering materials exist in the universe such as metals and non-metals (leather, rubber, asbestos, plastic, ceramics, organic polymers, composites, and semiconductors). Some commonly used engineering materials are broadly classified as shown.



- **Metals:** is a solid material which is typically shiny, malleable, fusible, and ductile, with good electrical and thermal conductivity. Metals are polycrystalline bodies consisting of a great number of fine crystals. Pure metals possess low strength and do not have the required properties. So, alloys are produced by melting or sintering two or more metals or metals and a non-metal, together. Alloys may consist of two or more components. Metals and alloys are further classified into two major kind namely ferrous metals and non-ferrous metals.

- **Types of metals:** Metals are typically classified into two main categories: ferrous and non-ferrous metals.



  - **Ferrous metals** are those which have iron as their main constituent, such as pig iron, cast iron, wrought iron and steel. Ferrous metals are magnetic and give little resistance to corrosion.
  - **Non-ferrous metals** are those which have a metal other than iron as their main constituent, such as copper, aluminium, brass, bronze, tin, silver zinc, invar etc. Non-ferrous metals are not magnetic and are usually more resistant to corrosion than ferrous metals.

Metal properties: Metals are substances that have various physical, mechanical, and chemical properties, such as luster, conductivity, malleability, and reactivity. Some of the common properties of metals are:

✓ **Physical properties**

- **Hardness:** Metals are very hard by nature (except for a few like mercury) and they cannot be easily torn or broken. This makes it more durable and hence can be used for long-standing needs like buildings, bridge construction, etc.
- **Density & Weight:** Metals have very high density. Hence a small size of metal would have more weight than comparative other materials.

- **Tensile strength:** Metals have good tensile strength, so they can be moulded into different shapes.
- **Luster:** Metals have shiny surfaces, hence metals like gold, silver, platinum, and copper have heavy use for decorative jewellery. Their powders are added to make metallic paints.
- **Insoluble:** Metals are insoluble in water or any other solvents. Their oxides are soluble in acids and water.
- **Corrode:** Metals tend to get oxidized when exposed to air and get rust. Due to corrosion, they get destroyed over time.
- **Conductivity:** Metals are good conductors of heat and electricity. Hence, metals like copper, silver, aluminium, etc., are used for making electric wires.
- **High melting points:** Metals have a high melting point. Hence, they appear to be heat resistant. Due to their high melting points and hardness, they are used in making automobile engines.
- **Stretching and malleability:** Most metals show the property of expansion on heating. This feature helps in other uses like thermostats, forming desired shapes, etc.

✓ **Chemical properties**

- **High molecular weights:** Metals have a high atomic number and atomic weights.

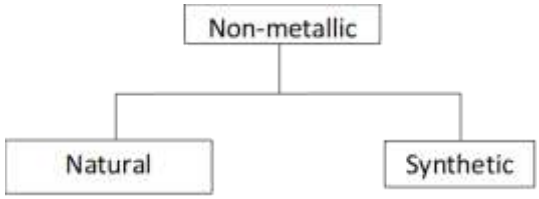
- **Metallic oxides:** All metals can form oxides. These oxides are alkaline in nature and have a high pH above 7 when dissolved in water. Examples are calcium oxide, aluminium oxide, ferric oxide, potassium oxide, etc.
- **They react with acids:** Metals react with acids and get eroded slowly.
- **Free electrons:** Metals have free electrons in the outermost shells. Hence, they readily give out electrons and tend to form ionic bonds.

✓ **Mechanical properties:** The mechanical properties of a metal are those properties that involve a reaction to an applied load. The mechanical properties of metals determine the range of usefulness of a material and establish the service life that can be expected. Mechanical properties are also used to help classify and identify material. The most common properties considered are:

- **Strength:** its ability to withstand an applied load without failing or deforming plastically. As a result, strength determines the durability of parts created from such metals, which is especially important for parts subjected to high-stress applications.
- **Ductility**: Metal ductility measures the way that metals can withstand tensile, or stretching, stress without failing. A metal is ductile when it can be drawn out without losing its strength or breaking.
- **Hardness**: is a characteristic that determines the surface wear and abrasive resistance. The ability of a material to resist denting from impact is related to hardness as well as a material's ductility.
- **Impact resistance**: Resistance of a metal to impacts is evaluated in terms of impact strength. A metal may possess satisfactory ductility under static loads but may fail under dynamic loads or impact. Impact strength is most often determined by the Charpy test.
- **Fracture toughness:** Metals hold the highest values of fracture toughness. Cracks cannot easily propagate in tough materials, making metals highly resistant to cracking under stress and gives their stress–strain curve a large zone of plastic flow.
- **Application of metals:** Metals are usually very strong, most durable, and highly resistant to everyday wear and tear. As such, they have been used since ancient times for a lot of things. And even today with advances in technology and a lot of other things the uses of metals have broadened greatly. Metals even play a key role in the economy. Let's look at some important and popular metal uses are:
  - In the Construction Industry and manufacturing.
  - In electronics
  - In medicine

- Machinery, Refractory and Automobiles
- Decorative products

- **Non-metals:** Non-metallic material are any materials, which do not contain a metal, do not produce heat or electricity and that are structurally brittle.



  - ✓ **Natural material** is any product or physical matter that comes from plants, animals, or the ground. Minerals and the metals that can be extracted from them (without further modification) are also considered to belong into this category, examples are wood, wool, sand, coal, natural gas, stone, soil, Are natural materials.
  - ✓ **Synthetic materials** are formed when humans deliberately mix substances together for the express purpose of creating new materials with desirable properties. Most synthetic materials are the result of chemical reactions during which the atomic structures of the original substances are rearranged to form the new material. Common examples of synthetic materials are plastics, ceramics, and composites.
  - ✓ **Composite:** A composite material is a material which is produced from two or more constituent materials. These constituent materials have notably dissimilar chemical or physical properties and are merged to create a material with properties unlike the individual elements. Within the finished structure, the individual elements remain separate and distinct, distinguishing composites from mixtures and solid solutions. Typical engineered composite materials include:
    - Reinforced concrete and masonry,
    - Composite wood such as plywood,
    - Reinforced plastics, such as fiber-reinforced polymer or fiberglass,
    - Ceramic matrix composites (composite ceramic and metal matrices),
    - Metal matrix composites

    There are various reasons where new material can be favored. Typical examples include materials which are less expensive, lighter, stronger, or more durable when compared with common materials.

- **Moulding sand:** Molding sand, also known as foundry sand, is sand that when moistened and compressed or oiled or heated tends to pack well and hold its shape. It is used in the process of sand casting for preparing the mould cavity.Sand casting operations use silica sand (SiO_2). The general sources of receiving molding

sands are the beds of sea, rivers, lakes, granular elements of rocks, and deserts. Sand is inexpensive and suitable as mould material because of its high temperature resistance. Generally, there are two types of sand: naturally bonded (bank sand) and synthetic (lake sand). Natural moulding sands contain sufficient binder. Whereas synthetic moulding sands are prepared artificially using basic sand moulding constituents (silica sand in 88-92%, binder 6-12%, water, or moisture content 3-6%) and other additives in proper proportion by weight with perfect mixing and mulling in suitable equipment.

Several factors are important for the selection of sand for mould:

- ✓ Sand having fine, round grains can be closely packed and form a smooth mould surface. Fine-grained sand enhanced the mould strength; the fine grains also lower the permeability of mould.
- ✓ Good permeability of mould and core allows gases and steam evolved during casting to escape easily.
- ✓ The mould should have good collapsibility to avoid defects in the casting, such as hot tears and cracking.

Types of moulding sand.

- ✓ **Green sand:** Green sand is also known as tempered or natural sand which is a 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. It 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. Molds prepared by this sand do not require backing and hence are known as green sand moulds. This sand is easily available, and it possesses low cost. It is commonly employed for production of ferrous and non-ferrous castings.
- ✓ **Dry Sand:** Green sand that has been dried or baked in a suitable oven after the making moulds 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 moulds.
- ✓ **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. Patterns are not used for loam moulding and shape is given to mould by sweeps. This is particularly employed for loam moulding used for large grey iron castings.
- ✓ **Facing Sand:** Facing sand forms the face of the mould. It is next to the surface of the pattern, and it meets molten metal when the mould is poured. Initial coating around the pattern and hence for mould surface is given by facing sand. Facing sand has high strength refractoriness. Facing sand is made of silica sand and clay, without the use of already

used sand. Different forms of carbon are used in facing sand to prevent the metal burning into the sand. A facing sand mixture for green sand of cast iron may consist of 25% fresh and specially prepared and 5% sea coal. They are sometimes mixed with 6-15 times as much fine moulding sand to make facings. The layer of facing sand in a mould usually ranges between 20-30 mm. From 10 to 15% of the whole amount of moulding sand is the facing

- ✓ **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 moulding flask. moulding sand is mainly employed for this purpose. The backing sand is sometimes called black sand because that old, repeatedly used moulding sand is black in color due to addition of coal dust and burning on meeting the molten metal.
- ✓ **System Sand:** Is mechanized foundries where machine moulding is employed. So-called system sand is used to fill the whole moulding flask. In mechanical sand preparation and handling units, no facing sand is used. The used sand is cleaned and re-activated by the addition of water and special additives. This is known as system sand. Since the whole mould is made of this system sand, the properties such as strength, permeability and refractoriness of the moulding sand must be higher than those of backing sand.
- ✓ **Parting Sand:** Parting sand without binder and moisture is used to keep the green sand to stick to the pattern and 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.
- ✓ **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 is composed of linseed oil, resin, light mineral oil and other bind materials. Pitch or flour and water may also be used in large cores for the sake of economy.

- **Properties of moulding sand:** The basic properties required in moulding sand and core sand are described below:
  - ✓ **Refractoriness:** Refractoriness is the property of molding sand which enables it to withstand high temperatures of molten temperature without breaking down or fusing thus facilitating to get sound casting.
  - ✓ **Permeability:** It is also termed porosity. It is that property of sand which allows the escape of any air, gases, or moisture present or generated in the mould when the molten metal is poured into it. All these gaseous

generated during pouring and solidification process must escape otherwise the casting becomes defective.

- ✓ **Cohesiveness:** It is property of molding sand by virtue which the sand grain particles interact and attract each other so that the pattern is withdrawn from the mold without damaging the mold surface and edges. Thus, the binding capability of the molding sand gets enhanced to increase the green, dry, and hot strength property of molding and core sand.
- ✓ **Adhesiveness:** It is property of moulding sand due to which it is capable of adhering with foreign material such sticking of moulding sand with inner wall of moulding box. It is entirely due to this property that the heavy sand mass is successfully held in the moulding flask and manipulated as desired without any danger of it falling.
- ✓ **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 mould. For this, the sand grains must be adhesive, i.e. they must be capable of attaching themselves to another body.
- ✓ **Dry Strength:** As soon as the molten metal is poured into the mould, 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 to avoid erosion of mould wall during the flow of molten metal. The dry strength also prevents the enlargement of mould cavities caused by the metallostatic pressure of the liquid metal.
- ✓ **Flowability:** It is the ability of the sand to get compacted and flow uniformly to all portions of pattern when rammed and distribute the ramming pressure evenly all around in all directions. Generally sand particles resist moving around corners or projections. In general, flowability increases with the addition of moisture and clay content and reduction of green strength and grain size.
- ✓ **Collapsibility:** After the molten metal in the mould gets solidified, the sand mould must be collapsible so that free contraction of the metal occurs, and this would naturally avoid the tearing or cracking of the contracting metal. In absence of this property the contraction of the metal is hindered by the mold and thus results in tears and cracks in the casting. This property is highly desired in cores.
- ✓ **Plasticity:** It refers to the condition of acquiring predetermined shape under pressure and to retain it when the pressure is removed. To have a good impression of the pattern in the mold, molding sand must have good plasticity. Generally, fine grained sand has better plasticity. It depends on the content of clay, which absorbs moisture when sand is dampened.

- **Application of moulding sand:** Molding sand is a crucial element in the casting process used to create metal, ceramic, or other materials' shapes and structures. It serves several essential functions during casting, including:

✓ Creating the Mold Cavity: Moulding sand is used to form the shape of the casting. It is packed around the pattern or core to create a mold cavity that replicates the desired part's shape.

✓ Support and Alignment: Molding sand helps support the pattern and align it properly within the mold box. This ensures that the final casting has the correct dimensions and shape.

✓ Facilitating Pouring: Molding sand must withstand the high temperatures and thermal stresses generated when molten metal is poured into the mold. It should not break down or erode, allowing the metal to flow smoothly into the mold cavity.

✓ Ventilation and Gating: Molding sand is used to create channels and gates within the mold, which help guide the molten metal to the mold cavity and allow gases to escape. Proper gating and venting are essential to prevent defects in the casting, such as shrinkage cavities and porosity.

✓ Cooling: Molding sand can absorb some heat from the molten metal, aiding in the solidification of the casting and preventing hot tears or other defects.

✓ Parting Material: Molding sand can be used to separate the cope (top half) and drag (bottom half) of the mold during the casting process. This parting material allows for easy removal of the pattern and access to the mold cavity.

✓ Recyclability: Molding sand is typically a mix of sand, clay, and other additives. It can be reclaimed and reused in subsequent casting processes, reducing waste and cost.

✓ Surface Finish: The type of moulding sand used can influence the surface finish of the casting. Finer sand with a well-prepared mold can result in a smoother and more detailed casting surface.

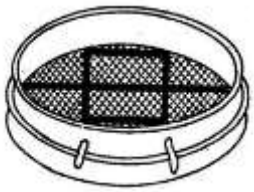
- **Description of tools:**

  Types of foundries tools or casting tools and equipment used in foundry shops are used for carrying out different operations. **Such as sand preparation, pouring, moulding, and casting. These tools are classified as hand tools and conditioning tools.** They are flasks, power-operated equipment, metal melting equipment, and fettling and finishing equipment

- **Casting tools:** Casting tools, also known as casting equipment or foundry tools, are a set of specialized instruments and equipment used in the process of casting.
  - **Shovel:** shovels are other types of casting tools that consist of a customized sheet metal or steel pan with a wooden handle. They are used for moving or transferring the molding sand into the container, molding box, or flask.

Shovels are basically used for mixing, tempering, and conditioning the foundry sand by hand. The shovel should be maintained by keeping it clean.

- **Hand riddle:** Hand riddle consists of a screen of standard circular wire mesh equipped with circular wooden frame. It is generally used for cleaning the sand for removing foreign material such as nails, shot metal, splinters of wood etc. from it. Even power operated riddles are available for riddling large volumes of sand.



- **Rammers:** Rammers are required for striking the molding sand mass in the molding box to pack or compact it uniformly all around the pattern. The common forms of rammers used in ramming are hand rammer, peen rammer, floor rammer and pneumatic rammer.

- **Types of rammers:**
  - **Hand rammer:** is generally made of wood or metal. It is portable and has one end that carries a wedge-type construction. It is used for ramming the sand in bench molding work.
  - **Peen rammer:** is generally used in packing the molding sand in pockets and corners. Peen rammer has a wedge-shaped construction with a metallic rod at the bottom.
  - **Floor rammer:** floor rammer is heavy and layers when compared with hand rammer. It consists of a long steel bar with a peek at one end and a flat portion on the other. Floor rammer is used in floor molding for ramming sand for larger molds.
  - **Pneumatic rammer:** this type of rammer is used for making large molds just as floor rammer. It eases work, saves time, and reduces hard labor.

- **Sprue pin:** Sprue pin is used to produce a vertical hole (Runner and riser) in a sand casting. It is made of wood, metal, or tapered rod. It is pushed in cope to join the mold cavity and produces a cylindrical or conical shape in the molding sand.

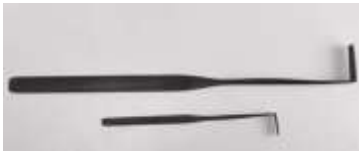
- **Strike off bar:** Strike bars are sand casting tools that are made of iron and wood. They are used to remove or strike off excess sand from the top of a molding box. It is made of a flat bar having a straight edge.

- **Mallet:** Mallets are sand casting tools used in driving the draw spike into the pattern. It's also used for rapping to easily separate the mold from the pattern from leaving the mold cavity. Causing it not to damage the mold surface. Generally, a mallet is used in carpentry or sheet work.

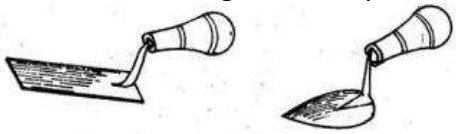
- **Draw spike:** Draw spike is a tapered steel rod having a screw head on the end and a loop or ring at the end. It is used for driving into a pattern that is embedded in the molding sand and reps the pattern. To get separate from the pattern and finally draw it out from the mold cavity.

- **Vent rod:** Vent rods are types of casting tools made of a round-headed wooden handle and a pointed edge. At the end made of wire of a thin spiked steel rod. It is used after ramming and striking excess sand to produce a series of small holes in the molding sand in the cope portion. The holes pierce allows the steam and gases produced during the pouring process and solidifying stage to escape.

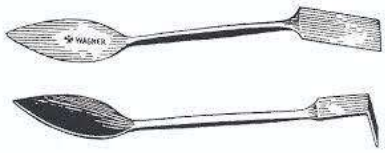
- **Lifters:** A lifter is also known as a cleaner or finishing tool. It's used for cleaning, repairing, and finishing the bottom and sides of the deep and narrow opening in the mold. The lifter is made of thin sections of steel of various lengths and widths with one end bent.



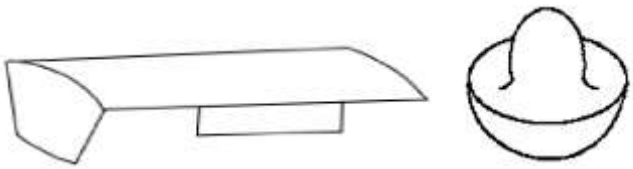
- **Trowels:** These types of foundry tools are used for finishing flat surfaces and joints and partings lines of the mold. It's made of a metal blade made of iron and with a wooden handle. It's also used in guts and repairs mold surfaces.



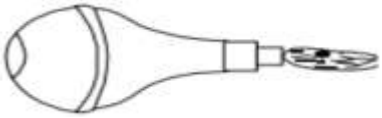
- **Slicks:** Slicks are types of foundry tools that are generally used for repairing and finishing mold surfaces and their edges. It's done after the withdrawal of the pattern. The common types of slicks are heart and leaf, square and heart, spoon and bead, and heart spoon. Their nomenclature is largely due to their shapes.



- **Smoothers:** Smoother is given a different name according to their names. It is generally known as finishing tools used for repairing and finishing flat and round surfaces, round or square corners, and edges of mold cavity.



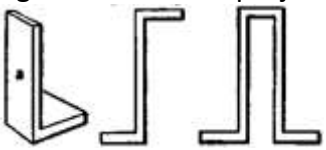
- **Swab:** Swabs are small hemp fiber brush used for moistening the edges of sand mold surface and pattern. It is also used for coating the liquid blacking on the mold faces in dry sand molds.



- **Spirit level:** The spirit level is used by the molder to check whether the sand bed or molding box is horizontal or not.

- **Gate cutter:** A gate cutter is made of a small, shaped sheet metal commonly used for cutting runners and feeding gates for connecting sprue holes with the mold cavity.

- **Gaggers:** Gaggers are made of pieces of wire or rods bent at one or both ends which are used for reinforcing the downward projecting sand mass in the cope.



- **Bellows:** Bellows are used to blow away the loose or unwanted sand from the surfaces of the mold cavity.

- **Clamps, cotters, and wedges:** Are made of steel used for clamping the molding boxes firmly together during pouring.

- **Measuring instrument:** Measurement instruments are tools or devices that help up assign a known standardized numerical value to some object or event such as its weight, length, voltage, current, volume, pressure, vacuum, light intensity, spectral content, surface roughness, material hardness, temperature, time difference between events.

  Common measuring tools which are used in sand casting.

  ✓ **Tape measure or measuring tape** is a flexible ruler used to measure length or distance.

- ✓ **Steel ruler:** It is a type of straightedge measuring tool that measures actual sizes in either imperial or metric measurements and for drawing straight lines.

- ✓ **Engineering Square:** They are used to accurately check and mark angles, or to verify the squareness of straight edges and lines.

- ✓ **Calipers:** It is a kind of commonly used measuring tool, which cannot directly see the size, so it must be used together with the steel ruler. Calipers are used to measure the outer diameter and inner diameter of sand mold (core), groove width, etc.

- ✓ **Verification tools:** Casting verification tools are typically used in the manufacturing industry to ensure the quality and integrity of cast metal or other materials. These tools are essential for verifying that the cast components meet the required specifications and standards.

- **Spectrometer:** It is used to detect the composition of the material, and the spectrometer automatically displays the numbers and analyzes them to determine which elements are contained in the article.

- **Universal Testing Machine**: It is also known as universal material testing machine, It can perform mechanical tests on metals and other materials, including tensile strength, bending strength, elongation, yield strength, etc., optional fixtures can test sheets, bars, and other materials Complex structure

- **Leak Test Machine:** It can detect liquid or air leakage in a pipeline or container. An ultra-high sensitivity combustible gas leak detection instrument. Using the semiconductor detection principle is more suitable for finding and detecting the location of micro-leakage of combustible air.

- **Miscellaneous tools:** Miscellaneous tools are tools gathered or considered together of various types of different kinds which are used in casting. These tools include but they are not limited to.
  - ✓ **Spanners:** Spanners, also known as wrenches in North America, are hand tools used to turn or rotate nuts and bolts. They come in various sizes and types, each designed for specific purposes. Spanners typically consist of a handle and a jaw, which fits around the nut or bolt to provide leverage and allow you to turn it.

  - ✓ **Files:** A metal file is a hand tool used for shaping and smoothing metsal, as well as other materials such as wood and plastic. It typically consists of a handle and a long, narrow piece of hardened steel with a series of parallel teeth or ridges (known as the "cut" or "tooth") on its surface. These teeth or ridges are designed to remove material when the file is pushed or pulled across the surface of the workpiece.

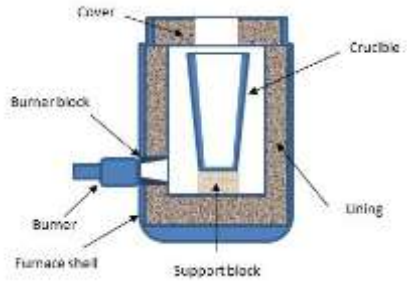
- ✓ **Screwdrivers:** A screwdriver is a simple hand tool used for turning screws or bolts. It typically consists of a handle and a shaft with a flattened or cross-shaped tip. The tip of the screwdriver is designed to fit into the screw head's corresponding shape, allowing you to turn the screw either clockwise (to tighten) or counterclockwise (to loosen).

- ✓ **Clamp:** A "clamp" can refer to a variety of devices or tools used for securing, fastening, or holding objects firmly in place. The specific definition of a clamp can vary depending on its context, but generally, it is a mechanical device designed to apply pressure, force, or tension to hold two or more objects together or prevent movement.

- **Description of casting equipment:**
  - ✓ **Furnace:** A casting furnace, also known as a foundry furnace or a melting furnace, is a specialized piece of equipment used in foundries and metalworking facilities to melt and prepare metal for casting processes.
    Melting is an equally important parameter for obtaining quality castings. Several furnaces can be used for melting the metal to make metal casting. The choice of furnace depends on the type of metal to be melted.

- **Types of furnaces:** Some of the furnaces used in metal casting are Crucible furnaces, Cupola, Induction furnace, Reverberatory furnace.

- **Crucible furnaces:** It is a simple and very old type of melting unit commonly used in foundry. The crucible furnace typically uses a refectory crucible with contains a metal charge. The actual crucible is a container that can withstand very high temperatures and is therefore used to melt materials such as metals.The charge is heated using conduction through the walls of the crucible, it's usually fueled by either coke, oil, gas, or electricity.



- **Advantages and disadvantages of crucible furnaces**

- The advantages provided by crucible furnaces include ease of operation and maintenance and low investment costs. With an operating concept based on these types of furnaces, a foundry is also capable of melting small batches of various alloys. There are practically no limitations as to the type of alloy. The melt can be treated directly in the crucible and the alloy can be quickly and easily replaced as necessary.
- However, for higher production quantities the application of crucible furnaces is not efficient anymore. The main reasons for that are the relatively high specific energy consumption, on the one hand, and manual operation, on the other. Manual charging causes very high operational costs. Moreover, only completely dry metal must be used for subsequent charging, since wet charge material causes ejection of metal resulting in great risks for personnel.

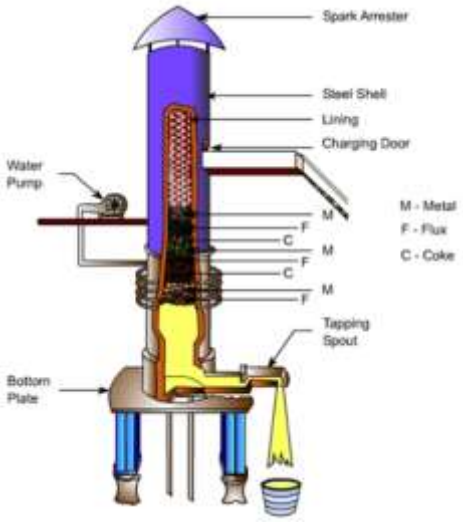
✓ **Cupola furnace:** They are tall, cylindrical furnaces used to melt iron and ferrous alloys in foundry operations. Alternating layers of metal and ferrous alloys, coke, and limestone are fed into the furnace from the top. A schematic diagram of a cupola is shown in Figure below. This diagram of a cupola illustrates the furnace's cylindrical shaft lined with refractory and alternating layers of coke and metal scrap. The molten metal flows out of a spout at the bottom of the cupola.

- **Description of Cupola**

- The cupola consists of a vertical cylindrical steel sheet lined inside with acid refractory bricks. The lining is generally thicker in the lower portion of the cupola as the temperature is higher than in the upper portion.
- There is a charging door through which coke, pig iron, steel scrap and flux are charged.
- The blast is blown through the tuyeres.

- These tuyeres are arranged in one or more row around the periphery of cupola.
- Hot gases which ascend from the bottom (combustion zone) preheat the iron in the preheating zone.
- Cupolas are provided with a drop bottom door through which debris, consisting of coke, slag etc. can be discharged at the end of the melt.
- A slag hole is provided to remove the slag from the melt.
- Through the tap hole molten metal is poured into the ladle
- At the top conical cap called the spark arrest is provided to prevent the spark emerging too outside

✓ **Operation of Cupola furnace:** The cupola is charged with wood at the bottom. On the top of the wood a bed of coke is built. Alternating layers of metal and ferrous alloys, coke, and limestone are fed into the furnace from the top. The purpose of adding flux is to eliminate the impurities and to protect the metal from oxidation. Air blast is opened for the complete combustion of coke. When sufficient metal has been melted that slag hole is first opened to remove the slag. A tap hole is then opened to collect the metal in the ladle.



Advantages of Cupola Furnace

- Simple in Construction.
- A wide range of materials can be melted.
- Less floor space is required.
- Very skilled operators are not required.
- It can be easily operated by low-skilled people.
- Low cost of operation.
- Low cost of maintenance.
- Low cost of construction.

Disadvantages of Cupola Furnace

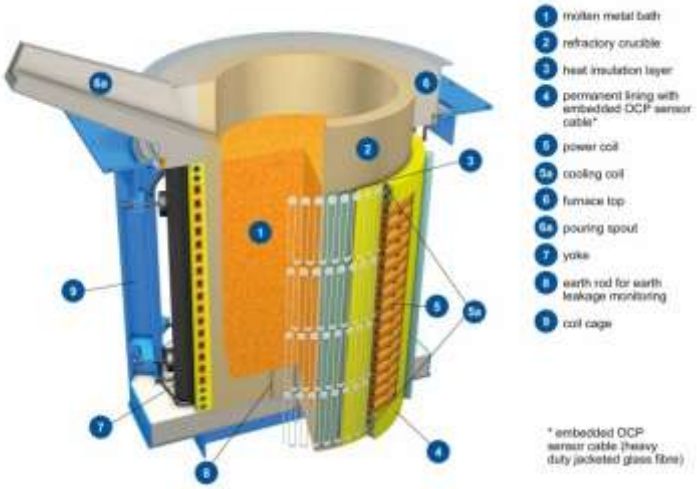
- It is very hard to control the temperature in this furnace.
- Metal elements are converted to their oxide, which is not suitable for casting.

- **Applications of Cupola Furnace**
  - It is mainly used to convert pig irons to molten irons.
  - More types of cast irons are produced from this furnace-like malleable and grey cast iron.
  - The copper base alloy is also manufactured by this device.

- **Induction furnace:** Induction heating is a heating method. The heating by the induction method occurs when an electrically conductive material is placed in a varying magnetic field. Induction heating is a rapid form of heating in which a current is induced directly into the part being heated. Induction heating is a non-contact form of heating.

  The heating system in an induction furnace includes:
  - Induction heating power supply,
  - Induction heating coil,
  - Water-cooling source, which cools the coil and several internal components inside the power supply.

The induction heating power supply sends alternating current through the induction coil, which generates a magnetic field. Induction furnaces work on the principle of a transformer. An alternative electromagnetic field induces eddy currents in the metal which converts the electric energy to heat without any physical contact between the induction coil and the work piece. The furnace contains a crucible surrounded by a water-cooled copper coil. The coil is called primary coil to which a high frequency current is supplied. By induction secondary currents, called eddy currents are produced in the crucible. High temperature can be obtained by this method. Induction furnaces are of two types: cored furnace and coreless furnace. Cored furnaces are used almost exclusively as holding furnaces. In cored furnace the electromagnetic field heats the metal between two coils. Coreless furnaces heat the metal via an external primary coil.



- **Advantages of Induction Furnace**

- Induction heating is a clean form of heating
- High rate of melting or high melting efficiency
- Alloyed steels can be melted without any loss of alloying elements
- Controllable and localized heating

- **Disadvantages of Induction Furnace**
  - High capital cost of the equipment
  - High operating cost

✓ **Moulding box:** The molding box is the key equipment during the casting production. According to the different use, it is divided into negative pressure sand box and simple single-layer sand box and pumping side and so on. Types of Molding Boxes

- **Box Type Molding Box:** A box type molding box is shown in Figure is also known as permanent flask; these flasks should not be removed till the pouring of molten metal is completed. These boxes are generally made of steel and used for small and medium-sized castings.

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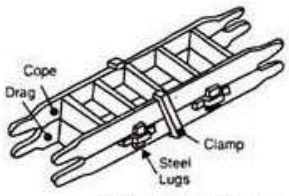
- **Snap Type Molding Box:** A snap type molding box is shown in Figure. These boxes are fitted with a hinge at one corner and a fastener at the diagonally opposite corner. After the mould has been made, it is moved to the position where it is to be cast. These boxes are used for production of small castings and in machine molding.

- **Wooden Molding Box:** A typical wooden molding box is shown in Figure below, the handles are an integral part of the boxes and are provided at the extended sides. The upper part known as cope has a cross wooden partition but not the drag. These partitions help in supporting the sand when the core is lifted. For accurate placing of cope and drag together, steel lugs are provided. The clamps and wedges are used for holding the lugs in their position.



- **Sand mixer:** The foundry sand mixer machine is a foundry equipment used to mix molding sand or core sand. The foundry sand mixer machine generally has the following functions: the machine is to mix the old sand, new sand, molding sand binder and auxiliary materials evenly, so that the binder and auxiliary materials are evenly distributed. Effective coating on the surface of sand grains.
  Foundry sand mixer machines can be divided into wheel-type foundry sand mixer machines mainly based on rolling and grinding; blade-type foundry sand mixer machines mainly based on mixing; Rotor type foundry sand mixer machine and balance wheel type foundry sand mixer machine with rolling and mixing functions.

✓ **Types of foundry sand mixer machine**

- **Wheel type foundry sand mixer machine:** The wheel-type foundry sand mixer machine first appeared in the early 20th century and is still widely used in the mixing of core sand with clay as a binder. This kind of sand mixer is equipped with a roller with a certain weight. During sand mixing, the roller can not only revolve around the main shaft of the sand mixer, but also rotate around the roller shaft. The roller grinds the molding sand while rolling, so that the molding sand particles are covered with a film of binder. When mixing surface sand and core sand, the mixing quality is better than other sand mixers. In the early 1950s, a spring-loaded grinding wheel sand mixer was used. Due to the use of spring pressure, the self-weight of the grinding wheel was reduced, and it could be rotated by a higher spindle. Therefore, the sand mixing effect is uniform and consistent, and the sand mixing efficiency is improved.

- **Vane foundry sand mixer machine:** The vane type foundry sand mixer machine is used to mix resin non-bake sand. This type of sand mixer uses a rotating blade. When mixing sand, the dry sand enters two sand mixing tanks, and the binder is

added to one of the sand mixing tanks. The hardener is added to another sand mixing tank for premixing with the original sand, and then enters the vertical mixer from the end outlet of the sand mixing tank. Drain after quick mixing to fill sandbox or core box. After filling, the passage of hardener and binder is automatically cut off, and the sand inlet gate is closed at the same time, and the residual molding sand in the groove is discharged.

- **Counterflow foundry sand mixer machine:** Counter-flow casting sand mixer is a new type of sand mixer for mixing clay green sand with the development of high-speed and high-pressure molding automatic production lines. Its structural feature is that a scraper and a high-speed rotor with blades are installed on the eccentric part of the sand mixer chassis, and the chassis rotates clockwise.

The rotor and the scraper rotate counterclockwise, and the speed of the rotor is higher than that of the chassis. When mixing sand, since the chassis and the rotor have opposite motions and the rotational speed is different, the molding sand on the chassis will obtain different speed differences, and corresponding friction and shear force will be generated between the sand and gravel, resulting in grinding, mixing, and crushing effect. Not only the mixing efficiency is high, but the quality of the mixed sand is also better.

- ✓ **The function of the foundry sand mixer machine**

  The foundry sand mixer machine strengthens the uniformity of molding sand preparation, and the equipment has strong power. It can meet the state of more uniform mixing of materials in production. The equipment uses stirring rotors, material troughs, and scraper tools to accelerate the more uniform mixing of materials. The power of the equipment is durable, the mixing effect is strong, and it can meet higher production requirements in production.The foundry sand mixer machine mainly relies on three components: stirring rotor, material tank, and fixed scraper tool. The foundry sand mixer machine is simple and quick to process materials, and the equipment adopts the strong counter current mixing principle to strengthen the mixing function. Promote the rapid running of materials in the cylinder, high operating efficiency, high equipment loading rate, high energy utilization rate, and more uniform processing of materials.

- ✓ **Precautions for using a foundry sand mixer machine.**

  The first is the equipment problem. The quality of the sand mixer itself should be tested and the design should be reasonable. For example, the sampling door, there is no sampling door, or the sampling door is damaged due to long-term use, the sampling door is rusted due to long-term non-use, and the improper installation position of the sand mixer makes the sampling

door unusable. The safety factor is relatively low, and accidents are prone to occur.

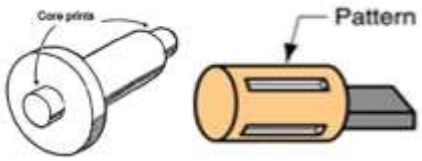
There is also no protective door at the mouth of the closed sand mixer, and no protective fence on the walking platform of the open sand mixer, which creates conditions for illegal sampling, so reliable protective nets should be installed in places where illegal sampling is easy. In order not to affect the operator's observation of the working condition of the sand mixer, a protective net with a larger mesh can be selected, but the premise is that people cannot reach into it. The role of the protective net is to prevent staff from operating illegally or switching the power supply with tools, so its height should not be lower than 1.6 meters.

There is also a sand mixer. There is no door or machine at the entrance of the sand mixer, and the electrical cannot be interlocked, so safety technical transformation is required. Make it mechanical and electrical interlock, safe and reliable. When the door at the entrance of the sand mixer is opened, the sand mixer automatically cuts off the power supply and the grinding wheel stops rotating. This is mainly to prevent accidents caused by the mis-operation of others when someone maintains the equipment inside the machine, or when maintenance personnel stand in the machine and operate illegally.

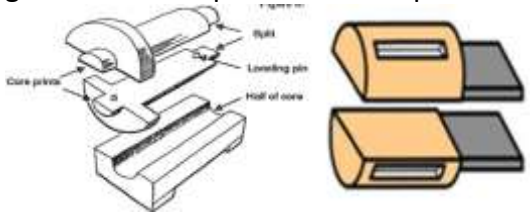
✓ **Pattern:** is a replica or model of the desired part to be produced through the casting process. It is the model from which the final casting is made. It is the image of the casting in every respect, except one, and that is size.

- **Types of Patterns**
  - Solid pattern or single
  - Split pattern or gated pattern
  - Match- plate pattern
  - Cope and drag pattern.

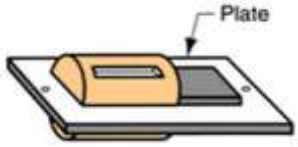
- **Solid pattern or single:** they are single copies of casting. The parting surface is hand formed. Gating systems are cut by hand in mould material.



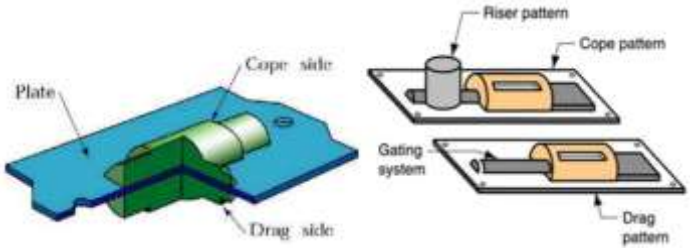
- **Split pattern** is the pattern which is split into two half parts. One part of the pattern is in the drag and the other part is in the cope.



- **Match- plate pattern:** it is a **s**plit pattern attached on either side are known as the match plate patterns. In match plate pattern the cope and drags portions mounted on opposite sides of a plate (usually metallic) called the match plate. The gates and runners are also mounted on the match plate.



- **Cope and drag pattern:** it consists of two patterns, one pattern for the cope and one pattern for the drag. Patterns are used to create impressions in the sand and together form a replica of the desired part to be cast, along with the necessary gating system to fill the mold with aluminum.



✓ **Pattern materials:** As we know, patterns are used in the casting process to make a mould cavity. In which the pattern is prepared by giving a particular pattern allowance, but at the same time it is very important to select the pattern material, which we will know in detail further. Shrink rules are used to avoid pattern allowances when making patterns.

The following factors aid in the selection of the appropriate pattern material:

- 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, shell molding, investment casting.
- Method of moldings like a hand or machine moulding.
- Complexity and size of the casting.

- The common materials from which patterns are made are the following: Wood, Metal, Plaster, Plastic, Wax.

✓ **Wood:** Wood patterns are used where the number of castings to be produced is small and the size of the pattern is large. Commonly used woods for making patterns are teak, deodar, mahogany, pine, etc.

- **Advantages of Wood Materials**

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

- **Disadvantages of Wood Materials**

- 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.
- It is susceptible to moisture, due to which it may crack or split.
- Its life, due to the above reasons, is shorter than that of other pattern materials.
- It is used in cases when a small number of castings are required.

✓ **Metal:** 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**

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

- **Disadvantages of Metal**

- They are expensive as compared to wood, so it is used less, where a smaller number of castings have to be done, it is not used.
- It requires machining to obtain different shapes and finer surfaces and again it takes a separate cost.
- 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.

- It tends to rust in large numbers.

✓ **Plaster:** Plaster can be made from plaster of Paris or gypsum cement. To obtain the plaster pattern, the plaster mix is poured into a mold made by a sweet pattern or master pattern of the wood.

Advantages of Plaster

- It can be easily cast into complex shapes and worked easily.
- Its expansion can be easily controlled, and it has very high compressive strength.
- A distinctive feature of this cement is that unlike the action of the metal, it expands upon solidification.
- If a cement of the proper coefficient of expansion is selected, the effect of shrinkage of the casting can be automatically neutralized.
- It can be worked easily using woodworking tools.

Disadvantages of Plaster

- Can only be used for small castings.

✓ **Plastic:** The plastic used as a patterned material is thermosetting resins, epoxy, PVC, polyurethane foam, etc.

Advantages of Plastic Material

- Plastic is gradually adapting to the pattern material due to its distinctive features:
- Light in weight.
- High strength.
- High resistance to wear.
- High resistance to corrosion due to moisture.
- Fine surface.
- Low solid shrinkage.
- Reasonable cost.

Disadvantages of Plastic Material

- These are fragile.
- These may not work well when subjected to severe shock conditions like machine molding.

✓ **Wax:** Wax patterns are used exclusively in investment casting. For this, a die or metal mold is made in two parts in which hot wax is poured. The die is kept cool by spreading water around it. When the wax cools, the parts of the die are separated, and the wax pattern is drawn.

Advantages of Wax

- Provide a very good surface finish.

- Provide high accuracy for costs.
- After being molded, the wax pattern is not pulled out of the mold like other patterns rather the mold is inverted and heated by which it comes out or evaporated. Thus, there is no chance of the mold cavity being damaged while removing the pattern.

Disadvantages of Wax

- Equipment and process costs are high.
- This process requires a high level of skill.

✓ **Pattern application**

Casting patterns are essential tools in the field of metal casting and other casting processes. They are used to create molds into which molten metal, plastic, or other materials are poured to produce complex shapes and parts. Casting patterns have a wide range of applications in various industries, including:

- **Foundry Industry.**
- **Sand Casting:** Wooden, metal, or plastic patterns are used to create sand molds for casting various metals, such as iron, steel, aluminum, and bronze. Sand casting is versatile and used to make a wide range of components.
- **Jewelry Manufacturing:** Wax patterns are used to create molds for casting intricate jewelry pieces. This process is common in jewelry making for producing complex and finely detailed designs.
- **Dental and Medical Equipment:** Dental prosthetics and orthodontic devices are often produced using casting patterns. Wax or resin patterns are used to create molds for dental restorations like crowns, bridges, and dentures.
- **Aerospace and Automotive Industries:** Aerospace and automotive industries use casting patterns to create high-precision components, such as turbine blades, engine parts, and other critical components.
- **Art and Sculpture:** Artists use casting patterns to create sculptures and artworks in various materials, including bronze and other metals. These patterns help replicate the artist's original sculpture accurately.
- **Tool and Die Making:** Casting patterns are used in the production of dies and molds for manufacturing various tools and components. This is crucial in the manufacturing industry to maintain consistent product quality.
- **Prototype Development:** When developing new products or prototypes, casting patterns can be used to create test parts quickly and cost-effectively, allowing for design iterations and adjustments before mass production.

✓ **Crucible:** A crucible is a vessel in which metallic elements are melted to be cast into new objects or to create a new alloy. The material of your crucible should always have a much higher melting point than that of the materials you are heating. They may also be made of steel or iron to melt softer metals such as aluminum and zinc because these metals melt at a temperature below that of the crucible material.

- **Types of casting crucibles are:**
  - **Ceramic crucible:** Ceramic crucibles are made from kiln-fired clay and are stable at high temperatures. They have been used in metalworking for over 7000 years. Modern ceramic crucibles are often manufactured with clay and graphite to ensure durability.
  - **Clay graphite crucible:** Graphite crucibles are primarily used to cast both non-ferrous and ferrous metals because they are non-reactive and able to withstand extremely high temperatures.
  - **Silicon-carbide crucible:** Most used in modern laboratories, silicon-carbide crucibles are resistant to extremely high temperatures and are not chemically reactive, delivering uncontaminated results.
  - **Steel crucible:** Steel crucibles can be used to melt metals with a lower melting point such as aluminum and zinc. They are inexpensive and easy to work with. However, they may easily scale and flake, thus contaminating your final alloy.
- **Applications of casting crucible.**

  A casting crucible is a container used in the casting process to melt and pour molten metal or other materials into moulds to create various objects and parts. Here are some common applications of casting crucibles:
  - **Metal Casting:** Casting crucibles are widely used in foundries and metalworking industries for casting various metals such as aluminum, bronze, copper, and steel. They provide a controlled environment for melting and pouring molten metal into moulds to create parts, components, and sculptures.
  - **Jewellery Making:** Jewellers use small, specialized crucibles to melt precious metals like gold, silver, and platinum for making jewellery. These crucibles

are essential for creating custom jewellery designs and casting metal into intricate mould.

- **Educational and Research:** Casting crucibles are used in educational settings and research laboratories for experimentation, material testing, and metal analysis. They help students and researchers understand the principles of metallurgy and material science.
- **Metal Recycling:** Crucibles are employed in metal recycling facilities to melt down and reuse scrap metals. This is an environmentally friendly practice that conserves resources and reduces waste.
- **Alloys Production:** Crucibles are used in the production of various alloys by melting different metals and mixing them to achieve desired material properties and characteristics.

✓ **Hand Riddles:** are used for the fine sifting of foundry sand onto the mold surface. This ensures uniform coverage to prevent casting defects. These riddles are made from galvanized wire screen and heavy gauge plastic rims for long life.

Practical activity 1.3.2: Selecting tools, materials and equipment used in casting process.

Tasks

1: You are requested to go to manufacturing store/workshop and perform the selection of t he right casting materials, tools and equipment to be used in casting process.
2: Wear the PPEs
3: Based on trainer demonstration, select tools, materials and equipment related to the task
4: Present your work to the trainer and whole class.
5: Read key reading 1.3.2 and ask clarification where necessary.
6: Perform the task provided in application of learning 1.3.

Key readings: 1.3.2

Selecting casting tools, materials and equipment

- **The selection of tools, materials, and equipment for casting process preparation** is critical to the efficiency and safety of the process. Several factors influence these choices, and considering these factors is essential for successful casting operations. Here are some key factors affecting the selection of tools, materials, and equipment for preparing casting process:

- ✓ **Application and Purpose**: The specific application and purpose of the casting process will determine the type of tools, and equipment needed.
- **Material Compatibility**: The materials being joined must be compatible with the casted product and equipment used. The choice of casting product should match the materials being casted to ensure a strong and durable connection.
- **Environment and Conditions**: The operating environment, including factors like temperature, humidity, exposure to chemicals, and corrosion potential, can influence the selection of materials and coatings for casting and equipment.
- **Size and Dimensions**: The size and dimensions of the components being casted, as well as the desired appearance and play a role in choosing materials, tools, and equipment.
- The number of casting to be produced.
- Quantity of production.
- Dimension accuracy and surface finish.
- Nature of molding process like sand casting, permanent mold casting, shell molding, investment casting, etc.
- Method of moldings like a hand or machine moulding.
- Complexity and size of the casting.
- The common materials from which patterns are made are the following: Wood, Metal, Plaster, and Plastic. The steps in the casting process are

Metal Casting Product Examples

- Pump Housing.
- Ring Segment
- Industrial Furnace Doors.
- Fire Hydrant Housing.
- Heat Treatment Furnace.
- Aluminum Gear Box.

- ✓ **Process of Sand casting:** Sand casting is a metalworking method which is widely used in casting process, as almost all metals can be sand casted. Its main characteristic is the use of expendable sand molds to form complex metal parts that can be made of nearly any alloy. This method typically has a low production rate because the sand mold must be destroyed in order to remove the part and it has a tendency to yield products with a comparatively rough surface finish.

while performing the foundry casting process must follow the following steps:

Step 1: Choose patterns materials
Step 2: Choose material for pattern making
Step 3: Choose Split Patterns
Step 4: Casting pattern allowances
Step 5: Finishing or Machining allowance and Place Mold Pattern in Sand
Step 6: Set Up the Gating System

Step 7:	Remove the Mold Pattern
Step 8:	Wait for Metal to Cool
Step 9:	Break Open Mold to Remove the Metal Casting

Points to Remember

- Casted product dimensions and Conditions of work place should be determine the factors to be consider for selecting materials, tools and equipment used in casting
- While Applying the selection of materials, tools, and equipment must be think about purpose of accurate cast product
- Poor selection of casting tools , materials and equipment can affect an accurate of product

Application of learning 1.3.

Suppose that you have made a visit at BC manufacturing company Ltd, which is specialized in irrigation by using water pumping system, after that visit of BC manufacturing company Ltd ask you to make a visit report after completed activity of selecting materials, tools, and equipment used in casting process and submit your report to the trainer focused on:

i. Casting Materials identification
ii. Casting Tools identifying
iii. Casting Equipment identification

Indicative content 1.4 : Pre- Casting Activities.

Duration: 2 hrs.

Theoretical Activity 1.4.1: Description of workplace arrangement and Pre-casting activities

Tasks:

1: Answer the following questions:

i. What do you understand about casting process
ii. What mean Sand preparation, Pattern making, Mold preparation and Mainte nance as the methods of casting process?

2: Provide the answer for the asked questions and write them on papers.

3: Present the findings/answers to the whole class

4: Pay attention to the trainer clarification and ask questions where necessary

5: For more clarification, read the key readings 1.4.1.

Key readings 1.4.1 Description of workplace arrangement and pre-casting activities

- **Sand preparation:** Natural sands are generally not well suited for casting purposes. On continuous use of molding sand, the clay coating on the sand particles gets thinned out causing decrease in its strength. Preparing casting sand is an important step in foundry and metal casting processes. Casting sand, also known as foundry sand or molding sand, is used to create molds into which molten metal is poured to produce cast metal parts.

✓ **Here are the basic steps involved in preparing casting sand:**

- **Selection of Sand:** The first step in preparing casting sand is to choose the right type of sand. Typically, foundry sand is made from high-quality silica sand, which is clean, well-graded, and has a low clay content. The sand should be free from impurities, organic matter, and other contaminants.
- **Grain Size and Distribution:** Foundry sand should have a specific grain size and distribution to provide good mold compaction and permeability. The size and

distribution of sand grains can be controlled through screening and mixing with other additives.

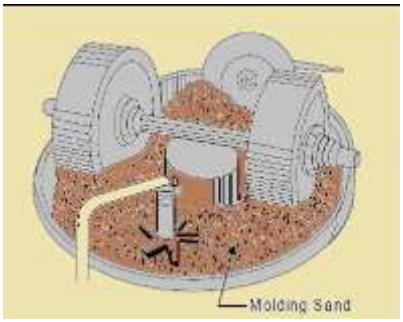
- **Moisture Content:** Controlling the moisture content of the sand is crucial. The sand should have the right amount of moisture to facilitate molding and prevent excessive drying during the casting process. The moisture content is usually controlled through water addition.
- **Additives:** Various additives may be mixed with the sand to enhance its properties. These additives can include clay, binders, and other chemicals to improve mold strength, reduce gas defects, and enhance the overall mold properties.
- **Sand Conditioning:** The sand mixture may be conditioned or milled to ensure uniform distribution of additives and moisture. This can be done using equipment like sand mixers or mullers.
- **Testing:** To ensure the prepared casting sand meets the required specifications, it is essential to perform various tests such as permeability, green compression strength, and moisture content tests.
- **Storage:** Once the casting sand is prepared, it should be stored in a clean and controlled environment to prevent contamination and maintain its properties until it is ready to be used for molding.
- **Sand Reclamation:** After the casting process, foundry sand can be reclaimed and reused, reducing waste and cost. Sand reclamation processes involve removing binders and contaminants from used sand so that it can be mixed with new sand for future casting.

Thus, proper sand conditioning accomplishes uniform distribution of binder around the sand grains, control moisture content, eliminate foreign particles and aerates the sands. Therefore, there is a need for sand conditioning for achieving better results. The foreign materials, like nails, hard sand lumps and metals from the used sand are removed.

Sand crusher: are generally used for aerating or separating the sand grains by increasing the flowability through whirling the sand at a high speed by an impeller towards the inner walls of the casting.

Aerating can also be done by riddling the sand mixture oil on a one fourth inch mesh screen or by spraying the sand over the sand heap by flipping the shovels.

The aeration separates the sand grains and leaves each grain free to flow in the direction of ramming with less friction. The final step in sand conditioning is the cooling of sand mixture because if the molding sand mixture is hot, it will cause molding difficulties.



✓ **The requirements of good molding sands are as follows.**

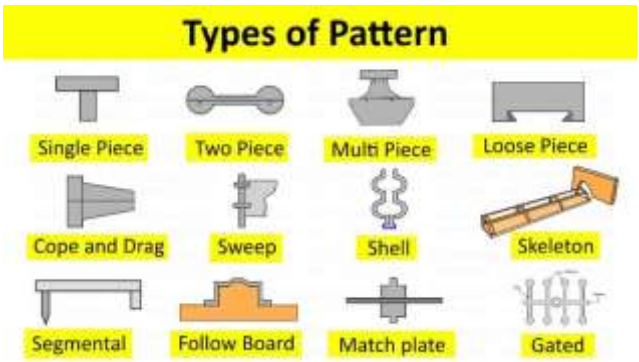
iv. It must allow the free passage of air and gases generated when in contact with molten metal. This is the "permeability" of the sand.

v. When rammed it must retain the shape given to it and resist the pressure of the molten metal. This is known as its "cohesive" quality.

vi. It must be able to withstand high temperatures without fusion. This is called "refractory" quality.

vii. It should easily come away from the cold casting, and leave a clean, smooth surface. This is known as its "stripping" quality.

- **Pattern making:** Pattern is a replica of the part to be cast and is used to prepare the mould cavity. It is the physical model of the casting used to make the mould. Made of either wood or metal.

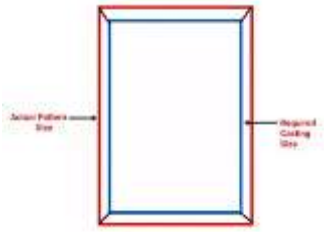


A pattern is used to form the mold cavity into which molten metal is poured to produce a casting. As such, it is a tool in the hands of the foundryman. A great deal of success in producing a good casting depends on the quality and design of the pattern. For example, a pattern that does not have the proper draft is difficult to draw from the sand without breaking the mold.

The design of the casting itself, as well as that of the pattern, must be taken into consideration to make moulding less difficult. The casting design should be as simple as possible, since it will determine the ease with which a pattern can be drawn from the mold, the number of loose pieces required in the pattern, and the number of cores needed.

- ✓ **Pattern allowances:** The pattern and the part to be made are not same. They differ in size; pattern is always made larger than the final part to be made. The excess dimension is known as Pattern allowances. This change in the pattern is due to when the cast solidifies, it shrinks at some limit due to metal shrinkage property at the time of cooling. So, to compensate for this, a pattern is made a little bigger.
- ✓ **Types of Pattern Allowance**
  - Shrinkage Allowance
  - Draft Allowance
  - Machining Allowance
  - Deformation or Camber Allowance
  - Shake or Rapping Allowance
- ✓ **Shrinkage Allowance:** Shrinkage is defined as the reduction during the cooling or solidification process. This is a common property of all materials. The magnitude of shrinkage varies from material to material, but each material must shrink. For avoiding this, the pattern is made larger than the required size of the casting product with the help of the shrink rule.

  Then the difference between actual pattern size and required casting size is known as shrinkage allowance.



The shrinkage allowance is given in the pattern in mm/m (millimeter/meter). Which is different for different materials.

There are following some shrinkage allowance given inside the pattern for different materials which are used in casting.

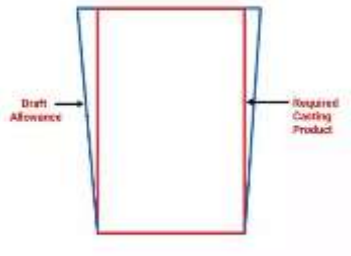
- For grey cast iron shrinkage allowance is given from 6.95 to 10.5mm/m.
- For white cast iron and steel, it is given up to 20.8 mm/m.
- For Aluminium shrinkage allowance given 17 mm/m and for aluminum alloy given from 12.5 to 15 mm/m
- For brass, it is given up to 15.3 mm/m.

The following are three types of shrinkage that happen during the casting process.

- **Liquid Shrinkage:** The liquid contraction that occurs during cooling before solidification is called liquid shrinkage. After pouring the molten metal into the mold cavity, the level of the molten metal decreases during cooling due to the liquid shrinkage.
- **Solidification Shrinkage:** The contraction phase changes from liquid to solid, which is called solidification shrinkage. The solidification shrinkage reduces the height of the casting metal.

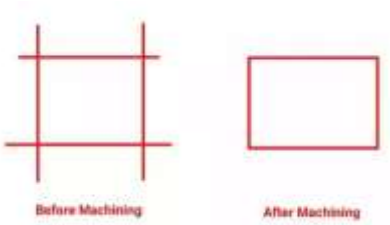
- **Solid Shrinkage:** The shrinkage of solidified casting at room temperature due to thermal contraction is called solid shrinkage. The solid shrinkage further reduces the height of the casting metal.

✓ **Draft Allowance:** During removing the pattern from the mold cavity, the parallel surfaces in the direction in which the pattern is withdrawn are slightly damaged and converted into slightly tapered surfaces. To compensate for these changes, these parallel surfaces on the pattern are slightly tapered by about 1 to 2 degrees. These small changes in the surface of the pattern are called draft allowances to protect it from damage.



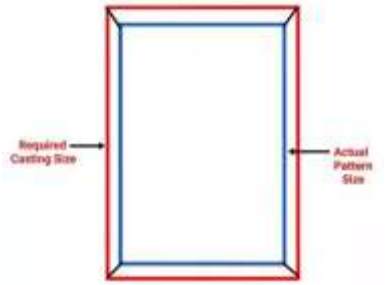
✓ **Machining Allowance:** As we know that the product of the casting process gives a very poor surface finish, so the surface of the final product of casting is always rough. But we required a product that is polished and has a good surface finish. So, to have a good surface finish, the final product of the casting is machined with the help of a lathe machine, milling machine, shaper machine, slotting machine with these processes such as turning, grinding, shaping, and drilling to obtain a surface finish.

This allowance is added to the basic size of the pattern. It ranges from less than 2 mm to 15 mm depending on the size and material of the pattern.



✓ **Deformation, Distortion or Camber Allowance:** When the metal is in the cooling process, stress is developed during the solidifying of this metal due to uneven metal thickness in the casting process. This stress can cause deformation or bend in the casting. To avoid this bending or deformation in castings, camber is provided in the opposite direction so that when bending occurs due to uneven thickness of metal, the casting product becomes straight. These small changes in a pattern to avoid bending in the casting process are called bending or camber allowances.

✓ **Shake or Rapping Allowance:** When the pattern is to be removed from the sand of the casting, a slight shake is required to remove the pattern from the sand, and this will increase the dimension of the casting slightly. To avoid this increase in the dimension of the casting, the pattern is made slightly smaller than the casting. These small changes in the dimensions of the pattern in the casting process are called the shaking or rapping allowance.



- **Mould preparation:**

  Castings are made by pouring molten metal into refractory mould and allowing the metal to solidify. The solidified metal will retain the shape of the mold cavity and can be removed from the mold when the metal is solid. A mold is made by shaping a suitable sand mixture around a pattern of the desired form. A metal or wood box (flask) is used to retain the sand. The pattern is then removed from the sand, leaving a cavity in the sand into which the molten metal can be poured.

✓ **Characteristics of casting mould.**

1. Strong enough to hold the weight of the metal.
2. Resistant to the cutting action of the rapidly moving metal during pouring.
3. Generate a minimum amount of gas when filled with molten metal.
4. Constructed so that any gases formed can pass through the body of the mold itself rather than penetrate the metal.

✓ **Procedures to make mold.**

- The drag flask is placed on the board.
- Dry facing sand is sprinkled over the board.
- Drag half of the pattern is located on the mould board. Dry facing sand will provide a non-sticky layer.
- Molding sand is then poured in to cover the pattern with the fingers and then the drag is filled completely.

- Sand is then tightly packed in the drag by means of hand rammers. Peen hammers (used first close to drag pattern) and butt hammers (used for surface ramming) are used.
- The ramming must be proper i.e., it must neither be too hard or soft. Too soft ramming will generate weak mould and imprint of the pattern will not be good. Too hard ramming will not allow gases/air to escape and hence bubbles are created in casting resulting in defects called 'blows. Moreover, the making of runners and gates will be difficult.
- After the ramming is finished, the excess sand is levelled/removed with a straight bar known as strike rod.

- Vent holes are made in the drag to the full depth of the flask as well as to the pattern to facilitate the removal of gases during pouring and solidification. Done by vent rod.
- The finished drag flask is now made upside down exposing the pattern.
- Cope half of the pattern is then placed on the drag pattern using locating pins. The cope flask is also located with the help of pins. The dry parting sand is sprinkled all over the drag surface and on the pattern.
- A sprue pin for making the sprue passage is located at some distance from the pattern edge. Riser pin is placed at an appropriate place.
- Filling, ramming, and venting of the cope is done in the same manner.
- The sprue and riser are removed, and a pouring basin is made at the top to pour the liquid metal.
- Pattern from the cope and drag is removed.
- Runners and gates are made by cutting the parting surface with a gate cutter. A gate cutter is a piece of sheet metal bent to the desired radius.
- The core for making a central hole is now placed into the mould cavity in the drag. Rests in core prints.
- Mould is now assembled and ready for pouring.

- **Maintenance:** Maintenance is combination of all technical, administrative, and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform a required function.

✓ **Maintenance technics**

- **Cleaning:** Cleaning means a solvent cleaning operation or activity carried out to keep clean general work areas where manufacturing or repair activity is performed, to clean tools, machinery, moulds, forms, jigs, and equipment.
- **Lubrication:** Lubrication is the control of friction and wear by the introduction of a friction-reducing film between moving surfaces in contact. The lubricant used can be a fluid, solid, or plastic substance.Many different substances can be used to lubricate a surface.

Oil and grease are the most common. Grease is composed of oil and a thickening agent to obtain its consistency, while the oil is what lubricates. Oils can be synthetic, vegetable or mineral based as well as a combination of these.

- **Adjustment:** This small alteration or movement made to achieve a desired fit. Adjustments are an ordinary part of daily work routines and if they are handled properly, can result in higher rates of productivity and efficiency.The problem is that many equipment adjustments happen at inappropriate times or without the consent of management. Shift changes and other workplace events inevitably lead to adjustments by individual operators and can lead to a disruption of production standards. Adjustments are made because of many reasons; the following are some examples:

✓ **Pre-casting maintenance procedures:** Pre-casting maintenance procedures are essential for ensuring the durability and quality of pre-cast concrete or other pre-cast construction elements. Proper maintenance helps prevent structural issues and extends the lifespan of pre-cast components.

Here are some key pre-casting maintenance procedures:

Step 1: Visual Inspection: Regularly inspect pre-cast elements for signs of damage, cracks, or deterioration. Look for any visible defects and address them promptly.

Step 2: Cleaning: Keep pre-cast surfaces clean and free from dirt, debris, and other contaminants. Regularly wash them with a mild detergent or water to remove stains and prevent surface deterioration.

Step 3: Repairs: Address any cracks or damage promptly to prevent further deterioration. Depending on the severity, repairs may involve patching, sealing, or even replacing the pre-cast element.

Step 4: Sealing and Coating: Apply appropriate sealants or coatings to protect pre-cast elements from moisture infiltration, chemical exposure, and environmental factors. Sealants help maintain the integrity of the surface.

Step 5: Drainage: Ensure that water drainage systems are in place to prevent water from pooling on or around pre-cast elements. Proper drainage helps prevent water-related damage and freeze-thaw cycles.

Step 6: Record Keeping: Maintain records of all maintenance activities, including inspection reports, repair work, and any changes to the pre-cast elements. This documentation helps track the history of maintenance and provides a reference for future work.

Step 7: Consult Manufacturer Recommendations: Follow any specific maintenance guidelines provided by the pre-cast element manufacturer. They may have product-specific recommendations for optimal maintenance.

Step 8: Inspection and Testing: Periodically conduct non-destructive testing or quality assessments to ensure the structural integrity of pre-cast elements.

Practical Activity 1.4.2: Performing pre-casting activities used in casting process

Tasks:

As manufacturing technician, you are requested to perform the procedures for casting proce ss

1: Select and Wear appropriate PPE related to the task.

2: Select materials, tools and equipment related to the task.

3: Present your final work/ product to the trainer or classmates.

4: Read key reading in 1.4.2.

5: Perform the provided task in application of learning 1.4.

Key readings

Performing pre-casting activities methods used in casting

The procedures to be followed during casting process should be carefully respected step by step

Step 1: **Steps for Mould sand preparation:** Mould sand preparation is a critical step in the foundry process used for creating metal castings. Properly prepared mould sand is essential to ensure the quality and integrity of the final casting. The following are the typical steps involved in mould sand preparation:

Step 2: **Materials, tools, and equipment selection:** Choose the appropriate type of material, tools and equipment based on the specific requirements of the casting.

Step 3: **Sand preparation:** select the appropriate sand and mix the selected sand with a binder and water to create a homogeneous mixture. The binder is

typically clay, and its type and quantity depend on the casting process and the properties needed for the mold.

Step 4: **Sand Conditioning:** To achieve the desired mold properties, the sand mixture may need additional conditioning. This can involve adjusting the moisture content or adding additives, such as coal dust or dextrin, to enhance mold strength or collapsibility.

Step 5: **Sand Mulling:** The prepared sand mixture is mulled or kneaded to ensure uniform distribution of the binder and moisture. Mulling can be done manually or with the help of mechanical equipment.

Step 6: **Sand Testing:** Samples of the sand mixture are taken and tested for properties like permeability, strength, and compactability. These tests help ensure the sand meets the required specifications for the casting process.

Step 7: **Pattern Assembly:** Assemble the pattern or core box, which represents the shape of the final casting, and embed it in the moulding sand mixture. This forms a mold cavity.

Step 8: **Molding:** Molding involves packing the sand mixture around the pattern to create the mold. This can be done using various techniques, including green sand molding, no-bake molding, and shell molding, depending on the casting process.

Step 9: **Gating and Riser Placement:** Install gating and riser systems to control the flow of molten metal and to provide a reservoir for excess metal to prevent shrinkage defects.

Step 10: **Shakeout pattern and Cleaning:** After the casting has solidified, remove the pattern from the sand mold through a process called shakeout. Clean the mold to remove any loose sand and prepare it for the metal pouring stage.

- **Casting process working principles:**

Pre-casting is a casting method in which structural components or elements are manufactured in a controlled environment, typically a factory.

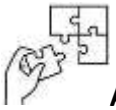
The procedures for casting process are:

- ✓ **Design and Planning:** Pre-casting begins with careful design and planning. Engineers and architects create detailed plans for the precast elements, considering the specific requirements and constraints of the project.

- ✓ **Material Selection:** High-quality materials are chosen for pre-casting, such as concrete, steel reinforcement, and molds. The materials must meet the project's specifications and standards.
- ✓ **Mold Preparation:** Precast elements are formed in molds, which can be made of various materials like steel or fiberglass. The molds are carefully designed and fabricated to match the desired shape and dimensions of the precast components.
- ✓ **Concrete (sand) Mixing:** A precisely controlled concrete mix is prepared, considering factors like strength, durability, and aesthetics. Quality control measures are implemented to ensure consistency in the concrete mixture.
- ✓ **Filling sand into mould:** The prepared concrete mixture is poured into the molds, ensuring that it completely fills the mold and is properly compacted. Vibrators may be used to remove air bubbles and ensure a dense, high-quality product.
- ✓ **Curing:** The precast elements are allowed to cure in a controlled environment, typically in a curing chamber or under controlled temperature and humidity conditions. Proper curing is essential for achieving the desired strength and durability.
- ✓ **Stripping and Finishing:** Once the concrete has achieved sufficient strength, the precast elements are removed from the molds. They may undergo surface finishing processes, such as sandblasting or acid etching, to achieve the desired texture and appearance.
- ✓ **Quality Control and Inspection:** Each precast element undergoes rigorous quality control and inspection to ensure it meets the project's specifications and standards. Any defects or imperfections are addressed before transportation.
- ✓ **Transportation:** Precast elements are transported to the casting site using specialized vehicles, such as flatbed trucks or trailers. Careful handling is essential to prevent damage during transit.
- ✓ **Installation:** On-site, precast elements are lifted and assembled according to the project's design and plans. Connections, such as bolts or welding, are used to secure the elements together. Precision is crucial to ensure a tight fit and structural integrity.
- ✓ **Safety Measures:** Safety protocols and precautions are essential throughout pre-casting and installation to protect workers, equipment, and the environment.

Points to Remember

- If you are performing the procedures for casting should be remind the, sand preparation, sand moulding mixture, mixing sand with additives, and materials, tools, and equipment for having a good product.
- While performing casting process do not forget the methods to be follow including sand preparation, Pattern making, Mould preparation and Maintenance technics.
- Ensure that the casting product design must be complete, accurate, and meets to all specifications.



Application of learning 1.4.

The manager of AJ. Manufacturing Company wishes to recruit competent technician in casting to give a support of workers during casting activity of 100-vehicle wheel rim. After compression of working principles and process of casting operations including:

i. Sand preparation
ii. Mould preparation
iii. Pattern making
iv. Maintenance technics

You are requested to give them a support of the activities to be done as you trained both theoretical activity 1.4.1 and practical activity 1.4.2

Learning outcome 1 end assessment

Theoretical assessment

1. **Choose the correct answer**

i. The following are the key terms to be used in casting, except:

a) Metal casting process
b) Casting
c) Mould
d) Molding material
e) Team casting mould
f) Pouring cup

iii. The below are the type of hazard, except

a) Physical hazard
b) Biological hazards
c) Injury hazard
d) Chemical hazards
e) Electrical hazards

2. Read the following statements and answer by "**TRUE**" if the statement is correct or "**FALSE**" if it is wrong**.**

a) **Casting** is a rolling process in which a liquid material usually metal is poured into a mold that has a cavity of the desired shape.
b) **Metal casting process** is a process in which hot liquid metal is poured into a mould that contains a hollow cut out or cavity of the desired finished shape and the liquid metal is then left to solidify, which is removed from the mould.
c) **Facing sand** is the small amount of carbonaceous material sprinkled on the inner surface of the mould cavity to give a better surface finish to the castings.
d) **The working principles of casting is means** is a small funnel shaped cavity at the top of the mould into which the molten metal is poured.
e) The some of applications of metal casting such as airplane marine and cooking rise in mould?

3. Answer the questions below by using "**Yes**" or "**NO**":

i. The below are the following methods of casting process (pre-casting activities):
   a. Properly prepared mould sand means Sand preparation
   b. Assemble the pattern or core box, which represents the shape of the final
   c. Moulding involves packing the sand mixture around the pattern to create the mold
   d. Cleaning of casted product
   e. Lubrication of tools and equipment is compulsory after every use
   f. Adjustment of tools and equipment done before and after use

4. Fill in the blank using the appropriate word" **Safety precautions, Hazard prevention, Properties of casting martials" and "Safely"**
   a) Here are some ……for casting workplace preparation such as wearing appropriate personal protective equipment (PPE)
   b) Inspect and maintain all equipment and tools before use in order to ……..As the manufacturer's instructions.
   c) Always operate in a well-ventilated area and don't mix molten metal even with trace amounts of moisture for being ……..
5. Match the definition in column B with their corresponding terms in column A and write the letter corresponds to the right answer in the provided space

Answer	Column A	Column B
1…….	A. **Materials**	1.Is a solid material which is typically shiny, malleable, fusible, and ductile, with good electrical and thermal conductivity
2…..	B. **Metals**	2.Are typically classified into two main categories: ferrous and non-ferrous metals.
3…..	C. **Metal properties**	3.Refers to a thing that something else is made from, it can also be used to describe something that is made of matter and exists in the physical world.
4……	D. **Types of metals**	4.Are the properties of a metal are those properties that involve a reaction to an applied load.
5……	E. **Mechanical properties**	5.Are substances that have various physical, mechanical, and chemical properties
6…..	F. **Non-metals**	6.Is mechanized foundries where machine molding is employed, to fill the whole molding flask.
7	G. **System Sand**	7.Are the material are any materials,

Practical assessment

GEMCO casting industries won a tender of casting 14 V8engine pistons of (300 x 200) mm, for the crashed oil motors from auto-repair garage. They want to prepare a mould that will be used in the casting piston using sand. Referring to the previous activities, as you are competent in casting process, you are requested to prepare sand mould for casting process.

References

Turkeli, A. (2009). *Sand additives and sand properties*.

Parker, R. D., & Sisson, R. D. (2010). *Casting: An introduction to the casting of metals*. Springer.

ME 222 Manufacturing Technology - I (3-0-0-6): Introduction to manufacturing processes.

Indicative contents

2.1. Casting metals for aluminium with its alloys.

2.2. Production of a casting.

Key Competencies for Learning Outcome 2: Carry-Out Aluminium with Its Alloys Casting.

Knowledge	Skills	Attitudes
• Identification of low temperature metal for casting aluminium with its alloys • Description of Aluminium with its alloys metal • Description of casting procedures used in production of a casting	• Making casting for aluminium with its alloys • Identifying Low temperature metal used in casting metals for aluminium with its alloys • Performing casting procedures such as Sand preparation, Molding, Melting of metal, Pouring into mold, Casting , Cleaning and finishing	• Being Attentive during carry-out aluminium • Being Obedient while performing casting procedures • Having Teamwork spirit in low metal used in casting • Having Flexibility during sand preparation • Having Self-confident while performing casting procedures

Duration: 30 hrs.

Learning outcome 2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Differentiate properly the Low temperature metal used for casting aluminium with its alloys.
2. Describe appropriately raw materials used in casting process based on their properties.
3. Perform clearly the procedures of sand casting as used in manufacturing process.
4. Make correctly casting process for aluminium with its alloys as used in sand casting process
5. Identify correctly the expected product according to the properties of used materials.
6. Describe properly casting procedures used in manufacturing production

Resources

Equipment	Tools	Materials
• PPE • Sand mixer • Furnace • First aid kit • Crucible • Pattern • Moulding box • Fire fighting equipment	• Casting flasks • Strike bar • Mallet • Sprue pin • Shovel • Draw spike (screw) • Vent rod • Hand riddle • Rammer and Lifters • Vernier caliper • Tape measure	• Grease • Sand • Aluminium metals • Ingots • Additives • Lubricants (oil)

	• Spirit level and Bellows	

Indicative content 2.1 : Casting Metals for Aluminium with its Alloys.

Duration: 10 hrs.

Theoretical Activity 2.1.1: Description of low melting temperature metal and Aluminium with its alloys

Tasks:

1: You are requested to answer the following questions:

i. Identify the main Low temperature metals used in casting

ii. Describe casting metals for aluminum with its alloys as "low temperature metal and Aluminum with its alloys metal

iii. State the properties of low temperature metal and aluminum with its alloys metal.

2: Provide the answer of asked questions on paper

3: Present your findings to your classmates and trainer.

4: Pay attention to the trainer's clarification and ask questions where necessary

5: Read the key reading 2.1.1.

Key readings 2.1.1

Description of low melting temperature metal and Aluminium with its alloys

- **Low temperature metals used in casting:**

✓ **Potassium (K)**: Is a chemical element, at room Temperature Potassium is a solid me tal at room temperature (around 20°C or 68°F. It has with several physical properti es, including:

- **Density:** Potassium has a relatively low density compared to many other metals . Its density is about 0.89 grams per cubic centimeter (g/cm³).
- **Melting Point:** The melting point of potassium is relatively low compared to oth er metals. It melts at approximately 63.38°C (146.08°F).
- Boiling Point: Potassium has a low boiling point, which is around 774°C (1,425°F).
- **Conductivity:** Potassium is a good conductor of electricity and heat due to its m etallic properties. It has high electrical conductivity and thermal conductivity.
- **Malleability and Ductility:** Potassium is a malleable and ductile metal, meaning it can be easily shaped and stretched into various forms without breaking.
- **Luster:** Potassium has a bright, shiny luster when freshly cut, but it tarnishes rap

idly when exposed to air, forming a dull oxide layer.

- **Atomic Structure:** Potassium has an atomic number of 19, and its atoms consist of 19 protons, 19 electrons, and varying numbers of neutrons, depending on th e isotope. Its atomic symbol is K.

✓ **Sodium** is a chemical element with the symbol "**Na"** and atomic number 11.

It has several physical properties, including:

- **Silver** Color: Sodium is a soft, silvery-white, highly reactive metal. It has a metall ic luster and is similar in appearance to other alkali metals.
- **Low Density:** Sodium has a relatively low density, which means it is lightweight compared to many other elements.
- **Low Melting and Boiling Points:** Sodium has a low melting point of 97.79 degre es Celsius (208.02 degrees Fahrenheit) and a low boiling point of 883 degrees C elsius (1621 degrees Fahrenheit). This low melting point allows sodium to easily melt and form a liquid at relatively low temperatures.
- **High Thermal and Electrical Conductivity**: Sodium is a good conductor of heat a nd electricity. It has high thermal and electrical conductivity, which makes it use ful in various industrial applications.
- **Softness:** Sodium is a soft metal that can be easily cut with a knife. Its softness a llows it to be easily molded into various shapes.
- **Reactivity:** Sodium is highly reactive with water and air. It quickly tarnishes in th e presence of oxygen, forming a layer of sodium oxide on its surface. When exp osed to water, it reacts vigorously to produce sodium hydroxide and hydrogen g as.

✓ **Indium** is a chemical element with the symbol "**in"** and atomic number 4 9.

It has several notable physical properties:

- **Soft and Malleable:** Indium is a relatively soft and malleable metal. It can be eas ily cut, bent, and shaped without fracturing. Its malleability makes it useful in va rious industrial applications.
- **Silver-White Luster:** Indium has a bright, silver-white luster, which gives it a visu ally appealing appearance.
- **Low Melting Point:** One of the most distinctive properties of indium is its low m elting point. It melts at a temperature of approximately 156.6 degrees Celsius (3 13.9 degrees Fahrenheit), which is relatively low compared to many other metal s. This low melting point makes indium a valuable material for certain low-temp erature applications, such as solders and fusible alloys.
- **High Ductility:** Indium is highly ductile, meaning it can be stretched into thin wir es without breaking. This property makes it useful for various electrical and elec tronic applications.
- **Good Conductor of Electricity:** Indium is a good conductor of electricity, making it suitable for use in electrical contacts and other electronic components.
- **Low Thermal Neutron Capture Cross-Section:** Indium is known for its low therm

al neutron capture cross-section. This property makes it useful in nuclear applic ations, such as controlling nuclear reactions and as a neutron absorber in nuclea r reactors.

- **High Reflectivity**: Indium has a high reflectivity for both visible and infrared ligh t, making it useful for optical coatings and mirrors.

✓ **Lithium** is a chemical element with the symbol **"Li"** and atomic number 3. It is the lightest metal and one of the alkali metals in the periodic table.

Lithium possesses several physical properties, including:

- **Silver-White Appearance:** Lithium is a soft, silvery-white metal with a metallic l uster.
- **Low Density**: Lithium has a low density, making it less dense than most other m etals. It is one of the least dense elements.
- **Low Melting Point**: Lithium has a relatively low melting point of approximately 180.5 degrees Celsius (356.9 degrees Fahrenheit), which means it can melt at re latively low temperatures.
- **Low Boiling Point**: Lithium also has a low boiling point, around 1,342 degrees Ce lsius (2,448 degrees Fahrenheit).
- **Ductile and Malleable**: Like many metals, lithium is ductile and malleable, mean ing it can be drawn into wires and hammered into thin sheets without breaking.
- **Good Conductivity**: Lithium is an excellent conductor of heat and electricity, wh ich makes it useful in various applications, including in batteries.
- **Low Hardness**: Lithium is relatively soft and can be easily cut with a knife.
- **Reactivity**: Lithium is highly reactive with water and air. It can tarnish and corro de quickly when exposed to moisture or oxygen, forming a layer of lithium oxide or lithium hydroxide on its surface.

✓ **Tin** (**Sn**) is a chemical element with several physical properties, including:

- **Melting Point:** Tin has a relatively low melting point of approximately 231.93 de grees Celsius (449.47 degrees Fahrenheit). This property makes it easy to work with in various industrial applications, including soldering.
- **Boiling Point:** The boiling point of tin is around 2,270 degrees Celsius (4,118 deg rees Fahrenheit).
- **Density:** Tin has a density of about 7.29 grams per cubic centimeter, which mak es it relatively dense for a non-ferrous metal.
- **Color:** Tin has a silvery-white, lustrous appearance.
- **Malleability:** Tin is highly malleable, which means it can be easily shaped or pou nded into thin sheets without breaking.
- **Ductility:** It is also ductile, meaning it can be drawn into thin wires without fract uring.
- **Conductivity:** Tin is a relatively good conductor of electricity. It is often used in electrical components and solders because of its conductivity.

✓ **Lead** is a chemical element with the symbol **Pb** and atomic number 82. It

has several physical properties, including:

- **Density:** Lead is a dense metal with a high density of about 11.34 grams per cubic centimeter (g/cm^3) at room temperature. This high density makes it heavy and is one reason why lead is commonly used in applications where weight is desirable, such as in radiation shielding.
- **Melting Point:** Lead has a relatively low melting point of approximately 327.5 degrees Celsius (621.5 degrees Fahrenheit), which makes it easy to melt and shape.
- **Boiling Point:** Lead has a boiling point of about 1,749 degrees Celsius (3,180 degrees Fahrenheit).
- **Color:** Lead is a bluish-white metal when freshly cut, but it can develop a dull gray appearance when exposed to air due to the formation of a surface layer of lead oxide.
- **Malleability:** Lead is a malleable metal, which means it can be easily shaped and molded into various forms. It can be rolled into sheets or drawn into wires.
- **Ductility:** Lead is also ductile, meaning it can be stretched into thin wires without breaking.
- **Electrical Conductivity:** Lead is a relatively poor conductor of electricity compared to many other metals. It is not commonly used for electrical wiring or electronic applications due to its limited conductivity.
- **Thermal Conductivity:** Lead is a relatively good conductor of heat, making it useful in applications where heat needs to be transferred or contained, such as in radiation shielding and soldering.

- **Aluminum with its alloys metal:**
  - ✓ **Aluminium (or Aluminium)** is a chemical element with the symbol **Al** and atomic number 13. It has several physical properties, including:

- **Silvery-White Color:** Aluminum has a silvery-white appearance, making it aesthetically appealing and commonly used in various applications.
- **Low Density:** Aluminum is a lightweight metal with a relatively low density compared to many other metals, such as iron or copper. Its low density makes it valuable for applications where weight reduction is essential, like in the aerospace and automotive industries.
- **Good Thermal Conductivity:** Aluminum is an excellent conductor of heat, making it useful for heat exchangers, radiators, and other applications where efficient heat transfer is required.
- **Good Electrical Conductivity:** While not as conductive as copper, aluminum still has good electrical conductivity, making it suitable for electrical conductors and wiring.
- **Malleability and Ductility:** Aluminum is malleable and ductile, meaning it can be easily shaped and formed into various products, including sheets, foils, wires,

and structural components.

- **High Corrosion Resistance:** Aluminum naturally forms a thin oxide layer on its s urface, which provides protection against corrosion. This oxide layer makes alu minum highly corrosion-resistant in many environments.
- **Non-Magnetic:** Aluminum is not magnetic, which can be advantageous in applic ations where magnetic interference is a concern.
- **Low Melting Point:** Aluminum has a relatively low melting point of approximate ly 660.3 degrees Celsius (1220.5 degrees Fahrenheit), which makes it easy to wo rk with in various manufacturing processes.
- **Good Reflectivity:** Aluminum has high reflectivity for both visible light and non- visible forms of electromagnetic radiation, which is why it is often used in mirro rs, reflectors, and insulation materials.
- **Recyclability:** Aluminum is highly recyclable, and recycling consumes significantl y less energy compared to producing new aluminum from bauxite ore. This prop erty makes aluminum an environmentally friendly material.

  - ✓ **Aluminum alloys** are materials that consist primarily of aluminum and ot her elements such as copper, magnesium, silicon, and zinc. These alloys a re known for their excellent combination of physical properties, making t hem widely used in various applications. Some of the key physical proper ties of aluminum alloys include**:**

- **Low Density:** Aluminum alloys have a relatively low density, which makes them lightweight compared to many other metals. This property is advantageous in a pplications where weight reduction is important, such as in the aerospace and a utomotive industries.
- **High Strength-to-Weight Ratio:** Despite their low density, aluminum alloys can exhibit good mechanical strength. They offer a high strength-to-weight ratio, m aking them suitable for applications that require both strength and low weight, such as in the construction of lightweight structures and vehicles.
- **Good Conductivity:** Aluminum alloys have excellent electrical and thermal cond uctivity. This property is important in electrical wiring, heat exchangers, and oth er applications where efficient heat transfer or electrical conductivity is necessa ry.
- **Corrosion Resistance:** Aluminum alloys naturally form a protective oxide layer o n their surface, which provides them with good corrosion resistance. This oxide layer helps prevent further oxidation and degradation in various environments, including exposure to moisture and some chemicals.
- **Ductility and Formability:** Aluminum alloys are generally highly ductile and can be easily formed into various shapes through processes like rolling, extrusion, a nd forging. This makes them suitable for manufacturing a wide range of product

s.

- **Non-Magnetic:** Aluminum alloys are non-magnetic, which can be advantageous in applications where magnetic interference or attraction is undesirable.
- **Reflectivity:** Aluminum is a highly reflective material for both visible and infrare d light. This property is exploited in applications like reflective coatings, mirrors, and heat shields.
- **Recyclability:** Aluminum alloys are highly recyclable, and recycling aluminum re quires significantly less energy compared to producing it from primary sources. This makes aluminum a sustainable and environmentally friendly material choic e.
- **Good Machinability:** Many aluminium alloys are easy to machine, which simplifi es the manufacturing process for a wide range of products.

Points to Remember

- The Low temperature metal are Potassium, Sodium, Indium, Lithium, Tin, Lead must be used in casting metals for aluminium with its alloys.
- Low Density, High Strength-to-Weight Ratio, Good Conductivity, Corrosion Resistance, Ductility and Formability, Non-Magnetic, Reflectivity, Recyclability and Good Machinability are the properties of low temperature metal must be focused.

Indicative content 2.2: Production of a Casting.

Duration: 20 hrs

Theoretical Activity 2.2.1: Description on production of a casting.

Tasks:

1: You are requested to answer the following question:

i. Discuss on the casting procedures required in production of a casting

2: Provide the answer of asked questions on papers.

3: Present your findings to your classmates and trainer.

4: Listen carefully trainer clarification and ask questions where necessary.

5: Read the key reading 2.2.1

Key readings 2.2.1 Description of casting procedures used in production of a casting

- ✓ **Sand preparation / sand reclamation:** Preparing sand for casting is a critical ste p in the foundry process. High-quality casting sand is essential to ensure that th e final castings have a smooth surface finish and accurate dimensions.

The primary purpose of preparing sand for casting is to create a mold that can withstan d the heat of molten metal and retain its shape while allowing for the proper flow of m etal into the cavity.

- ✓ **Molding:** Molding is the process of manufacturing by shaping liquid or pliable ra w material using a rigid frame called a mould or matrix. The primary purpose of molding is to create a hollow cavity in the desired shape and then fill it with a m aterial that will harden or set, ultimately forming the final product.
  This may have been made using a pattern or model of the final object. The liquid hardens or sets inside the mould, adopting its shape.
  A mould or mold is a hollowed-out block that is filled with a liquid or pliable material such as plastic, glass, metal, or ceramic raw material.
  A mould is the counterpart to a cast. Moulding is a technique through which a material, often plastic, but also metal, rubber, or powder mixtures is shaped on the outline of a die or mould.
- ✓ **Melting of metal:** The preparation of molten metal for casting is referred to as h eating metal from a solid state to a liquid state due to an increase in temperatur e. It is usually done in a specifically designated area of the foundry, and the mol

ten metal is transferred to the pouring area where the moulds are filled. Meltin g may be done by gas or electricity.

- ✓ **Pouring into mold:** Casting processes involve the use of molten material, usuall y metal. This molten material is then poured into a mould cavity that takes the f orm of the finished part. The molten material then cools, with heat generally be ing extracted via the mould, until it solidifies into the desired shape.

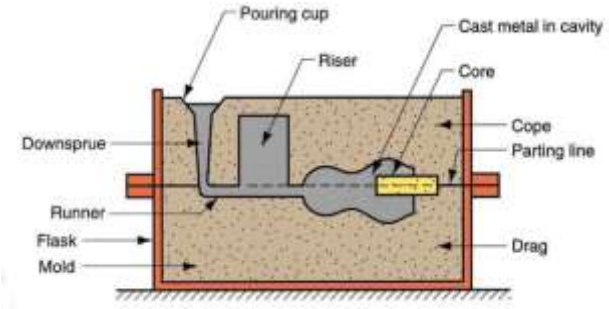
- ✓ **Casting:** A casting is the process of pouring molten metal into a mold and allowi ng it to solidify. Solidification during casting is a critical process in metal and ma terial manufacturing, particularly in foundry and casting operations. It refers to the transformation of a liquid material, typically a molten metal or alloy, into a s olid form within a mold or casting cavity. The solidification process is influenced by several factors, including temperature, heat transfer, and the alloy's compos ition.
- ✓ **Cleaning and finishing:** is the process of taking cooled, molded cast assemblies and preparing them for use. Depending on the process used, (nobake, green san d, investment, etc.) the castings will require various levels of finishing.

These are the cleaning and finishing procedures to be followed:

- Removal of sand, scale, and excess metal from the casting.
- Burned-on sand and scale are removed to improve the surface appearance of th e casting.
- Excess metal, in the form of fins, wires, parting line fins, and gates, is removed.
- Inspection of the casting for defects and general quality is performed.
- Casting finishing is the process of taking cooled, moulded cast assemblies and pr eparing them for use.

- Once the castings are separated from the trees or risers, all flash and parting line metal must be removed.
- Each of these is a result of casting using compacted moulds.
- Depending on the casting finish quality, finishing may involve several steps of gri nding from coarse to fine.
- After finishing, castings are inspected for surface quality. Inspection can be perfo rmed manually by visual checking, manually by template comparison or by an au tomated inspection station.

Notice: Metal casting process begins by creating a mould, which is the 'reverse' shape of the part we need. The mould is made from a refractory material, for example, sand. The metal is heated in an oven until it melts, and the molten metal is poured into the m ould cavity. The liquid takes the shape of a cavity, which is the shape of the part. It is co oled until it solidifies. Finally, the solidified metal part is removed from the mould.



Practical Activity 2.2.2: Performing casting procedures.

Task:

1: Referring to the previous activity 2.2.1, you are requested to go in manufacturing workshop/ foundry and performing casting procedures

2: Wear appropriate PPE related to the task.

3: Select all required materials, tools and equipment needed to perform casting procedures.

4: Present your final work/ product to the trainer /classmates.

5: Read key reading in 2.2.2.

6: Perform the provided task in application of learning 2.2.

Key readings 2.2.2

Performing casting procedures

- **The steps to be followed when producing good casting product:**
  - ✓ **Choose a suitable location:** Make sure you have enough space to perform the procedures.
  - ✓ **Material Selection:** Choose the appropriate material for your casting, considering factors like strength, durability, corrosion resistance, and cost.
  - ✓ **Sand selection:** choose the right sand according to the product specifications.
  - ✓ **Positioning pattern into flask and fill sand into mold:** this step of sand casting involves the placement of the pattern in mold sand. The size and shape of the casting is directly influenced by the mold.
  - ✓ **Set up the gating system:** most casting processes involve the use of a gating system, and sand casting is no exception. Consisting of pouring cup and tunnels or gates to the mold, it's used to funnel the molten mold into the mold cavity.
  - ✓ **Remove the mold pattern:** with the gating system set up, manufacturing companies can then remove the mold pattern from the sand. When the mold pattern is placed inside the sand, the sand takes its shape. As a result, the mold pattern can be removed.
  - ✓ **Pouring molten metal into mold cavity**: now it's time to pour the molten metal into the mold cavity. Once the metal or alloy has turned from a solid state to a liquid state, it's poured into the mold cavity.
  - ✓ **Wait for the metal to cool after the molten metal** has been poured into the mold cavity, manufacturing companies must wait for it to cool. As the molten metal cools, it will revert from a liquid state back to a solid state.
  - ✓ **Break open mold to remove the metal casting:** on this step you remove the mold to get casted product.
  - ✓ **Finishing and cleaning after getting casted product** and **make surface finish for use.**

Points to Remember

- After comprehension of previous activities, you note that whether casting procedures are appropriately followed such Sand preparation, Molding, Melting of metal, Pouring into mold, Casting, Cleaning and finishing.

Application of learning 2.2.

Suppose that, the manager of T&B manufacturing workshop request your trainer a support of training his workers about the appropriate casting procedures to be followed when you are in production of a casting. You are requested to perform the procedures followed before workers of T&B manufacturing workshop

As follow:

i. Selecting the appropriate material for casting
ii. Selecting the right sand according to the product specifications.
iii. Positioning pattern into flask and fill sand into mold
iv. Setting up the gating system
v. Removing the mold pattern from the sand
vi. Pouring molten metal into mold cavity
vii. Waiting for the metal to cool
viii. Opening mold to remove the metal casting to get casted product.
ix. Finishing and cleaning casted product and make surface finish for use

Learning outcome 2 end assessment

Theoretical assessment

1. **Choose the correct answer,**

i. The following are Low temperature metal required for casting metals for aluminium with its alloys, except:

a) Potassium
b) Conductivity
c) Sodium
d) Reactivity
e) Indium
f) Both B and D

ii. Aluminium with its alloys metal has some several physical properties, except

a) Thermal Conductivity
b) Low Density
c) A and B are correct
d) High Corrosion Resistance
e) Low Melting Point
f) Aluminium alloys
g) All above are not correct

iii. The following are the casting procedures , except

a) Good Machinability
b) Creating a mould
c) Sand preparation
d) Melting of metal
e) Pouring into mould
f) All above are correct

2. Match the definition in column **A** with their corresponding terms in column **B** and write the answer in column **C** of the table below:

Answer	Column A	Column B
1…….	A. Molding	1.Is referred to as heating metal from a solid state to a liquid state due to an increase in temperature.
2……..	B. Pouring into mold	2.Is a critical step in the foundry process, High-quality casting sand is essential to ensure that the final castings have a smooth surface finish and accurate dimensions
3……	C. Melting of metal	3.This property is important in electrical wiring, heat exchangers, and other applications where efficient heat transfer or electrical conductivity is necessary.
4……	D. Sand preparation	4.Is the process of manufacturing by shaping liquid or pliable raw material using a rigid frame,
5……	E. Good Conductivity	5.Aluminum has high reflectivity for both visible light and non-visible forms of electromagnetic radiation, which is why it is often used in mirrors, reflectors, and insulation materials.
6……	F. Boiling Point	6.This molten material is then poured into a mould cavity that takes the form of the finished part. The molten material then cools, with heat generally being extracted via the mould, until it solidifies into the desired shape.
7……	G. Good Reflectivity	7.Lead has a boiling point of about 1,749 degrees Celsius (3,180 degrees Fahrenheit).

Practical assessment

WHOTECH company ltd located in NYABIHU District won a tender of making gates. Want to fix aluminium décor on them, but they don't have qualified person in casting. As you are manufacturing technician in casting. You are requested to cast a sample décor for them which are shaped as arrowhead with 50mm width, 100mm length and tail of 50mm.

References

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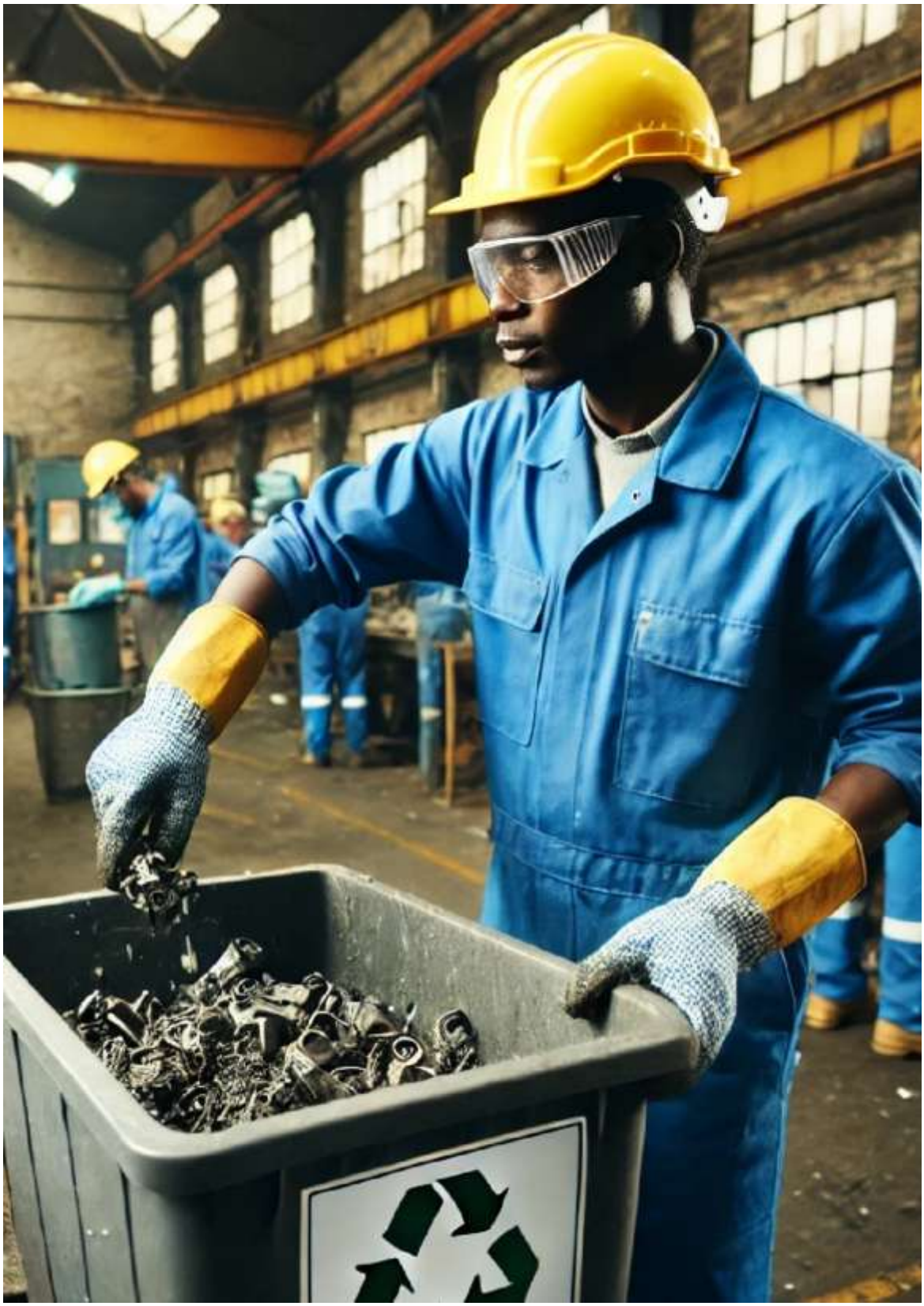
Campbell, J. (2003). *Castings*. Butterworth-Heinemann.



Indicative contents	
1.1.	**Checking of casted product.**
1.2.	**Product finishing operation.**
1.3.	**Post-casting activities**

Key Competencies for Learning Outcome 3: Perform Post Casting Activities.

Knowledge	Skills	Attitudes
• Description of casted product defects • Description of product finishing operations • Description of waste disposal • Identification of Cleaning techniques • Description of the procedures for storing tools and equipment used in casting	• Checking defects on casting product • Finishing operations on product surface • Storing materials, tools and equipment. • Cleaning tools, equipment and workplace	• Being attentive • Having Punctuality • Have Self confidence • Being adaptive • Have critical thinking • Being time manager

Duration: 10 hrs.

Learning outcome 2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Check correctly the quality of casted product as used in casting process.
2. Perform correctly finishing techniques as required in surface operation of casted product.
3. Clean properly tools, equipment and work place after casting process.
4. Store properly materials, tools and equipment for casting.
5. Differentiate correctly casting waste disposal as required for finishing product.

Resources

Equipment	Tools	Materials
• PPEs • First aid kit • Furnace • Sand mixer • Polishing machine • Fire extinguisher	• Casting flasks • tongs • travels • strike bar • mallet • sprue pin • shovel • draw spike (screw) • vent rod • vent wire • lifter • hammer • slick • bulb swab	• Lugs • pen • sand • aluminium metals • ingots • additives coal dust • corn flour • dextrin • sea coal • pitch • wood flour

Indicative content 3.1: Checking of Casted Product.

Duration: 4 hrs.

Theoretical Activity 3.1.1: Description of casted product defects

Tasks:

1: You are requested to answer the following questions:

i. Define term" **Casting defects**"
ii. Discuss on casting defects categories
iii. Identify the methods of preventing casting defects

2: Join your group and work on the assigned task.
3: Present your findings to your classmates and trainer.
4: Listen carefully trainer clarification and ask questions where necessary.
5: Read the key reading 3.1.1

Key readings 3.1.1 Description of casted product defects

- **Definition of Casting Defects:**

Casting defects: are unwanted irregularities that appear during the metal casting proce ss. Defects increase manufacturing costs and waste and can lead to products and parts that do not perform as designed.

- **Casting defects categories**

Common defects in these cast parts can be broken into **two categories** — internal and superficial — depending on where they occur in the part.

✓ **Internal Defects**

By their nature, internal defects can be harder to spot when inspecting a finished castin g product.
These defects occur within the part and are not apparent during a visual inspection. So me of the most common internal defects are:

- **Inclusions**
- **Gas Porosity**
- **Shrinkage Porosity**

They are typically only identified after machining the part or through X-ray identificatio n. Internal defects can significantly reduce the finished casting's structural integrity and must be avoided.

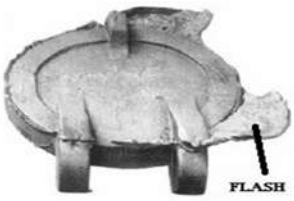
- ✓ **Superficial Defects:** these defects occur on the surface of the casting product, a re typically easier to catch during a visual inspection. Although they can be easie r to find, superficial defects can be detrimental to the quality of the finished par t. Superficial defects must be dealt with to ensure a high-quality casted product. Some of the most common superficial defects are:
  - **Blisters**
  - **Cracks**
  - **Cold Laps**
  - **Laminations**
  - **Lakes**
- ✓ **The following are other casting defects can be categories:**
- **Gas Porosity:** When gases are trapped inside the molten metal during casting, p orous areas are formed inside the part as the casting solidifies. These gases ofte n show up in poorly vented areas of the casting and can occur when too much d ampness is present.
- **Blowholes:** Found below the part's surface, blowholes are large cavities that of ten are not found until the part is machined or analyzed with x-rays. When cove red by thin layers of metal, blowholes are called blisters.
- **Open Holes:** When blowholes appear at the casting surface, they are called ope n holes, caused by gas trapped in the casting during pouring.
- **Pinholes:** Smaller than blowholes, these pockets of porosities are typically less t han 2mm in diameter and are often found in groups with many other pinholes. These groupings tend to occur in the cope (upper) part of the mold in poorly ve nted pockets.
- **Shrinkage Defects**: As the metal used in casting cools, the size of the part shrink s. While this shrinkage is normal, careful consideration is required to prevent sh rinkage in the cavity from occurring and ruining the part. Uneven shrinking can also leave residual stresses in the part, altering the part's performance. Keeping the liquid metal in the mold at an even temperature is key.
- **Open Shrinkage Defects:** Open to the atmosphere, air compensates for these d efects as the part shrinks leaving surface deformities on the casting. Pipes and c aved surfaces are two types of open shrinkage defects that occur on the surface of the casting.
- **Closed Shrinkage Defects:** is similar to porosity, closed shrinkage defects occur below the surface, inside the casting. Hot spots and isolated pools of hot liquid are common causes of closed shrinkage defects.
- **Warping:** During or after solidification, a casting can take on an unwanted chan ge in dimension. This type of deformity can render the casting ineffective and is often more pronounced in large, flat sections of the casting.

- **Metallurgical Defects:** Improper cooling can change the microstructure of the fi nished part in different sections.
- **Hot or Hard Spots:** If sections of the casting are able to cool more quickly, hard spots can occur due to the change in microstructure. These hard spots can add difficulty to machining processes.
- **Hot Tears or Cracks:** As the casting cools, cracks or tears can form typically in th e form of irregular crevices in a branched pattern.
- **Pouring Metal Defects:** is Cold shuts, misruns, and slag inclusion can all occur if the molten metal used in casting is not prepared and handled properly. Too low of temperatures limits the amount of time the liquid metal has before solidifyin g.
- **Misruns:** If the molten metal is not properly heated it may not flow properly to all of the extremities, resulting in a misrun. Castings with parts missing are a cle ar sign of a misrun.
- **Cold Shut or Lap:** A line or crack with a round edge on the casting surface is a go od indication of a cold shut defect. This surface defect creates a stress concentr ator that makes the overall casting weaker.
- **Slag Inclusion:** Often called scabs, these irregular metallic crusts appear on the casting surface. Only a few millimeters thick, slag inclusion or scabs are similar t o rat tails.
- **Cold Shots:** globules formed from splattering during pouring can become entrap ped in the molten liquid.
- **Mold Material Defects:** If the mold being used is not in good condition or is not prepared properly, the mold itself can lead to defects in the casting. Soft molds from a lack of ramming can lead to many of these defects,
- **Cuts and Washes:** These areas of excess metal appear when the molten metal e rodes the molding sand. Often the defect is tilted in one direction, showing the direction the metal flowed as it entered the mold.
- **Fusion:** When the grains of sand in the mold fuse with the molten metal, fusion defects occur. The casting will have a thin crust with a brittle, glassy appearance to it. This appearance will firmly adhere to the casting.

- **Swells:** As the name suggests, swells appear as an enlargement of the casting. S wells typically have the shape of a light, smooth bulge on vertical casting faces.
- **Run Out:** When liquid metal leaks out of the mold, you have a 'run out' defect. Because there is not enough molten metal left, the part typically appears incom plete or missing.

- **Drops:** Irregularly shaped projections on the cope surface of casting are called d rops. These defects occur when sand falls or drops into the casting while the me tal is still in the liquid phase.
- **Metal Penetration:** If the molding sand has gaps, liquid metal will often penetr ate the mold. Look for a rough, uneven surface finish on the casting.

- **Rat Tails, Buckles, and Veins:**
- Irregular lines or cracks on the casting are called rat tails or reins. When rat tails are really bad, they are called buckles. Typically these defects occur on the bott om surface of the mold.
- **Casting Shape Defects:** Even when the mold is prepared properly, defects can o ccur during the casting process.
- **Shift or Mismatch:** For casting to set properly, the upper (cope) and lower (drag) parts of the mold must line up correctly at the parting line. This type of defect is easy to detect as the casting will look as though the mold shifted at the partin g line.
- **Flash, Fin, and Burrs:** Any unwanted and excess material attached to a casted p roduct that occurs at the parting faces.



- **Preventing Common Defects in Casting**

  Using best practices for mold design, casting parameters, and cleaning processes often eliminates the bulk of defects common to low-pressure casting.

  Inclusions

  Inclusions are irregularly shaped holes inside the cast part caused by contaminants in the molten metal. These contaminants weaken the strength of the final part and should be prevented.

✓ **Causes**

- Low furnace charge purity
- Improperly cleaned die cavity

- Improper mold-release agent
- Polluted molten metal alloy

✓ **Solutions**

- Ensure purity of furnace charge
- Use a well-mixed, high-quality mold-release agent
- Purify metal liquid and remove slags
- Clean ladles and die cavities

✓ **Gas Porosities:** Similar to inclusions, gas porosities are caused by pockets of vapor or gas caught inside the molten metal instead of solid contaminants. These pockets of gas bubbles reduce the strength of the cast part.

✓ **Causes**

- Hydrogen in the molten metal
- Gases involved during the filling
- Gases released from the mold.

✓ **Solutions**

- Keep alloy ingots dry and clean before smelting
- Prevent overheating of the molten metal
- Keep casting parameters especially injection speed
- Follow best practices for sprue and runner design
- Use high-quality mold-release agents
- Use mold flow analysis to predict mold performance in the design process

✓ **Blisters:** Just like on human skin, blisters on a cast part are visually similar. Caused by gas expansion under the surface, these bulges on the part surface are similar to gas porosity defects.

✓ **Causes**

- Overheated die temperature
- Insufficient pressure-holding time
- Insufficient blowing time after spraying the mold-release agent
- Poor venting performance of the gating system
- Gases involved in the injection process

✓ **Solutions**

- Optimize release agent quality and usage
- Increase pressure-holding time
- Adjust casting parameters like injection speed
- Lower die and smelting temperatures

✓ **Cracks:** Just as it sounds, cracks are irregular appearances on the casted product surface. Cracks tend to increase in size when forces are applied to the product, significantly decreasing the strength of the finished product.

- ✓ **Causes**
  - Poor alloy mix,
  - Inadequate casting parameters
  - Inferior mold design can cause cracking.
  - Too low temperature
  - High Zn element concentration in an Al-Si alloy
  - high Mg element concentration in Al-Mg alloy
  - high concentration of Fe element
  - Non-uniform wall thickness in the cast product
  - Contaminants in mold decreasing the plasticity of parts
- ✓ **Solutions**
  - Ensure the correct elemental composition of the alloy used in melting
  - Improve die temperature and casting parameters
  - Adjust mold design to ensure uniform wall thicknes

Practical Activity 3.1.2: Perform defects checking on the casted product.

Task:

1: Referring to the previous activity 3.1.1, you are requested to go in manufacturing workshop/ workplace and perform the procedures for checking defects on casted products

2: Wear appropriate PPE related to the task

4: Pick casted product and perform the procedures for checking defects

5: Present your work to the trainer, workshop assistant or your classmates

6: Read key reading in 3.1.2.

7: Perform the task provided in application of learning 3.1.

Key readings 3.1.2 Checking Defects of Casted Product.

- **Procedures for checking defects on casted product**

Before work begins, you should follow several steps:

- ✓ **Wear PPE that provides the best protection for the task**.

- Always wear approved safety glasses or goggles when using a portable grinder.
- Face protection is highly recommended to protect against flying debris.
- Don't wear loose clothing or jewellery and make sure long hair is secured.
- Evaluate the task and work environment to determine if additional PPE is required like gloves, a dust mask or hearing protection

✓ **Review the casting specifications:** Start by familiarizing yourself with the casting specifications provided for the product. Understand the intended design, material requirements, dimensions, and any specific quality criteria outlined in the specifications.

✓ **Conduct a visual inspection of the casted product.** Look for any obvious defects such as cracks, porosity, surface irregularities, or dimensional variations. Pay attention to critical areas identified in the specifications.

✓ **Utilize appropriate measurement tools such as calipers, micrometers, or gauges to measure critical dimensions of the casted product.** Compare these measurements against the specified tolerances to identify any dimensional deviations.

✓ **Documentation Throughout the inspection process, make detailed notes, take photographs, and record the results of each step.** This documentation can serve as a reference for quality control, analysis, and comparison with future inspections.

✓ **Analyse the gathered data and observations to determine the severity and nature of the defects.** Prepare a comprehensive report that includes descriptions of the defects, their locations, and any necessary corrective actions. The report should also include recommendations for process improvement to prevent similar defects in future castings.

✓ **When checking casting defect you should be carefully to these key and follow the following steps:**

- Focus on identifying a casting defect based on its appearance.
- Be aware of the interactive nature of foundry processes and variables.
- Use rigorous experimental design methods to study complex causes of defects.

Step 1 – Identify the Defect

Foundry personnel have a tendency to identify a defect based on cause like slag defect or sand inclusions. While this is an acceptable method, after the diagnosis is done, the International Atlas of Casting Defects recommends that unknown defects be classified based on appearance rather than cause.

The key advantage of this classification system is that foundries are allowed to have multiple labels for the defect and leaves it more open to investigate different causes for the defect.

Step 2 – Experimental Design

When the castings were poured with the manual ladles, the frequency of inclusion defects was very low. When the castings were poured with the automatic pouring system, the frequency of inclusion defects was very high. Also, it was observed that on a same day at the same time, under similar sets of green sand parameters, frequency of the inclusion defects was still higher with the automatic pouring system compared to manual pour. This would suggest that metal and molding sand were not primary causes of defect. For this reason, no trials were run with modified base iron metallurgy or modified molding sand properties.

Step 3 – Gating Design and Filtration Review

Often, foundry personnel jump to modifying the gating system when they observe slag/dross defects. While turbulence in the gating system may be an important factor, the gating system is one of the few constants in the multi-variable production environment of the foundry. Since this gating system worked well in the manual pouring system, no major modifications were proposed. It was noticed that the cross-sectional area of the sprue base and runner was very large and the pouring time was controlled by manual pouring operation. It is strongly recommended that computer simulations of solidification and flow are conducted to review the performance of the gating system. Oxidation of iron and formation of inclusions will likely increase as the velocity of the metal increases. Slowing down the flow and keeping the gating system full may show a reduction in surface inclusions.

There are two aspects of filter sizing: the primary sizing is related to ensuring that the filter does not act as the choke. The standard rule of thumb is the cross-sectional area of the filter should be at least 4-6 times that of the choke.

In the case of this project, the filter was considered adequate for the specific application. Excellent guidelines are available for sizing and placing filters in gating system.

Step 4 – Preliminary Trials

It is important that trials be conducted with just a handful of variables. Proper experimental designs are required to ensure interaction effects are captured (effect of pouring time, temperature and chemistry together, for example). Pours

were grouped by heat, and at least 10-20 molds were poured per heat. It is important to measure and document all variables related to the casting.

Step 5 – Production Trials

Production trial volumes and details are important in a quality assurance program. Production trials for automotive applications typically require thousands of castings. Some foundries might review data for a whole shift or for several heats to ensure repeatability and reliability of quality. Data tracking includes pouring temperatures, pouring times, microstructure, chemistry, lab tests related to mechanical properties, and other information.

During the preliminary and production trials, the pouring was done automatically but the metal transfer was manual (by forklift) and, therefore, took more time, resulting in a higher than normal temperature loss. Following the five-step process, key recommendations to reduce the defect included:

- Increase the pouring temperatures.
- Control pouring temperatures (by improving ladle insulation).
- Reduce magnesium additions.
- Increase the bismuth addition after MgFeSi treatment.
- Improve the automatic pouring ability to pour in the center of the cup.
- Reduce velocity and turbulence of the metal in the mold.
- Operate the automatic pouring system with fully automatic ladle filling.

Casting defects can be tested through various methods such as visual inspection, non-destructive testing (e.g., ultrasonic testing, radiography, dye penetrant testing), and destructive testing (e.g., mechanical testing, metallurgical analysis) to identify and evaluate any flaws or irregularities in the casting. Metal Casting Testing Methods

The various methods of Metal Casting Testing are:

- **Chemical composition**
    - Casting finish
    - Dimensional analysis
    - Mechanical properties
    - Casting soundness
    - Chemical Composition

Chemistry inspection stands as one of the most prevalent quality tests conducted for castings. In this process, a master melter combines raw elements or pre-alloy materials to form a specific charge, akin to following a recipe. The charge composition can be adjusted as necessary. Subsequently, the molten metal is poured into a designated mould or directly into the final product. Whether

through a sample or the final pour, the customer determines whether a chemistry test is performed to assess the composition and ensure it aligns with the required specifications.

- **Casting Finish**

  Casting finish inspection is carried out post-casting to verify its compliance with customer specifications. Assessing the casting finish is typically a subjective process, where visual examination is performed using panels with varying degrees of surface roughness. Evaluating surface roughness does not rely on a definitive tool but rather relies on visual observation to determine if the finish meets the required standards.

Points to Remember

- After delivering casting defects types, causes and remedies, these are the mainly casting defects including: Gas Porosity, Shrinkage defects, Mold material defects, pouring metal defects, Metallurgical defects and Casting shape defects
- After comprehension of previous activities, you must check whether the casted product fulfils the specifications accordingly.
- The following methods: Visual inspection, use checking tools, Documentation, Analysis and making report must be focused when checking casted product.

Application of learning 3.1.

You were recently hired as a manufacturing worker for a wheel company. There are many new cast things you need to do at work. Referring to the previous activities both theoretical 3.1.1 and practical 3.1.2. Trainer recommend you to go to the workshop and perform defects checking on 100 casted steering wheels. Identify the procedures to be applied during checking and preventing defects on casted steering wheel as remembered below specifications:

i. Steering wheel diameter 350 mm
ii. Steering wheel length 95mm

Indicative content 3.2: Product Finishing Operation.

Duration: 4 hrs.

Theoretical Activity 3.2.1: Description of product finishing operations in casting process.

Tasks:

1: you are requested to answer the following question:

i. Discuss on polishing and machining as elements of surface finishing on casted product

2: Provide the answers for asked question on papers.

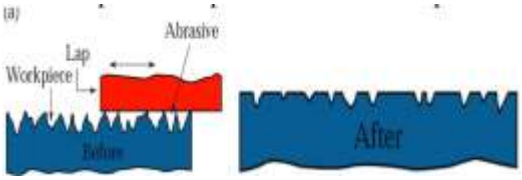
3: Present your findings to your classmates and trainer.

4: Pay attention to the trainer clarifications and ask questions where necessary

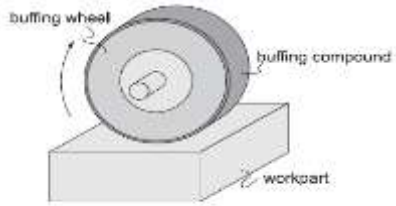
5: Read the key reading 3.2.1

Key readings 3.1.1 Description of product finishing operations.

- **Surface finishing:** The surface finish has a vital role in influencing functional characteristics like wear resistance, fatigue strength, corrosion resistance and power loss due to friction. The term "**surface finish**" refers to a surface's final texture at the end of production.
  - **Polishing:** Polishing is a finishing operation to improve the surface finish by means of a polishing wheel made of fabrics or leather and rotating at high speed. The abrasive grains are glued to the outside periphery of the polishing wheel. Polishing operations are often accomplished manually and described as follow:
  - **Lapping:** The term "lapping" is used to describe a number of various surface finishing operations where loose abrasive powders are used as the grinding agent at normally low speeds. It is a process reserved for products that demand very tight tolerances of flatness, parallelism, thickness, or finish.
  - **Characteristics of lapping process:**
    - Use of loose abrasive between lap and the work piece
    - Usually lap and work piece are not positively driven but are guided in contact with each other.
    - Relative motion between the lap and the work should change continuously so that path of the abrasive grains of the lap is not repeated on the work piece.

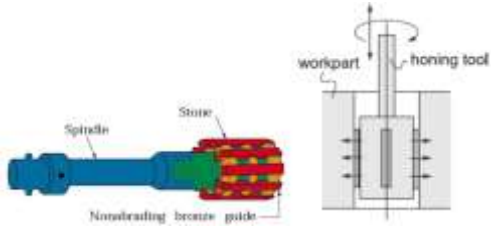


- **Buffing**: is a finishing operation like polishing, in which abrasive grains are not gl ued to the wheel but are contained in a buffing compound that is pressed into t he outside surface of the buffing wheel while it rotates. As in polishing, the abra sive particles must be periodically replenished. As in polishing, buffing is usually done manually, although machines have been designed to perform the process automatically. Buffing wheels are made of discs of linen, cotton, broad cloth, an d canvas.

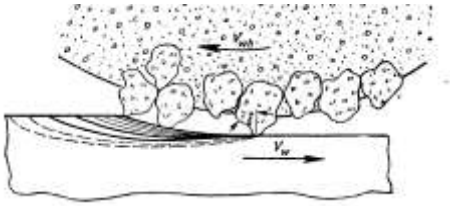


Schematics of the buffing operation.

- **Honing**: is a finishing process, in which a tool called hone carries out a combined rotary and reciprocating motion while the work piece does not perform any wo rking motion. Most honing is done on internal cylindrical surfaces, such as auto mobile cylindrical walls.



- **Grinding**: is the most common form of abrasive machining. It is a material cutting process which engages an abrasive tool whose cutting elements are grains of abrasive material known as grit. These grits are characterized by sharp cutting points, high hot hardness, chemical stability, and wear resistance. The grits are held together by a suitable bonding material to give shape of an abrasive tool



- **Machining:** is the process of shaping and sizing product to a specific form and

size. Typically, machine relates to metalworking, although it can also refer to the manufacture of wood, plastic, ceramic, stone, and other materials. If you have raw materials that you wish to mold into a certain shape for a specific purpose, you'll employ machining procedures to do it. Nuts and bolts, vehicle parts, flanges, drill bits, plaques, and a range of other equipment and things used in a variety of industries are examples of machined products.Machining can also be seen as a crucial finishing technique in which tasks are created to the appropriate dimensions and surface polish by gradually eliminating surplus material from the prepared blank in the form of chips using a cutting tool(s) that are pushed through the work surface (s).

Practical Activity 3.2.2: Perform Finishing Operations.

Task:

1: Referring to the previous activity 3.2.1, you are requested to go in manufacturing workshop/foundry and perform finishing operations on casted product
2: Select and Wear appropriate PPE related to the task.
3: Pick casted product and perform finishing operations.
4: Execute product finishing by applying appropriate operation.
5: Present your work to the trainer or classmates.
6: Read key reading in 3.2.2.
7: Perform the provided task in application of learning 3.2.

Key readings 3.2.2 Performing the finishing on casted product:

- **Surface finishing several polishing steps to ensure the desired product**:
- **Read the casting product specifications:** Start by carefully reviewing the casting specifications provided by the manufacturer or designer. This includes information about the material used, surface requirements, dimensional tolerances, and any specific finishing instructions.
- **Choose the right tools and equipment:** Based on the casting specifications and

identified defects, select the appropriate tools and equipment for finishing. This may include files, sandpaper, abrasive wheels, grinding machines, polishing compounds, and other finishing tools.

- **Read the material safety data sheets** (Instructional manuals): Before working with any tool or equipment during the finishing process, read the instructional manual provided by the manufacturers. This information will help you understand the potential hazards, proper handling procedures, and necessary personal protective equipment (PPE).
- **Determine the sequence of operations:** Develop a plan for the sequence of finishing operations based on the casting specifications and the desired surface quality. This may involve multiple steps such as grinding, sanding, polishing, deburring, and surface coating.
- **Follow proper safety protocols:** Ensure that you are familiar with the safety guidelines and protocols associated with the finishing process. This includes using appropriate PPE, maintaining a clean and organized workspace, and following safe operating procedures for the equipment and tools.
- **Execute the finishing operations:** Perform the planned finishing operations step by step, following the chosen sequence. Take your time to ensure each step is completed accurately and consistently, paying attention to detail, and maintaining the desired dimensions and surface finish.
- **Inspect the finished product:** Once the finished operations are complete, thoroughly inspect the product to ensure it meets the required specifications and quality standards. Check for any remaining defects or imperfections and make necessary adjustments or rework if needed.
- **Document the process (reporting):** Keep a record of the finishing process, including the tools, techniques, and parameters used. This documentation will be useful for future reference, quality control, and process improvement.

- **Polishing casted product steps**:

✓ Check if the material needs sanding
✓ Select the appropriate polishing compound and buffing tools
✓ Apply Polishing Compound
✓ Repeat the previous step
✓ Final Polish cast product
✓ Clean and Protect product

Points to Remember

- After comprehension of previous activities, you must check whether the casted product fulfils the specifications accordingly.
- The following methods: Visual inspection, use checking tools, Documentation, Analysis and making report must be focused when checking casted product.
- Surface finishing operations including: Polishing, Buffing, Honing, Grinding and Machining must be focused while you are product finishing operation during casting
- The product specifications, tools and equipment used should be consider during surface finishing operations of casted product.
- The main steps you should consider when execute surface finishing of casted product are product specifications and right tools and equipment

Application of learning 3.2.

Amina works in a manufacturing repair shop, her sales many casted products such as ring segment castings, industrial furnace doors, fire hydrant housing and Aluminium gearbox etc. After selling some of them, they ordered new product of selling. Suppose that, you are completed activities 3.2.1 and 3.2.2. Your shop neighbour request you to perform surface finishing operations before supplying casted products to the seller.

Indicative content 3.3: Post-casting activities.

Duration: 2 hrs.

Theoretical Activity 3.3.1: Description of cleaning technics, waste disposal methods and store tools, materials and equipment forecasting

Tasks:

1: you are requested to answer the following questions:

i. Discuss on "**waste disposal management**"
ii. Identify cleaning techniques of tools, equipment and workplace
iii. Describe casting tools and equipment storage procedures

1: Provide the answers for asked questions on papers

2: Present your findings/answers in whole class.

4: Listen carefully trainer clarifications and ask questions where necessary.

5: Read the key reading 3.3.1

Key readings: 3.3.1. Description of cleaning technics, waste disposal methods and store tools, materials and equipment for casting

- **Describe waste disposal management:**
  - ✓ **Waste** is a substance, which is no longer suited for its use and involves the proper management and disposal of various waste materials generated during casting processes. Many different types of waste are generated, including:
    - solid waste
    - hazardous waste
    - Industrial non-hazardous waste
    - Agricultural and animal waste
    - Medical waste,
    - Construction and demolition waste
    - Extraction and mining waste
    - Oil and gas waste
  - ✓ **Goals of waste disposal are**:
    - **Minimize environmental impact**: Ensure that waste does not contaminate soil, water, or air, which can harm ecosystems and human health.
    - **Protect public health:** Dispose of waste in a way that reduces the risk of disease transmission and exposure to harmful substances.

- **Conserve resources:** Promote recycling and resource recovery to minimize the depletion of natural resources.

✓ **Techniques and methods to properly dispose of your hazardous waste:**

- **Segregation:** Waste materials should be segregated based on their properties, such as hazardous and non-hazardous waste, metal scraps, solvents, oils, paints, and other chemical waste. This helps ensure appropriate disposal methods for each type of waste.
- **Recycling:** Metal scraps and waste can often be recycled, reducing the need for disposal. Establishing recycling practices within the metalworking facility can help recover valuable materials and minimize environmental impact. Recycling also conserves energy and reduces greenhouse gas emissions associated with metal production.
- **Hazardous waste management:** Metalworking processes may involve the use of hazardous materials, such as chemicals, solvents, and metal coatings. These waste materials should be handled and disposed of in compliance with local regulations. Contact a licensed hazardous waste disposal service to properly manage and dispose of such waste.
- **Reuse and repurposing:** Whenever possible, consider reusing or repurposing waste materials within the metalworking facility. For example, metal scraps can be used for fabrication of smaller parts or incorporated into other projects, reducing the overall waste generated
- **Treatment of wastewater:** Metalworking processes often produce wastewater contaminated with heavy metals, oils, and other pollutants. Implementing appropriate treatment systems, such as settling tanks, filtration, and chemical treatment, can help remove contaminants before discharging the wastewater into the sewage system or local water treatment plants.

✓ **Here are some common methods for casting waste disposal:**

- **Recycling:** Many casting facilities recycle scrap metal generated during the casting process. This can help reduce the amount of waste sent to landfills and save on raw material costs.
- **Reuse:** Some casting waste, such as casting sand or mold materials, can be reused in subsequent casting processes if it meets quality standards.

- **Landfill Disposal:** Non-recyclable and non-hazardous waste from the casting process is often disposed of in landfills. It's important to follow local regulations and guidelines for proper landfill disposal.
- **Hazardous Waste Disposal:** If the casting process involves hazardous materials or chemicals, they must be properly stored and disposed of following strict hazardous waste disposal regulations.
- **Treatment and Neutralization:** Some waste may require treatment or neutralization to make it safe for disposal. This is especially relevant if the waste contains corrosive, reactive, or toxic materials.
- **Solidification and Stabilization:** Some casting waste can be solidified and stabilized to reduce leaching of contaminants. This process is used for hazardous waste disposal to make it safer for landfills.
- **Resource Recovery:** Certain casting waste materials may contain valuable components that can be recovered through specialized processes, such as extracting precious metals or other valuable substances.
- **Composting:** Organic materials used in casting, like binders or additives, can be composted if they are biodegradable. This can be an eco-friendly disposal method.
- **Waste Minimization:** Implementing waste minimization techniques, such as improving casting process efficiency and reducing material usage, can help reduce the overall generation of waste.

- **Cleaning:** Cleaning is the process of removing unwanted substances, such as dirt, infectious agents, and other impurities, from an object or environment.

After casting activities tools and equipment must be cleaned to store them in good condition even workplace has to be cleaned.

✓ **Cleaning techniques of tools, equipment and workplace:**

- **Air pressure cleaning:** Air pressure cleaning is a process of removing dust from equipment, tools and working places by using air pressure.

- **Cleaning with cloth rugs:** Dry water stains by blotting the rug with an absorbent cloth immediately to prevent watermarks. Vacuum the rug regularly to keep dirt and debris from staining the fibers, if your rug has fringe, avoid vacuuming the fringe.

- ✓ **Clean the Workplace/ Foundry:** The workplace environment influences employees' productivity, performance, and wellbeing. No matter the industry, maintaining a clean workplace may help keep staff members safe, healthy, and efficient at the end of the job, working place must be kept clean so that to provide safe working environment.

Workplace cleaning tools

- **Brooms and Dustpans:** Brooms are used for sweeping dirt and debris from floors, while dustpans are used to collect and dispose of the swept materials.
- **Mops and Buckets:** Mops are used to clean and sanitize floors. Microfiber mops are popular for their effectiveness in trapping dust and dirt. A bucket is used to carry water and cleaning solutions for wet mopping.
- **Vacuum Cleaners:** Vacuum cleaners are used for cleaning carpets and rugs, as well as hard floors. They come in various types, including upright, canister, and backpack vacuums.
- **Microfiber Cloths:** Microfiber cloths are highly effective at capturing dust and dirt, making them suitable for cleaning surfaces like desks, countertops, and electronic devices.
- **Sponges and Scrub Brushes:** Sponges and scrub brushes are used for scrubbing and removing stubborn stains and dirt from surfaces.

- **Casting tools and equipment storage:** After cleaning tools and equipment are stored in their correct storage condition according to their types, sizes, and material. When storing casting tools and equipment, proper storage helps maintain the condition and longevity of the tools while ensuring they are organized and easily accessible.

Practical Activity 3.3.2: Perform cleaning, waste disposal management, storage procedures of materials, tools and equipment used in casting

Task:

1: Referring to the previous activity 3.3.1, you are requested to go in manufacturing workshop and perform cleaning and storing materials, tools and equipment as part of casting
2: Wear appropriate PPEs related to the work to be perform.
3: Clean and store tools, materials and equipment used in casting process
4: Present your work to the trainer or classmate.
5: Read the key reading 3.3.1.
6: Perform the task provided in application of learning 3.3

Key readings: 3.3.2 Perform cleaning, waste disposal management, storage procedures of materials, tools and equipment used in casting

- **Cleaning materials, tools and equipment used in casting:**
  - ✓ **Guidelines to be followed while cleaning materials, tools and equipment:**
    - Understand manufacturer recommendations
    - Wear appropriate personal protective equipment (PPEs)
    - Turn off and disconnect equipment
    - Remove residual material
    - Select appropriate cleaning agents
    - Clean all parts thoroughly
    - Dry completely
    - Inspect for wear and damage
    - Reassemble and test
    - Document the cleaning process
    - Establish a routine cleaning schedule
    - Train personnel
    - Handle waste properly
- **Waste disposal steps followed:**
  - ✓ Identify the type of waste
  - ✓ Separate waste
  - ✓ Follow safety protocols
  - ✓ Prepare waste for disposal
  - ✓ Label and document

- ✓ Choose a disposal method
- ✓ Schedule and arrange for pickup or drop-off
- ✓ Verify compliance
- ✓ Review and improve
- ✓ Educate and train personnel

- **Storing casting tools, and equipment properly**

✓ **Other essential to maintain steps for storing these items:**

- **Clean and prepare before** storing any tools, or equipment, make sure they are clean and free from any debris, dust, or contaminants. Clean and dry them as necessary.
- **Inspect for Damage:** Examine the casted products, tools, and equipment for any damage, wear, or defects. Repair or replace any damaged items before storage.
- **Organize and Categorize:** Organize and categorize items based on their type and use. This makes it easier to locate them when needed.
- **Proper Shelving and Racks:** Use appropriate shelves, racks, or storage units to keep tools and equipment off the floor to prevent damage and to maintain order.
- **Rust Prevention:** For metal tools and casted products, apply a rust inhibitor or coat them with a light layer of oil to prevent rust formation during storage.
- **Safety Measures:** If you are storing tools and equipment with sharp edges or points, use safety measures such as sheathing or guards to prevent accidents while handling them.
- **Lock and Secure:** If you have valuable or sensitive equipment, ensure that the storage area is secure, and consider using locks or security measures to prevent theft.
- **Accessibility:** Arrange your storage layout to make items easily accessible. The most frequently used tools or products should be readily available, while less-used items can be stored further away.
- **Documentation:** Keep a detailed inventory list of the stored items, including their location, condition, and usage history. This will help you keep track of your inventory and prevent items from getting lost or misplaced.

Points to Remember

- Waste disposal management, cleaning technics, storing tools, materials and equipment must be focused during post casting activities.

- While sand casting has numerous types of waste disposal management, casted product storage and procedures of cleaning materials, tools and equipment must be follow properly.
- During post- casting, activities should have Proper Shelving, Rust Prevention methods and Safety Measures.

Application of learning 3.3.

Suppose that, the manager of B&C manufacturing workshop requests your school a support of invigilating exam of his workers about conducting waste disposal management, cleaning technics and storage procedures of materials, tools and equipment. Referring to the activity 3.3.2. Ask your trainee to attend the supervision of that practical exam about to:

i. Waste disposal management,

ii. Cleaning technics and

iii. Storage procedures of materials, tools and equipment after carry out casting

Learning outcome 3 end assessment

Theoretical assessment

Written assessment

1. Some of the statements below are TRUE others are FALSE answer the following statements by writing "**True**" if the statement is correct or "**False**" if the statement is not correct.

i. Grinding is the most common form of abrasive machining. It is a material cutting process which engages an abrasive tool whose cutting elements are grains of abrasive material known as grit.

ii. Machining is the process of shaping and sizing materials to a specific form and size.

iii. Buffing is a punching operation like polishing, in which abrasive grains are not glued to the wheel but are contained in a buffing compound that is pressed into the outside surface of the buffing wheel while it rotates.

iv. Surface finish" refers to a surface's final texture at the end of production.

v. Runout happens when the mold un-leaks, leaving an inadequate amount of metal to form the desired casting.

vi. Before storing any casted products, tools, or equipment, make sure they are clean and free from any debris, dust, or contaminants. Clean and dry them as necessary**.**

2. Choose the correct answer

i. Which are the below is the casting defects categories?

a. Superficial Defects

b. A and E both are correct

c. Gas Porosity

d. Shrinkage Porosity

e. Internal Defects

ii. The following are many different types of waste are generated, except:

a) solid waste

b) hazardous waste

c) Industrial non-hazardous waste

d) Dustbin disposal waste

e) Medical waste

iii. The following are the cleaning techniques of tools, equipment and workplace, except:

a) Using Air pressure cleaning

b) Using cloth rugs

c) Using organized and easily accessible things

d) Using Vacuum Cleaners

e) Using Brooms

iv. The following are the steps for storing casting tools and equipment, except:

a) Keep detailed inventory list of the stored items.

b) Clean and add waste on tool and equipment before storing

c) Organize and categorize items based on their type and use

d) Use appropriate shelves, racks, and storage units to keep

e) Make sure they are clean and free from any debris, dust, or contaminants.

Practical assessment

DUHUZIMBARAGA company Ltd located in NYABIHU District won a tender of supplying 4000 aluminium cast door locker handles to fix on doors at ICYEREKEZO modern village located in the same district, before these lockers being supplied must be checked defect, finished surface, cleaned and stored. The company need a competent person for performing the mentioned task. As a competent trainee in post-casting activities. You are requested to reach the company for performing the mentioned activities within 8 hours.

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