Foundry Works

Level-I

Based on March 2022, Curriculum Version 1

Module Title: - Performing Gravity Die casting

Module Code: IND FDW1 M06 0822

Nominal Duration: 70 Hours

Prepared by: Ministry of Labor and Skill

August 2022

Batu town, Oromia; Ethiopia

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Acknowledgments

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

Acronyms

CP	Core print
DC	Die casting
FDW1	Foundry work level 1
GDCP	Gravity die casting process.
IND	Industrial
LAP	Learning activities performance
LO	Learning outcome
M06	Sixth module
NDT	Non-destructive testing
PPE	Personal protective equipment
TTLM	Teaching training and learning materials
TVT	Technical and vocational training
UC	Unit of competency

Introduction to the Module

This training material is designed to incorporate the knowledge, skill, and attitude of the trainees to perform gravity die casting within the nominal time duration of **70** hours. In this module, the trainees will understand the uses of gravity die casting operations and escalate the importance of die casting foundry technology which contributes to get high quality of casting. On the completion of theoretical training and through the hands-on practice given, they will acquire some of the basic skills and techniques of die casting processes. To this end, the module focuses on the fundamental aspects and practices in gravity die casting foundry works including safety practices, and selecting of metals to be melted, pouring, based on the required theoretical and practical parts to perform basic metal casting operations. Individual/group projects should be given in order to improve the skills of trainees in die casting operations.

In the foundry field; performing gravity die casting project helps to get the net shape of the intended industrial products. Foundries are one of the largest contributors to the manufacturing sector including recycling old and new materials, and melting and recasting millions of tons of scrap metal every time to create new products. It gives a high rate of production, with dimensional tolerances, and good surface finish. Moreover, many foundries use permanent mold in their casting process, this module is designed to meet the industry requirement under the foundry works based on the occupational standards, particularly for the unit of competency; **Performing gravity die casting** to achieve learning outcomes expected in level-I.

This module covers the units including:

- Preparing equipment
- Carrying out manual pouring
- Removing materials
- Cleaning die

The learning objectives of the module help the trainees to:

- Prepare equipment
- Carry out manual pouring
- Remove materials
- Clean die

Module Instruction

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

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

Unit one: Preparing Die Equipment

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

- Using safety cloth and apparatus.
- Mixing die coats.
- Maintaining die temperatures.
- Locating and closing die correctly.
- Placing die correctly on machine.
- Attaching air cooling systems.

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

- Use safety cloth and apparatus
- Mix different die coats
- Maintain die temperature
- Locate and close die correctly.
- Place die correctly on machine.
- Attach air cooling systems.

1.1. Safety Cloth and Apparatus

Foundry safety cloth is very important to protect hazards in the foundry workshop. Wearing appropriate safety close and using the right type of die casting apparatus are crucial conditions of foundry works. Personal injuries such as burns caused by molten metal, hot castings, hot oil and heat from die casting tooling, cuts and abrasions from castings and flash, slips and falls resulting from poor housekeeping, and sprains, strains and fractures that are the result either from work conditions or unsafe acts all contribute accident. Safety equipment includes glasses and aluminized suits. masks, gloves, gauntlet, safety shoes, aprons, etc.

Appropriate safety must be worn when casting metals. Aprons, gloves and leggings should be leather as this offers the most protection is a spillage of molten aluminum occurs. Normal textile material burns through very quickly and should not be used for the casting process. In addition, strong, leather shoes should be worn at all times in the workshop as they offer the best protection for feet. In industry shoes with steel toe caps are a basic requirement as shown in Figure 1.1.

1.1.1 Permanent Mold Casting

In permanent mold casting, high production rates (i.e. number of casting shots per hour) can be achieved due to the higher conductivity of the mold material (over sand or plaster) and the instant preparedness of the mold from one to the next. The most common material is steel which is coated with a refractory wash of acetylene, soot, sodium silicate or talc-based material before casting. This is to allow a) easy removal of the casting once solidified; b) a particular unnatural solidification direction to occur in the part; c) no chemical reactions to occur between molten alloy and the steel; and d) a longer tool life. Permanent molds have a limited life of between 50,000-150,000 casting shots before wearing out due to repeated fluid flow from incoming molten metal or internal thermal fatigue cracking or both. Worn out molds are replaced or repaired. Castings produced using permanent mold casting show relatively high strength compared to the castings produced by sand casting, due to the higher heat transfer rates and faster solidification times. Typically, permanent mold casting is used for manufacturing aluminum, magnesium and copper alloy-based products.

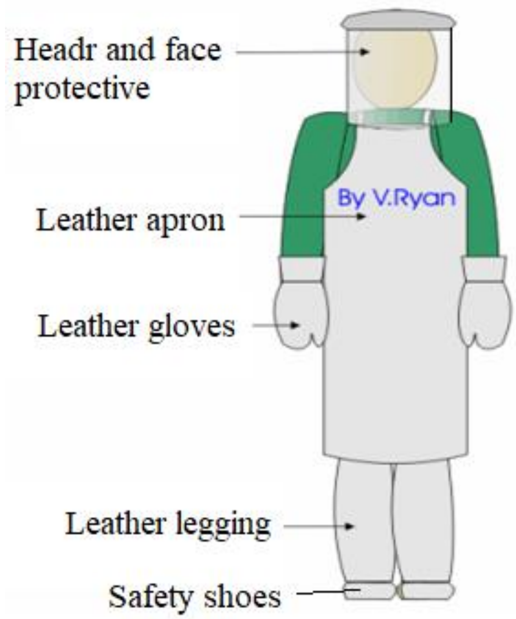


Figure 1.1 Wearing safety equipment

Basic points of the Die Casting Process

The die casting process is fundamentally simple but it is complicated by a massive array of ancillary equipment and details. There are only three basic factors (see below) that affect the final product that results from the rapid conversion of metal in the ingot form to a net shape. Some assumptions are usually made when dealing with die casting that help to visualize the logical chain of events that occur during each cycle. These assumptions are:

- Since the casting alloy is injected into the die cavity at a superheated temperature, it behaves like a hydraulic fluid during the very brief period of cavity fill.
- The metal travels in a straight line until it meets an obstruction and then the stream splashes and breaks up into turbulent eddies. During cavity fill, it follows the path of least resistance.

- Die casting is a turbulent process since liquid casting alloy travels through the system at extremely high rates of speed.

Most die castings are made from nonferrous metals, specifically zinc, copper, magnesium and aluminum-based alloys, but ferrous metal die castings are possible. The die casting method is especially suited for applications where many small to medium sized parts are needed with good detail, a fine surface quality and dimensional accuracy and consistency.

1.1.2 Die casting machines

There are two principal types of die casting machines, either classified as hot chamber or cold chamber machines, which fundamentally only vary with respect to the method of molten metal injection into the die cavity. In the hot chamber machine process, the liquid metal injection mechanism is submerged in the molten metal, and the cylinder is automatically filled with metal prior to each casting operation when the injection plunger rod is withdrawn. This process is typically applied for low melting point casting alloys, which cause the minimum of attack on the injection system material during the contact with the liquid metal (e.g. zinc and magnesium alloys).

In the cold chamber machine process, the injection mechanism is separated from the molten metal, and the cylinder is filled with metal prior to each casting operation using a ladle. A schematic of a cold chamber machine in charging position. The cold chamber process minimizes the liquid metal exposure of the injection system components, and it is normally applied for casting alloys with higher melting points, e.g. aluminum and copper alloys. A die can be constructed as a single or multiple-cavity die to produce single or multiple castings of identical shape during each casting operation cycle.

1.1.2.1 Gravity Die Casting

Gravity die casting process is used to create intricately shaped components for a wide range of industrial applications in the defense, medical and energy sectors. It involves pouring molten metal, under the force of gravity, into a pre-formed cast iron block which is fully machined to produce the die. The demand for net shape die castings, which require little or no machining, is steadily increasing. Stringent customer requirements are forcing die casters to deliver high quality castings in increasingly short lead times. Dimensional conformance to customer specifications is an inherent part of die casting quality. The dimensional attributes of a die casting are essentially dependent upon many factors--the quality of the die and the degree of control over the process variables being the two major sources of dimensional error in die castings.

When the flow of molten metal into the mold cavity is due to the gravitational force, then it is called gravity die casting. In this process, the molten metal is to be poured into the casting cavity via the pouring basin. Because of the problem of flow of the molten metal into every corner of the casting cavity due to the gravitational force, the gravity die casting will be used for producing the simple shape of the castings only. Die casting is a very commonly used type of permanent mold casting process. It is used for producing many components of home appliances (e.g rice cookers, stoves, fans, washing and drying machines, fridges parts), motors, toys and hand-tools. Surface finish and tolerance of die cast parts is so good that there is almost no post-processing required. Die casting molds are expensive, and require significant lead time to fabricate; they are commonly called dies. There are two common types of die casting: hot- and cold-chamber die casting.

Gravity die casting is process of die casting which is molten metal such as Aluminum poured into the metallic mold without any external pressure. Temperature of casting is nearby 750 degree Celsius. Because of the metal mold, the same mold can be used for producing an infinite number of castings, hence the process is also called a Permanent Mold Casting Process. There are two types of die casting.

- Gravity die casting
- Pressure die casting.

Each of the die casting type need their specific safety considerations. Trainees who are involved in the casting activity regularly have to deal with potentially hazardous activities and substances to reduce the associated risks to as low a level as possible and in doing so, keep our workforce as safe as possible.

Terms Used in die Casting

Cavity: The recess or impression in the die steels in which the casting is formed.

Casting alloy: The material from which the die casting is produced.

Alloy: A metallic material that consists of two or more chemical elements whose physical properties are normally different from those of the separate ingredients.

Cooling medium: The liquid—either water, steam, or air—that is utilized to remove the heat conducted into the die steels by the injection of liquid metal during each casting cycle.

Core: A casting die component that forms an internal feature that is separate from the die insert. It may be stationary and perpendicular to the parting plane or may be located in another direction to be actuated by a movement each time the die is opened.

Deburr: Removal of sharp edges or fins by manual, mechanical, chemical, or electrical discharge methods.

Die: Two metal blocks that incorporate the cavity, metal feed system, and thermal channels into the tool that is used to produce die castings.

Die casting: A process in which a die casting is formed by a mass of molten metal by forcing a heat flux through a mold onto the liquid mass affecting solidification. The resultant solidification patterns and rates determine whether or not the casting satisfies the customer's requirements.

Die life: The number of acceptable shots of castings that can be produced from a die casting die before it must be replaced or extensively repaired.

Die temperature: Usually refers to surface temperatures of die components that come into contact with the casting alloy. The temperature through the thickness of a die component is very complicated and when dealing with the metallurgy of the die steels this term also applies to deeper temperatures.

Dross: Metal oxides that form either within or upon the surface of a liquid metal bath.

Eject: To press the solidified casting away from the core in the die casting die.

Ejector pin: A rod that pushes the casting off from cores and out of the die cavity.

Fixture: A device that holds a die cast near a net shape in a fixed position while a secondary operation is performed on it to convert it to a net shape.

Flash: A thin fin of metal that occurs at die partings, vents, and around moving cores. This objectional metal is due to working and operating clearances in the die.

Porosity: Voids or pores in casting that are caused by entrapped air (gas porosity) or volumetric shrinkage during cavity fill (shrinkage porosity).

Preheat: The practice of heating a die casting die to at least 200 ^{O}F above ambient temperature to minimize the thermal shock from the first few shots in a production run.

Process Control: Control of the process variables within an acceptable range so that high quality castings are produced by the manufacturing process.

Refractory: A material that is not damaged by heating to high temperatures.

1.1.1 Die casting range of product capabilities

Die casting is an important manufacturing technology used in many industries. Companies can make nearly all parts using different casting processes. Die castings are used practically in all manufacturing industries to produce several types of equipment including:

- Automotive Vehicles
- Agricultural Machinery
- Garden Equipment
- Building Hardware
- Office Furniture
- Electrical and Electronic Equipment
- Office Machines
- Hand Tools
- Recreational Equipment
- Home Appliances
- Portable Power Tools
- Industrial Products, etc.

1.2. Mixing die coats

For coatings, the logical starting point is suggested that specific gravity or weight per volume measurement (in lbs./gal. or grm/cc) should come first. Starting with a newly opened drum or pail, the wash should be thoroughly mixed. (See section on ready-to-use coatings for proper mixing equipment.) Mixing should continue until the specific gravity of drawn samples equals the manufacturer's certified value. The measurement should be taken as soon as possible after mixing has stopped, and should fall within the producer's specified range. A sample then can be taken for the following schedule of tests, which will ascertain the accuracy of the supplied analysis:

1) Percent solids/Percent liquid
2) Weight per gallon
3) Solvent identification by specific gravity
4) Refractory identification by specific gravity
5) Organic content by loss on ignition
6) Organic content by carbon determination

Adequate storage and appropriate preparation of the coating materials are of vital importance for obtaining the optimum performance of the coating. Selecting appropriate die coating and mixing for a typical die casting is very important to coat mold wall with a thin layer which protects sticking of mold wall and cast product. A die coating for use on the surface of a metal mold or die component contacted by molten metal in low pressure or gravity die casting, said die coating including a porous layer of die produced by deposition, using a thermal spraying procedure of a powder coating, low pressure and gravity die casting, the surface of each metal mold or die component, which is contacted by molten metal, is provided with a mold or die coating.

A ceramic-based coating is used at a thickness of from about 0.05 to 1.0 mm. The main function of the coating is to provide a degree of insulation which is intended to prevent premature solidification of the molten metal, and thereby enable the complete filling of the die cavity before solidification starts. However, the coating also is to protect the steel die surfaces from erosion or corrosion by impingement by or contact with molten metal. The purpose of foundry coating is to maintain die walls and enhance the surface quality of castings. A high thermal integrity barrier is created between the metal and the die wall.

1.2.1 Die Coatings

Permanent mold dies casting is a process that uses iron or steel molds (dies), enabling large numbers of the same part or castings to be produced. These permanent mold dies to erode and quickly dissolve with a molten metal contact. This erosion is even quicker in areas with the turbulent metal flow or high drag. A die coating protects the surface of the die from molten aluminum and prevents this erosion from occurring. Once molten aluminum begins to erode the die, castings will stick or drag on the die and eventually wear it down. As the aluminum and metal die solder or stick together, sticking and dragging of the casting to the die will occur. These areas will appear as indentations and other defects on the casting.

Die coatings provide insulating properties to the die and reduce thermal shock during the cast. Thermal shock can lead to a roughness defect on the die called heat checking (many small cracks on the die face), which may appear as small protrusions on the casting. Primarily, die coatings are designed to achieve controlled directional solidification by promoting the solidification of the cast metal in one direction. If heat transfer is properly controlled in all the various parts of the die, then directional solidification can be achieved. Thermal characteristics of die coat thickness in permanent mold casting or gravity die casting (GDC) of aluminum alloys, die coating at the casting-mold interface is the most important single factor controlling heat transfer and, hence, it has the greatest influence on the solidification rate and development of microstructure. While the alloy is liquid, the coating material has only a weak influence over heat flow and the thermal contact resistance seems to be governed more by coating porosity and thickness.

Die coats are a range of water-based release coatings for pressure die casting applications. This coating is ideally suited for thin-walled intricate Aluminum castings. This coating is an emulsion of specialty additives that enable easy release of the casting from the die. A die coating for use on the surface of a mold or die component contacted by molten metal in low pressure or gravity die casting, said die coating including a porous layer of ceramic material produced by co-deposition, using a thermal spraying procedure, of a powder of ceramic material and a powder of a suitable organic polymer material and, after the co-deposition, heating of said polymer material to cause its removal.

Water-base, high solids **zircon coating** is the most economical and effective method of reducing metal penetration and burned on the sand. The improvement in a surface finish that is produced by the coating is often eliminated by rough handling and shot-blasting in the cleaning room, thus improvement in coating formulation must go hand in hand with improved cleaning methods.

- Every effort should be made to replace the use of solvent-based coatings with high solids water-based zircon coatings.
- As casting size and pouring severity increase, thicker coating films are needed to reduce metal penetration.

A process for providing a die coating on the surface of a mold or die component, wherein an initial coating of organic polymer material and ceramic material is formed on the surface by co-deposition of powders of the materials by a thermal spraying procedure, and the initial coating is heated so as to remove the polymer material and leave a porous coating of the ceramic material. Factory recommendations of coating composition should be required in order to produce low cost and high-quality castings. A mold or die component having a surface for contact by molten metal in low pressure or gravity die casting, said surface being coated in a section or sections thereof with a non-porous ceramic die coating and in another section or sections thereof, with a die coating.

There are many commercially available coatings, such as DYCOTE, permanent mold coatings that combine inorganic binders with insulating and/or lubricating refractory elements. They are designed to satisfy a wide range of performance and manufacturing needs, including lubricity, durability, surface texture, and insulation. DYCOTE standard and long-life die dressings for nonferrous alloys Castings are manufactured in sand or permanent molds. The molten metal, which flows into these molds, is highly aggressive, and casting integrity can be adversely affected by undesired interactions with the substrate. Refractory coatings provide a protective barrier between the molten metal and the mould or core substrate. It is this barrier that is of paramount importance in ensuring the integrity of the as-cast surface of the finished component, and hence inconsistencies within the coating structure or the application method will be reflected in the surface quality of the component.

1.2.1.1 Function of coating

Die coat in the gravity die casting in order to obtain smooth surface finish and to avoid direct exposure of mold to the molten metal in order to avoid direct chilling effect. The material used for die coating is generally calcium carbide and silicon mixture and graphite. The coating has several advantages including:

i. Heat Transfer Control

- Heat transfer through the various areas of a die is the most important characteristic of a die coating because it can control the filling of the die and directional solidification.
- Insulation properties of the coating(s), methods used to apply the coating(s), and thickness of the coating(s) determine the coating's ability to control heat transfer and directional solidification.

ii. Metal Flow Control

- A coating assists in filling the die because it insulates the molten aluminum from the die. The coarseness of the coating, the size of the refractory charge within the coating, and the insulation (or thermal conductivity) of the coating play a major role in how molten metal flows within the die.

iii. Easy Release

- When a casting solidifies, it begins to contract, which creates compressive forces which can attach the casting to the die that can be strong enough to create cracks in the casting and drag on the die. Typically, very thin layers of release coatings are applied as a sacrificial topcoat to the die coating(s) used on the die.

Good Surface Finish.

A good surface finish is directly related to the choice of die coating. Without heat transfer control, metal flow control, and easy release, metallo-static pressure will dictate the quality of the casting.

Protect the Die

- Die coatings cannot provide permanent protection. Although factors such as binding agent, surface preparation, and chemistry influence coating life, all die coatings must be maintained. Typically, the longer the performance life of the coating, the more consistently the dies will operate and last.

1.2.1.2 Die casting and the role of coatings

Die casting is a process that uses permanent molds made of metal (dies) enabling large batches of identical castings to be produced. Contrary to sand molds, in which the permeability of the compacted sand allows the air to escape freely during casting, metal molds are impermeable and therefore must be designed with suitable air vents. In die casting, coating selection and its method of application are at least as important as other factors, such as the design of the die, type of alloy, temperature of the metal and so on. The principal functions required of a coating for die casting are:

- Control of the metal flow to ensure that it reaches all parts of the die at a sufficient temperature to prevent the formation of seams, cold laps, etc.
- Control of heat transfer to obtain better solidification and ensure that the castings are properly fed.
- Coating helps to create longer die life.

Figure 1.2 Die coating

The solidification time of these alloys in the die casting process mold increases with increase in the pouring temperature of melt, decreases with increase in the pre-heat temperature of mold. The molten metal in the cavity solidifies rapidly through the internal cooling of the die. When the casting has solidified, the die halves and the moveable tool components are unlocked and the mobile parts withdrawn. Thereafter, the die halves are opened and the casting ejected. Subsequently, the tool surfaces may be externally cooled and lubricated by spraying to prevent adherence of the next casting. The complete die casting operation cycle is very rapid, and the process allows high manufacturing rates up to100 castings per hour per cavity depending the die design. The solidification begins from the wall of die towards of the center Figure 1.3.

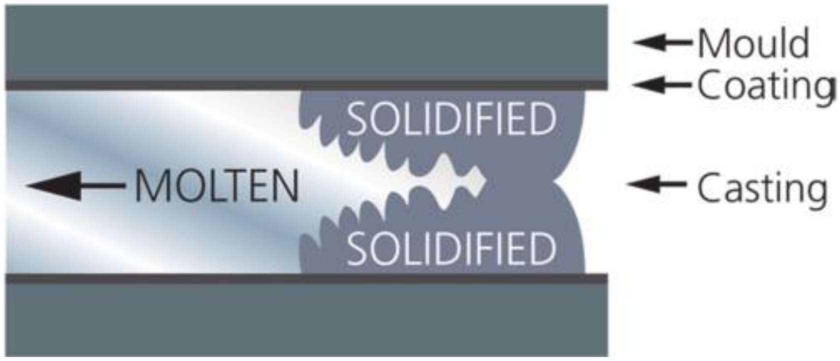


Figure 1.3 Solidification of molten metal in the die

The demand for net shape die castings, which require little or no machining, is steadily increasing. Stringent customer requirements are forcing die casters to deliver high quality castings in increasingly short lead times. Dimensional conformance to customer specifications is an inherent part of die casting quality. The advantages of die casting process are as follows:

- An economical process used for a wide range of complex applications.
- A process that can be fully automated.
- Post machining can be eliminated.
- Parts have high dimensional accuracy, close tolerance, and longer service life.
- Mold can be used repeatedly because it is made up of metal.
- No external pressure is required for gravity die casting process.
- Modern process technology that ensures consistent quality
- High-quality surface finish for decorative applications.

The disadvantages of Die Casting Process are as follows:

- The die cost used in the die casting process is very high.
- It is not applicable to high melting point alloys and metals.
- The larger parts cannot be cast in the die casting process.

1.2.2 Materials used for die casting

In the gravity die casting process the metal enters the mold under gravity. Despite recent innovations and advances in die casting technology that have significantly expanded the products, the development of complementary new alloys. The pouring of molten metal into the mold and its subsequent filling are quite critical steps in metal casting, since the behavior of the liquid metal and its freezing determine whether the cast shape will be properly formed and free from defects. Aluminum is one of the most popular metals used in die casting. Aluminum is a very lightweight metal, so it's great for creating lightweight parts without sacrificing strength. Aluminum parts can also withstand higher operating temperatures and have more finishing options. The range of materials used for die casting are low melting metals and alloy including aluminum alloys, non-ferrous and ferrous.

1.2.2.1 Coatings for Wet Application

Mold and core coatings for wet application are of two types, carbon-base and carbon-free coatings. Both types are sold in either powder or paste form. The adherence of the coating on the mold or core surface depends on the moisture in the sand. Carbon-based coatings may contain several types of graphite, coke, anthracite or any of the numerous combinations that can be made from these materials. Carbon-free coatings may contain silica, mica, zircon flour, magnesite, olivine, clays, talc or a combination of these materials. Many coatings formulations contain both carbonaceous and non-carbonaceous raw materials to take the advantage of the synergistic characteristics of both types. Foundry coatings for wet application are also classified into two, based on their carrier systems. Those employing an aqueous carrier and those in which organic solvent carriers are used. The former must be dried after application while the later are self-drying or can be ignited and dried by their own combustion. Both classes of coating make use of the refractory materials.

1.2.3 Preparing the Die Cleaning for coating

A fundamental requirement is cleaning the surface to be coated: no residue of previous coatings must remain and also no oil, grease or soot. Cleaning can be performed with wire brushes or by blasting with sand, alumina steel shot etc.

1.2.4 Coating application Method

There are numerous ways to apply the coating, including by brush, spray, and immersion. Spray application is the simplest and most effective technique for dies. For plain parts (runners and risers) where the lining needs to be substantially thicker or for little details that need to be coated differently from the rest of the die, brush application is used. For copper alloys, where the coating also needs to cool the die, immersion application is most frequently utilized.

Figure 1.4 Coating Spray gun

Coatings are basically applied by brushing, swabbing, dipping, or spraying. Brushing produces a film that is the most resistant to metal penetration because the mechanical movement of the brush forces the coating into the sand crevices. High solids coatings, however, produce brush marks. For some reason, casting users readily accept grinding marks but frown on brush marks. In contrast, many foundrymen judge the excellence of a coating from the brush marks. It is a controversial subject that requires clarification. Spraying is certainly the most popular method of application. Although specialized equipment is non-existent, there are a variety of paint spray systems that can be adapted for the application of core and mold coatings. The Murphy or suction spray gun at full airline pressure is the least desirable and should never be used.

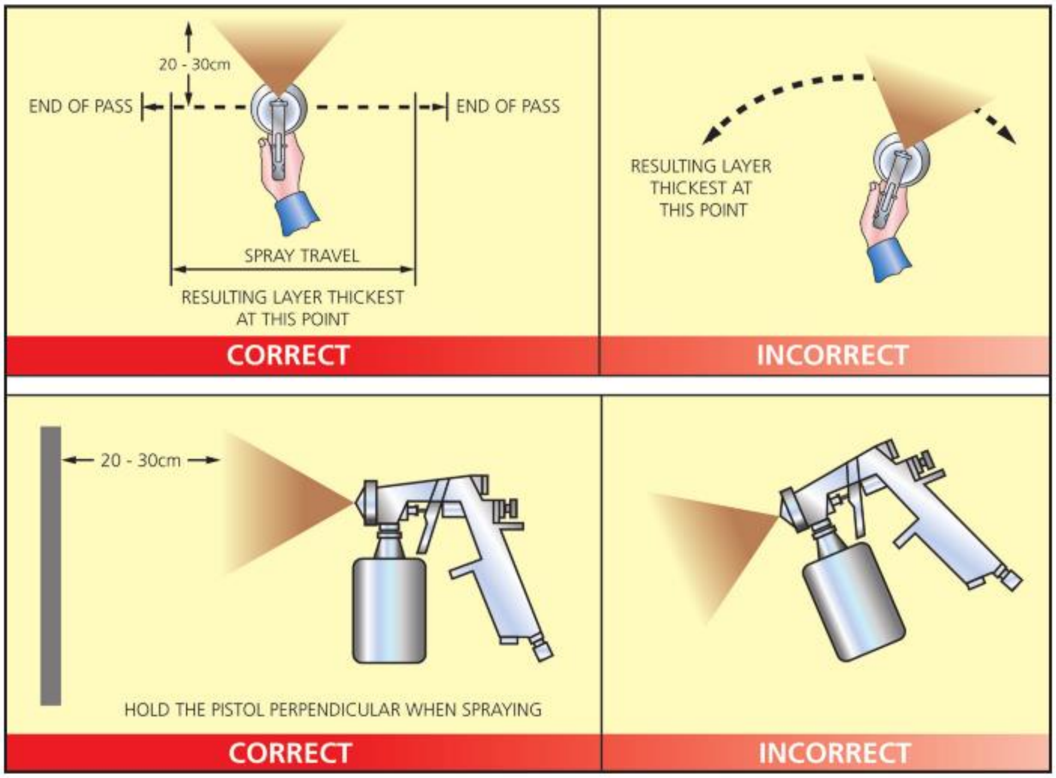


Figure 1.5 Coating spray technique

1.3. Maintaining die temperatures

To prevent the adverse effects of poorly regulated casting temperatures, a die-cast cooling system is highly recommended. These devices will optimize process efficiency, protect critical equipment, and ensure the production of high-quality parts. The temperature required for melting and holding molten alloy in preparation for die casting. The proper selection and adjusting melting and holding temperature are clearly important factors in minimizing defects in die-casting operations. In addition to energy consumption, high temperature influences metal loss due to oxidation, metal quality, and causes maintenance requirement.

In the gravity die casting process the metal enters the mold under gravity. The pouring of molten metal into the mold and its subsequent filling are quite critical steps in metal casting, since the behavior of the liquid metal and its freezing determine whether the cast shape will be properly formed and free from defects. The solidification time of these alloys in the die casting process mold increases with increase in the pouring temperature of melt, decreases with increase in the pre-heat temperature of mold. Sufficient degasification of the melt improves the solidification process.

1.3.1 Controlling Die Temperature

Controlling die temperature activity starts from pre-heating up to the solidification of die cast. Pre-hearting the die is important while thinking to coat the die and before pouring. Die temperature is a parameter that must be controlled, in order to get the best bond between the coating and the die. Although an experienced operator may be able to judge to temperature, best results are obtained by using a suitable thermocouple. Contact thermocouples and infrared or laser thermometers are now available for controlling die temperature. This enables the caster to apply the coating at the correct temperatures.

Preheating in the gravity die casting is done to remove the possibility of formation of temperature gradients. If we increase the preheat temperature from a particular range then it may affect the die coating and also it may create defects like rough surface finish and also if the temperature is removed considerably then this may cause a particular chilling effect which in turn leads to less solidification of core and due to this difference in solidification rate defects like solidification shrinkage may occur. A significant precondition for the production of high quality castings is keeping an optimum temperature of the respective parts of the mold cavity surface.

1.3.2 Pouring temperature

Pouring temperature generally varies from 650 to 800 degree Celsius. When we pour aluminum alloy then its fluidity is completely dependent upon pouring temperature. Generally, a better fluidity in higher temperature is connected with the decreasing viscosity and surface tension of molten metal with the increasing of pouring temperature, which leads to the increasing filling speed. At the same time, the heat capacity of molten alloy rises with increasing temperature of the pouring, what results in the increase of filling time. On the other hand, the oxidation liability of magnesium alloy increases with the pouring temperature rise, what increases the viscosity and decreases the filling speed. Therefore, growth rate of fluidity above 735 °C is lower than between 695 °C and 735 °C. The pouring temperature also affects the microstructure formation at a greater extent and which in turn affects the final structure and toughness of casting product.

1.4. Locating and closing die correctly

The parting line of a die cast component represents where the two different sides of the mold come together. This line often (but not always) marks the border between the inside and outside of the part. This line runs exactly where the two portions of the die meet together. This line is usually referred to as the parting line, and it is the parting line that defines which half will act as the “cover” die and which one will act as the “ejector” die.

1.5. Placing die correctly on machine

The major feature of die casting is being a permanent mold containing a negative impression. The gravity die casting technique is mainly used to cast light alloys. Before the process begins, the mold must be heated and sprayed with a coating. The molten metal is poured in the die and allowed to flow with the help of gravitational force. The metal alloy then cools and the die cast part removed. These activities related with the correct pacing of the selected or attaching the dies on the machine.

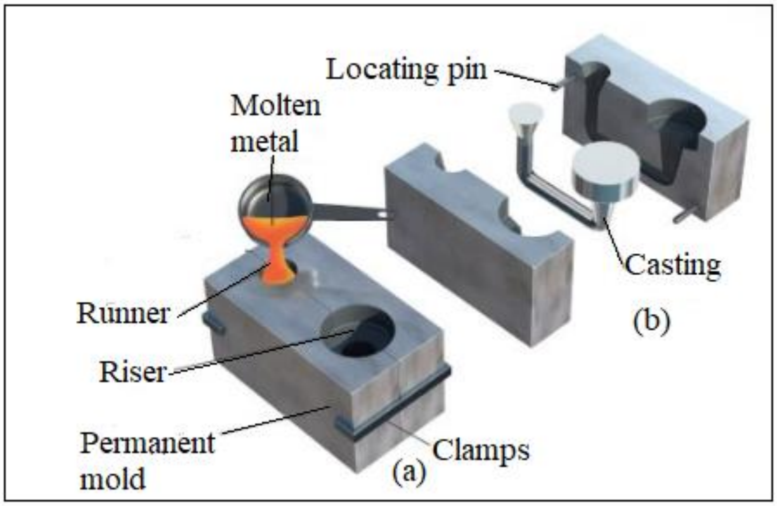


Figure 1.6 Gravity die casting process

1.6. Attaching air cooling systems

Die casting is a very cost-efficient method of forming thin-walled and complex near net-shaped products with close geometric tolerances and good surface finish. Low melting point alloys based on aluminum, zinc, magnesium, and copper are frequently used. Many different types of products are manufactured by die casting, such as engine blocks, cylinder head covers, valves, pipe couplings, etc. and other components for the automotive industry and for heating, ventilation and sanitary installations, etc.

Self-check-1

Part 1. Write short answer with readable handwriting.

1. Enlist the steps involved in the die casting process.
2. Write a brief note on coating materials.
3. Define gravity die casting.
4. What are the functions of coating in die casting?
5. Mention some of the advantages of die casting over other manufacturing Processes.
6. List coating materials used for gravity die casting.
7. Write a note on how to mix coating.
8. What is the function of chills in die casting process?
9. What is the function of cooling system in die casting?
10. List safety equipment used for gravity die casting?

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

"A"	**"B"**
1) Personal protective equipment	a) A thin layer of metal that occurs at the die parting
2) Pressure die casting	b) Die mold
3) Die cavity	c) Helps for directional solidification
4) Deburr	d) Used for coating of mold wall
5) Dross	e) Colling of cast
6) Flash	f) Safety cloth
7) Die fixture	g) Create longer die life
8) Die coating	h) Utilizes external pressure for pouring of molten metal
9) Function of coating	i) Removal of sharp edges
10) Solidification	j) Scales and metal oxide
11) Chill	A device that holds a die cast

Unit two: Carry out Manual Pouring

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

- Reducing porosity and lamination
- Identifying cast conditions
- Making allowance for adequate cooling time
- Making continues pour rate during filling
- Monitoring die coating condition

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

- Reduce porosity and lamination
- Identify cast conditions
- Make allowance for adequate cooling time
- Make continues pour rate during filling
- Monitor die coating condition

2.1. Reducing porosity and lamination

The air in the system should be pushed out of the cavity ahead of the molten metal. In the actual case, the solid wave front does not fully develop. The metal flow is somewhat turbulent, so that air is entrained, possibly forming porosity in the casting. The metal solidification process tends to drive this porosity away from the surface into the core of the section. Die castings normally exhibit smooth surfaces with no visible defects, but metal removal operations that cut deep enough to penetrate this skin may expose the porosity which could lie beneath. Where product applications require a smooth surface, or where the porosity is interconnected and pressure tightness is required, the presence of such porosity would call for impregnation of the die casting. The last area of the die cavity to fill tends to exhibit the poorest quality. This area generally has the coolest metal and potentially the highest porosity. It is therefore common practice to locate overflow cavities at the die parting plane in these areas. The overflows receive the poor-quality metal, raising the quality of adjacent metal in the die cavity. Overflows are carefully sized, because they constitute additional extraneous metal, or scrap, which must be recycled.

Casting defects are undesirable in critical structural areas and on decorative surfaces, particularly those that are bright finished or painted. Minor defects that would not be particularly noticeable can become quite obvious after surface treatment. Elimination of defects is generally accomplished through control of the casting process, and is the responsibility of the die caster. However, the product designer should also be conversant with the various types of defects, particularly those that can be reduced by appropriate design practice. There are several defects in die casting including cracks, non-fill areas, shrinks, mis-runs, cold shuts, and swirls, gas porosity, shrinkage porosity, segregation, soldering and oxidizing, surface blisters, galling or drag, warped castings, etc.

Figure 1.7 Atypical gravity casting pouring process

2.1.1 Remove of casting from die

To avoid the formation of a bond between casting and metal mold, the Silicon powder will be sprinkled on the mold surface before pouring the molten metal into the casting. After Solidification, the component removes from the dies. Now it has to remove from the casting cavity by means of Ejector pins. Due to the ejector pins, the ejecting die will be moved from its original location such that the component produced will be moved away from the casting cavity.

2.2. Identifying cast conditions

There are many methods to test and detect issues inside the casting. These techniques help to make sure that it does not fail under load. The two main types of internal inspection methods are destructive as well as non-destructive testing. As the name implies, the destructive method involves opening up a casting, to check its metal properties closely. The inspecting person would look for porosity, inclusions and shrinkage. In contrast, the other method does not involve cutting the cast object to check its external and internal soundness. It is done by workers of a foundry, clients of die casters, as well as NDT technicians. Of course, non-destructive testing includes visual inspection.

Ensuring the quality of the casted components is critical in the process of die casting. This is done mostly in the post-casting stages, where the components are subjected to different examination procedures. This will help in identifying the defects in the casted components and applying the necessary fixes before shipping them off to the respective clients. The castings that emerge first are subjected to rigorous inspections that focus on their dimension and patterns. Some of the inspection methods used for identifying defects in castings are described below.

Ultrasonic Inspection

Ultrasonic inspection can detect any sort of cracks or other abnormalities within the casting, with very high accuracy. Most die-cast companies used ultrasonic testing to check the quality of the casted components. In this process, an ultrasonic signal is sent through the casting and the return signal is monitored to find errors in the casting. If the casting has any defect in its interior, it can change the wavelength of the signal that is reflected back to the detector thereby helping to identify any defects. Moreover, the time interval between the transmitted and received signal can help to ascertain the exact location of the defect inside the casting.

Radiographic Examination

Radiographic examination is another inspection method used to identify defects in casting. This method is expensive as it needs the proper equipment and only some die casting companies use it. A radiographic examination involves the use of both X-rays and γ-rays for detecting any sort of defect in the casting. A film placed behind the casting can register the flow of rays through the casting in the form of variations in exposure that will help to identify any defects. An advantage of radiographic examination is that it can detect most of the defects such as cracks, void, tears, nonmetallic inclusions, and porosity in the castings.

Visual Inspection

Carrying out a detailed visual inspection is the most commonly used method to identify any defects in castings. A visual inspection can reveal some of the commonly occurring defects on casted components such as surface cracks, roughness, missing cores, and shifts. Special instruments such as an articulating fiberscope are used to carry out detail examinations of the surface of the castings. Moreover, other method like hitting the cast with a mallet and checking the tone is also used to identify any cracks in the casting surface. Using visual inspection and microstructural analysis, the quality of cast should be evaluated for the purpose of checking based on the design requirements**.**

2.3. Making allowance for adequate cooling time

In the casting manufacturing process, molten metal is poured using gravity or injected vertically using low pressure, or injected horizontally (or vertically) using high pressure and vacuum into a non-expendable or expendable mold or die (as appropriate) and allowed to solidify. This die contains a hollow cavity of the desired product shape including sufficient distortion, machining and finishing tolerances built into the cavity design. Even though there have been significant developments in all manufacturing technologies over the recent years, casting is still one of the most widely adopted manufacturing techniques used to produce complicated shapes which could not be obtained by any other process.

The castings structure depends on its solidification/cooling history; hence it is very important to control the solidification itself. The solidification rate can be controlled either using exothermic materials, chills or by design of the gravity die casting mold. The cooling rate is closely connected to the solidification rate, which can be defined either as the velocity of solidification rate, (i.e. the velocity of the solidification front) or the as the liquid-solid phase transformation rate, measured in units of m/sec. Generally, the microstructure is refined by increasing the heat extraction and corresponding increase in solidification rate. In fundamental and theoretical studies, casting structure is often represented as unidirectional and columnar, with grains or branches represented by cylinders with rounded tips. In fact, the microstructure of commercial alloy casting consists of dendrite equi-axed grains. The microstructure is therefore considered on two levels: grain size and dendrite arm spacing.

2.4. Making continues pour rate during filling

Pouring needs continuous and uniform speed filling of die cavity. This helps the cast to get uniform structure and cooling rate. The pouring angle and melting temperature also basic parameters for filling of the die mold. The volume of cavity and the alloys to basted need a careful calculation in order to avoid the shortage of molten metal wile filling.

2.5. Monitoring die coating condition

After the cast has ejected, it is necessary to monitor the conditions of mold wall and maintain the coating for the next use. It must be smooth enough to get good quality surface finish for the other continual casting process.

Self-check 2	Questions related to carry out manual pouring

Part-1. Choose the best answer

1. Blowing of air is required in water passages of gravity die casting.
   a) True b) False
2. Cores in permanent molds used in gravity die casting are made up of __________.
   a) metals b) metals and non-ferrous c) metals and sand d) only sand
3. A chill is used to promote directional solidification in gravity die casting.
   a) True b) False
4. In gravity die casting, ________ the thickness of the mold walls, greater the amount of heat removal.
   a) lesser b) equal c) greater d) negligible
5. A permanent mold is made up of two halves.
   a) True b) False
6. Molten metal is poured into the molds due to gravity with ________ external pressure in gravity die casting.
   a) High b) low c) medium d) no
7. Gravity die casting makes use of a permanent mold.
   a) True b) False
8. Which of the following materials is mostly used as a die material in gravity die casting?
   a) Grey cast iron b) lead c) aluminum d) Magnesium

9. The die life is less for higher melting temperature alloys in gravity die casting.
   a) True b) False
10. If the heavy coating is produced then which of the following can be used to maintain the progressive solidification?
   Aaa0 sprue b) Riser c) Chills d) Pouring basin
11. Better surface finish with the close dimensional tolerances of the casting can be obtained in gravity die casting.
   a) True b) False
12. All kinds of metals can be cast easily in the gravity die casting.
   a) True b) False
13. Which of the following processes is mose suitable for thecasting of connecting rods and pistons of the auomobile?
   a) Precision investment casting c) gravity die casting
   b) shell molding d) centrifugal casting

Answer key

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

Part 2. Give short answer

1) What materials used in gravity die casting?
2) What is gravity die casting?
3) What are the differences between expendable and non-expendable molds?
4) What are the common defects in die casting?
5) Enlist the advantages of die coating monitoring?
6) Explain the use of continuous pouring in the die cavity.
7) Mention defects of casting in the die casting process.
8) What is chilling in the solidification process of gravity die casting?
9) What is trimming?
10) Enlist coating materials used for gravity die casting.

Operation sheet-2.1	Questions related to carry out manual pouring

Title: Gravity die casting using aluminum alloy scraps

Supplies and materials: die coating materials, aluminum and permanent die mold. If the gravity die casting machine is not found in the shop, make permanent mold using milling and other machines.

Purpose: to produce aluminum cast product using gravity die casting.

Tools required: safety equipment, gravity die machine, core, etc.

Procedure

- Clean the dies
- Heating the die
- Apply coating
- Insertion of cores
- Melting aluminum ally
- Pouring molten metal
- Mold opening and ejecting cast product
- Trimming or finishing operations

Operation sheet-2.2	Practical work related to carry out manual pouring

Title: Produce metal castings using gravity die casting technique, prepare permanent die mold from steel by yourself if there is no gravity die casting machine in the shop and apply aluminum casting. The dies can be prepared using milling machine to create cavity from cast and steel allow.

Purpose: Make ready gravity die casting equipment; produce castings using gravity die casting machine, and clean the die body after use.

Procedures:

- Die is manufactures from steel using machining.
- Die is inspected to ensure that it matches with the job to be cast.
- Die coat is mixed.
- Die temperature is maintained at the level scheduled on the job sheet.
- Personal Protective Equipment (PPE) is important.
- Die coat is applied in sequence and in a safe manner.
- Die is securely located on the machine and closed.
- Pour the molten metal using gravity advantage.
- Allow to cool the molten metal
- Eject the cast.
- Do finishing operation where necessary and evaluate product quality.
- After the die cooling, clean the die wall and inspect the machine.
- Clean the work area and return tools in their places.

LAP test-2	Practical work related to carry out manual pouring

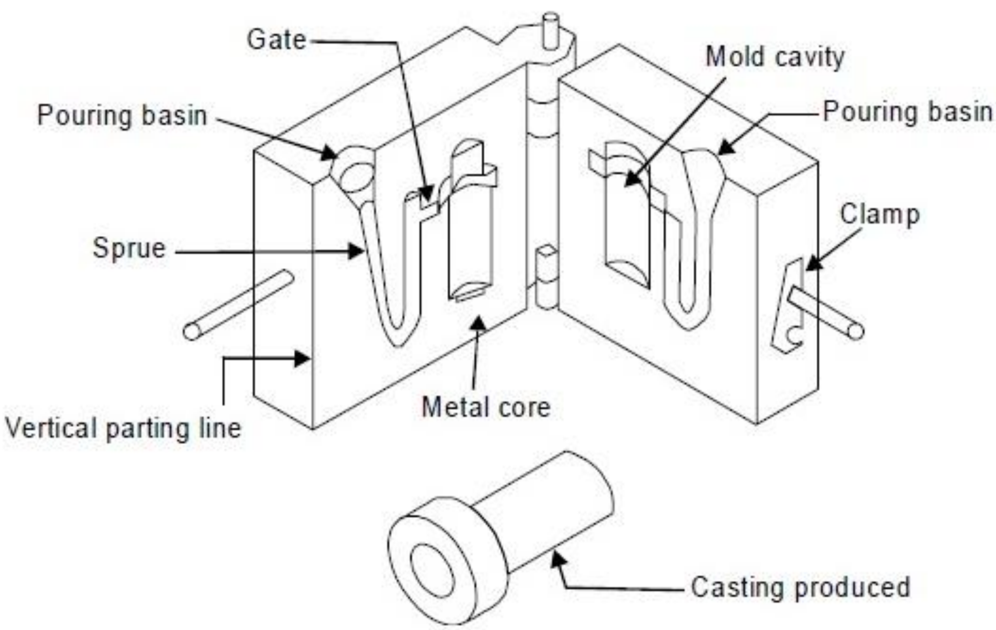
Name: ___________________________ Date: _____________

Time started: _____________________ Time finished: ________________

Instruction:

Given all the necessary tools and equipment, all activities must comply with applicable workplace procedures and must be consistent with accepted industry standard practice. The material used in gravity die casting is a non-ferrous metal.

Task 1: Perform gravity die casting following standard operating procedures from low melting point alloy materials such as aluminum alloy, magnesium alloy and others available low melting metals. Make a mold as shown in the figure bellow, if you there is no gravity die casting machine in your shop. Dimensions can be given by the trainer.



Unit three: Removing Materials

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

- Considering safety precautions.
- Removing of casting from die.

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

- consider safety precautions.
- remove of casting from die.

3.1. Considering safety precautions

Working in a foundry, definitely there are many harmful factors such as fine dust, toxic gases, noise, temperature, splashing molten metal, etc. If these hazards are not tightly controlled or prevented, they can threaten seriously the foundry worker's health as well as working effectiveness. Metal handling is a major safety concern because of the superheated liquid state and very high temperatures involved. The dangers to humans are the full range of burns and explosions directly from the casting alloy in the liquid state. All metal handling equipment from the furnaces to the ladles to the cold chambers and goose necks is too hot to touch without a serious injury. Thus, extreme caution must be exercised by following all of the rules for behavior around molten metals.

The area around the die casting machine is hostile to humans because it is hot, dirty, at times smoky, wet, noisy, and dangerous! Die casting historically has not demonstrated an acceptable level of safety performance when compared to other metal casting industries. Some type of protective clothing is required at every plant engaged in die casting. Foundry workers used, ear plugs to protect hearing, and wear steel toed shoes for obvious reasons, and many times a helmet for head protection are also specified. In special areas like metal melting, protective clothing like heavy sleeves and spats prevent burns. Speaking of noise, it is this writer's considered opinion, after many years spent around die casting operations, that the noise of the hydraulic pumps, constant spraying, electric motors, impact thumps, fans, trucks, sirens, horns, harsh public address systems, etc. forms a constant confusion of sounds that is so distracting that it dulls the other senses.

Safety precaution needs great attention to control the possible hazards associated with foundry works. The general safety requirement is listed below, but not limited to them.

- Your safety is your personal responsibility.
- Always follow the correct procedures.
- Never take shortcuts.
- Take responsibility and clean up if you made a mess.

- Clean and organize your workspace.
- Ensure a clear and easy route to emergency exits and equipment.
- Be alert and awake on the job.
- Use the proper tool for the job.
- Communicate safety hazards to other personnel.

Foundry hot work safety rules (general safety)

1. Personal Protective Equipment - Clothing covering all skin, purpose-built or made of natural materials like leather, heavy wool, or heavy cotton. No Polyester or nylons.

2. Tidy foundry area - Pouring area to be free from all items not involved in pouring process.

3. Clamp or Weight Flasks - Hydrostatic pressure of liquid metal can lift a lot of weight - once the cope and drag or dies have separated due to this pressure the uncontrolled flow of metal is extremely hazardous.

4. Use Dry Clean Metal - Impurities on the surface of the melted metal may become an airborne breathing hazard e.g.. lead paint etc. in the melt these impurities often increase the dross to be removed from the melt.

5. Preheat all metal and furnace tools - This reduces the risk of condensation and tools and furnace recharge metal from steam explosions occurring in the melt.

6. Move the melt slowly & a short distance furnace to flask - It is said that liquid metal is runnier than water and splashes further - minimize the possibility of spills and splashes.

7. Know what you're melting - The characteristics like melting temperature of the metal is good to know before you start and more importantly know the adverse health effects of hazardous alloy elements like Lead, Zinc, mercury or Beryllium.

8. Inspections before use - knowing the condition of the crucible the furnace walls the fuel lines burners and pouring tools is critical. Failure of any of these items during a melt or pour can be extremely undesirable.

9. Watch for a bubbling sprue - low permeability sand or excess moisture in the mold can result in a steam build up or blow back out the sprue.

10. Plan emergency exit route - Identify before you start to pour what your escape routes are if the unexpected eventuates. like a flask failure leading to a metal leak, Bubbling sprue, cracked crucible, faulty pouring hardware etc.

11. Be Alert - Working in the foundry tired, sick, drugged, stoned or drunk is just plain dumb!

12. Zn & Mg Fluxing - These metals and others (like phosphorous) evaporate and ignite easily at relatively low temperatures Fluxing the melt properly with alloys that contain these metals will avoid the undesirable loss of these metals from the alloy.

13. No Water - Water or moisture that manages to get below the surface of liquid metal in the furnace or mold will become a bomb within milliseconds

14. Watch for leaks - That strange aroma is the melt that has leaked out of the back of the flask trickled around under the drag along the floor and is now consuming the soles of your boots.

15. First Aid - despite the best planning, maintenance, preparation, and care, are employed, sometimes accidents happen in the workshop. Thus, the full first kit is ready always in the shop to help the victim until reaches the hospital.

3.2. Removing of casting from die

The process of removing a casting from a die mold begins with determining the right time and temperature to do the removal of the cast from the permanent mold. After the liquid metal has been poured, it must freeze before unmolding, but there are other timing considerations besides simple solidity. If pulled too soon, the surface of the metal may chemically react to the cool air with unwanted effects. Metal microstructures change based on their rates of heating and cooling. Pulling a too-hot casting into relatively cold air can cause the structure to become more brittle.

Gravity die casting, may also called as permanent mold casting, is a typical die casting technique to create high quality metal components which have low melting points, such as aluminum and zinc alloys. In gravity die casting process, the molten metal is poured from a ladle into the mold, then fills the mold cavity under the force of gravity and fastly solidified to achieve metal parts and after solidification removing the cast product safely is important. Unlike other casting methods, gravity die casting is a simple pouring of the molten metal into the mold without any additional pressure applied. And, gravity die casting can use both metal and sand cores, referred to as semi-permanent mold casting, for greater complexity of design. It is the perfect choice for applications that require a solution that's somewhere in between sand casting and high-pressure die casting. Gravity die casting requires lower mold cost than high pressure die casting, but more durable than sand casting by using a steel mold. The mold is a permanent form that consists of two halves. Die Casting is the manufacturing process by which a liquid material is pressurized in to the mold, which contains a hallow cavity of the desired shape, and then molten metal is allowed to solidify. The solidified part is known as casting which is ejected to complete the process.

Self-check-3

1) Part 1. Give short answer
2) What is the importance of applying safety precautions in the foundry shop?
3) Explain the safety required while removing a cast from the die cavity.
4) What are the process parameters of gravity die casting?
5) Explain the differences of expendable and non-expendable mold types.
6) Mention the methods used for transporting of hot metals?

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

"A"	**"B"**
12) Hot metal handling	a) Heating the dies before pouring
13) Safety precaution	b) Door used for escaping when hazard occurs
14) Tidy working area	**c)** No external pressure is required for the metal flow
15) Preheating die mold	d) Ejection of cast
16) Emergency exit door	e) Non-expendable mold
17) Removing of cast from the die	f) Ensuring something is safe
18) Gravity die casting	g) h) Movement of hot metals
19) Permanent mold	i) wide working area j) Narrow working area

Unit four: Cleaning the die

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

- Operating Shot Blaster
- Dressing furnace
- Cleaning ladle
- Cleaning work area

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

- Operate Shot Blaster
- Dress furnace
- Clean ladle
- Clean work area

4.1. Operating Shot Blaster

Shot blasting is a mechanical cleaning process that uses spheres of material to remove oxides and other debris from the surface of another material. Although less commonly mentioned than sandblasting, shot blasting belongs in the same family of abrasive blasting processes in which sandblasting is categorized. Shot Blasting is a surface cleaning process using high-velocity steel abrasive. Shot blasting is the method through which it is possible to obtain excellent cleaning and surface preparation for secondary finishing operations. Shot blasting is commonly used for:

- The cleaning of iron, steel, non-cast parts, forgings, etc.
- Mechanical cleaning of sheets, rods, coils, wire, etc.
- Shot peening to alter mechanical properties (increasing resistance to fatigue for springs, gears, etc.)
- Preparing surfaces to be painted, coated, etc.

In general shot blasting concentrates abrasive particles at high speed (65-110 m/second) in a controlled manner at the material thereby removing surface contaminates due to the abrasive impact. Mold cleaning is not only an important process in mold maintenance, but also a bottleneck restricting mold maintenance. Part of mold manufacturing and development is much faster than mold cleaning. After rapid cleaning, the mold can be prepared for the next production, so the time required for mold cleaning is quite limited. Through the investigation of the factory, we know that the corridors in the factory and the molds configured in the workplace basically occupy the limited working space in the workplace. The residues accumulated in the mold have an impact on the quality of parts or the mold is worn, the mold needs to be cleaned, and the cleaning process only needs to be carried out. In gravity die casting, shot blasting can use substances such as 1) Glass beads. 2) Coal slag. 3) Plastics, and 4) Walnut shells.

Shot blasting uses high-velocity pellets or beads — made of steel, copper, aluminum or another substance — as its abrasive material. Shot blasting machines concentrate these beads in one area at extremely high speeds to clear materials such as rust, paints or other coatings.

Figure 4.1 Shot blasting

How does shot blasting works? Sometimes referred to as wheel blasting — uses a centrifugal wheel inside a large machine to clean surfaces. During this process, a motor creates enough kinetic force to shoot or push the pellets at your desired surface. This method is efficient and ideal for large surfaces. For centrifugal shot blasting, multiple people may use several machines to cover more ground, but one person could easily handle the job. This method is efficient as the centrifugal wheel needs very little power to run and it's easy to use.

Cleaning the dies requires basic skill. The improper Distribution of mold cleaning operations leads to the continuous production of molds with performance defects. In addition, it will increase significantly due to the increase of joints, burrs, corners, early electroplating or steel movement, and mold mixing. The problem of mold budget often comes from the conservative culture of "temporary fire extinguishing", which will never monitor or explain defects and find out the root cause of the problem. A modern blast furnace (BF) is refractory-lined to protect the furnace shell from high temperatures and abrasive materials inside the furnace. The refractory lining is cooled to further enhance the protection against the dispatch of excess heat that can destroy the refractory lining. BF has a complex refractory system to provide a long, safe life that is necessary for the blast furnace availability and for permitting nearly continuous furnace operation and casting.

Standardized Cleaning Procedures

Systematic mold maintenance is based on the consistency of maintenance requirements and maintenance operations. Develop detailed mold cleaning procedures. When various parts of the mold are cleaned edge wiping, general cleaning and main cleaning, the cleaning operation methods are also require their own cleaning procedures.

People often believe there are different kinds of shot blasting, but this method exclusively uses the centrifugal wheel to create force. It's common for people to use shot blasting and sandblasting interchangeably, even though they are different abrasion techniques. Sandblasting uses compressed air instead of a centrifugal turbine, while shot blasting will always use a centrifugal wheel regardless of the blasting medium. During sand blasting, the sand or other abrasive material shoots through a tube by the force of compressed air, allowing the user to control the blast's direction. This method is ideal for its flexibility and area focus, so it's preferred for cleaning smaller areas. The air compression method works well for finishing weldments and steel frames, but compressed air also reduces efficiency and increases the cost compared to shot blasting. Both techniques have a place in abrasion operations, but they're definitively different.

4.2. Dressing furnace

After a certain period of operation of the die mold and after visual inspection of coating wear, track marks and mold residue content in the ventilated and non-ventilated fields, technicians can determine the sequence and frequency of mold cleaning through visual inspection. Therefore, it is important to understand the safe operation cycle of the mold and document the observation results of residual residue and wear in the mold.

Furnaces provide heat energy obtained from fuel combustion, electricity, and other means. furnaces are classified by the fuel or method by which heat energy is generated including gas-fired, oil-fired, electric etc. Furnace wall dressing needs routine maintenance. Start by cleaning the outside of the furnace with a damp cloth, paying special attention to the vents, and making sure they're clear of dust and dirt. Next, shut off power to your furnace, then remove the outer cover to access the inside. Refractories are materials that are resistant to high temperature, used predominantly as furnace linings for elevated temperature materials processing and other applications in which thermomechanical properties are critical. The general requirement of a refractory material is the ability to withstand sudden changes in temperatures. Ability to withstand the action of molten metal slag, glass, hot gases, etc.

4.3. Cleaning ladle

Regular cleaning of melting furnaces is essential for two important reasons. Firstly, failure to remove deposits can reduce furnace capacity and impact melt quality, which in turn can increase scrap rates. Secondly, repeated build up can damage the refractory lining. This can result in unwanted heat loss (and the unwanted bills associated with this) and inefficiencies in the process which once again can have a detrimental impact on melt quality.

Once the melting furnace refractory lining is worn out, its ability to withstand metal penetration and erosion is compromised – minor wear can become a major issue relatively quickly. Having to replace a furnace lining after a certain time, depending on the operation, is inevitable. Having to replace it early is entirely avoidable with, among other measures, the right cleaning care. A quick check and cleaning furnace and ladle very important. Keeping the workshop clean makes trainees happy and satisfied in their foundry shop in addition to sustaining safety. Therefore, to improve both the physical and psychological well-being of trainees, it's essential to maintain a clean and tidy work area all the time to reduce hazards.

4.4. Cleaning work area

At the end of the casting process, the workspace should be cleaned up once all finishing die-casting processes have been completed. The workshop should be cleared of extra dust and scrap materials after die cleaning and after removing other leftover, undesired materials so that they can be properly stored for recycling. Maintaining a tidy workshop will help you stay organized and keep an inventory. Clean the work area after use. Return all tools and equipment includes large melting furnaces, ladles, and work space.

Self-check-4

Give short answer

1) What is the difference between gravity die casting and pressure die casting?
2) What materials can be used for shot blasting?
3) What is a furnace? And list types of furnaces used in the foundry shop?
4) Write workshop cleaning advantages before and after gravity die casting operations?
5) What are the advantages of furnace dressing?
6) Write the process of furnace dressing operations.
7) Write the process of cleaning ladle.
8) What is shot blasting in gravity die casting?
9) What are the purposes of using shot blasting?
10) What does it mean refractory material?

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

"A"	**"B"**
20) Die cleaning	a) Covering the wall of furnace using refractory materials
21) Cleaning work area	b) Mold cleaning
22) Ladle	**c)** Remove oxides and scales from the die wall.
23) Dressing furnace	d) Time required to complete a work
24) Shot blasting	e) Make clean workplace
25) Wear of die mold	f) Melting equipment
26) Die operating cycle	g) Protecting fire accident
27) Furnace	h) Die surface damage
28) Fire extinguisher	i) Pouring equipment

Reference

1. B. Andresen, Die casting engineering: A hydraulic, thermal, and mechanical process. 2004.
2. R. K. Miller, Die Casting. 1989.
3. T. Sathish and S. Karthick, "Gravity Die Casting based analysis of aluminum alloy with AC4B Nano-composite," Mater. Today Proc., vol. 33.
4. S. Shamasundar and V. Gopalakrishna, "Gravity Die Casting Process Die Design and Process Optimisation," Dr. Janagan, Ennore Foundries Limited, Chennai, pp. 1–20, 2013.
5. E. J. Mayer, "die-casting machine."
6. T. Heinemann, Energy and Resource Efficiency in Aluminium Die Casting. 2015.
7. T. Uehara, "Die casting," J. Japan Inst. Light Met., vol. 21, no. 11, pp. 732–734, 1971,
8. P. L. Jain, Principles of Foundry Technology. 2003.
9. Uddeholms, "Uddeholm Tool Steels for Die Casting," p. 24, 2016.
10. R. Ganesh Narayanan, "ME 222 Manufacturing Technology-I (3-0-0-6) Introduction to manufacturing processes," p. 136, 2007.
11. B. Andresen, Die casting engineering: A hydraulic, thermal, and mechanical process. 2004.
12. A. M. Vyshakh M1* R Krishna Raj2 Sayooj A P1, "Experimental Investigation on Aluminium Gravity Die Casting," Int. J. Appl. Environ. Sci., vol. 9, no. 2, pp. 213–222, 2014.

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

TTLM	ስም	የትምህርት ደረጃ (A,B or C)	የተመረቁበት የሙያ ዓይነት	የመጡበት ክልል	የተቋም/የኢንዱስትሪ ስም	ሀላፊነት	ስልክ ቁጥር	ኢሜል
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