BRANCH: MECHANICAL ENGINEERING

SEMESTER: 3RD

SUBJECT: PRODUCTION TECHNOLGY

FACULTY: Er. ASISH KUMAR BEHERA

CONTENT

4.2 State advantages of powder metallurgy technology technique

4.3 Describe the methods of producing components by powder metallurgy technique.

4.4 Explain sintering.

4.5 Economics of powder metallurgy.

5.0 Press Work 7

5.1 Describe Press Works: blanking, piercing and trimming.

5.2 List various types of die and punch

5.3 Explain simple, Compound & Progressive dies

5.4 Describe the various advantages & disadvantages of above dies

6.0 Jigs and fixtures

6.1 Define jigs and fixtures

6.2 State advantages of using jigs and fixtures

6.3 State the principle of locations

6.4 Describe the methods of location with respect to 3-2-1 point location of rectangular jig

6.5 List various types of jig and fixtures.

Metal Forming Processes

Metal forming processes are an essential part of our society, and without them, our society would come to a grinding halt.

Some of the most common types of metal forming techniques are:

1. Roll forming
2. Extrusion
3. Press braking
4. Stamping
5. Forging
6. Casting

Extrusion: Definition & Classification

Extrusion is a manufacturing process that involves forcing base metal through a pre-shaped die to create objects with a specific shape and profile. As the metal passes through the die, it's shape changes to reflect the die's shape. There are different types of extrusion processes, however, including cold, hot, friction and micro.

Classification or Types of Extrusion Process:

Different types of Extrusion Processes:

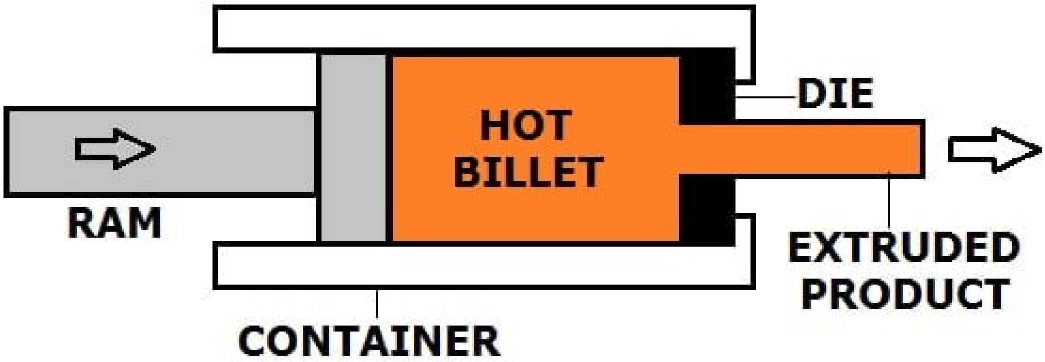
- Hot extrusion
- Cold extrusion
- Warm extrusion
- Friction extrusion
- Micro extrusion
- Direct extrusion
- Indirect extrusion
- Hydrostatic extrusion and
- Impact extrusion Process.

1. Hot Extrusion Process:

In this Hot extrusion process, the billet is worked above its recrystallization temperature. This hot working allows to keep the work piece from work hardening and makes the ram push it easily through the die.

Hot extrusions are generally performed on horizontal hydraulic presses. The pressure involved in this process can vary from 30 MPa to 700 MPa. To intact the high pressure, lubrication is employed. Oil or graphite is used as a lubricant in low-temperature extrusions and glass powder is used for high-temperature extrusions.

The billet is supplied a heat between 0.5 Tm to 0.75 Tm to obtain a quality operation.



Advantages of Hot extrusion Process:

- Deformation can be controlled as per requirements.
- The billet is not subjected to strengthening due to work hardening.
- Lesser forces are required to press.
- Materials with premature cracks can also be worked.

Disadvantages of Hot extrusion Process:

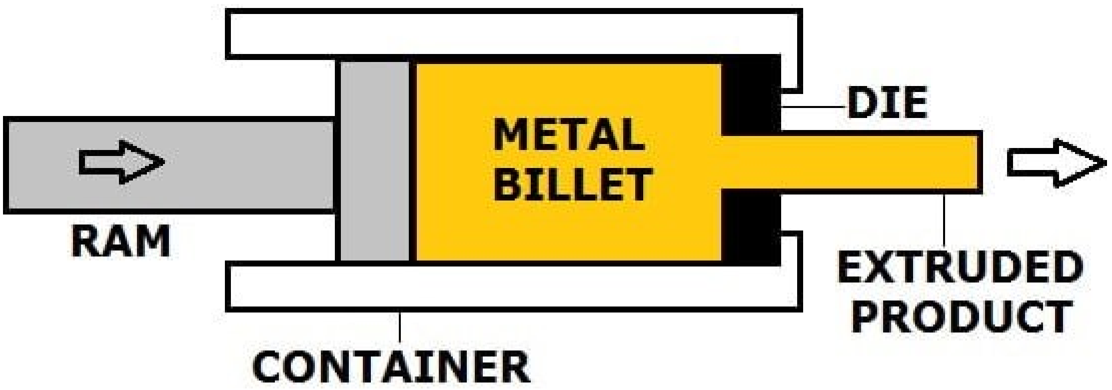
- Poor surface finish.
- Dimensional accuracy is comprisable.
- Lower container life.
- Possibility of surface oxidation.

2. Cold Extrusion:

It is the process of shaping metal by striking it with a slug. This striking is accomplished with a punch or ram in a closed cavity. The ram forces the metal through the die cavity to transform the solid billet into a solid shape.

In this process, the workpiece is subjected to deformation at room temperature or slightly above room temperature.

For the forces required to be too high, a powerful hydraulic press is used in this technique. The pressure ranges up to 3000 MPa.



Advantages:

- No oxidation.
- Improved strength of the product.
- Closer tolerances.
- Improved surface finish.
- Hardness is improved.

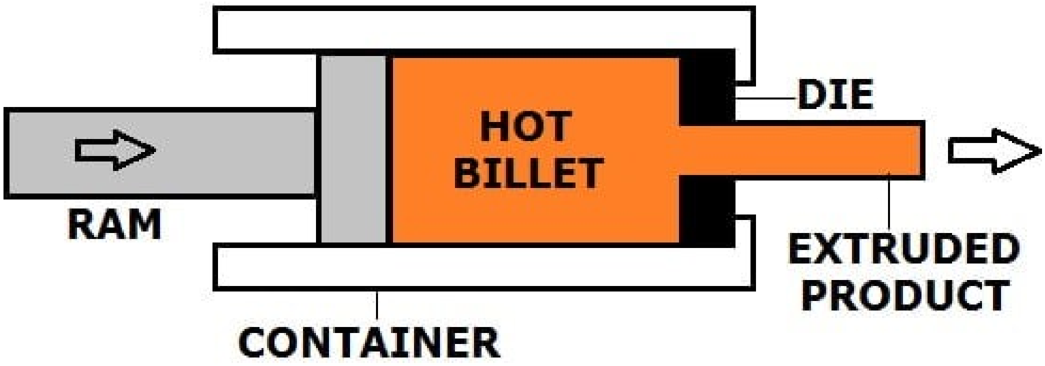
Disadvantages:

- Higher forces are required.
- More power is required to operate.
- Non-ductile materials cannot be worked.
- Strain hardening of the material being extruded is a limitation.

3. Direct or forward extrusion:

In the direct extrusion process, a metal billet is first placed into the container. The container has a contoured die hole. A ram is utilized to drive the metal billet through the die hole and the product is fabricated. IN this type, the direction of the metal flow is the same as that of the direction of movement of the ram.

As the billet is forced to move toward the die opening, a large amount of friction is produced between the surface of the billet and the container walls. The existence of friction necessitates a significant increase in the ram force thus consuming more power.



In this process, extruding brittle metals such as tungsten and titanium alloys is difficult because they get fractured during the process. The tensile forces throughout the process induce micro-cracks to form quickly, resulting in fractures.

Extruding brittle metals such as Tungsten and Titanium alloys is difficult because they fracture during the process. Tensile forces induce micro-cracks to form quickly, resulting in fractures.

Also, the presence of an oxide layer on the billet's surface intensifies the friction. This oxide layer has the potential to cause flaws in the extruded product.

In order to overcome this problem, a dummy block is placed between the ram and the work billet to help mitigate the friction.

Tubes, cans, cups, small size gears, shafts, and other extruded goods are examples.

Some parts of the billet always remain at the end of every extrusion. It is called the butt. It is removed from the product by cutting it immediately past the exit of the die.

Advantages of direct Process:

- The process is capable of extruding longer workpieces.
- Improved mechanical properties of the material.
- Good surface finish.
- Cold and hot extrusions are possible.
- Ability to operate continuously.

Disadvantages of direct Process:

- Brittle metals cannot be extruded.
- Large force and high-power requirement.

- Possibility of oxidation.

4. Indirect or backward extrusion:

In this backward extrusion process, the die remains stationary, whereas the billet and container move in combination. The die is mounted on the ram rather than the container.

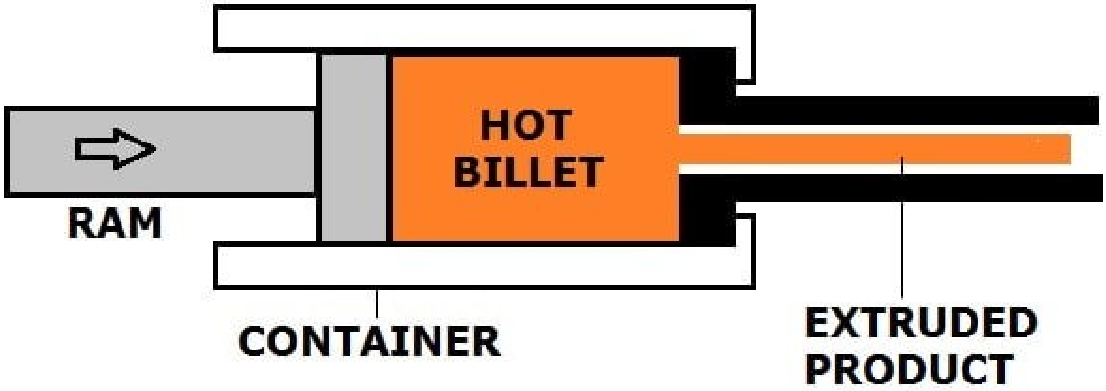
The metal flows through the die hole on the ram side in the opposite direction of the ram's movement as it is compressed by the ram.

When the billet is compressed, the material will pass between the mandrel and therefore the die opening.

Since there is no relative motion between the billet and the container, no friction is recorded. This lifts up the process over the direct extrusion process causing the ram force used is smaller than in the direct extrusion.

In order to keep the die stationary, a "stem" that is longer than the container's length is used. The column strength of the stem determines the final and maximum extrusion length.

Because the billet moves in combination with the container, all frictional forces are easily eliminated.



Advantages of indirect Processes:

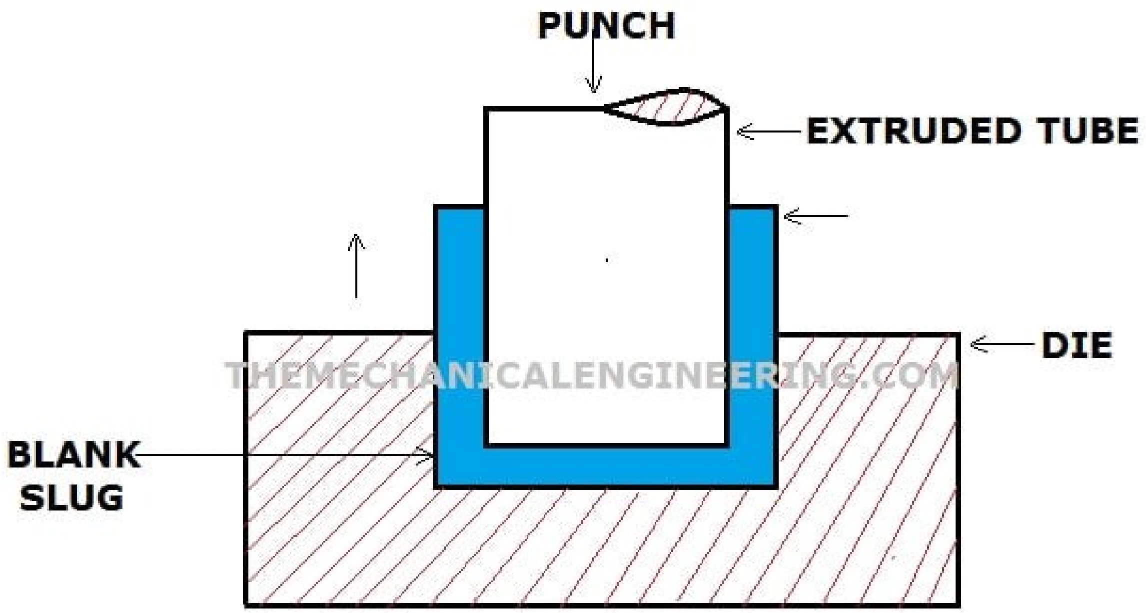
- Less extrusion force is required.
- Smaller cross-sections can be extruded.
- Reduction of friction by 30%.
- Enhanced operation speed.
- Very little wear is recorded.
- Extrusion faults or coarse-grain ring zones are less likely to arise because the metal flow is more consistent.

Disadvantages of indirect Process.

- Cross-section of the material extruded is confined by the size of the stem employed.
- Possibility of residual stresses past extrusion.
- Impurities and defects affect the surface finish and make the product comprisable.

5. Impact extrusion:

Impact extrusion is another major method for producing metal extruded profiles. In contrast to the traditional extrusion process, which requires high temperatures to soften the material, impact extrusion often uses cold metal billets. These billets are extruded at high pressure and efficiency.



A suitably lubricated slug is placed in a die cavity and hit with a punch in a single stroke during a conventional impact extrusion operation. This causes the metal to flow back around the punch through a gap between the die and the punch.

This process works better with softer materials such as lead, aluminum, or tin.

This process is always performed in a cold state. The backward impact process allows for very thin walls. Make toothpaste tubes or battery boxes, for example.

It is performed at a quicker rate and with shorter strokes. Instead of exerting pressure, impact pressure is employed to extrude the billet through the die. Impacting, on the other hand, can be performed by forwarding or backward extrusion, or a mix of the two.

Advantages:

- Large reduction in size.
- Quick process. Reduced machining time up to 90%.
- Increased production rate.
- Increased tolerance integrity.
- Up to 90% raw material saving.

Disadvantages:

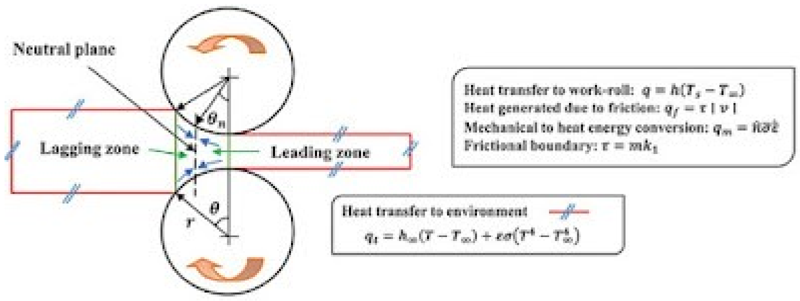
- A very high compressive force is required.
- The size of the billet is a limitation.

What is rolling process?

The rolling process is a very economical process for producing large volumes of material with a constant cross-section. It is one of the most important and widely used industrial metal forming operations providing the final product with high production and close control.

Working principle of rolling

Rolling is a process where the metal is compressed to reduce its cross-sectional area between two rotating rolls. This is one of the most widely used of all the metalworking process, because of its higher productivity and low cost. Rolling would be able to produce components having a constant cross-section throughout its length. Many shapes such as L, I, T are possible, but not very complex shapes. Special sections such as railway wagon wheels can also be produced by rolling individual pieces.



Working principle of rolling

Roll passes

The final rolled products such as plates, flats, sheets, rounds and sections are obtained in a number of passes starting from billets or slabs. The roll passes sequence can be broadly classified into three types.

- Break down pass :

There are used for reducing the cross-sectional area nearer to what is desired. This is the first pass of the sequence.

- Roughing pass :

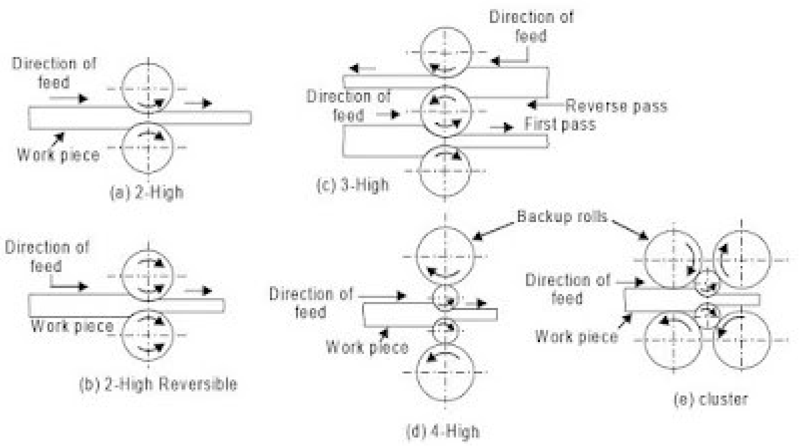
In this pass also, the cross-section gets reduced, but along with it, the shape of the rolled material comes nearer to the final shape.

- Finishing pass :

This is the final pass, which gives the required shape of the rolled section. Generally, the finishing pass follows a leader pass.

Rolling arrangement

The arrangement of rolls in the rolling operation is also called a rolling stand. It varies depending on the application. The different possible configuration is presented below.



Rolling Arrangement

The first one is the two high non-reversing rolling stand arrangement, is the most common arrangement. In this, the rolls always move in only one direction. Another 2-high rolling stand arrangement is the same but the direction of roll rotation can be reversed.

The three high rolling mill is used for rolling of two continuous passes in a rolling sequence without reversing the drives.

A four-high rolling mill is essentially a two-high rolling mill, but with small-sized rolls. The other two rolls are backup rolls for providing the necessary rigidity to the small rolls. A better backup with a cluster arrangement of rolls can be provided to the small rolls.

Generally, the rolls are made of chilled cast iron, carbon steel and alloy steel. The smaller rolls may be made of hard materials like tungsten carbide.

Types of the rolling process

The rolling process mainly divided into two types

- Hot Rolling
- Cold Rolling

Hot Rolling

Hot rolling is a process of milling that involves rolling the steel at a high temperature (usually above 1700°F) above the recrystallization temperature of the steel. It can be easily shaped and formed when steel is above the recrystallization temperature, and the steel can be made in much larger sizes.

At the time of scaling, the major problem occurred. During the hot rolling process, no dimensional precision is maintained for hot rolled steel.

Hot rolling can improve the processing performance of metals and alloys because coarse grains during foundry are broken, the cracks are healed, casting defects are reduced and eliminated hence, cast microstructure is transformed into a deformed structure to improve processing properties is the main advantage. The hot-rolled steel of various sections has residual stress caused by uneven cooling that has some influence on the performance of steel member under external force. Such as stability, deformation, fatigue and other aspects may have adverse effects is the main disadvantage.

Cold Rolling

Cold rolling is a process that introduces the sheet metal or strip stock between rollers and then compresses and squeezes it. The cold-rolled sheet can be manufactured under different conditions such as skin-rolled, quarter hard, half-hard, full hard depending on how much cold work has been performed.

In a cold rolling metal passes through rollers at temperatures below its recrystallization temperature so that increases the yield strength and hardness of the metal.

Commonly cold-rolled products include strips, sheets, bars and rods that are usually smaller than their counterparts that are hot rolled.

This process actually increases strength by up to 20 per cent through strain hardening and good dimensional accuracy and surface finish are the main advantages of cold rolling. There will be residual stress on the cross-section, which will affect the buckling resistance of the steel is the main disadvantages.

Four Types of Rolling Mills

- Four-high rolling mill. A four high rolling mill is used for reducing material to minute thicknesses. ...
- Cluster rolling mill. ...
- Continuous Mill. ...
- Planetary Rolling Mill.

Branch: Mechanical

Semester: 3rd Sem

Subject: PRODUCTION TECHNOLOGY

Chapter: 2

Faculty:

Chapter -2

Welding

Welding is a fabrication process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool, causing fusion. Welding is distinct from lower temperature techniques such as brazing and soldering, which do not melt the base metal (parent metal).

Classify various welding processes.

1. **Fusion welding**

   Electrical energy
   - Arc welding
   - Electron beam welding

   Chemical energy
   - Gas welding

   Light energy

   Laser welding

2. **Pressure welding**

   Electrical energy

   Resistance welding:
   - Resistance spot welding
   - Projection welding
   - Seam welding
   - Upset welding
   - Flash welding

   Chemical energy
   - Explosion welding

   Mechanical energy
   - Cold pressure welding

3. **Brazing/soldering**

   Electrical energy
   - Induction heating brazing (soft brazing = soldering)

   Chemical energy
   - Torch brazing (flame brazing)

   Light energy
   - Light beam brazing

   Laser brazing

What Is Flux?

Flux is a complex composition made from both organic and inorganic materials. The different ingredients have specific uses, such as producing shielding gas or creating slag designed to work with specific applications.

How Does Flux Work?

Flux "melts" into the weld pool where it rises to the top and creates slag. It simultaneously reacts with the heat and releases a shielding gas. So, the slag and gas formation protects the weld from the natural reactive gasses in the atmosphere.

But slag formation also purifies the weld, which is definitely a good thing. But once the weld has hardened, you must remove the slag using a wire brush, chipping hammer, or an angle grinder.

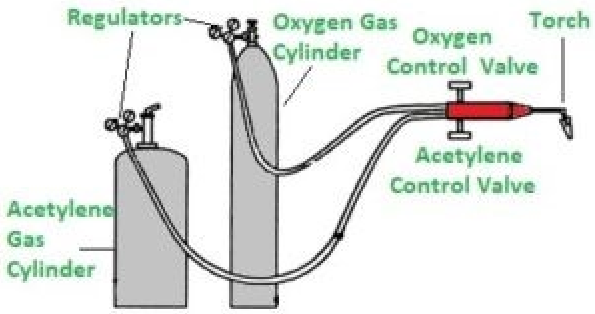
The resulting slag when flux is used is why some welders will refer to any welding process that uses flux as "slag welding."

what Is Oxy Acetylene Welding?

Oxy Acetylene Welding is a type of Gas Welding Process that is used to join and cut the metals. It was developed by Edmond Fouche and Charles Picard, the French Engineers. In the name Oxy Acetylene Welding, we can observe two words oxy and acetylene; the word Oxy meant Oxygen, and Acetylene is the order-less hydrocarbon gas. So, the combination of oxygen and acetylene both are used to weld the metal parts.

Oxy Acetylene is also called as Oxy-Fuel Welding or Oxy-welding, or Gas welding**.** Furthermore**,** in Gas Welding, various flue gases are used with addition to Oxygen which depends upon the material and its strength. Even though the gases vary, the *components, and process of welding will be remain same*.

Oxy Acetylene Welding Equipment:



A typical Oxy Acetylene Welding consists of

- **Gas Cylinders:** In the Gas Cylinders, the gases like Oxygen and Acetylene are stored at high pressure whenever the welding needs to be done, the gas is released manually.
- **Regulator:** A Regulator is a fixed part of the Cylinder; it is used to stop or slow down the pressure of the gas that is used to weld.
- **Welding Torch:** A Welding Torch is the main component in the oxy acetylene equipment where the flame is produced and used to weld or cut the materials. A welding torch produces a high-temperature flame according to the welding material.
- **Non-Return Valve:** Non-Return Valve is a type of valve that ensures the flow of gas is in one direction (that too out of the cylinder, regulator, and to the Torch.)

Working Principle of Oxy Acetylene Welding

The working principle of Oxy Acetylene Welding is simple in the process even though it is effective and efficient. The *temperature of the flame* is about **3,500 degrees** centigrade. It uses the Fuel gases like Oxygen and Acetylene to weld the material.

In this process, the welding torch produces the high-temperature flame with the help of oxygen and acetylene. Due to the high flame, the metal that needs to be weld gets weak and melted, meanwhile, a filler material is used to fill the gaps between two workpieces. As the filler is cooled, the two workpieces will be joined.

Usage of type of Filler material depends upon the metal that needs to be weld. For example, if we want to weld the mild steel metal, then we have to use the mild steel filler. Similarly, if we want to weld the aluminium metal, then we have to use the aluminium filler.

Advantages and Disadvantages of Oxy Acetylene Welding:

The advantages of Oxy Acetylene Welding are

- It is simple in construction, no huge parts and equipment are used in its installation like Arc Welding.
- It is easy to operate and no need for highly skilled technicians to operate it.
- Not only for welding but also oxy acetylene is used to separate or cut the materials into pieces.
- This type of Welding is cheaper.
- As Oxy Acetylene uses the gases like oxygen and acetylene, it can be used to weld ferrous and even non-ferrous metals.
- The intensity of the flame can be adjusted to high and less by using the valve.
- It can be used for high melting metals and even for low melting metals.

The disadvantages of Oxy Acetylene Welding are

- The temperature of the flame is less when compared to the arc welding.
- As like arc welding, the oxy acetylene does not have a high flux shield over the weld.
- It is suitable for thin materials and medium thin materials whereas it is not suitable for thick materials.

Applications of Oxy Acetylene Welding:

The applications of oxy acetylene welding are vast and necessary. They are

- It is used in the industries like metal joining and metal cuttings.
- It is used in the Automobile repairs to join the damaged parts.
- Fabricating Workshops and industries.

Types of flame:

As we know there are three basic welding flames. These are as follow.

Natural Flame:

As the name implies, this flame has equal amount of oxygen and gases fuel by the volume. This flame burns fuel completely and does not produce any chemical effect on metal to be welded. It is mostly used for welding mild steal, stainless steel, cast iron etc. It produces little smoke. This flame has two zones. The inner zone has white in color and has temperature about 3100 degree centigrade and outer zone has blue color and have temperature about 1275 degree centigrade.

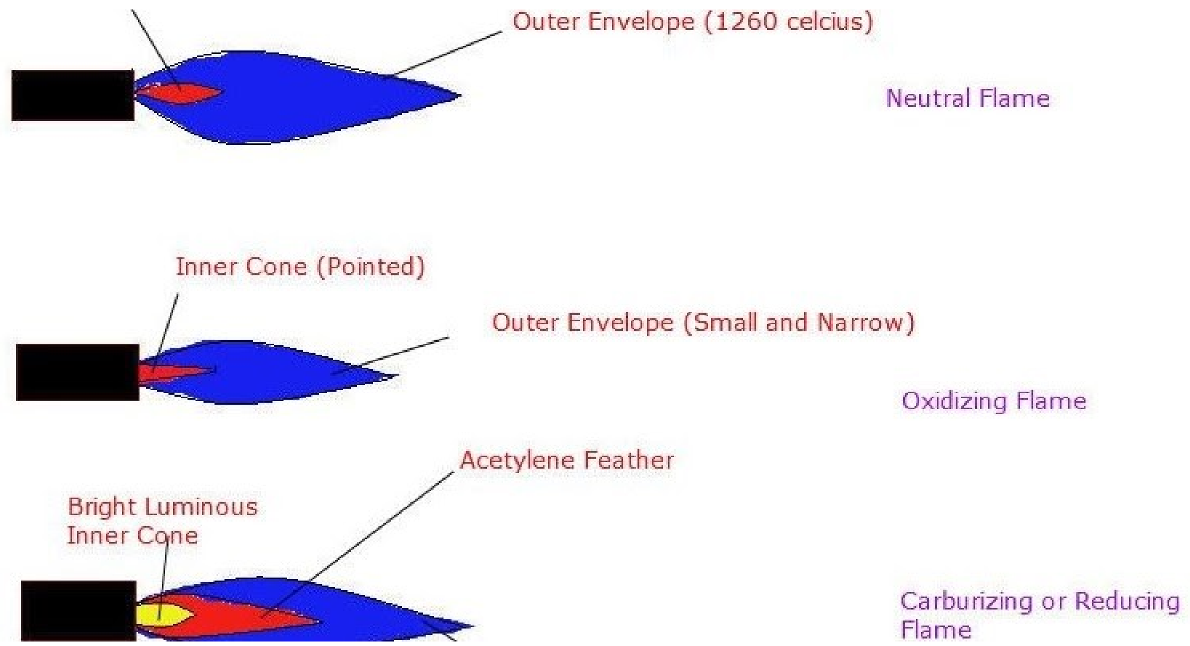
Carburizing Flame:

This flame has excess of fuel gas. This flame chemically reacts with metal and form metal carbide. Due to this reason, this flame does not used with metal which absorb carbon. It is smoky and quiet flame. This flame has three regions. The inner zone has white color, the intermediate zone which is red in color and outer cone has blue color. The inner cone temperature is about 2900 degree centigrade. This flame is used to weld medium carbon steel, nickel etc.

Oxidizing Flame:

When the amount of acetylene reduces from natural flame or amount of oxygen increases, the inner cone tend to disappear and the flame obtain is known as oxidizing flame. It is hotter than natural flame and has clearly defined two zones. The inner zone has very bright white color and has temperature of about 3300 degree centigrade. The outer flame has blue in color. This flame is used to weld oxygen free copper alloy like brass, bronze etc.

This is all about types of flames used in welding. If you have any query regarding this article, ask by commenting. If you like this article, don't forget to share it on social networks. Subscribe our website for more interesting articles. Thanks for reading it.

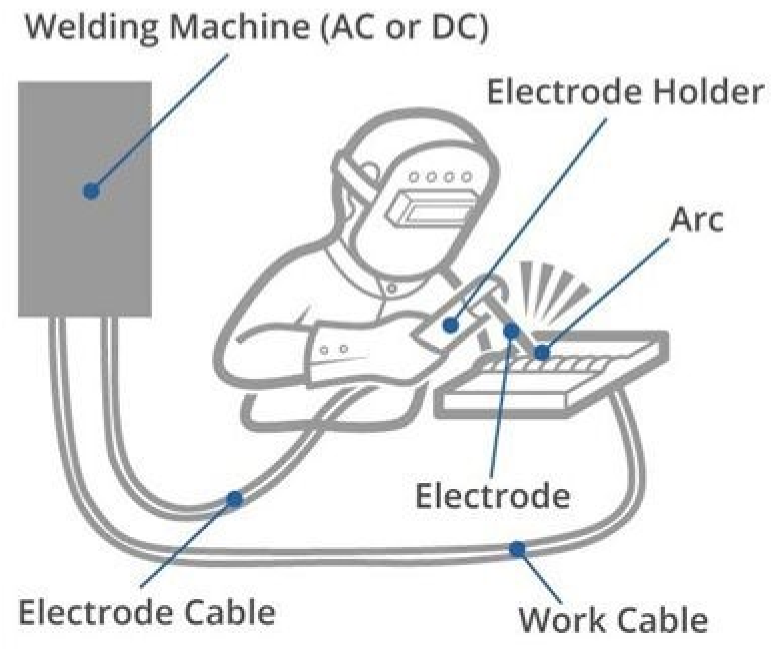


Explain Arc welding process.

Arc welding is a type of welding process using an electric arc to create heat to melt and join metals. A power supply creates an electric arc between a consumable or non-consumable electrode and the base material using either direct (DC) or alternating (AC) currents.

How does it Work?

Arc welding is a fusion welding process used to join metals. An electric arc from an AC or DC power supply creates an intense heat of around 6500°F which melts the metal at the join between two work pieces.



The arc can be either manually or mechanically guided along the line of the join, while the electrode either simply carries the current or conducts the current and melts into the weld pool at the same time to supply filler metal to the join.

Because the metals react chemically to oxygen and nitrogen in the air when heated to high temperatures by the arc, a protective shielding gas or slag is used to minimise the contact of the molten metal with the air. Once cooled, the molten metals solidify to form a metallurgical bond.

What are the Different Types of Arc Welding?

This process can be categorised into two different types; consumable and non-consumable electrode methods.

Consumable Electrode Methods

Metal Inert Gas Welding (MIG) and Metal Active Gas Welding (MAG)

Also known as Gas Metal Arc Welding (GMAW), uses a shielding gas to protect the base metals from contamination.

Shielded Metal Arc Welding (SMAW)

Also known as manual metal arc welding (MMA or MMAW), flux shielded arc welding or stick welding is a process where the arc is struck between the metal rod (electrode flux coated) and the work piece, both the rod and work piece surface melt to form a weld pool. Simultaneous melting of the flux coating on the rod will form gas, and slag, which protects the weld pool from the surrounding atmosphere. This is a versatile process ideal for joining ferrous and non-ferrous materials with a range of material thicknesses in all positions.

Flux Cored Arc Welding (FCAW)

Created as an alternative to SMAW, FCAW uses a continuously fed consumable flux cored electrode and a constant voltage power supply, which provides a constant arc length. This process either uses a shielding gas or just the gas created by the flux to provide protection from contamination.

Submerged Arc Welding (SAW)

A frequently-used process with a continuously-fed consumable electrode and a blanket of fusible flux which becomes conductive when molten, providing a current path between the part and the electrode. The flux also helps prevent spatter and sparks while suppressing fumes and ultraviolet radiation.

Electro-Slag Welding (ESW)

A vertical process used to weld thick plates (above 25mm) in a single pass. ESW relies on an electric arc to start before a flux addition extinguishes the arc. The flux melts as the wire consumable is fed into the molten pool, which creates a molten slag on top of the pool. Heat for melting the wire and plate edges is generated through the molten slag's resistance to the passage of the electric current. Two water-cooled copper shoes follow the process progression and prevent any molten slag from running off.

Arc Stud Welding (SW)

Similar to flash welding, SW joins a nut or fastener, usually with a flange with nubs that melt to create the join, to another metal piece.

Non-consumable Electrode Methods

Tungsten Inert Gas Welding (TIG)

Also known as Gas Tungsten Arc Welding (GTAW)**,** uses a non-consumable tungsten electrode to create the arc and an inert shielding gas to protect the weld and molten pool against atmospheric contamination.

Plasma Arc Welding (PAW)

Similar to TIG, PAW uses an electric arc between a non-consumable electrode and an anode, which are placed within the body of the torch. The electric arc is used to ionise the gas in the torch and create the plasma, which is then pushed through a fine bore hole in the anode to reach the base plate. In this way, the plasma is separated from the shielding gas.

Classification of Welding Electrodes

The welding industry has adopted the **welding rod classification** number series decided by the American Welding Society (AWS).

The identification system of the electrode for steel arc welding is adopted as follows.

- E- This E indicates electrode for arc welding
- The 1st two or three digits – It indicates the tensile strength in thousands of pounds /square inch of deposited material once tried to pull apart.
- The 3rd or 4th digit – It indicates the position of the weld. If 0 it shows no classification used, 1 is for every position, 2 for flat and horizontal, 3 is for flat position only.
- The 4th digit – It indicates the type of coating and the type of electric power supply, AC/DC, straight or reverse polarity.

- The number E6010 – Now it indicates an arc welding rod with a stress tensile strength of 60,000psi, can be used in all positions, and direct current with terse polarity.

What is Resistance Welding

Resistance welding is the joining of metals by applying pressure and passing current for a length of time through the metal area which is to be joined. The key advantage of resistance welding is that no other materials are needed to create the bond, which makes this process extremely cost effective.

There are several different forms of resistance welding (e.g. spot and seam, projection, flash, and upset welding) which differ primarily by the types and shapes of weld electrodes that are used to apply the pressure and conduct the current. The electrodes, typically manufactured from copper based alloys due to superior conductive properties, are cooled by water flowing through cavities inside the electrode and the other conductive tooling of the resistance welding machine.

Resistance welding machines are designed and built for a wide range of automotive, aerospace and industrial applications. Through automation, the action of these machines is highly controlled and repeatable allowing manufacturers to staff production readily.

Types of resistance welding application:

- *Spot Welding and Seam Welding*
  - Resistance Spot Welding, like all Resistance Welding Processes, creates welds using heat generated by resistance to the flow of welding current between the faying surfaces, as well as force to push the workpieces together, applied over a defined period of time. Resistance Spot Welding uses the face geometries of the welding electrodes themselves to focus the welding current at the desired weld location, as well as to apply force to the workpieces. Once sufficient resistance is generated, the materials set down and combine, and a weld nugget is formed.
  - Resistance Seam Welding is a subset of Resistance Spot Welding using wheel-shaped electrodes to deliver force and welding current to the parts. The difference is that the workpiece rolls between the wheel-shaped electrodes while weld current is applied. Depending on the particular weld current and weld time settings, the welds created may be overlapping, forming a complete welded seam, or may simply be individual spot welds at defined intervals.
- *Projection Welding*
  - Like other Resistance Welding Processes, Projection Welding uses heat generated by resistance to the flow of welding current, as well as force to push the workpieces together, applied over a defined period of time. Projection Welding localizes the welds at predetermined points by using projections, embossments or intersections, all of which focus heat generation at the point of contact. Once the weld current generates sufficient resistance at the point of contact, the projections collapse, forming the weld nugget.
  - Solid Projections are often used when welding fasteners to parts. Embossments are often used when joining sheet or plate material. An example of Projection Welding using material Intersections is cross-wire welding. In this case the intersection of the wires themselves

localizes heat generation, and therefore resistance. The wires set-down into one another, forming a weld nugget in the process.

- *Flash Welding*
    - Like other Resistance Welding Processes, Flash Welding uses heat generated by resistance to the flow of welding current, as well as force to push the workpieces together, applied over a defined period of time. Flash Welding is a Resistance Welding Process which generates resistance using flashing action. This action is created using very high current density at very small contact points between the workpieces. At a predetermined point after the flashing process has begun, force is applied to the workpiece, and they are moved together at a controlled rate. Rapid upset created by this force expels oxides and impurities from the weld.
- *Upset Welding*
    - Like other Resistance Welding Processes, Upset Welding uses heat generated by resistance to the flow of welding current, as well as force to push the workpieces together, applied over a defined period of time. While similar to Flash Welding, in Upset Welding the workpieces are already in firm contact with one another, so no flashing occurs. Pressure is applied before the current is started, and is maintained until the process is complete.

MIG Process

Metal inert gas (MIG) welding is also known as gas metal arc welding (GMAW). It uses a semi-automatic or fully automatic arc to create the weld with a consumable wire electrode as the filler material and a shielding gas to protect the weld, promote weld penetration and reduce weld bead porosity.

The electrode and the shielding gas are both fed through the welding gun (or torch). The shielding gas is usually a mix of 75% argon and 25% CO_2, although other mixtures are also used depending on materials being welded and other variables.

It also uses a continuous, consumable wire electrode and a shielding gas, which are fed through a lead to a welding gun (sometimes called a torch). The composition and diameter of the wire electrode also varies according to the types of metal being joined, the part thickness and the joint configuration. The pace at which the electrode is fed into the weld is determined by the wire feed speed (WFS) settings, which needs to provide enough weld metal fir the join.

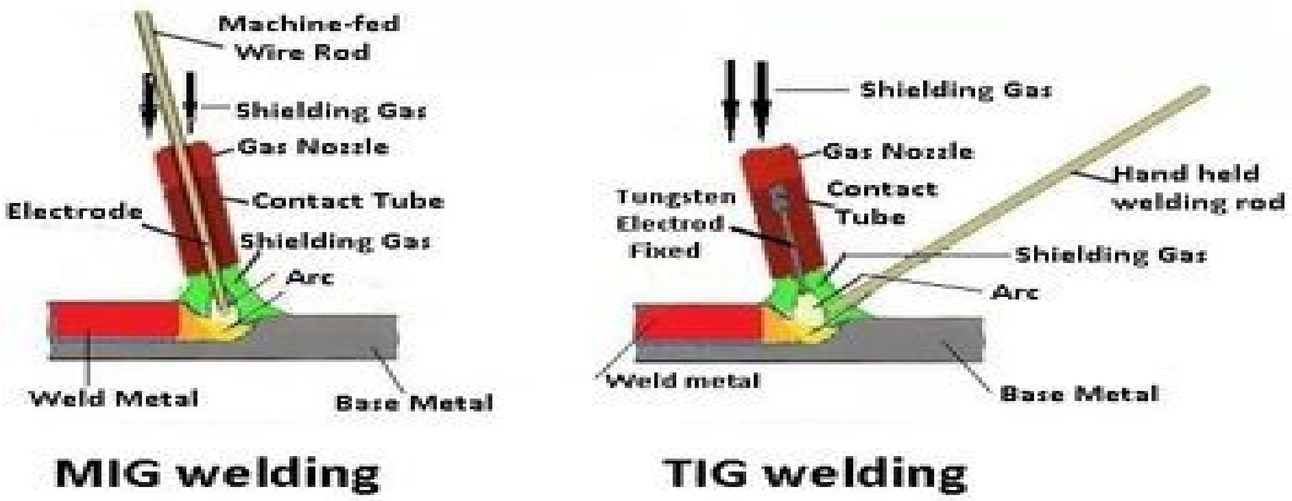
TIG Process

Tungsten inert gas (TIG) welding is also known as gas tungsten arc welding (GTAW). As with MIG, this welding process also uses an arc but, unlike with MIG, the electrode is a non-consumable tungsten electrode that is used alongside a separate consumable filler material. This filler is usually a rod that is manually fed into the weld pool, meaning that both hands are used for TIG welding – one for the tungsten electrode and the other for the filler rod.

The composition and size of the filler rod varies according to the weld being made. TIG welding also uses a shielding gas, although this is typically 100% argon as CO_2, as used with

MIG, promotes tungsten oxide formation that can prematurely wear your electrode and contaminate the weld.

TIG welding also uses a foot pedal so the welder can control the amperage, adjusting the heat during welding and allowing for precise control over the heat introduced to the metal.



Advantages and Disadvantages

MIG Advantages and Disadvantages

MIG, or metal inert gas, welding tends to be used to join large and thick materials, using a consumable wire that is both the electrode and filler material.

MIG welding is faster than TIG welding, creating shorter production times for welds and, subsequently, lower costs. MIG welding is also easier to learn, making it easier to produce welds that require little or no cleaning and finishing.

However, MIG welds are not as precise, strong or aesthetically pleasing as those produced by a skilled TIG welder.

TIG Advantages and Disadvantages

TIG, or tungsten inert gas, welding is a versatile technique that is capable of joining a wide range of small and thin materials, using a non-consumable tungsten electrode alongside an optional, separate filler rod.

TIG welding is slower than MIG welding, which increases production times and, subsequently, leads to increased costs. TIG welding is also harder to learn and requires skilled practitioners to deliver the correct weld precision and accuracy.

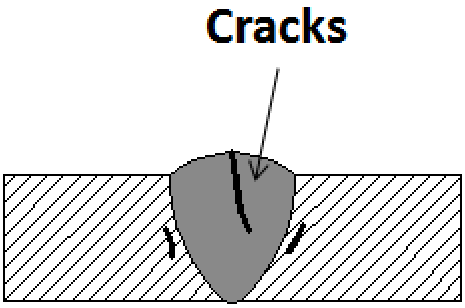
However, because TIG provides greater control over the welding operation, TIG welds are stronger, more precise, and more aesthetically pleasing than MIG welds.

State different welding defects with causes and remedies

Defects are common in any type of manufacturing, welding including. In the process, there can be deviations in the shape and size of the metal structure. It can be caused by the use of the incorrect welding process or wrong welding technique. So below we'll learn about the 7 most common welding defects, their types, causes and remedies.

Weld Crack

The most serious type of welding defect is a weld crack and it's not accepted almost by all standards in the industry. It can appear on the surface, in the weld metal or the area affected by



the intense heat.

There are different types of cracks, depending on the temperature at which they occur:

1. Hot cracks. These can occur during the welding process or during the crystallization process of the weld joint. The temperature at this point can rise over 10,000C.
2. Cold cracks. These cracks appear after the weld has been completed and the temperature of the metal has gone down. They can form hours or even days after welding. It mostly happens when welding steel. The cause of this defect is usually deformities in the structure of steel.
3. Crater cracks. These occur at the end of the welding process before the operator finishes a pass on the weld joint. They usually form near the end of the weld. When the weld pool cools and solidifies, it needs to have enough volume to overcome shrinkage of the weld metal. Otherwise, it will form a crater crack.

Causes of cracks:

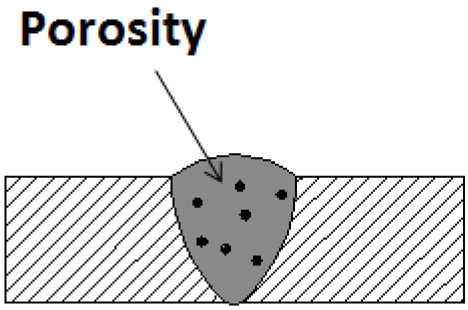
- Use of hydrogen when welding ferrous metals.
- Residual stress caused by the solidification shrinkage.
- Base metal contamination.
- High welding speed but low current.
- No preheat before starting welding.
- Poor joint design.
- A high content of sulfur and carbon in the metal.

Remedies:

- Preheat the metal as required.
- Provide proper cooling of the weld area.
- Use proper joint design.
- Remove impurities.
- Use appropriate metal.
- Make sure to weld a sufficient sectional area.
- Use proper welding speed and amperage current.
- To prevent crater cracks make sure that the crater is properly filled.

Porosity

Porosity occurs as a result of weld metal contamination. The trapped gases create a bubble-filled weld that becomes weak and can with time collapse.



Causes of porosity:

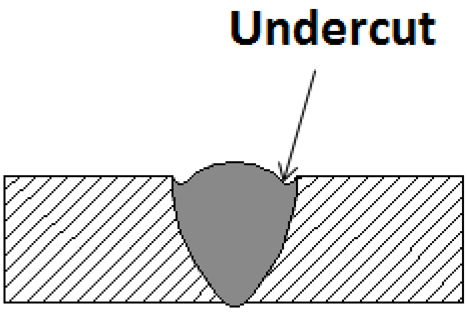
- Inadequate electrode deoxidant.
- Using a longer arc.
- The presence of moisture.
- Improper gas shield.
- Incorrect surface treatment.
- Use of too high gas flow.
- Contaminated surface.
- Presence of rust, paint, grease or oil.

Remedies:

- Clean the materials before you begin welding.
- Use dry electrodes and materials.
- Use correct arc distance.
- Check the gas flow meter and make sure that it's optimized as required with proper with pressure and flow settings.
- Reduce arc travel speed, which will allow the gases to escape.
- Use the right electrodes.
- Use a proper weld technique.

Undercut

This welding imperfection is the groove formation at the weld toe, reducing the cross-sectional thickness of the base metal. The result is the weakened weld and workpiece.



Causes:

- Too high weld current.
- Too fast weld speed.
- The use of an incorrect angle, which will direct more heat to free edges.
- The electrode is too large.
- Incorrect usage of gas shielding.
- Incorrect filler metal.
- Poor weld technique.

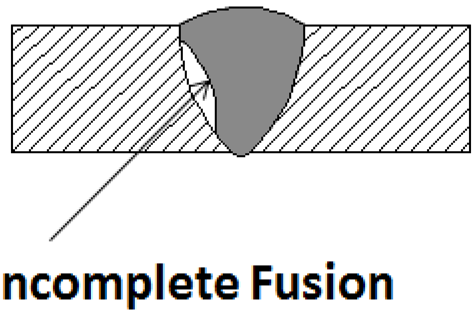
Remedies:

- Use proper electrode angle.
- Reduce the arc length.
- Reduce the electrode's travel speed, but it also shouldn't be too slow.
- Choose shielding gas with the correct composition for the material type you'll be welding.
- Use of proper electrode angle, with more heat directed towards thicker components.
- Use of proper current, reducing it when approaching thinner areas and free edges.
- Choose a correct welding technique that doesn't involve excessive weaving.
- Use the multipass technique

Incomplete Fusion

This type of welding defect occurs when there's a lack of proper fusion between the base metal and the weld metal. It can also appear between adjoining weld beads. This creates a gap in the joint that is not filled with molten metal.

Causes:



- Low heat input.
- Surface contamination.
- Electrode angle is incorrect.
- The electrode diameter is incorrect for the material thickness you're welding.

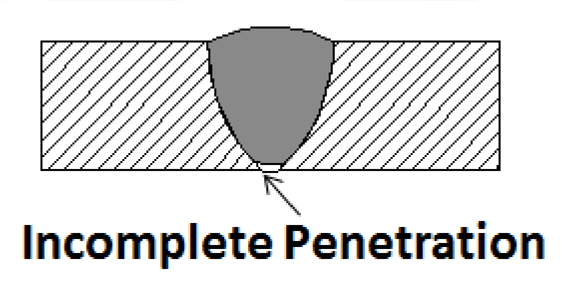
- Travel speed is too fast.
- The weld pool is too large and it runs ahead of the arc.

Remedies:

- Use a sufficiently high welding current with the appropriate arc voltage.
- Before you begin welding, clean the metal.
- Avoid molten pool from flooding the arc.
- Use correct electrode diameter and angle.
- Reduce deposition rate.

Incomplete Penetration

Incomplete penetration occurs when the groove of the metal is not filled completely, meaning the weld metal doesn't fully extend through the joint thickness.



Causes:

- There was too much space between the metal you're welding together.
- You're moving the bead too quickly, which doesn't allow enough metal to be deposited in the joint.
- You're using a too low amperage setting, which results in the current not being strong enough to properly melt the metal.
- Large electrode diameter.
- Misalignment.
- Improper joint.

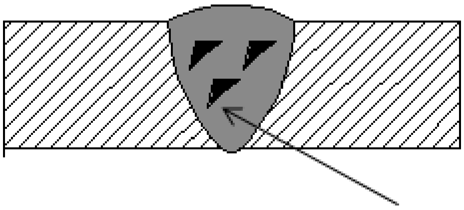
Remedies:

- Use proper joint geometry.
- Use a properly sized electrode.
- Reduce arc travel speed.
- Choose proper welding current.
- Check for proper alignment.

Slag Inclusion

Slag inclusion is one of the welding defects that are usually easily visible in the weld. Slag is a vitreous material that occurs as a byproduct of stick welding, flux-cored arc welding and submerged arc welding. Is can occur when the flux, which is the solid shielding material used when welding, melts in the weld or on the surface of the weld zone.

Causes:



Slag inclusion

- Improper cleaning.
- The weld speed is too fast.
- Not cleaning the weld pass before starting a new one.
- Incorrect welding angle.
- The weld pool cools down too fast.
- Welding current is too low.

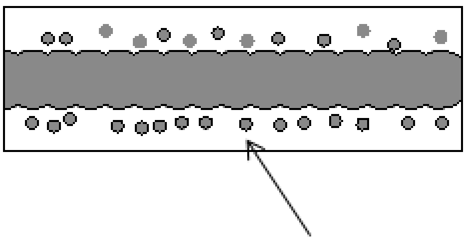
Remedies:

- Increase current density.
- Reduce rapid cooling.
- Adjust the electrode angle.
- Remove any slag from the previous bead.
- Adjust the welding speed.

Spatter

Spatter occurs when small particles from the weld attach themselves to the surrounding surface. It’s an especially common occurrence in gas metal arc welding. No matter how hard you try, it can’t be completely eliminated. However, there are a few ways you can keep it to a minimum.

Causes:



Spatter

- The running amperage is too high.
- Voltage setting is too low.
- The work angle of the electrode is too steep.
- The surface is contaminated.
- The arc is too long.
- Incorrect polarity.
- Erratic wire feeding.

Remedies:

- Clean surfaces prior to welding.
- Reduce the arc length.
- Adjust the weld current.
- Increase the electrode angle.
- Use proper polarity.
- Make sure you don’t have any feeding issues.

Branch: Mechanical

Semester: 3rd Sem

Subject: PRODUCTION TECHNOLOGY

Chapter: 3

Faculty:

Chapter-3

Casting

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process.

Different Types of Casting and the Casting Process

Although casting is one of the oldest known manufacturing techniques, modern advances in casting technology have led to a broad array of specialized casting methods. Hot forming processes, such as die-casting, investment casting, plaster casting, and sand casting, each provide their own unique manufacturing benefits. Comparing both the advantages and disadvantages of the common types of casting processes can help in selecting the method best suited for a given production run.

Sand Casting

Sand casting typically relies on silica-based materials, such as synthetic or naturally-bonded sand. Casting sand generally consists of finely ground, spherical grains that can be tightly packed together into a smooth molding surface. The casting is designed to reduce the potential for tearing, cracking, or other flaws by allowing a moderate degree of flexibility and shrinkage during the cooling phase of the process. The sand can also be strengthened with the addition of clay, which helps the particles bond more closely. Automotive products such as engine blocks are manufactured through sand casting.

Sand casting involves several steps, including patternmaking, molding, melting and pouring, and cleaning. The pattern is the form around which the sand is packed, usually in two parts, the cope and the drag. After the sand is compacted enough to replicate the pattern, the cope is removed and the pattern extracted. Then, any additional inserts called core boxes are installed and the cope is replaced. After the metal has been poured and solidified, the casting is removed, trimmed of the risers and gates that were used in the pouring process, and cleaned of any adhered sand and scale.

Sand casting's main advantages as a casting process include:

- Relatively inexpensive production costs, especially in low-volume runs.
- The ability to fabricate large components.
- A capacity for casting both ferrous and non-ferrous materials.
- A low cost for post-casting tooling.

Despite its benefits, sand casting yields a lower degree of accuracy than do alternate methods and it can be difficult to sand cast components with a predetermined size and weight specifications. Furthermore, this process has a tendency to yield products with a comparatively rough surface finish.

You can use the Thomas Supplier Discovery Platform to find Sand Casting Companies for your needs.

Investment Casting

Investment, or lost-wax, casting uses a disposable wax pattern for each cast part. The wax is injected directly into a mold, removed, and then coated with refractory material and a binding agent, usually in several stages to build up a thick shell. Multiple patterns are assembled onto common sprues. Once the shells have hardened the patterns are inverted and heated in ovens to remove the wax. Molten metal is then poured into the remaining shells where it hardens into the shape of the wax patterns. The refractory shell is broken away to reveal the completed casting. Investment casting is often used to manufacture parts for the automotive, power generation, and aerospace industries, such as turbine blades. Some of the central advantages and disadvantages of investment casting include:

- A high degree of accuracy and precise dimensional results.
- The ability to create thin-walled parts with complex geometries.
- The capacity for casting both ferrous and non-ferrous materials.
- Relatively high-quality surface finish and detail in final components.

Although it is highly precise, investment casting is usually more expensive than other comparable casting techniques and is typically only cost-efficient when sand or plaster castings cannot be used. However, the expense can sometimes be compensated for with reduced machining and tooling costs due to investment castings' quality surface results.

You can use the Thomas Supplier Discovery Platform to find Investment Casting Companies for your needs.

Plaster Casting

Plaster casting is similar to the sand casting process, using a mixture of gypsum, strengthening compound, and water in place of the sand. The plaster pattern is typically coated with an anti-adhesive compound to prevent it from becoming stuck against the mold, and the plaster is capable of filling in any gaps around the mold. Once the plaster material has been used to cast the part, it usually cracks or forms defects, requiring it to be replaced with fresh material. The advantages offered by plaster casting include:

- A very smooth surface finish.
- The ability to cast complex shapes with thin walls.
- The capacity for forming large parts with less expense than other processes, such as investment casting.
- A higher degree of dimensional accuracy than that of sand casting.

This process tends to be more expensive than most sand casting operations and may require frequent replacements of the plaster molding material. It is usually more effective and cost-efficient when the quality of the surface finish is an important requirement. Its application is generally limited to casting aluminium and copper-based alloys.

You can use the Thomas Supplier Discovery Platform to find Plaster Casting Companies for your needs.

Die Casting (Metal Casting Process)

Die casting is a method of molding materials under high pressure and usually involves non-ferrous metals and alloys, such as zinc, tin, copper, and aluminum. The reusable mold is coated with a lubricant to help regulate the die's temperature and to assist with component ejection. Molten metal is then injected into the die under high pressure, which remains continuous until the workpiece solidifies. This pressurized insertion is rapid, preventing any segment of the material from hardening before being cast.

After the process is completed, the component is taken out of the die and any scrap material is removed. A few of the major advantages provided by die casting include:

- Close size and shape tolerances.
- High component dimensional consistency and uniform design.
- A reduced need for post-casting machining.

Despite its advantages, die casting as a metal casting process has relatively high tool costs, making it more cost-efficient in high-volume product runs. It can also be difficult to ensure the mechanical properties of a die-cast component, meaning these products usually do not function as structural parts. As the molds are typically two-piece, die casting is limited to products that can be removed from the mold without destroying the mold, as is done in other casting processes.

For more information on Die Casting, you can review our Types of Die Casting guide, which goes into depth on the various types, alloys, and considerations for choosing a specific process/alloy combination.

Centrifugal Casting

Centrifugal casting is used to produce long, cylindrical parts such as cast iron pipe by relying on the g-forces developed in a spinning mold. Molten metal introduced into the mold is flung against the interior surface of the mold, producing a casting that can be free of voids. Originally invented as the de Lavaud process using water-cooled molds, the method is applied to symmetrical parts such as soil pipe and large gun barrels and has the advantage of producing parts using a minimal number of risers. For asymmetric parts that cannot be spun around their own axes, a variant of centrifugal casting, called pressure casting, arranges several parts around a common sprue and spins the molds around this axis. A similar idea is applied to the casting of very large gear rings, etc. Depending on the material being cast, metal or sand molds may be used.

Permanent Mold Casting

Permanent mold casting shares similarities with die casting and centrifugal casting, notably the use of reusable molds. These can be made of steel, graphite, etc. and are generally used to cast materials such as lead, zinc, aluminum and magnesium alloys, certain bronzes, and cast iron. It is a low-pressure process with pouring usually done by hand using multiple molds on a turntable. As the molds rotate through the various stations they are successively coated, closed, filled, opened, and emptied. One such method is known as slush casting, where the mold is filled but emptied before the metal fully hardens. Molten metal is dumped from the casting to produce a hollow, cast shell. A similar idea is used in the molding of hollow chocolate products such as Easter bunnies. The use of metal molds induces faster heat transfer through the mold, allowing the shell to harden while the core remains liquid.

The 6-Step Process of Sand Casting

Also known as sand molding casting, sand casting is a casting-based manufacturing process that involves the use of a sand mold. It’s used to create metal products and components in a variety of sizes and shapes. To put its popularity into perspective, statistics show over half of all metal castings — about 60% — are produced using sand casting. Below, you’ll learn more about the six primary steps of sand casting.

1) Place Mold Pattern in Sand

The first step of sand casting involves the placement of the mold pattern in sand. The size and shape of the casting is directly influenced by the mold. Therefore, manufacturing companies must create new molds to create metal products and components in specific sizes and shape.

2) Set Up the Gating System

Most casting processes involve the use of a gating system, and sand casting is no exception. Consisting of a pouring cup and tunnels or “gates” to the mold, it’s used to funnel the molten mold into the mold cavity. After placing the mold pattern in sand, manufacturing companies will set up a gating system such as this.

3) Remove the Mold Pattern

With the gating system set up, manufacturing companies can then remove the mold pattern from the sand. The mold pattern is no longer relevant at this point. When the mold pattern is placed inside sand, the sand takes its shape. As a result, the mold pattern can be removed.

4) Pour Molten Metal Into Mold Cavity

Now it's time to pour the molten metal into the mold cavity. Sand casting supports a variety of different metals and alloys, some of which include iron, steel, aluminum, bronze, magnesium, zinc and tin. Depending on the specific metal or alloy used, manufacturing companies may need to heat it up to 3,000 degrees Fahrenheit. Once the metal or alloy has turned from a solid state to a liquid state, it's poured into the mold cavity.

5) Wait for Metal to Cool

After the molten metal has been poured into the mold cavity, manufacturing companies must wait for it to cool. Again, different types of metal take different lengths of time to cool. As the molten metal cools, it will revert from a liquid state back to a solid state.

6) Break Open Mold to Remove the Metal Casting

The sixth and final step of sand casting involves breaking open the mold to remove the newly created metal casting. While molds patterns are typically reusable, the actual molds are not. Therefore, manufacturing companies must recreate a new mold each time they want to create a new metal product or component using sand casting.

TYPES OF MOULDING SAND

The various types of moulding sand are

1. Green sand
2. Dry sand
3. Loam sand
4. Parting sand
5. Facing sand
6. Backing sand
7. System sand
8. Core sand

1. Green Sand
→ Green sand is a mixture of silica sand and clay. It constitutes 18 % to 30 % clay and 6 % to 8 % water.
→The water and clay present is responsible for furnishing bonds for the green sand.
→It is slightly wet when squeezed with hand. It has the ability to retain the shape and impression given to it under pressure.
→It is easily available and has low cost.
→The mould which is prepared in this sand is called green sand mould.
→It is commonly used for producing ferrous and non-ferrous castings

2. Dry Sand
→After making the mould in green sand, when it is dried or baked is called dry sand.
→It is suitable for making large castings.
→The moulds which is prepared in dry sand is known as dry sand moulds.
→If we talk about the physical composition of the dry sand, than it is same as that of the green sand except water.

3. Loam Sand
→It is a type of moulding sand in which 50 % of clay is present.
→It is mixture of sand and clay and water is present in such a quantity, to make it a thin plastic paste.

→In loam moulding patterns are not used.
→It is used to produce large casting.

4. Parting Sand
→Parting sand is used to prevent the sticking of green sand to the pattern and also to allow the sand on the parting surface of the cope and drag to separate without clinging.
→It serves the same purpose as of parting dust.
→It is clean clay free silica sand.

5. Facing Sand
→The face of the mould is formed by facing sand.
→Facing sand is used directly next to the surface of the pattern and it comes in direct contact with the molten metal, when the molten metal is poured into the mould.
→It possesses high strength and refractoriness as it comes in contact with the molten metal.
→It is made of clay and silica sand without addition of any used sand.

6. Backing Sand
→Backing sand or flour sand is used to back up facing sand.
→Old and repeatedly used moulding sand is used for the backing purpose.
→It is also sometimes called black sand because of the addition of coal dust and burning when it comes in contact with the molten metal.

7. System Sand
→In mechanical sand preparation and handling units, facing sand is not used. The sand which is used is cleaned and reactivated by adding of water, binder and special additives. And the sand we get through this is called system sand.
→System sand is used to fill the whole flask in the mechanical foundries where machine moulding is employed.
→The mould made with this sand has high strength, permeability and refractoriness.

8. Core Sand
→The sand which is used to make core is called core sand.
→It is also called as oil sand.
→It is a mixture of silica sand and core oil. Core oil is mixture of linseed oil, resin, light mineral oil and other binding materials.
→For the sake of economy, pitch or flours and water may be used in making of large cores.

Different Types of Pattern

→ In casting process, Pattern is the replica of the device which is the output of casting process. This when molded in sand forms mold. After filling mold with the molten metal there is a formation of casting. Patterns play a very important role in casting as they decide the quality as well as perfection in a particular casting process. Gates and runners are the most important components in several types of pattern. Pattern is the basic requirement for creation of mold and it is always bigger than the size of casting. There should be a proper selection of pattern so it must be able to sustain rough handling. It forms mold cavity for casting processes. The patterns may be made of metals like aluminium, brass, plaster and wax.

There are some of the features of best pattern material used for designing:

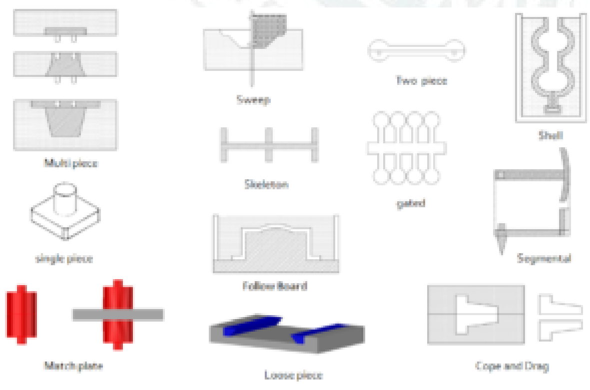
• Water resistant.
• Cheap in cost and have very less weight.
• Long lasting and hard.
• Industry oriented patterns are mostly designed simple and they are repairable.

During patterning processes, to handle any structural problems different allowances are made. These allowances include shrinkage allowances, Machining Allowance, shake allowances, Draft allowances and finally distortion allowances. Following are some of the key factors that decide the types of patterns of casting you must choose:

• Features of the particular casting process,
• Number of castings that are to be created and
• Physical specifications, means size of casting.

Types of Patterns
The various kinds of patterns that we use in casting process are

1) Single piece pattern
2) Two piece pattern
3) Gated pattern
4) Multi piece pattern
5) Match plate pattern
6) Skeleton pattern
7) Sweep pattern
8) Lose piece pattern
9) Follow board pattern
10) Cope and drag pattern
11) Segmental pattern and
12) Shell pattern



Types of Pattern in Casting

1) Solid or Single Piece Pattern
Single piece pattern is the cheapest pattern among all other types of pattern. This pattern generally used in simple processes. It is applied in small scale production. It is often used for the generation of large castings such as stuffing box of steam engine and for creating simple shapes, flat surfaces like simple rectangular blocks. The important characteristic of this pattern is that there is no need of joint in the mold area. In this pattern one surface is

considered as flat portion. This flat surface is used for parting plane. Sand tools are used to cut the sand which ultimately make gating system. The molding becomes a difficult task if there is absence of this flat surface. It is expected to lie in cope or drag.

2) Two- Piece Pattern

Two- piece pattern is also called as split piece pattern. It is the popularly used for intricate castings. The shape of casting decides the exact place of parting plane. This parting plane may be flat or irregular surface. In two- piece pattern half part is always molded in drag and other half part is molded in cope. The cope part of the pattern has dowel pins. These dowel pins are used to align the two halves of split piece pattern. Holes in the drag half of the two-piece pattern match exactly with dowel pins. It is used in applications where it is very difficult to withdraw casting from the mold. Two- piece patterns are used where the depth of casting is very high.

3) Multi Piece Pattern

Sometimes castings have very difficult and complicated designs. In such difficult situations multi piece types of patterns are used. 3 or more patterns are included in multi piece pattern. For instance, if we consider three- piece pattern which comes under multi piece pattern. This three- piece pattern consists of top, bottom and middle parts. The bottom part is drag, top part is cope where the middle part is termed as check box.

4) Match Plate Pattern

Basically Match plate pattern is a split pattern. Cope and drag areas are on the opposite faces of metallic plate. This metallic plate is termed as Match Plate. This type of pattern requires very less hard work and gives very high output. Because the gates and runners are also on the match plate. This is used in various manufacturing industries. This is very expensive and gives accuracy as well as high yield. This pattern is widely used for casting metals like aluminium.

5) Gated Pattern

Gated types of patterns are used to make multiple components inside the single mold. Gated pattern is nothing but the pattern consisting one or more patterns. For joining different patterns gates are used. These are loose patterns where gates and runners have already attached. These patterns are very expensive. Due to their high cost they are used for creating small castings. These small castings further are used in molding machines as well as in mass producing processes.

6) Skeleton Pattern

Skeleton pattern is used for castings which have simple size and shape. These castings are usually large in size. The only disadvantages of skeleton types of patterns are – it is applicable for small number of components and it is not cheap. Economically, it is not the best pattern. Stickler is used to remove extra sand. These are nothing but frames of wood that highlight the area which is to be cast. These patterns also help molder. They are widely used in process of pit or floor welding.

7) Sweep Pattern

In sweep pattern we make use of wooden board. This wooden board of proper size is to be rotated about one edge to shape the cavity as circular or rotational symmetry. Sweep pattern is often used when we have to create casting in very short interval of time. Molds of extensive symmetrical casting can be made easily with the help of sweep pattern. Sweep pattern consists of three parts spindle, base and sweep which is wooden board. Spindle is directed in vertical direction and base is attached with sand.

8) Loose Piece Pattern
It is very difficult to remove one piece of solid pattern which is above or below the parting plane having projections from the mold. With the help of loose piece types of patterns projections can be made by loose pieces. It requires skilled labor work as well as it is very expensive. There is one disadvantage of this loose piece pattern is that their shifting can be done due to ramming process.

9) Cope and Drag Pattern
Cope and drag pattern is a split pattern. This pattern has cope and drag on separate plate. Cope and drag pattern has two parts which are separately molded on molding box. After molding parts, these two separate parts are combined to form the entire cavity. Cope and drag pattern is almost like two-piece pattern. This pattern types are used in the production of large castings where the molds are very heavy and unhandy for a user.

10) Follow Board Pattern
Follow board pattern consists of tool that is a simple wooden board which is used for several reasons. The wooden board is used as a base in follow board pattern for molding process. This pattern is used in processes where casting structures are weak and they may break after the application of force.

11) Segmental Pattern
It is just a similar to that of sweep pattern. The working structure of segmental pattern and sweep pattern is almost similar. For designing require shape or structure of mold they both employ a part of pattern. As the name suggest segmental pattern is in the form of segments and used for molding circular or round structures. In sweep pattern there is complete rotation but in segmental pattern there is no complete rotation. For creating mold, we can rotate partly to get required output.

12) Shell Pattern
Shell pattern is specially used for obtaining hollow shaped structure. Along the center the parting process is done. The resultant halves produced after parting are both doweled.

Types of Pattern Allowances in Casting Process & Their Uses

What is Pattern?

For making the casting product in the casting process, a pattern is used to make a mold cavity in the sand.

Pattern Allowance

A pattern is a replica of casting which is used to make a mold cavity but it has slightly large dimensions. 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.These slight changes in the pattern are known as pattern allowance.

Types of Pattern Allowance

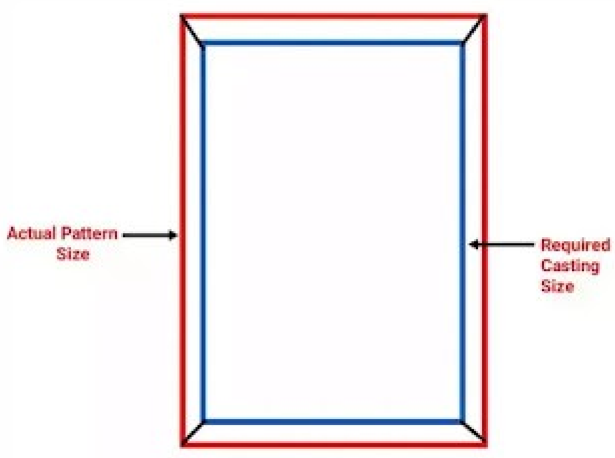
There are the following types of pattern allowances are used in the casting process.

- 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 and every material has to shrinks. 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.

Show in the figure.



Shrinkage Allowance

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

Which is different for different materials.

Shrinkage Allowances For Different Materials

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

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

Types of Shrinkage

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

- Liquid Shrinkage
- Solidification Shrinkage.
- Solid Shrinkage
-

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

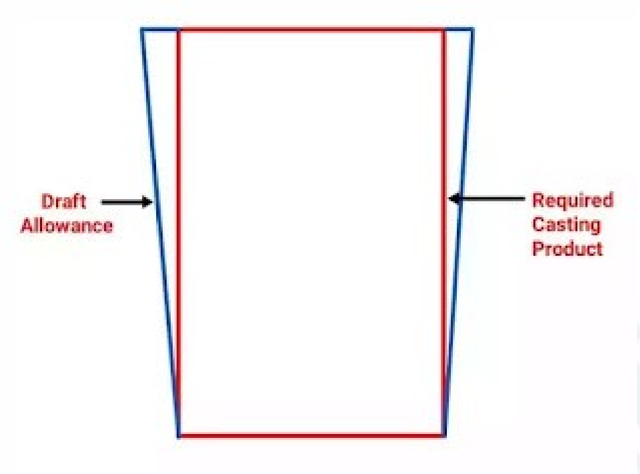
The contraction phase changes from liquid to solid, which is called solidification shrinkage. The solidification shrinkage reduces the height of the casting metal.

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

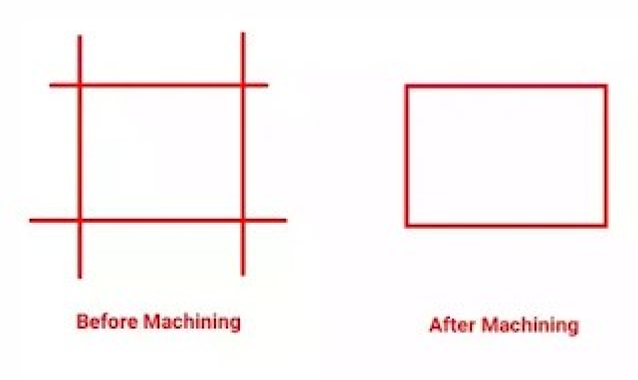
During removing the pattern from the mold cavity, the parallel surfaces in the direction in which the pattern is withdrawn are slightly damaged and also converted into slightly tapered surfaces.To compensate for these changes, these parallel surfaces on the pattern are slightly tapered by about 1 to 2 degrees.By which removal of the pattern from the mold cavity becomes easy and suitable and also does not affect the casting in any way.These small changes in the surface of the pattern are called draft allowances to protect it from damage.



Draft Allowance

Machining Allowance

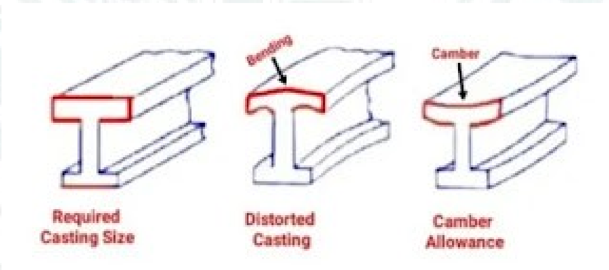
As we know that the product of the casting process gives a very poor surface finish, so the surface of the final product of casting always is rough. But we required a product that is polished and has a good surface finish. So in order to have a good surface finish, the final product of the casting is machined with the help of a lathe machine, milling machine, shaper machine, slotting machine with these processes such as turning, grinding, shaping, 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. Show in the figure casting product before machining with allowances and after machining.



Machining Allowance

Deformation or Camber Allowance

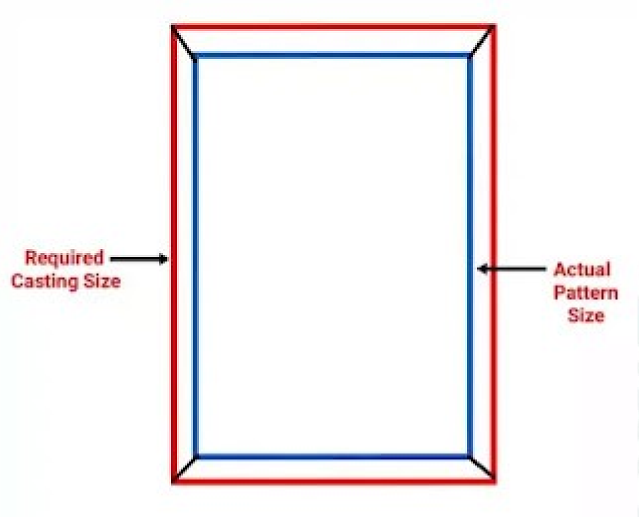
When the metal is in the cooling process, stress is developed during the solidifying of this metal due to uneven metal thickness in the casting process. This stress can cause deformation or bend in the casting. To avoid this bending or deformation in castings, camber is provided in the opposite direction 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.Show in the figure camber provided in a pattern.

hake 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.See in a figure shaking or rapping allowance.

Shaking or Rapping Allowance

CORE

According to state of core the cores can be classified into; Green sand cores: These are prepared by green sand. Oil sand cores. Loam sand cores

What is Cupola Furnace?

The cupola furnace is a melting device used to melt cast iron, bronze, and other alloying elements. It is mainly used to convert iron to cast iron.

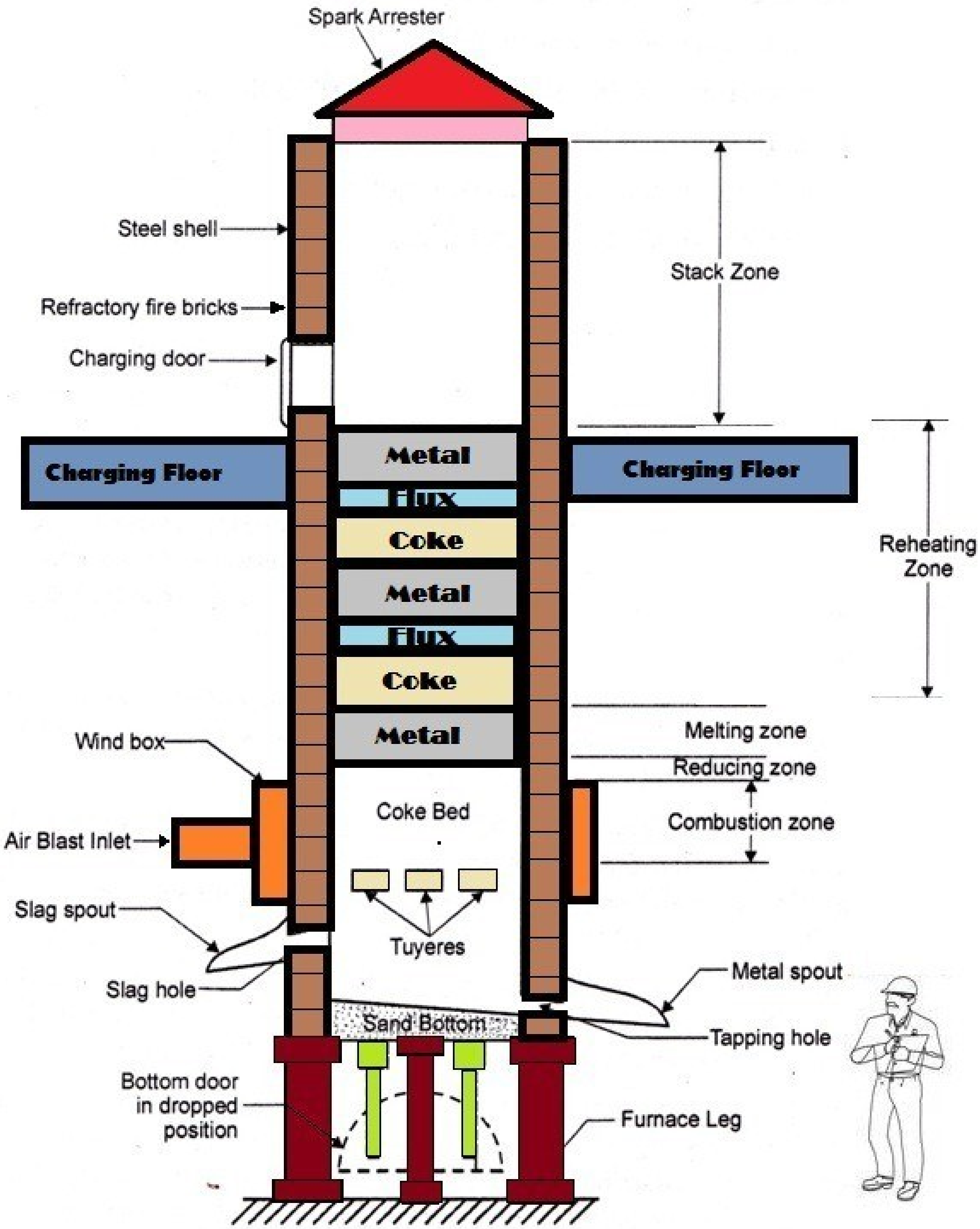
The Kapila furnace was first built in China during the period of the Warring States (403 –221 BCE). The cupola furnace is cylindrical in shape, and the equipment of this furnace is fitted vertically inside this cylindrical shell with a door.

For many years the cupola furnace was used to melt iron in iron castings as it produces a better cast iron than pig iron.The top of the cupola furnaces is sometimes fitted with a cap to avoid gases harmful to the environment, and this cap also protects from rainwater.

The cupolas shell is made of steel and consists of refractory brick and plastic refractory patching materials. The bottom of this shell is lined with a mixture of clay and sand and is a temporary lining. Sometimes coal is mixed with the soil lining so that when the coal is heated, it rots, and the bond becomes brittle.

Cupola construction

- The outermost part of the cupola furnace is a cylindrical steel shell.
- The diameter of this shell ranges from 1.5 to 13 feet, depending on the furnace’s size.
- They are lined with an inner edge of furnace Refractory brick and plastic refractory patch material.
- These furnaces is supported on cast iron legs mounted on a concrete base.
- At the bottom of the furnace, two cast iron doors are hinged with the bedplate of the furnace.
- Near the bottom, it has sent a bed above, which has a flow of molten iron.
- This sand bed is taped.
- Near the higher part of the taped sand bed, slag holes exist through which slag made of impurities come out.
- Below the down bed, there exists a tap hole through which molten iron comes out.
- Above the sending bed, tuners exist through which air reaches the furnace and helps in combustion.
- A cap or cap is present at the top of the furnace spark, which traps burning particles and releases only gases into the environment.
- Near the top of the furnace, a charging door exists through which metal, coke, and limestone are fed into the furnace.



Cupola furnace

Purpose of cupola

Here, the purpose of cupola furnace are as follows.

1. Similar to the blast furnaces, the cupola is a refractory-lined steel stack 20 to 35 feet (6 to 11 m) high, resting on a cast iron base plate with four steel legs.
2. Below the cupola furnace are two hinged doors supported in a closed position by a center prop. Coking beds, molten metal, and closed sand are molded to support successful charges.

3. The air forced into the combustion enters the cupola through the openings (tires) around the rim of the lower part of the cupola.

Working Principle of Cupola Furnace:

- The wood is first ignited over a bed of sand.
- When the wood starts burning properly, the coke is thrown from the top to the well at a predetermined height of about 40 inches. This makes a 40-inch coke bed.
- Then the combustion begins in the coke bed using fire from the burning wood and air from the trees.
- At this time, aerial explosions have flown at lower than normal rates to provoke coke.
- When the coke starts to burn properly after about 3 hours of burning, alternating layers of limestone, pig iron, and coke are charged until it reaches the level of the charging door.
- At this time, an air blast is carried out at a normal blowing rate, and combustion occurs more rapidly in the coke bed.
- All the oxygen from the air blast is consumed by combustion in the combustion zone.
- The chemical reaction that occurs is **$C + O_2 \rightarrow CO_2$ +** Heat.
- It is an exothermic reaction, and the temperature in the combustion zone varies from 1150 to 1850 ° Celsius.
- The portion of the coke bed above the combustion zone is a reducing zone.
- This region prevents oxidation of the metal charge while leaving it over and through.
- Ho carbon dioxide goes up through this region; some of it is reduced by the following reaction, **$CO_2 + C \rightarrow 2CO$**
- The zone of dilution of iron above the zone is a melting zone where solid iron is converted into molten iron.
- This molten iron falls down through the coke bed and collects in the well.
- In this region, sufficient carbon compacts are extracted by the molten metal and are characterized by the following chemical reaction: – **$3 Fe + 2 CO \rightarrow Fe_3 C + CO_2$**
- Above the melting zone, there is a preheating zone, where the inward gases are preceded by and the temperature of this zone is about 1900 degrees Celsius.
- In addition to limestone, fluorspar and soda ash are also used as flux materials.
- The main function of the flux is to remove impurities from the iron and protect the iron from oxidation.
- For normal blast rates, the first molten iron appears in the tap hole within 5 to 10 minutes after the start of the air blast.
- The charging door remains closed until the metal melts.
- The content of the charge goes down as the melting proceeds.
- The rate of charging, i.e., the rate of adding layers of charge, is equal to the rate of melting. The furnace is kept throughout the process.

- When the melting process is over and no more molten irons are required, the charge feeders stop, and the air blast also stops.
- The bottom plate opens when the prop is removed, and the slag is removed.
- The copula furnace is generally not used for more than 4 hours but may be used for 10 hours of continuous operation.
- The cupola furnace operates on a simple principle that produces carbon dioxide and heat from the combustion of coke and causes iron to melt.
- Iron melts when it flows downwards.

Advantages of Cupola Furnace

Here, the pros of cupola furnace are as follows.

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

Disadvantages of Cupola Furnace

Here, the cons of cupola furnace are as follows.

1. The main disadvantage is that sometimes it is very hard to control the temperature in this furnace.
2. Metal elements are converted to their oxide, which is not suitable for casting.

Applications of Cupola Furnace

Here, the different applications of cupola furnaces are as follows.

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

Die casting

Die casting is a metal casting process that is characterized by forcing molten metal under high pressure into a mold cavity. The mold cavity is created using two hardened tool steel dies which have been machined into shape and work similarly to an injection mold during the process. Most die castings are made from non-ferrous metals, specifically zinc, copper, aluminium, magnesium, lead, pewter, and tin-based alloys. Depending on the type of metal being cast, a hot- or cold-chamber machine is used.

The casting equipment and the metal dies represent large capital costs and this tends to limit the process to high-volume production. Manufacture of parts using die casting is relatively simple, involving only four main steps, which keeps the incremental cost per item low. It is especially suited for a large quantity of small- to medium-sized castings, which is why die casting produces more castings than any other casting process.[1] Die castings are characterized by a very good surface finish (by casting standards) and dimensional consistency.

Cast metal

The main die casting alloys are: zinc, aluminium, magnesium, copper, lead, and tin; although uncommon, ferrous die casting is also possible.[6] Specific die casting alloys include: zinc aluminium; aluminium to, e.g. The Aluminium Association (AA) standards: AA 380, AA 384, AA 386, AA 390; and AZ91D magnesium.[7] The following is a summary of the advantages of each alloy.

- Zinc: the easiest metal to cast; high ductility; high impact strength; easily plated; economical for small parts; promotes long die life.
- Aluminium: lightweight; high dimensional stability for very complex shapes and thin walls; good corrosion resistance; good mechanical properties; high thermal and electrical conductivity; retains strength at high temperatures.
- Magnesium: the easiest metal to machine; excellent strength-to-weight ratio; lightest alloy commonly die cast.
- Copper: high hardness; high corrosion resistance; highest mechanical properties of alloys die cast; excellent wear resistance; excellent dimensional stability; strength approaching that of steel parts.
- Silicon tombac: high-strength alloy made of copper, zinc and silicon. Often used as an alternative for investment cast steel parts.
- Lead and tin: high density; extremely close dimensional accuracy; used for special forms of corrosion resistance. Such alloys are not used in foodservice applications for public health reasons. Type metal, an alloy of lead, tin and antimony (with sometimes traces of copper) is used for casting hand-set type in letterpress printing and hot foil blocking. Traditionally cast in hand jerk moulds now predominantly die cast after the industrialisation of the type foundries. Around 1900 the slug casting machines came onto the market and added further automation, with sometimes dozens of casting machines at one newspaper office.

As of 2008, maximum weight limits for aluminium, brass, magnesium, and zinc castings are estimated at approximately 70 pounds (32 kg), 10 lb (4.5 kg), 44 lb (20 kg), and 75 lb (34 kg), respectively. By late-2019, press machines capable of die casting single pieces over-100 kilograms (220 lb) were being used to produce aluminium chassis components for cars.

The material used defines the minimum section thickness and minimum draft required for a casting as outlined in the table below. The thickest section should be less than 13 mm (0.5 in), but can be greater.

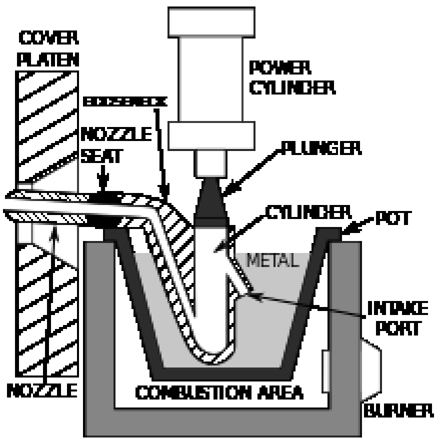
Metal	Minimum section	Minimum draft
Aluminium alloys	0.89 mm (0.035 in)	1:100 (0.6°)
Brass and bronze	1.27 mm (0.050 in)	1:80 (0.7°)

Magnesium alloys	1.27 mm (0.050 in)	1:100 (0.6°)
Zinc alloys	0.63 mm (0.025 in)	1:200 (0.3°)

Design geometry

- **Draft** is the amount of slope or taper given to cores or other parts of the die cavity to allow for easy ejection of the casting from the die. All die cast surfaces that are parallel to the opening direction of the die require draft for the proper ejection of the casting from the die.[12] Die castings that feature proper draft are easier to remove from the die and result in high-quality surfaces and more precise finished product.
- **Fillet** is the curved juncture of two surfaces that would have otherwise met at a sharp corner or edge. Simply, fillets can be added to a die casting to remove undesirable edges and corners.
- **Parting line** represents the point at which two different sides of a mould come together. The location of the parting line defines which side of the die is the cover and which is the ejector.[13]
- **Bosses** are added to die castings to serve as stand-offs and mounting points for parts that will need to be mounted. For maximum integrity and strength of the die casting, bosses must have universal wall thickness.
- **Ribs** are added to a die casting to provide added support for designs that require maximum strength without increased wall thickness.
- **Holes and windows** require special consideration when die casting because the perimeters of these features will grip to the die steel during solidification. To counteract this effect, generous draft should be added to hole and window features.

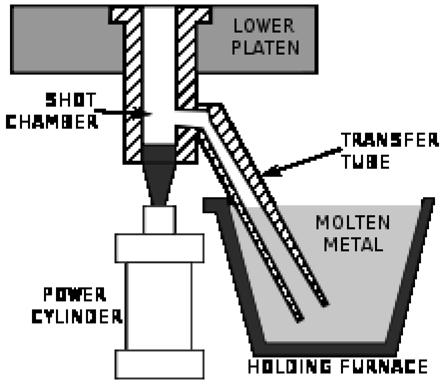
Hot-chamber die casting



Schematic of a hot-chamber machine

Hot-chamber die casting, also known as *gooseneck machines*, rely upon a pool of molten metal to feed the die. At the beginning of the cycle the piston of the machine is retracted, which allows the molten metal to fill the "gooseneck". The pneumatic- or hydraulic-powered piston then forces this metal out of the gooseneck into the die. The advantages of this system include fast cycle times (approximately 15 cycles a minute) and the convenience of melting the metal in the casting machine. The disadvantages of this system are that it is limited to use with low-melting point metals and that aluminium cannot be used because it picks up some of the iron while in the molten pool. Therefore, hot-chamber machines are primarily used with zinc-, tin-, and lead-based alloys.

Cold-chamber die casting



A schematic of a cold-chamber die casting machine.

These are used when the casting alloy cannot be used in hot-chamber machines; these include aluminium, zinc alloys with a large composition of aluminium, magnesium and copper. The process for these machines start with melting the metal in a separate furnace. Then a precise amount of molten metal is transported to the cold-chamber machine where it is fed into an unheated shot chamber (or injection cylinder). This shot is then driven into the die by a hydraulic or mechanical piston. The biggest disadvantage of this system is the slower cycle time due to the need to transfer the molten metal from the furnace to the cold-chamber machine. \

Centrifugal Casting

Centrifugal casting refers to several casting techniques that use rotation's centrifugal forces to distribute the molten metal to the outer regions of a circular mould cavity, where it solidifies to create a part. This technology first emerged in the early 1800s and can be a cost-effective method of creating complicated near-net shape parts compared to other manufacturing processes like forgings and fabrications.

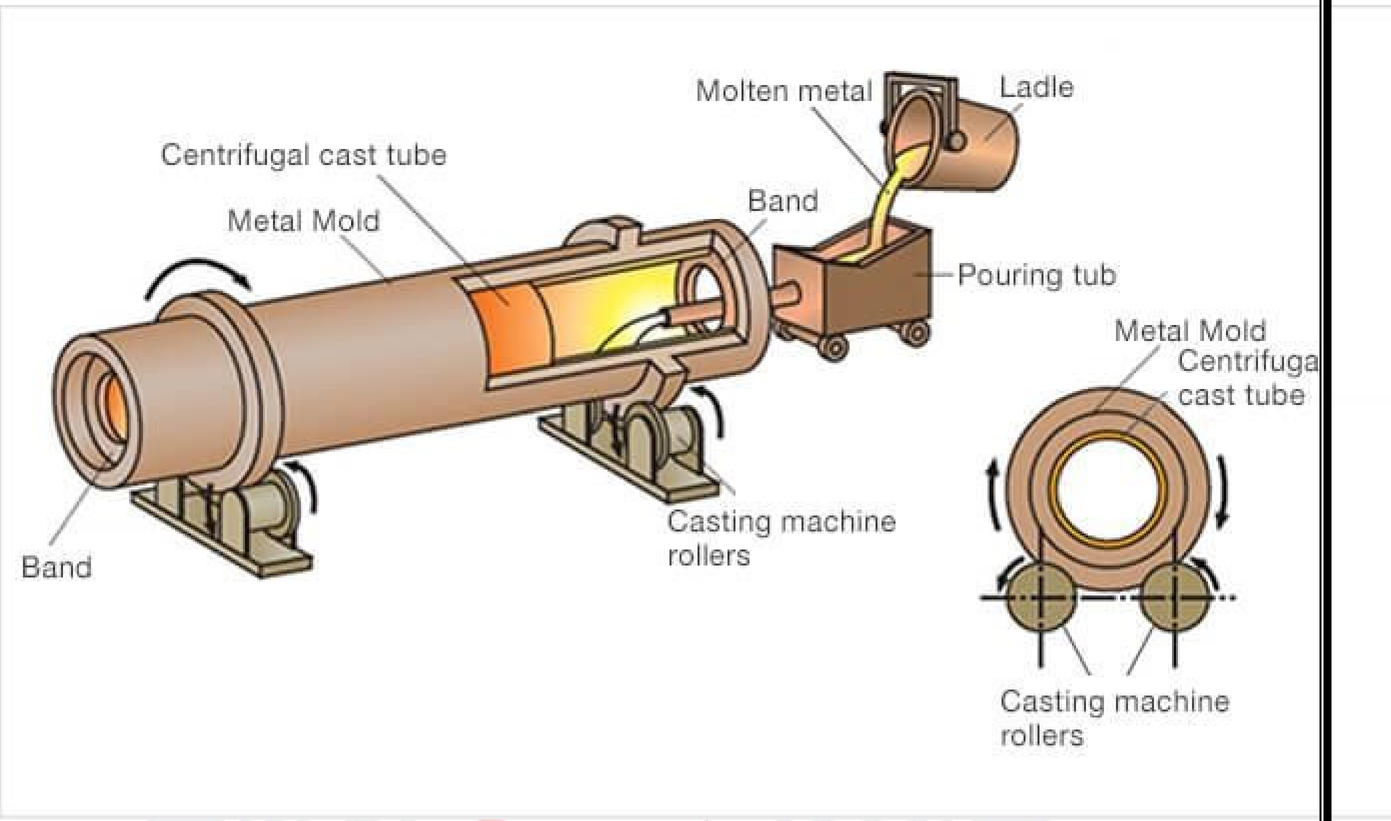
Centrifugal casting types and their applications

True centrifugal casting, semi centrifugal casting, and centrifuging are the three forms of centrifugal casting. The process is further divided into, vertical and horizontal, depending on their construction.sentrifugal casting has a wide range of applications in the industry and is used to make parts such as bushings, engine cylinder liners, rings, brake drums, water supply lines, sewage pipes, street lamp posts and gas pipes.

They are used in high-reliability applications such as jet engine compressor cases, hydro wear rings, and numerous military items because they produce components with excellent material soundness due to very high centrifugal forces.

How does centrifugal casting work?

Like any other metal casting process, all three of the centrifugal casting process follow the main casting steps of patternmaking, mould making, metal melting, molten metal pouring and post-processing.



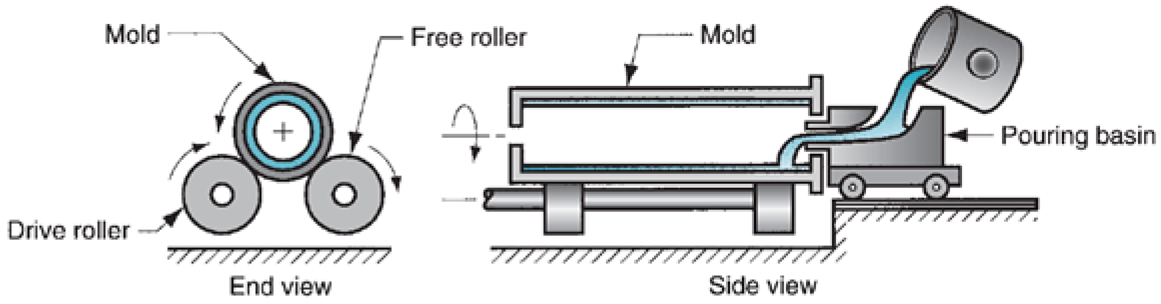
Casting process schematic (Source: Kubota)

The centrifugal casting process marginally differs between the three types but can be generalised into the following steps.

- The mould wall is coated with a refractory ceramic coating. In the case of True centrifugal casting mould, it involves applying ceramic slurry while spinning, drying and then baking.
- Molten metal from an external source is directly poured into the mould without any gating system through a spout.
- The molten material for the casting can be poured into a rotating mould or the mould can be rotated after it has been poured.
- The rotating mould's centrifugal forces drive the molten material to the cavity's outside wall once it's inside.
- Once the desired amount of molten metal is poured, the mould continuously spins until the part is entirely hardened.
- The mould is removed and opened after the casting has solidified and the casting is removed.

True Centrifugal casting

Molten metal is poured into a rotating horizontal mould to produce tubular parts such as pipes, tubes, rings, and bushes in this casting process. Mould rotation can take place on a horizontal or vertical axis, with the former being more common. The revolving speed of the horizontal true centrifugal casting is critical to the effectiveness of the casting process and part quality.



True Centrifugal casting set up

Moulds are made of steel, iron, or graphite, and they can be coated with a refractory lining to extend their life. The surfaces of the moulds are designed to allow for pipe casting with a range of outside styles. The inner surface of the casting remains cylindrical due to centrifugal forces that evenly distribute the molten metal.

Castings produced by true centrifugal casting have a high density, particularly in the outer portions of the component where centrifugal force is highest. Because centrifugal force constantly reallocates molten metal toward the mould wall during freezing, solidification shrinkage at the cast tube's outside is not an issue. Any imperfections in the casting tend to be on the inner wall and, if necessary, can be eliminated by machining.

How does True centrifugal casting work?

- Molten metal is poured straight into the mould without any gating mechanism.
- Once within the hollow, the centrifugal forces of the spinning mould propel the molten material to the cavity's exterior wall.
- After the necessary amount of molten metal has been poured, the mould is rotated until the part is hardened.
- After the casting has been set, the mould is removed, opened, and the part removed for post-processing.

Advantages

- These castings have a high density, a high mechanical strength, an excellent outer surface finish, and a fine-grained structure.
- Impurities and inclusions can be easily removed
- Gates are risers not required
- Hollow interiors without cores are formed.
- Can form very large parts with high accuracy
- Low equipment and labour cost
- Generates minimum scrap

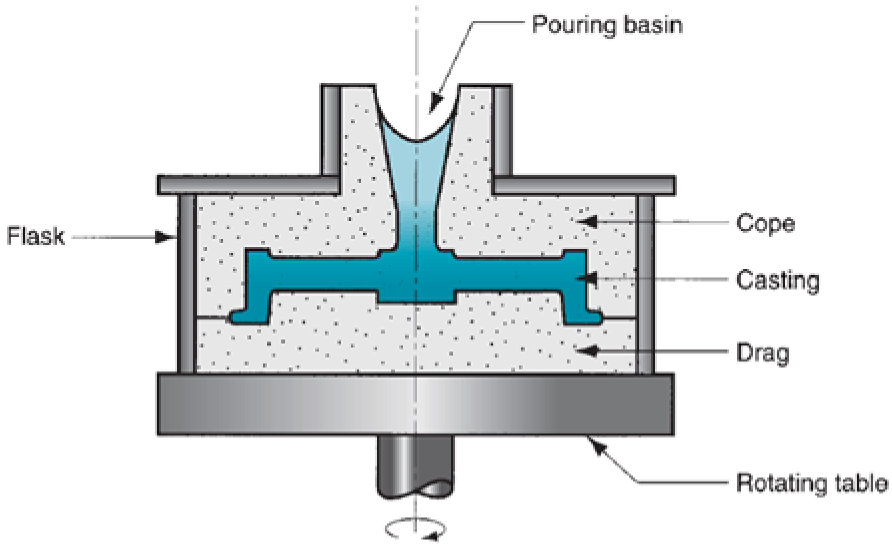
Disadvantages

- The casting inner surface diameter will not be accurate.
- This method is not suitable for all alloys.
- The true centrifugal casting process is limited to cylindrical parts
- Secondary machining is often required for inner diameter

- Long lead time possible

Semicentrifugal Casting

Semicentrifugal casting uses centrifugal force to produce solid casting rather than tubular casts. The image below shows an example of semi centrifugal casting where the moulds have their riser at the axis of rotation to feed the molten metal. Expendable moulds are more common and used to make parts such as spoked wheels, pulleys, gear blanks, brass bush and nozzles.



Semicentrifugal casting

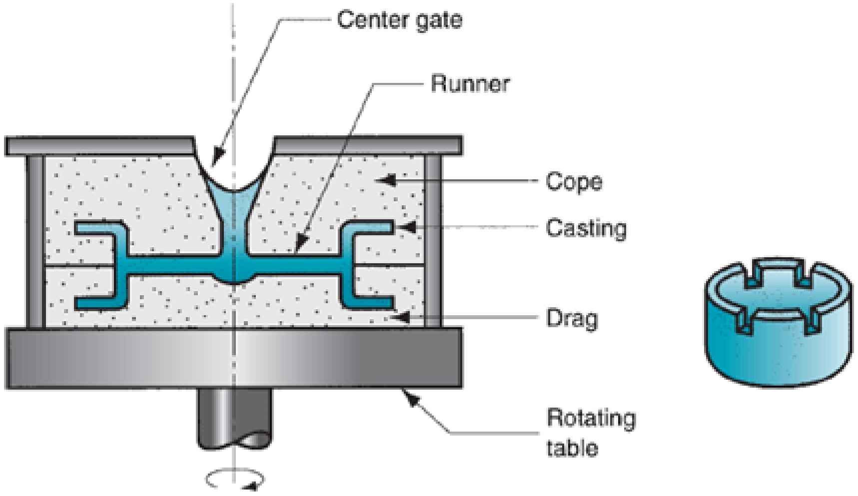
The exterior regions of items formed by semi-centrifugal casting have a higher density than the centre of the rotating axis. This casting procedure is used to make things like spoked wheels that have rotational symmetry and can have the casting centre removed. Removing the centre section of the cast also removes the cast's lowest-density component. The quality of the final casting is affected by factors such as rotating speed, component diameter, pouring temperature, pouring speed, mould temperature, and cooling rate.

How does semi-centrifugal casting work?

- As shown above, the expendable mould is set up around the central sprue.
- Molten metal is then poured into the sprue slowly from an external source using a small spout.
- The molten material may be poured into a rotating mould, or the rotation of the mould may commence after the pouring has taken place.
- Pouring stops once the correct amount of molten metal for the casting, runner and sprue is poured.
- The spinning continues after the pouring and distribution and during the solidification process.
- The equipment will stop rotating after the castings have completely frozen, and the pieces may be removed.

Centrifuging

Centrifuging, also known as centrifuge casting, involves the placement of mould cavities of any shape at a certain distance from the axis of spin. The molten metal is poured from the centre, and centrifugal forces push it into the mould cavity through the sprue and the runner. Like true centrifugal casting, the characteristics of the castings might change with distance from the spin axis. This method is used for small parts such as jewellery, small bushes and sleaves.



Centrifuging casting process

Centrifugal casting machines such as Neycraft, Tulsa, and Kerr, used to make jewellery and dental casting, are all based on the centrifugal casting technique.

How does Centrifuge casting work?

- As shown above, the mould is built to have cavities around the central sprue with runners connecting them.
- Molten metal is then poured into the sprue slowly from an external source using a small spout.
- The molten material may be poured into a rotating mould, or the rotation of the mould may commence after the pouring has taken place.
- The pouring stops once the correct amount of molten metal for the number of castings, runner and sprue is poured.
- The spinning continues after the pouring and distribution and during the solidification process.
- The mould will be stopped, and the components will be removed after the castings have been set.

Advantages

- Thin-walled and small parts are possible due to the centrifugal forces filling the cavity.
- Good surface finish due to the amount of forces imparted on the molten metal
- Since the cast parts are further away from the rotational axis, the part is denser
- Due to low density, impurities such as trapped gases and inclusions will be near the axis, away from the desired part

Disadvantages

- Not suitable for all the alloys
- Sprue and runner will have to be machined