Metal forming processes

Definitions Metal forming processes

- Metal forming is a very important manufacturing operation. It enjoys industrial importance among various production operations due to its advantages such as cost effectiveness, enhanced mechanical properties, flexible operations, higher productivity, considerable material saving.
- Production encompasses all types of manufacturing processes. Manufacturing refers to the conversion of raw materials into finished products employing suitable techniques. There are several methods of manufacturing such as metal casting, metal forming, metal machining, metal joining and finishing.

Metal forming

- Materials are converted into finished products though different manufacturing processes. Manufacturing processes are classified into shaping [casting], forming, joining, and coating, dividing, machining and modifying material property.

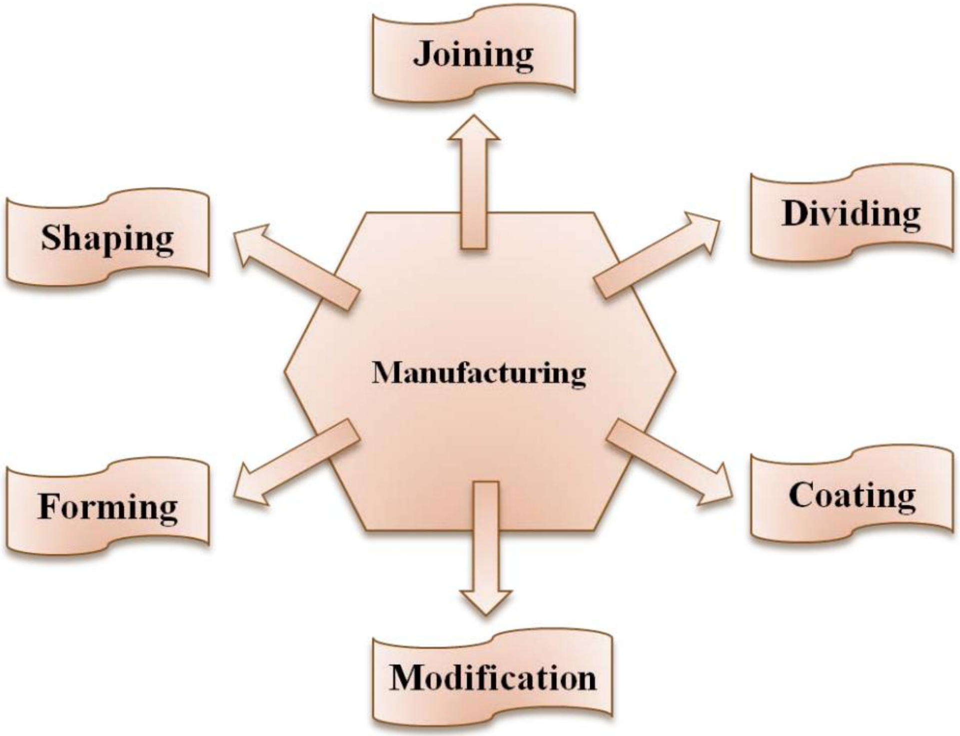


Fig.1.2.1: Various manufacturing operations on materials

Metal forming

- Of these manufacturing processes, forming is a widely used process which finds applications in automotive, aerospace, defense and other industries. Wrought forms of materials are produced through bulk or sheet forming operations. Cast products are made through shaping – molding and casting.
- A typical automobile uses formed parts such as wheel rims, car body, valves, rolled shapes for chassis, stamped oil pan, etc. In our daily life we use innumerable formed products e.g. cooking vessels, tooth paste containers, bicycle body, chains, tube fitting, fan blades etc
- Forming is the process of obtaining the required shape and size on the raw material by subjecting the material to plastic deformation through the application of tensile force, compressive force, bending or shear force or combinations of these forces.

Classification of forming

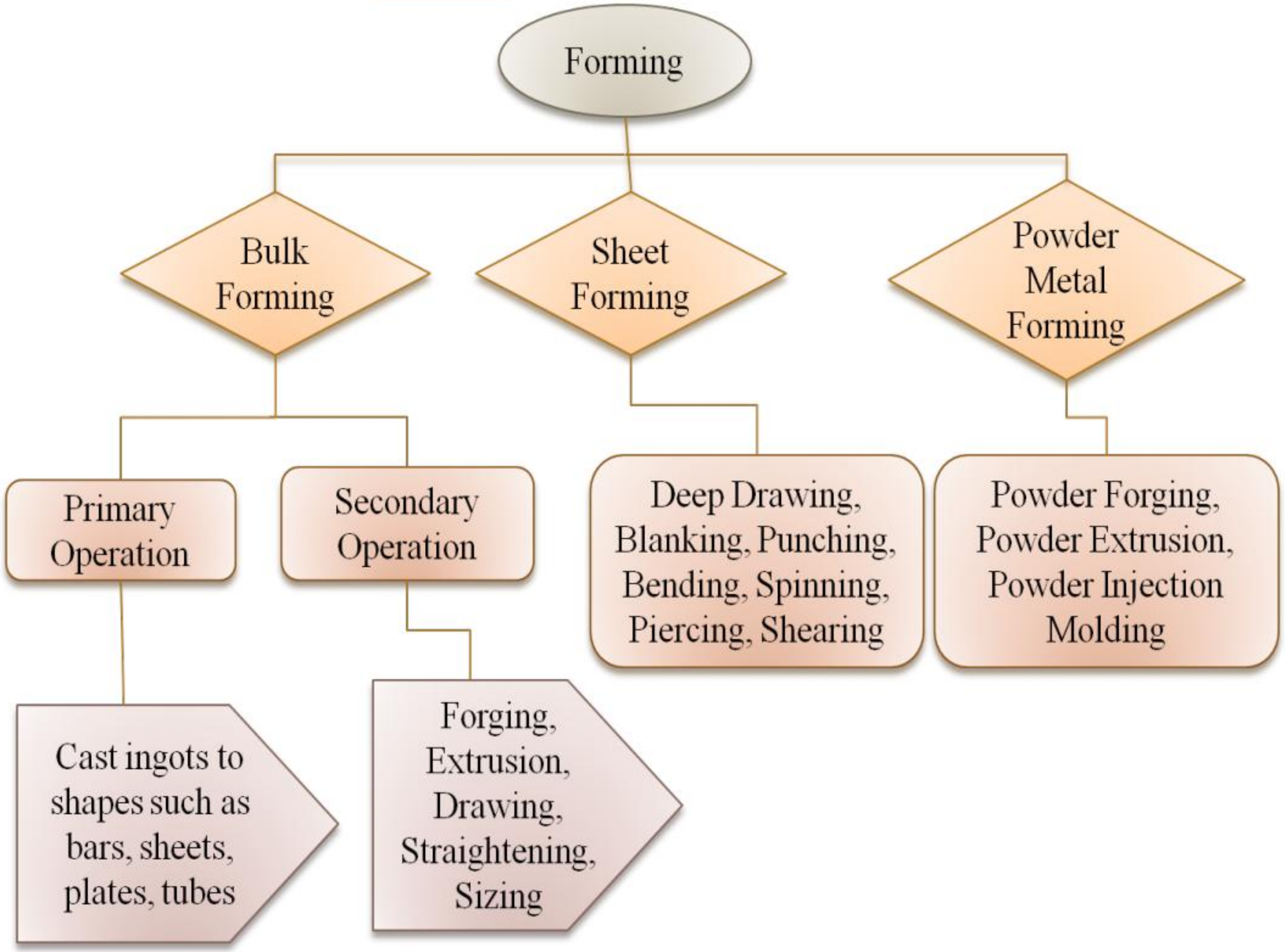


Fig. 1.3.1: Classification of metal forming processes

Classification of metal forming processes

- Typically, metal forming processes can be classified into two broad groups. One is <u>bulk forming</u> and the other is <u>sheet metal forming</u>.
- Bulk deformation refers to the use of raw materials for forming which have low surface area to volume ratio. Rolling, forging, extrusion and drawing are bulk forming processes.
- In bulk deformation processing methods, the nature of force applied may be compressive, compressive and tensile, shear or a combination of these forces.
- Bulk forming is accomplished in forming presses with the help of a set of tool and die.

Examples for products produced by bulk forming are: gears, bushed, valves, engine parts such as valves, connecting rods, hydraulic valves, etc.

Classification of metal forming processes

- Sheet metal forming involves application of tensile or shear forces predominantly. Working upon sheets, plates and strips mainly constitutes sheet forming.
- Sheet metal operations are mostly carried out in presses – hydraulic or pneumatic. A set of tools called die and punch are used for the sheet working operations.
- Bending, drawing, shearing, blanking, punching are some of the sheet metal operations.
- A new class of forming process called powder forming is gaining importance due to its unique capabilities.
- One of the important merits of powder forming is its ability to produce parts very near to final dimensions with minimum material wastage. It is called near-net-shape forming.
- Material compositions can be adjusted to suit the desirable mechanical properties. Formability of sintered metals is greater than conventional wrought materials. However, the challenge in powder forming continues to be the complete elimination or near-complete elimination of porosity.

Forming

- Forming is also classified as cold forming, hot forming or warm forming. Hot forming is the deformation carried out at temperatures above recrystallization temperatures.

Hot working: Involves deformation above recrystallization temperature, between 0.5Tm to 0.75Tm.

Advantages:

(1) significant plastic deformation can be given to the sample,

(2) significant change in workpiece shape,

(3) lower forces are required,

(4) materials with premature failure can be hot formed,

(5) absence of strengthening due to work hardening.

Disadvantages:

(1) shorter tool life,

(2) poor surface finish,

(3) lower dimensional accuracy,

(4) sample surface oxidation

Forming

- Cold working: Generally done at room temperature or slightly above RT.
- Advantages compared to hot forming:

  (1) closer tolerances can be achieved;

  (2) good surface finish;

  (3) because of strain hardening, higher strength and hardness is seen in part;

  (4) grain flow during deformation provides the opportunity for desirable directional properties;

  (5) since no heating of the work is involved, furnace, fuel, electricity costs are minimized,

  (6) Machining requirements are minimum resulting in possibility of near net shaped forming.

- Disadvantages:

  (1) higher forces and power are required;

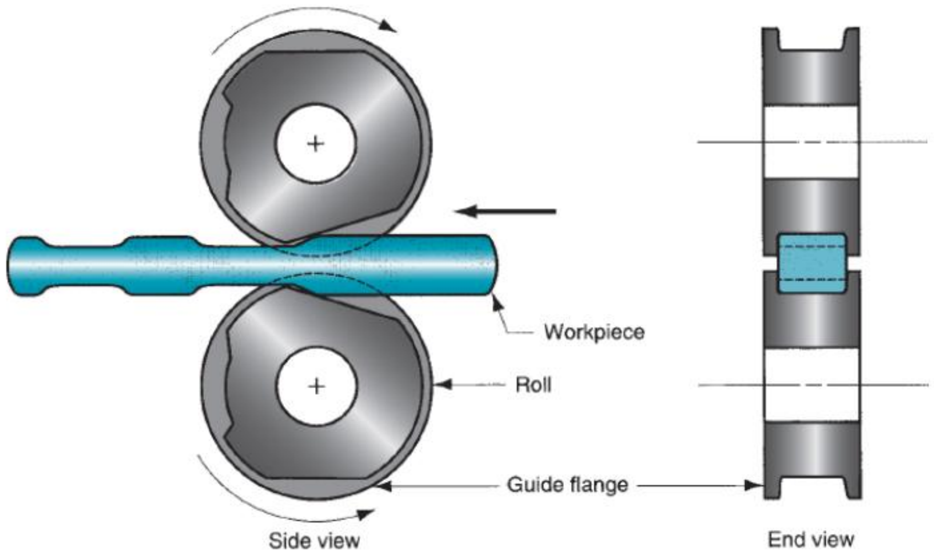
  (2) strain hardening of the work metal limit the amount of forming that can be done,

  (3) sometimes cold forming annealing-cold forming cycle should be followed,

  (4) the work piece is not ductile enough to be cold worked.

Rolling

- Roll forging: It is a forming process used to reduce the cross section of a cylindrical or rectangular rod by passing it through a set of opposing rolls that have matching grooves w.r.t. the desired shape of the final part. It combines both rolling and forging, but classified as forging operation. Depending on the amount of deformation, the rolls rotate partially. Roll-forged parts are generally stronger and possess desired grain structure compared to machining that might be used to produce the same part.



Forging

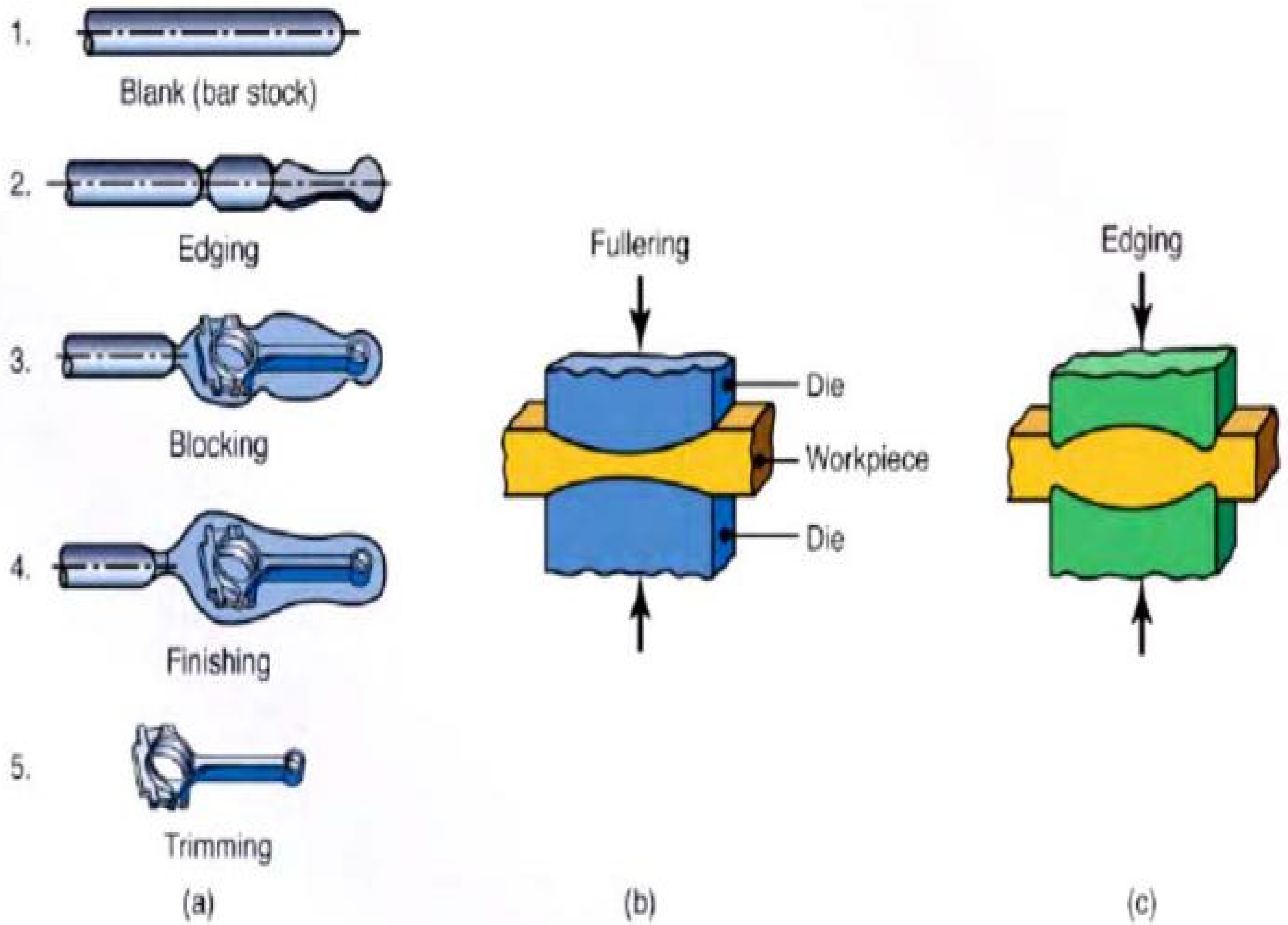
- Forging is the working of metal into a useful shape by hammering or pressing.
- The oldest of the metalworking arts (primitive blacksmith). • Replacement of machinery occurred during early the Industrial revolution.
- Forging machines are now capable of making parts ranging in size of a bolt to a turbine rotor.
- Most forging operations are carried out hot, although certain metals may be cold forged

Forging

- Forging is perhaps oldest metal working process and was known even during prehistoric days when metallic tools were made by heating and hammering.
- Forging is basically involves plastic deformation of material between two dies to achieve desired configuration.
- Depending upon complexity of the part forging is carried out as open die forging and closed die forging.
- In open die forging, the metal is compressed by repeated blows by a mechanical hammer and shape is manipulated manually.
- In closed die forging, the desired configuration is obtained by squeezing the workpiece between two shaped and closed dies.

Stages in forging a connecting rod for an internal combustion engine

a) bar stock;
b) fullering,
c) edging
d) rolling,
e) blocking,
f) finishing,
g) trimming;



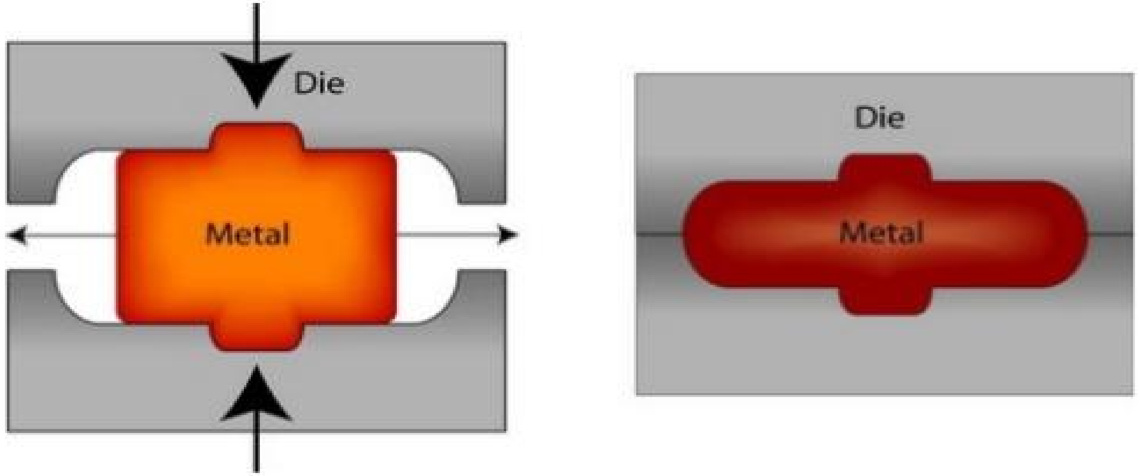
Smith forging

- Smith forging is also called flat die and open die forging. It includes the broad field for forging work produced between flat faced sizes and possibly supplemented by stock tooling.
- The final shape of the forging depends on the skill of the smith fir size and shape.
- It produces work pieces of lesser accuracy as compared to impression or closed die forging.
- Tooling is simple, inexpensive and allows the production of a large variety of shapes.

Smith Forging

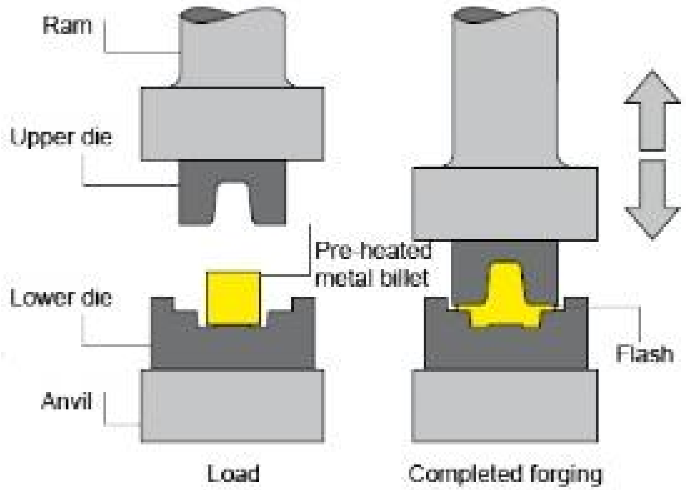
Drop forging

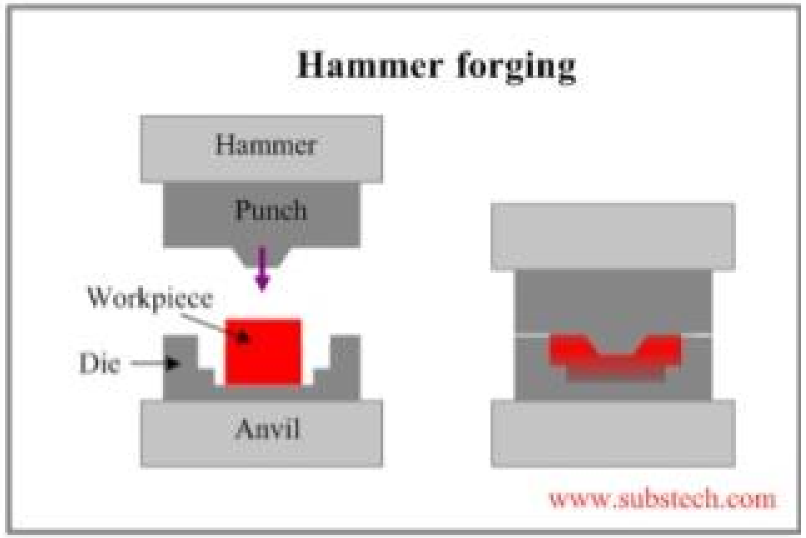
- Drop forging sometimes referred to as impression die forging comprises of die on the anvil which resembles a mould, the ram which falls and strikes the top of the workpiece can also be equipped with die. The metal work piece is heated and placed on the lower die while the ram falls down forcing the metal to fill the contours of the die blocks



Press forging

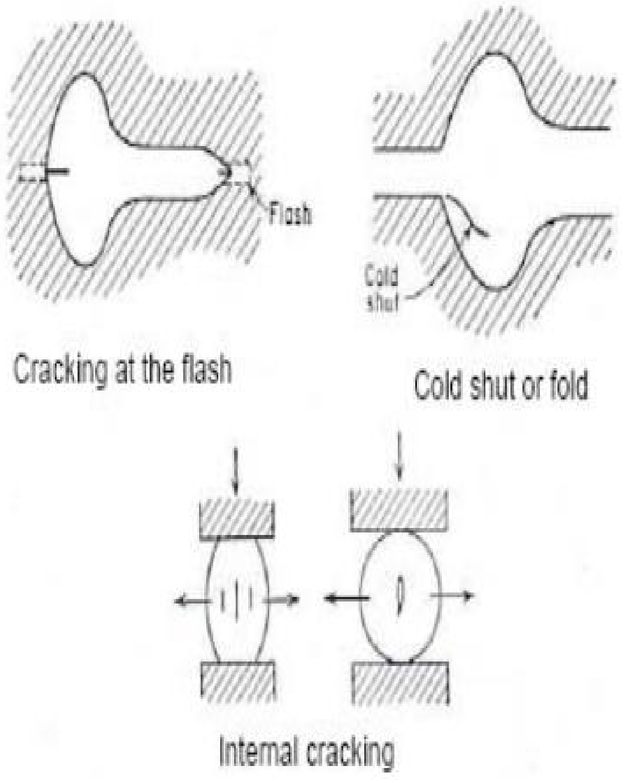
- Press forging is done in presses. The action is relatively slow squeezing instead of delivering heavy blows and penetrates deeply because it gives the metal time to flow
- Press forgings are shaped at each impression with a single smooth stroke and they stick to the die impression more rigidly





Typical forging defects

- Pitted surface, due to oxide scales occurring at high temperature stick on the dies.
- Surface cracking, due to temperature differential between surface and centre, or excessive working of the surface at too low temperature.
- Microcracking, due to residual stress.
- Flash line crack, after trimming-occurs more often in thin workpieces. Therefore should increase the thickness of the flash.
- Cold shut or fold , due to flash or fin from prior forging steps is forced into the workpiece.
- Internal cracking, due to secondary tensile stress.



Extrusion

Extrusion is used for processing most types of metals, thermoplastics and rubbers. The extrusion process is a simple process in which molten metal/polymer is forced through a shaped die using pressure. The pressure is generated from the action of screw rotation against barrel wall.

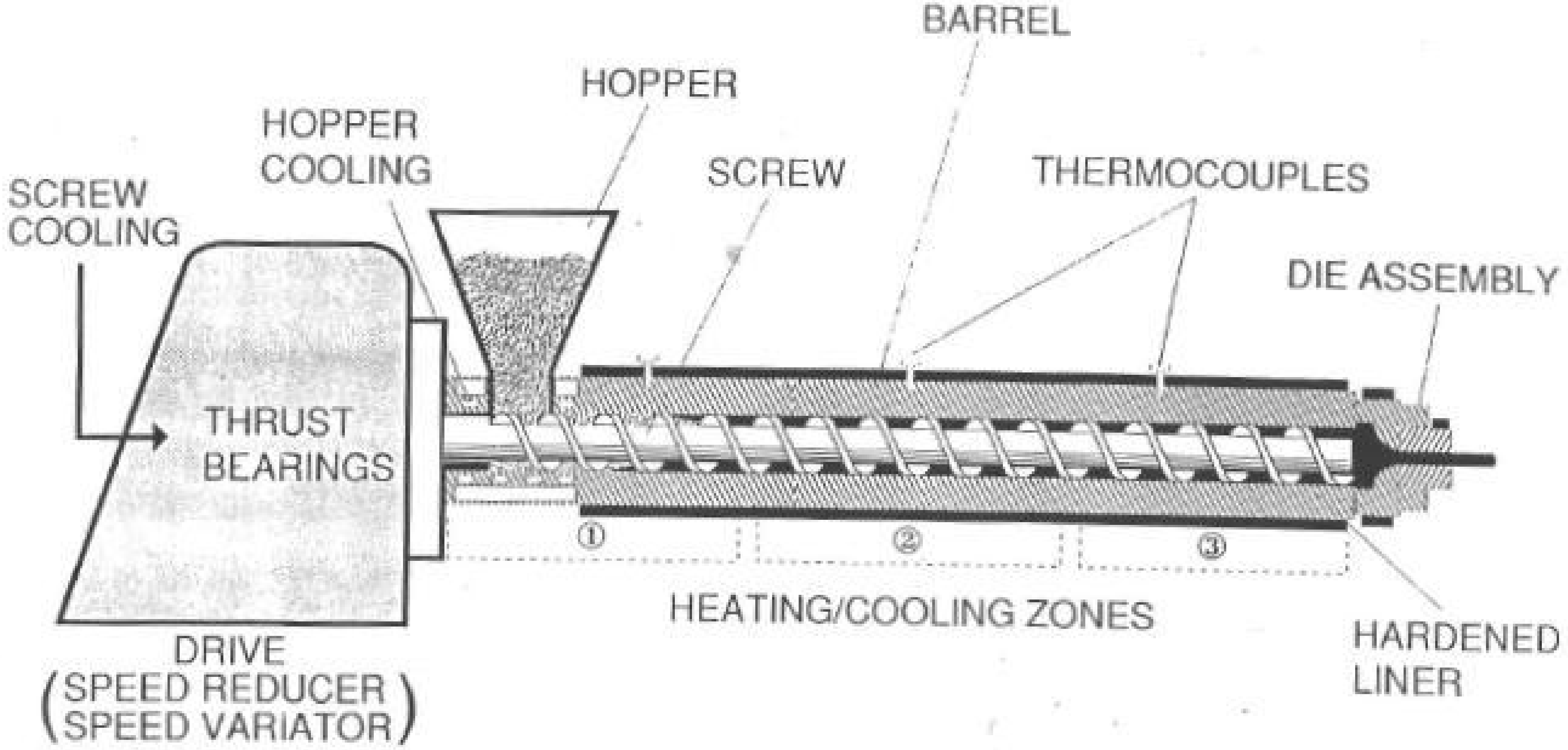
The components of an extruder include:

1. Drive
2. Gearbox and Thrust bearing
3. Feed hopper
4. Barrel

https://www.youtube.com/watch?v=P8BWQBP4Vhk

https://www.youtube.com/watch?v=WaB-dsB1Kfk

BASIC EXTRUDER



Advantages, Disadvantages & Limitations of Extrusion

Affordability

- The plastic extrusion process comes with low costs compared to other moulding processes and greater profit margins, making it an attractive option for businesses that have to process products in bulk.
- Most extrusion moulding uses thermoplastics, which can undergo repeated melting and hardening. Leftover materials, normally discarded as waste in other processes, can be reused, which lowers raw material and disposal costs.

Flexibility

- Extrusion moulding provides considerable flexibility in manufacturing products with a consistent cross-section. So long as the cross-section remains the same, extrusion moulding can produce complex shapes, such as decorative trims.
- With minor alteration to the process, manufacturers use extrusion moulding for plastic sheets. Variation on the extrusion process also allows for the manufacturing of products that mix plastic attributes, such as hard and soft surfaces.

Disadvantages

Size variance: Once the hot plastic is removed from the extruder, it will often expand. The process is called die swell. It is problematic to try and predict the exact degree of expansion. Because it is hard to predict the exact expansion, manufacturers often accept significant levels of deviation from the dimensions of the product.

Limitations

Extrusion plastic moulding does place limits of the types of products that can be manufactured. For example, plastic soda bottles narrow at one end to accommodate a cap, which normal extrusion moulding cannot achieve. Some alternatives require an investment in a different type of extrusion equipment.

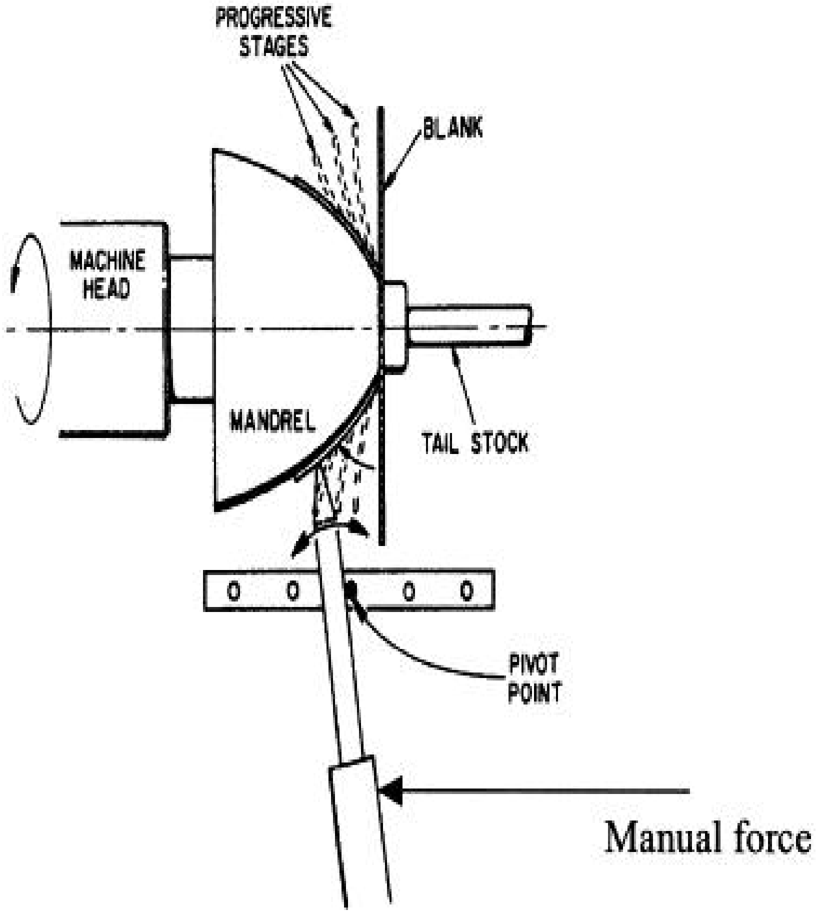
Metal spinning

- **Metal spinning**, also known as **spin forming** or **spinning** or **metal turning** most commonly, is a metalworking process by which a disc or tube of metal is rotated at high speed and formed into an axially symmetric part. Spinning can be performed by hand or by a CNC lathe.
- Metal spinning does not involve removal of material, as in conventional wood or metal turning, but forming (moulding) of sheet material over an existing shape.
- Metal spinning ranges from an artisan's specialty to the most advantageous way to form round metal parts for commercial applications.
- Artisans use the process to produce architectural detail, specialty lighting, decorative household goods and urns. Commercial applications include rocket nose cones, cookware, gas cylinders, brass instrument bells, and public waste receptacles. Virtually any ductile metal may be formed, from aluminium or stainless steel, to high-strength, high-temperature alloys including INX, Inconel, Grade 50 / Corten, and Hastelloy. The diameter and depth of formed parts are limited only by the size of the equipment available.

https://www.youtube.com/watch?v=43N44ICyuEU

Spinning process

The spinning process is fairly simple. A formed block is mounted in the drive section of a lathe. A pre-sized metal disk is then clamped against the block by a pressure pad, which is attached to the tailstock.
The block and workpiece are then rotated together at high speeds. A localized force is then applied to the workpiece to cause it to flow over the block. The force is usually applied via various levered tools.
Simple workpieces are just removed from the block, but more complex shapes may require a multi-piece block. Extremely complex shapes can be spun over ice forms, which then melt away after spinning. Because the final diameter of the workpiece is always less than the starting diameter, the workpiece must thicken, elongate radially, or buckle circumferentially.



Hydro forming process

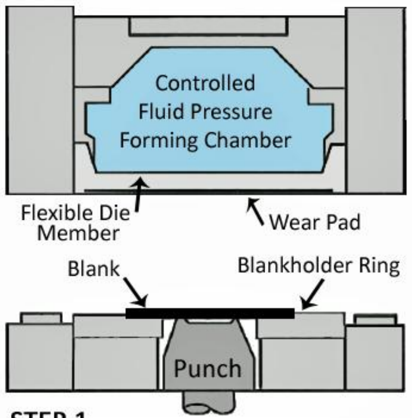
- **Hydroforming** is a cost-effective way of shaping ductile metals such as aluminium, brass, low alloy steel, and stainless steel into lightweight, structurally stiff and strong pieces.
- One of the largest applications of hydroforming is the automotive industry, which makes use of the complex shapes made possible by hydroforming to produce stronger, lighter, and more rigid unibody structures for vehicles.
- This technique is particularly popular with the high-end sports car industry and is also frequently employed in the shaping of aluminium tubes for bicycle frames.
- Hydroforming is a specialized type of die forming that uses a high pressure hydraulic fluid to press room temperature working material into a die.

https://www.youtube.com/watch?v=1QPSCXEoJKQ

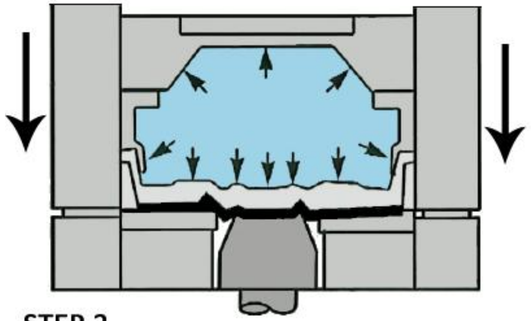
Hydro forming process

- To hydroform aluminium into a vehicle's frame rail, a hollow tube of aluminium is placed inside a negative mold that has the shape of the desired result.
- High pressure hydraulic pumps then inject fluid at very high pressure inside the aluminium tube which causes it to expand until it matches the mold.
- The hydroformed aluminium is then removed from the mold.
- Hydroforming allows complex shapes with concavities to be formed, which would be difficult or impossible with standard solid die stamping. Hydroformed parts can often be made with a higher stiffness-to-weight ratio and at a lower per unit cost than traditional stamped or stamped and welded parts.
- Virtually all metals capable of cold forming can be hydroformed, including aluminium, brass, carbon and stainless steel, copper, and high strength alloys.

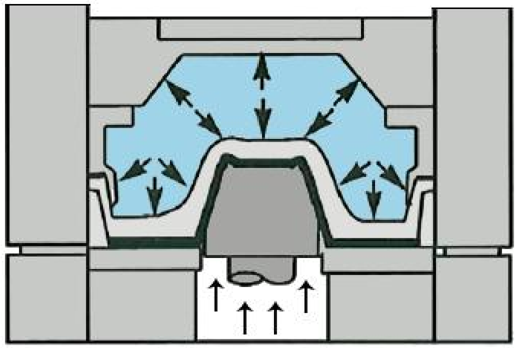
Hydro forming process



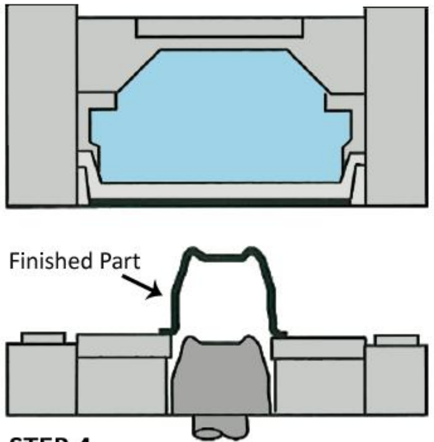
STEP 1
A metal blank is placed on blankholder ring.



STEP 2
Top of press lowered and fluid chamber pressurized.



STEP 3
Punch pushes upward, forming metal blank against pressure chamber.



STEP 4
Top of press raised, pressure released, and punch lowered. The part is now finished.

A hydroforming press operates like the upper or female die element. This consists of a pressurized forming chamber of oil, a rubber diaphragm and a wear pad. The lower or male die element, is replaced by a punch and ring. The punch is attached to a hydraulic piston, and the blank holder, or ring, which surrounds the punch.

The hydroforming process begins by placing a metal blank on the ring. The press is closed bringing the chamber of oil down on top of the blank. The forming chamber is pressurized with oil while the punch is raised through the ring and into the forming chamber. Since the female portion of this forming method is rubber, the blank is formed without the scratches associated with stamping.

The diaphragm supports the entire surface of the blank. It forms the blank around the rising punch, and the blank takes on the shape of the punch. When the hydroforming cycle is complete, the pressure in the forming chamber is released and the punch is retracted from the finished part.

Advantages of hydro forming process

- Freedom of design for complex parts
- Reduced number of individual parts of a body in white
- Minimization of assembled and/or welded connections
- Reduction of material and weight of part
- Higher mechanical strength
- Longer durability
- High dimensional and forming accuracy with reduced springback

DISADVANTAGES

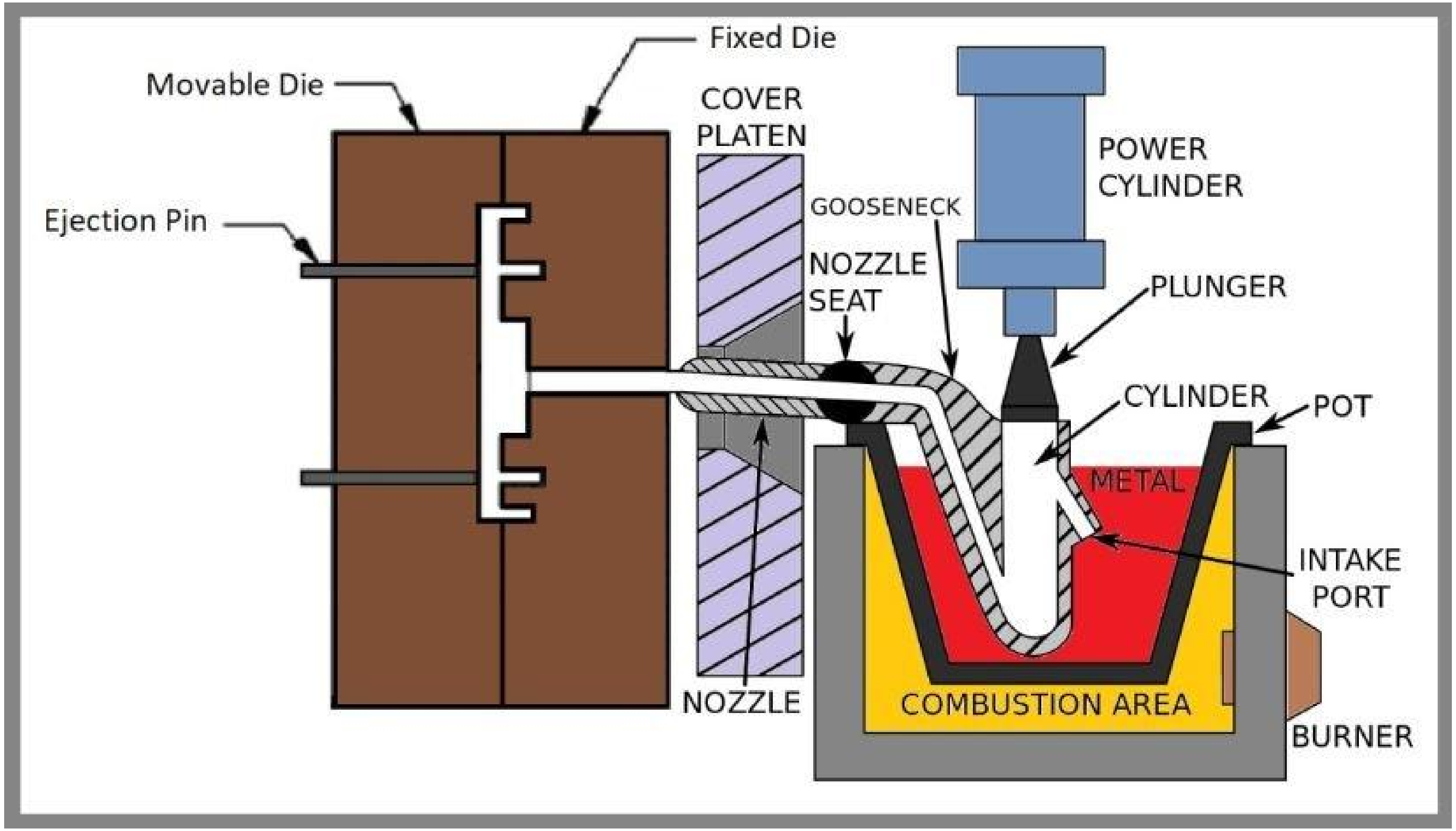
Hydro Forming also has some drawbacks,

- Slow cycle time.
- Expensive equipment.
- Lack of extensive knowledge base for process and tool design

Introduction to DIE casting

- Die casting is a variation of metalcasting
- Liquid metal injected into reusable steel mold, or die, very quickly with high pressures
- Reusable steel tooling and injection of liquid metal with high pressures differentiates die casting from other metal casting processes

Schematic of a hot-chamber machine

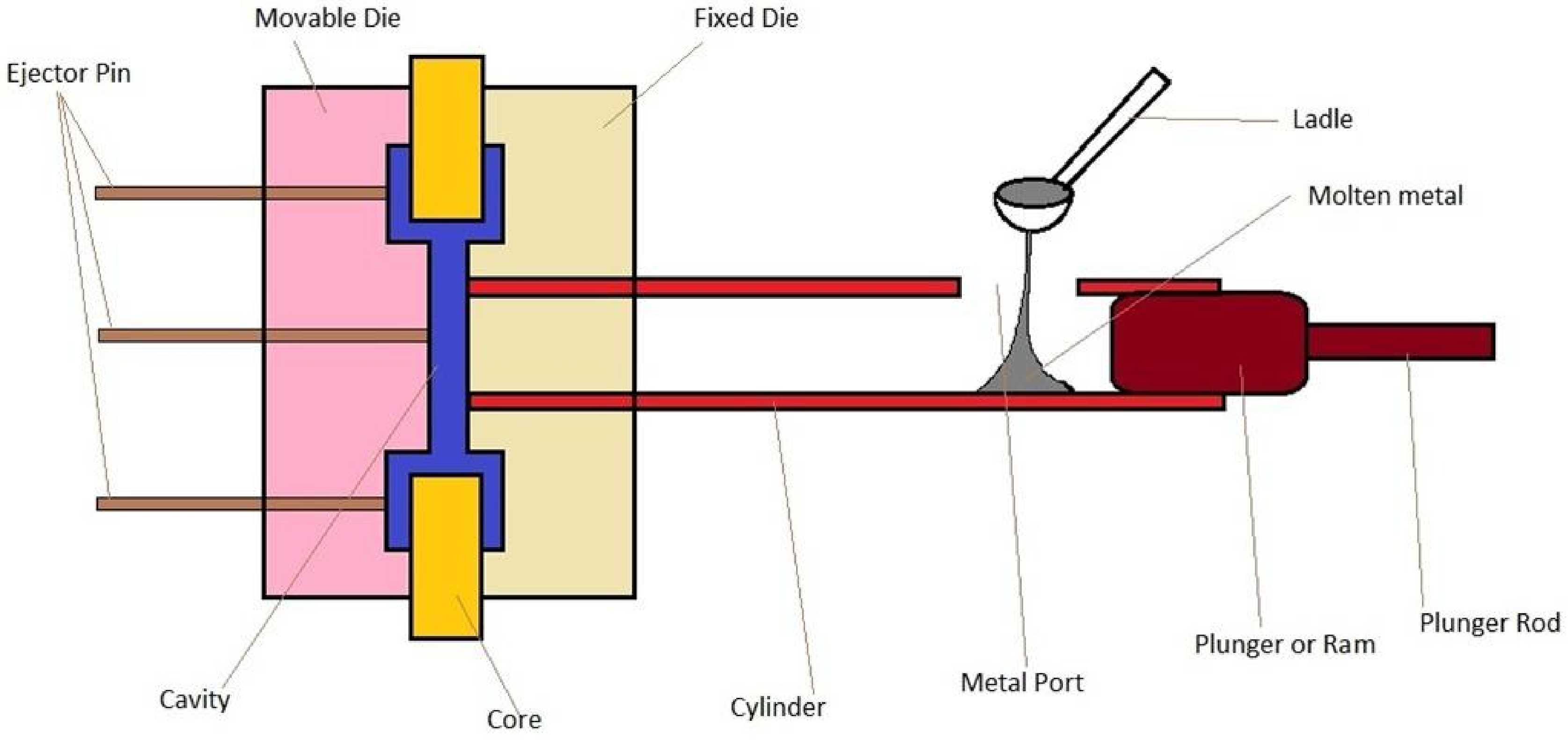


Hot-chamber die casting

- Hot-chamber die casting, sometimes called gooseneck casting, is the more popular of the two die casting processes. In this process, the cylinder chamber of the injection mechanism is completely immersed in the molten metal bath. A gooseneck metal feed system draws the molten metal into the die cavity.

  While direct immersion in the molten bath allows for quick and convenient mold injection, it also results in increased corrosion susceptibility. Due to this fact, the hot-chamber die casting process is best suited for applications that utilize metals with low melting points and high fluidity. Good metals for the hot-chamber die casting process include lead, magnesium, zinc and copper.

Cold Chamber Die casting



Cold-chamber die casting

- The cold-chamber die casting process is very similar to hot-chamber die casting. With a design that focuses on minimizing machine corrosion rather than production efficiency, the melted metal is automatically- or hand-ladled into the injection system. This eliminates the necessity for the injection mechanism to be immersed in the molten metal bath.

  For applications that are too corrosive for the immersion design of hot-chamber die casting, the cold-chamber process can be an excellent alternative. These applications include the casting of metals with high melting temperatures, such as aluminum and aluminum alloys.

Difference Between Hot chamber and cold Chamber Die casting

- Hot chamber die casting In this melting pot is in the machine itself and a goose neck is used to inject the material from melting pot through nozzle into the die.
  Cold chamber
  In this melting pot is outside the machine and a spool is used to put the molten material into the cylinder

Advantages

- Excellent dimensional accuracy (dependent on casting material, but typically 0.1 mm for the first 2.5 cm (0.005 in. for the first inch) and 0.02 mm for each additional centimeter (0.002 in. for each additional inch).
- Smooth cast surfaces (1—2.5 µm (40—100 µin.) rms).
- Thinner walls can be cast as compared to sand and permanent mold casting (approximately 0.75 mm (0.030 in.).
  Inserts can be cast-in (such as threaded inserts, heating elements, and high strength bearing surfaces).
- Reduces or eliminates secondary machining operations.
- Rapid production rates.
- Casting tensile strength as high as 415 MPa (60 ksi).

Disadvantages

- Casting weight must be between 30 grams (1 oz) and 10 kg (20 lb).
- Casting must be smaller than 600 mm (24 in.).
- High initial cost.
- Limited to high-fluidity metals.
- A certain amount of porosity is common.
- Thickest section should be less than 13 mm (0.5 in.).
- A large production volume is needed to make this an economical alternative to other processes.

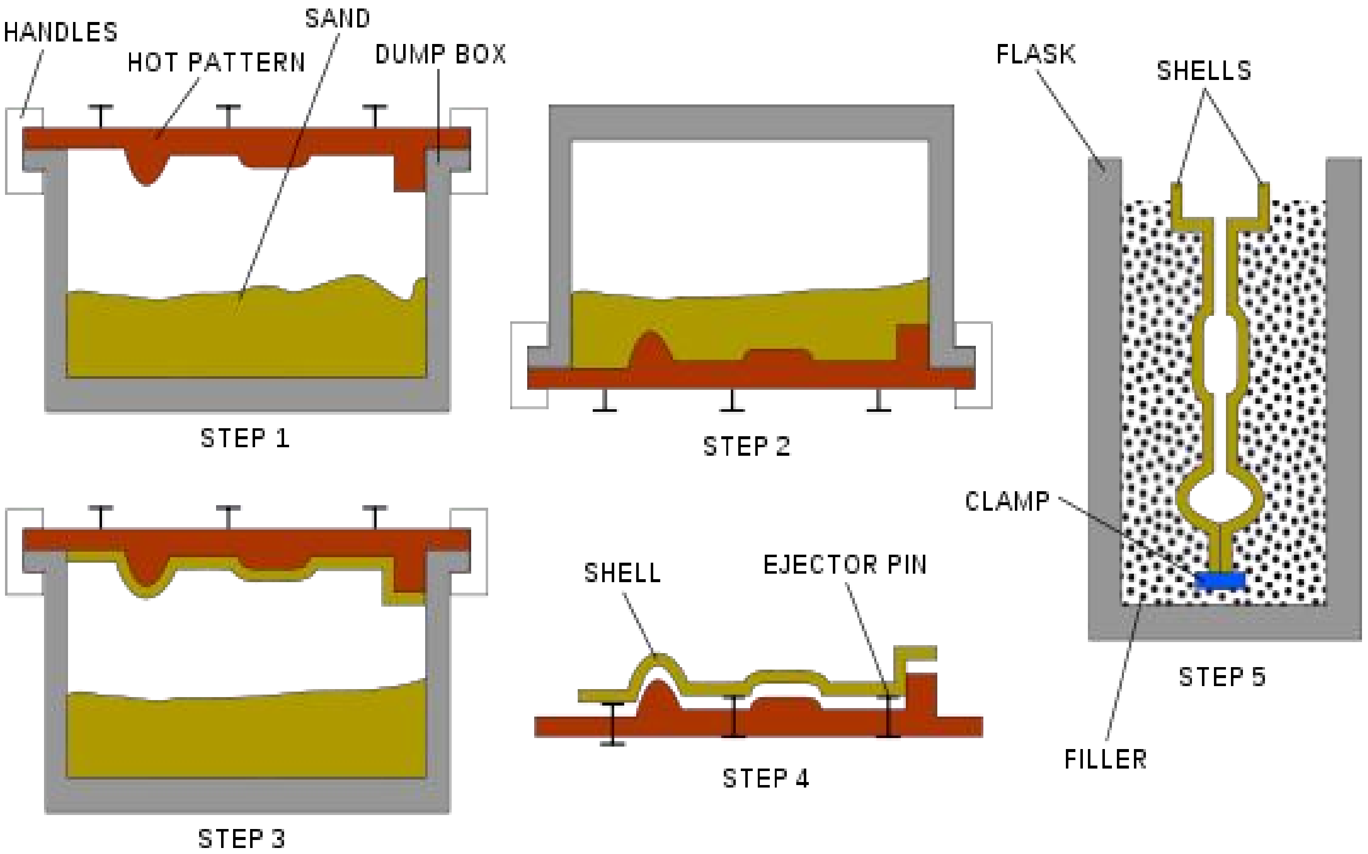
Shell Mold Casting

- Shell mold casting or shell molding is a metal casting process in manufacturing industry in which the mold is a thin hardened shell of sand and thermosetting resin binder, backed up by some other material. Shell molding was developed as a manufacturing process during the mid-20th century in Germany. Shell mold casting is particularly suitable for steel castings under 20 lbs; however almost any metal that can be cast in sand can be cast with the shell molding process. Also much larger parts have been manufactured with shell molding. Typical parts manufactured in industry using the shell mold casting process include cylinder heads, gears, bushings, connecting rods, camshafts and valve bodies.

Shell Mold Process

- The first step in the shell mold casting process is to manufacture the shell mold. The sand we use for the shell molding process is of a much smaller grain size than the typical green sand mold. This fine grained sand is mixed with a thermosetting resin binder. A special metal pattern is coated with a parting agent, (typically silicone), which will latter facilitate in the removal of the shell. The metal pattern is then heated to a temperature of 350F-700F degrees, (175C-370C).

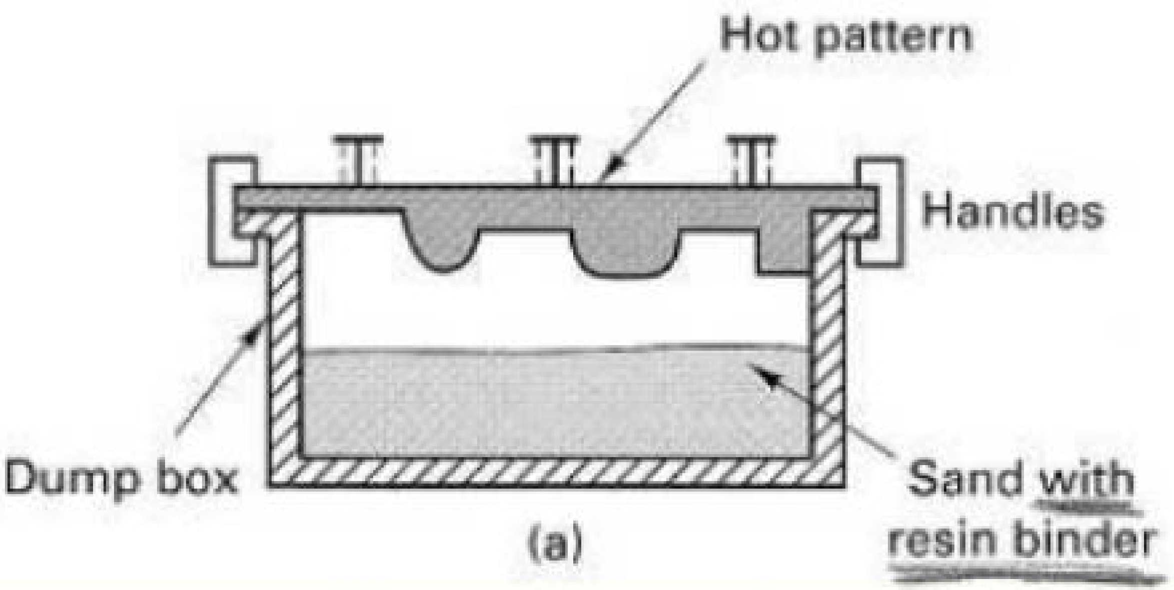
Shell Mold Process



SHELL-MOLD CASTING

(Sequential Operations)

(a) A heated pattern is placed over a dump box containing a sand and resin mixture.

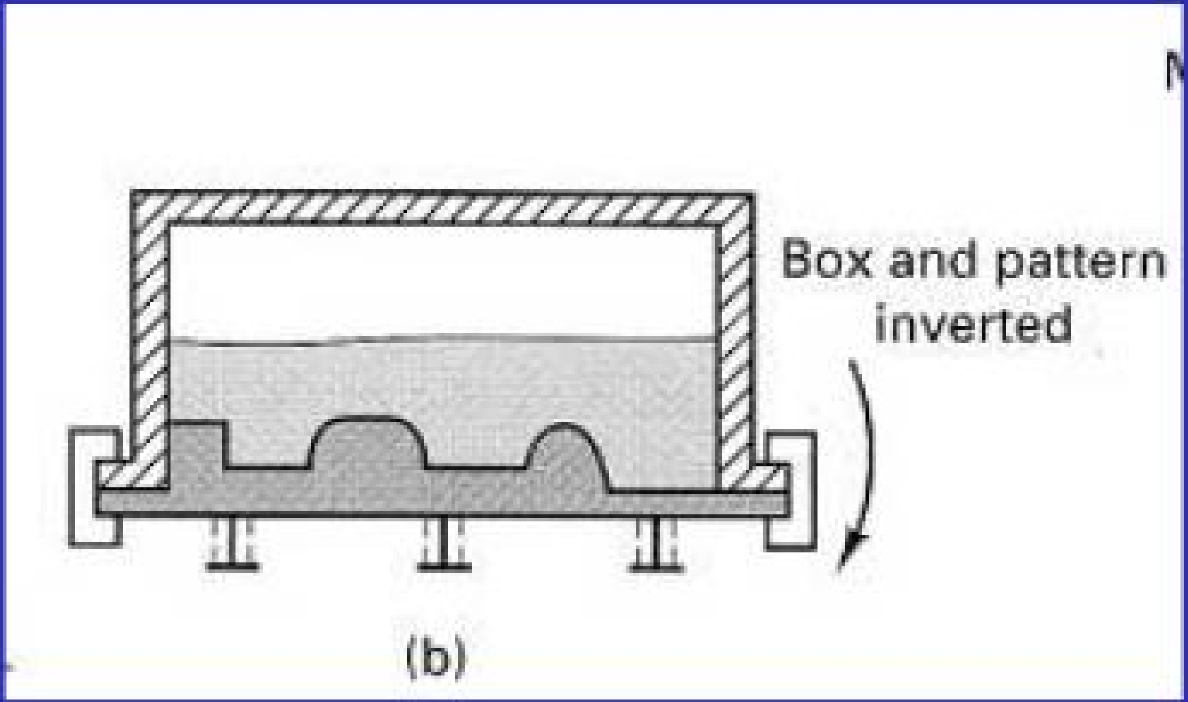


(a)

SHELL-MOLD CASTING

(Sequential Operations)

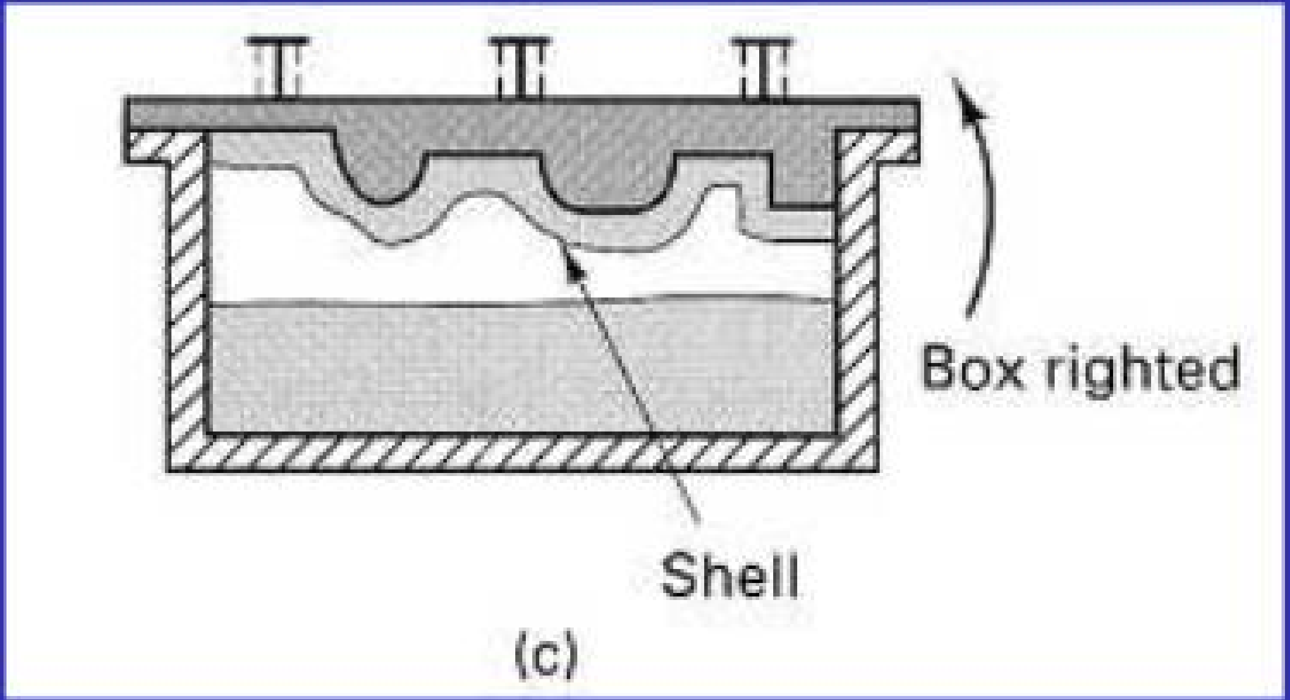
(b)The box is inverted and a shell partially cures around the pattern



SHELL-MOLD CASTING

(Sequential Operations)

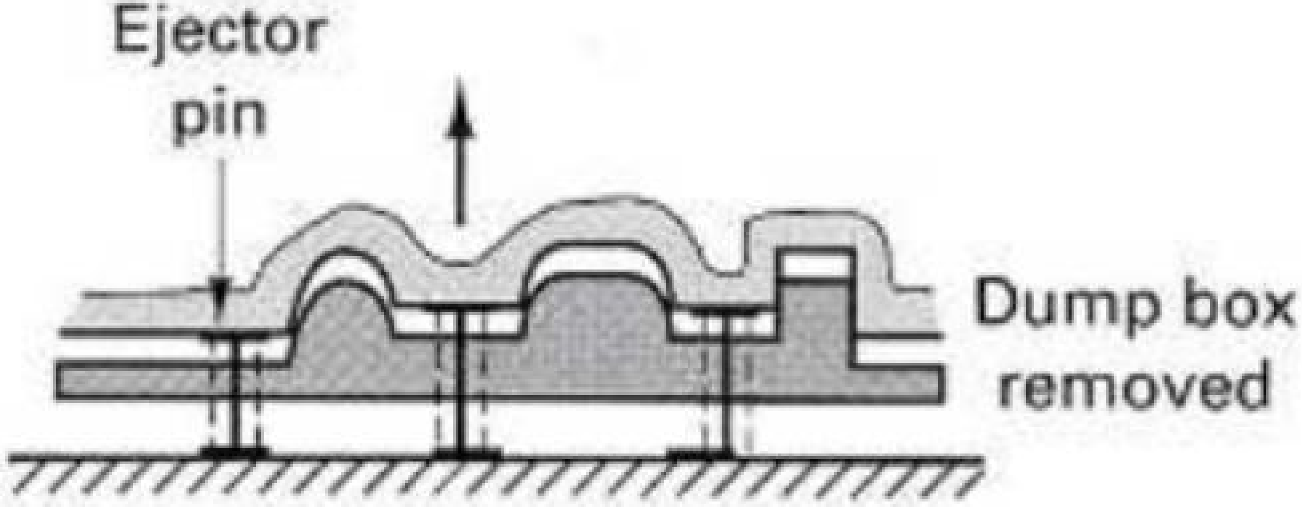
(c)The box is righted, the top is removed, and placed in an oven to further cure the shell.



SHELL-MOLD CASTING

(Sequential Operations)

(d) The shell is stripped from the pattern

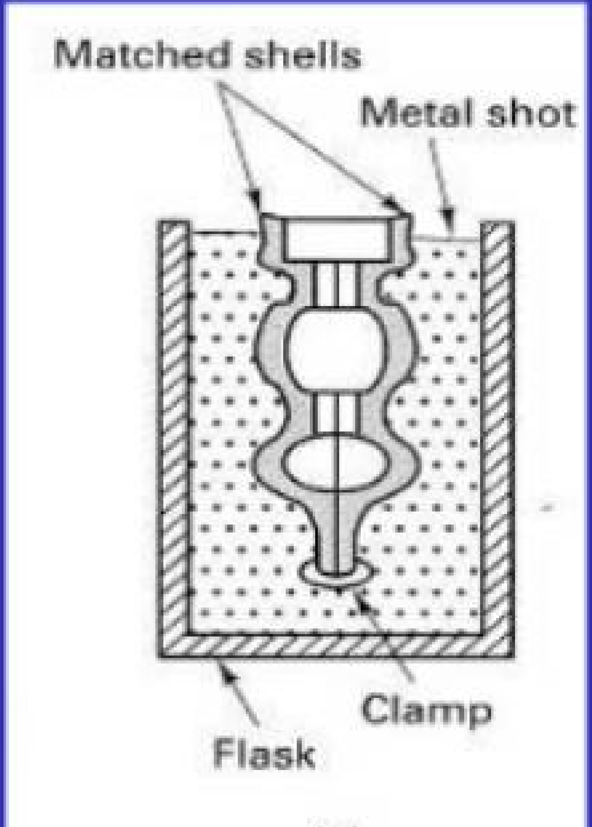


(d)

SHELL-MOLD CASTING

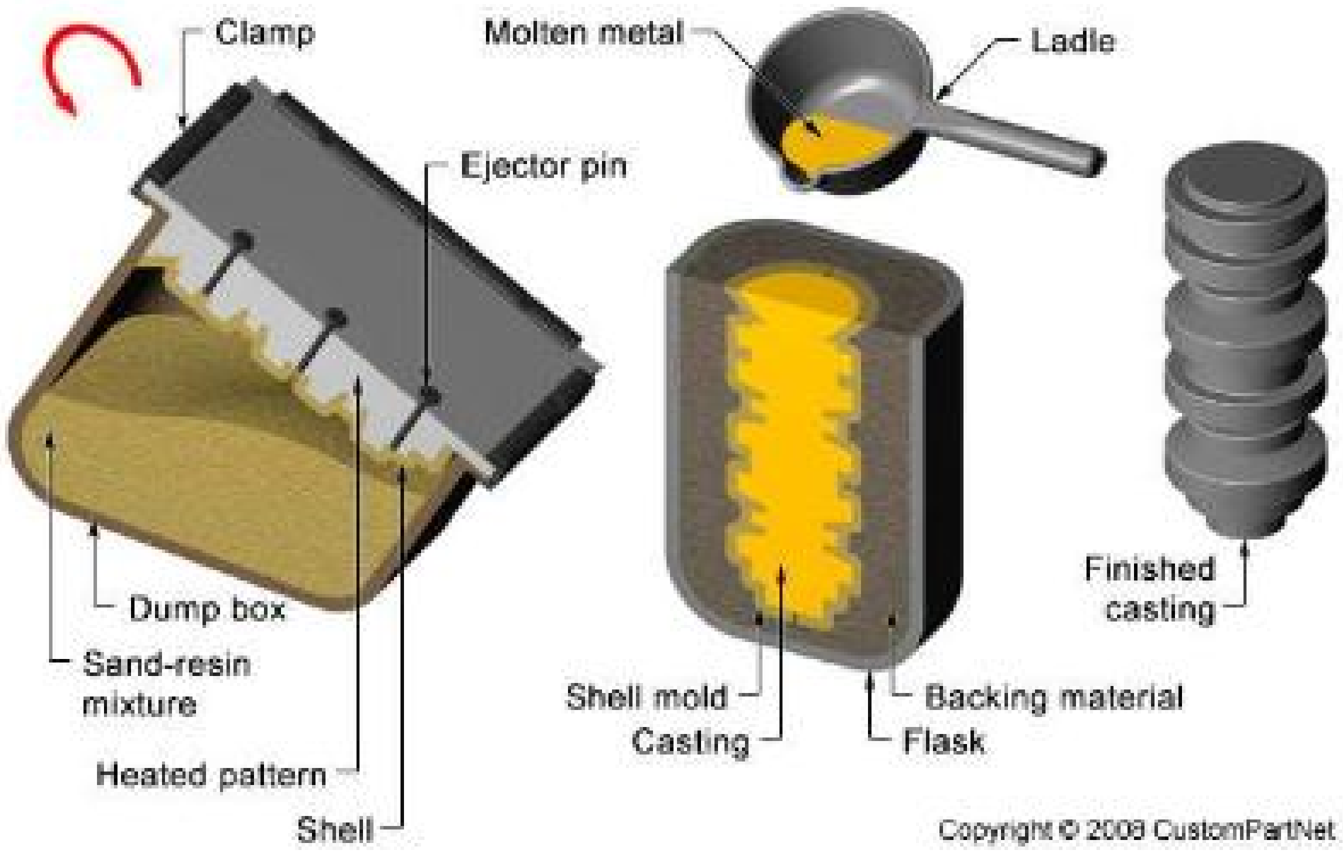
(Sequential Operations)

(e)Matched shells are then joined and supported in a flask ready for pouring.



(e)

Shell Mold Process



SHELL-MOLD CASTING

(Advantages/Disadvantages)

- **Advantages**
  - Better accuracy
  - Finish
  - Higher production rate
- Disadvantages
  - Limited part size

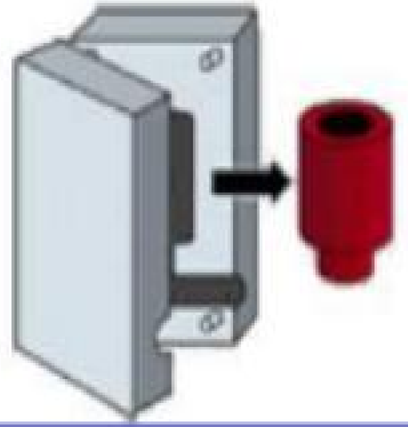
Advantages:

- Can form complex shapes and fine details,
- Very good surface finish,
- High production rate, Low labor cost,
- Low tooling cost, Little scrap generated.
- Can produce very large parts,
- Can form complex shapes,
- Many material options,
- Low tooling and equipment cost,
- Scrap can be recycled,
- Short lead time possible.

Disadvantages:

- High equipment cost
- Poor material strength
- High porosity possible
- Poor surface finish and tolerance

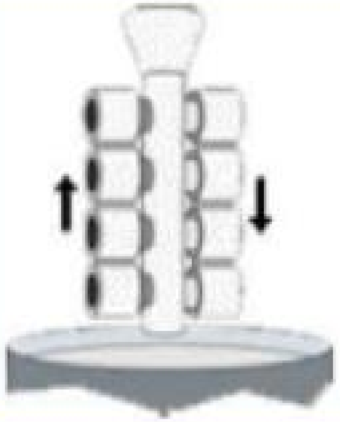
INVESTMENT CASTING (Description)



(a) Wax patterns are produced by injection molding

(b) Multiple patterns are assembled to a central wax sprue

INVESTMENT CASTING (Description)

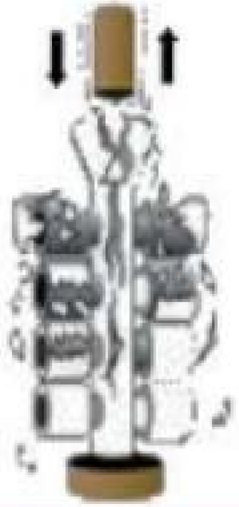


(c) A shell is built by immersing the assembly in a liquid ceramic slurry and then into a bed of extremely fine sand. Several layers may be required.

(d) The ceramic is dried; the wax is melted out; ceramic is fired to burn all wax

INVESTMENT CASTING (Description)

(e) The shell is filled with molten metal by gravity pouring. On solidification, the parts, gates, sprue and pouring cup become one solid casting.



(f) After metal solidifies, the ceramic shell is broken off by vibration or water blasting

INVESTMENT CASTING (Description)

(g) The parts are cut away from the sprue using a high speed friction saw. Minor finishing gives final part.

Advantages

- Many Intricate forms with undercuts can be cast.
- A very smooth surface is obtained with no parting line.
- Dimensional accuracy is good.
- Certain un-machinable parts can be cast to preplanned shape.
- It may be used to replace die-casting where short runs are involved.

Disadvantages

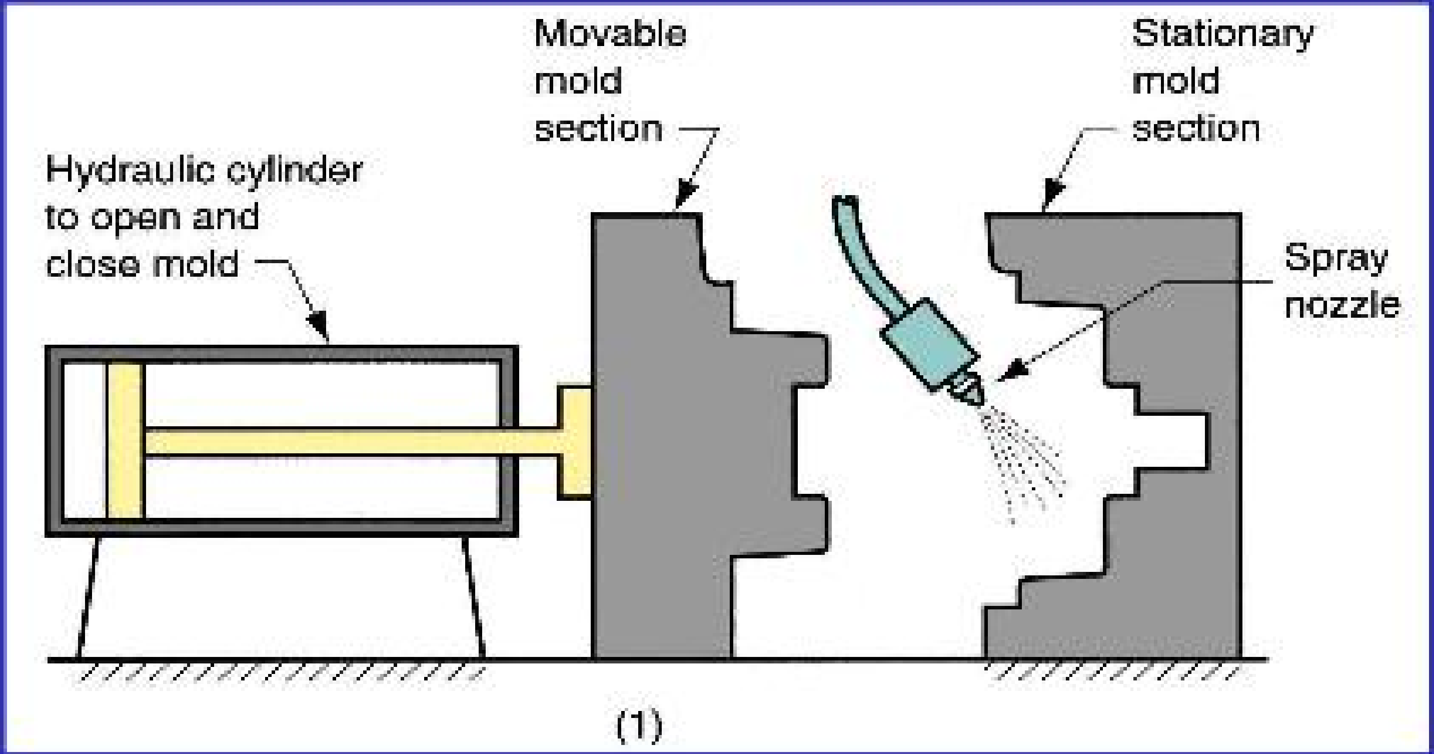
- This process is expensive, is usually limited to small casting, and presents some difficulties where cores are involved.
- Holes cannot be smaller than 1/16 in. (1.6mm) and should be no deeper than about 1.5 times the diameter.
- Investment castings require very long production-cycle times versus other casting processes.
- This process is practically infeasible for high-volume manufacturing, due to its high cost and long cycle times.

PERMANENT MOLD CASTING

(Description)

Permanent mold casting is a casting process involving pouring a molten metal by gravity into a steel (or cast iron) mold.

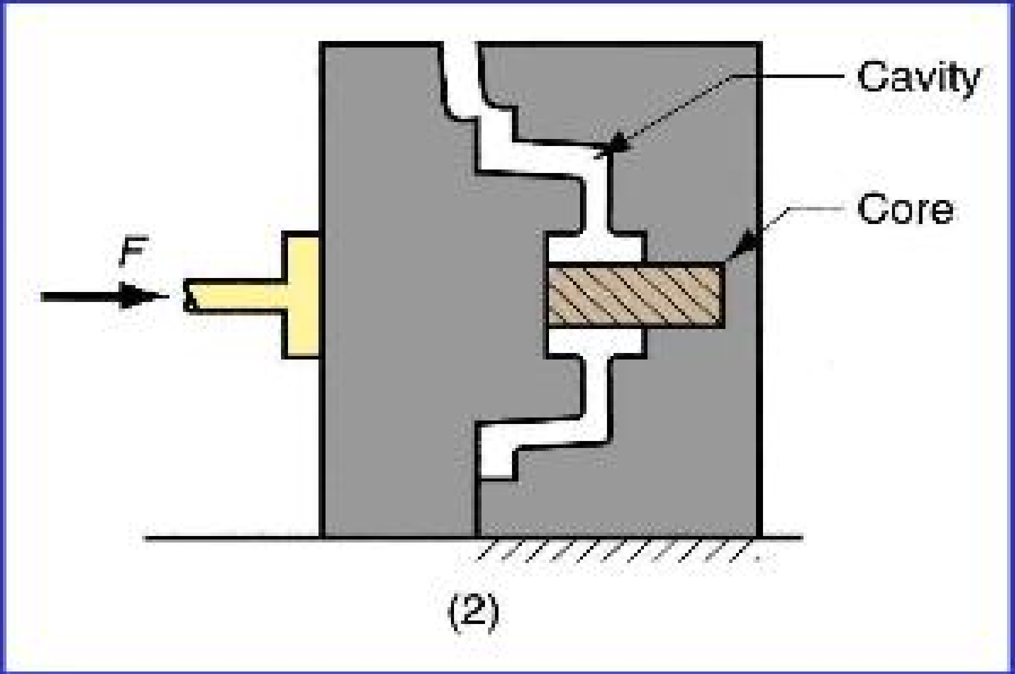
PERMANENT MOLD CASTING (Description)



3 Steps in permanent mold casting:

Step 1: mold is preheated and coated

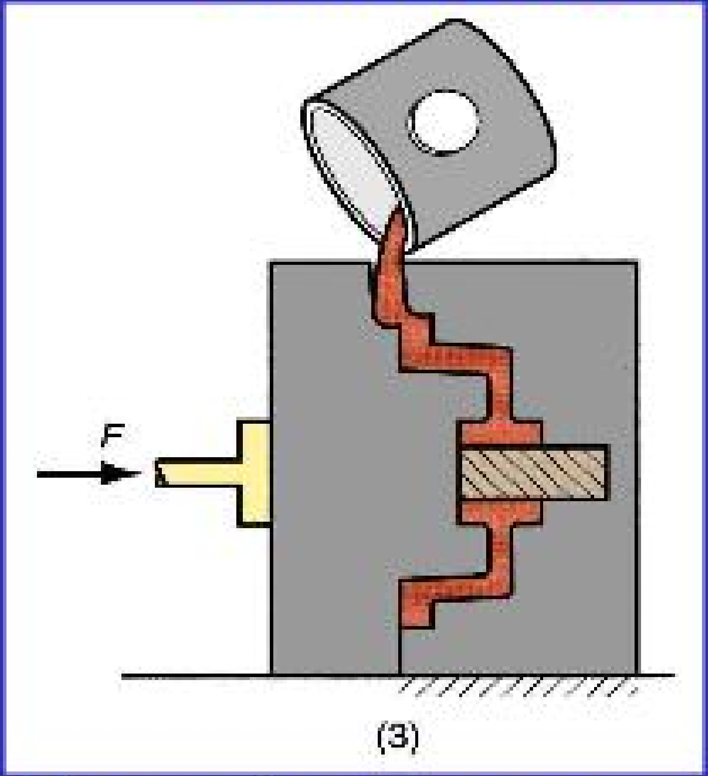
PERMANENT MOLD CASTING (Description)



Steps in permanent mold casting:

Step 2: cores (if used) are inserted and mold is closed.

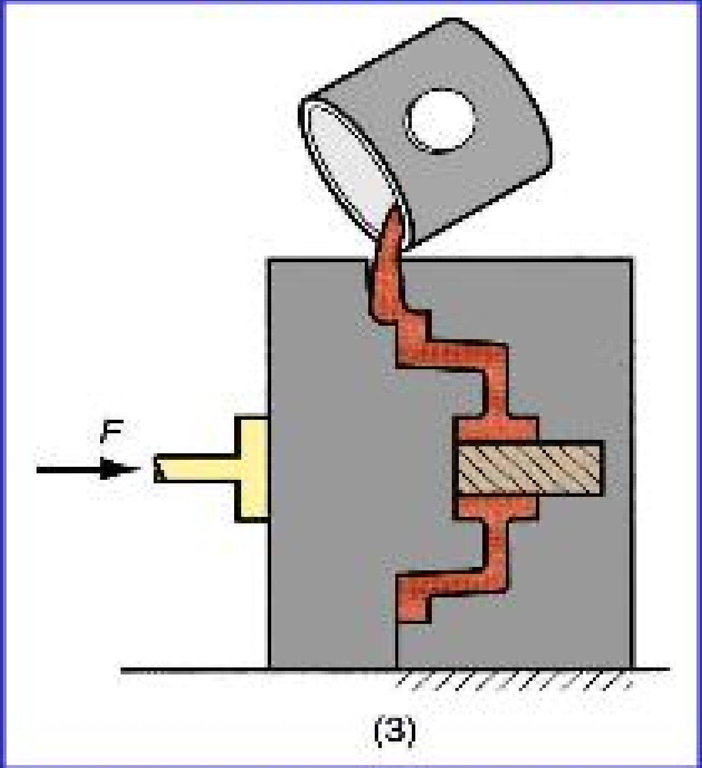
PERMANENT MOLD CASTING (Description)



Steps in permanent mold casting:

Step 3: molten metal is poured into the mold, where it solidifies.

PERMANENT MOLD CASTING (Description)



Steps in permanent mold casting:

Step 3: molten metal is poured into the mold, where it solidifies.

PERMANENT MOLD CASTING

(Description)

The permanent mold casting is similar to the sand casting process In distinction from sand molds which are broken after each casting a permanent mold may be used for pouring of at least one thousand and up to 100,000 casting cycles.

Manufacturing metal mold is much more expensive than manufacturing sand molds or investment casting process mold. Minimum number of castings for profitable use of a permanent mold is dependent on the complexity of its shape.

Ferrous and no-ferrous metals and alloys are cast by the permanent mold casting process.

PERMANENT MOLD CASTING

(Advantages/Disadvantages)

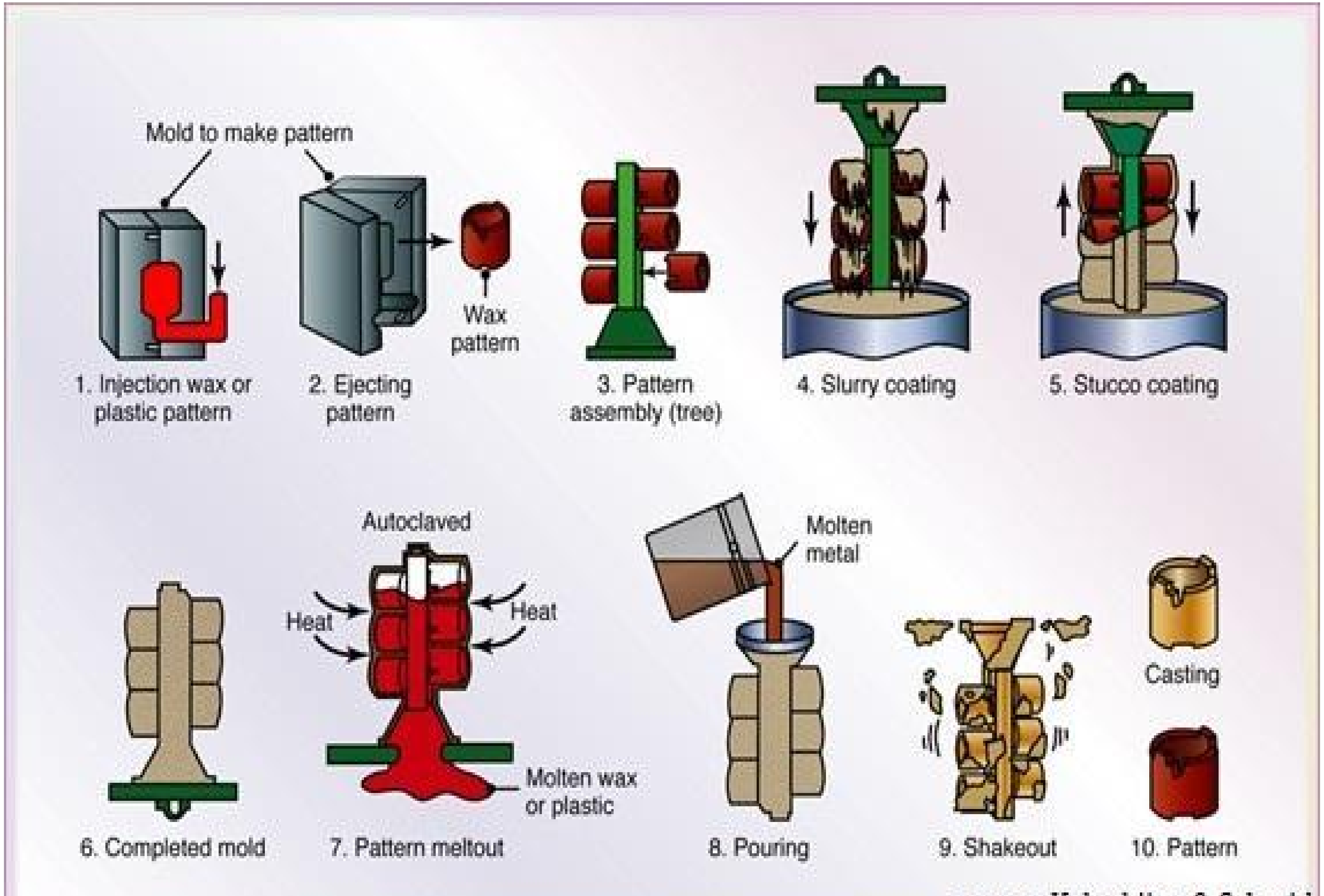
- **Advantages**
  - Better mechanical properties;
- Homogeneous grain structure and chemical composition;
- Low shrinkage and gas porosity;
- Good surface quality;
- Low dimensions tolerances

- **Disadvantages**
  - Costly mold,
  - simpler shapes only

Investment casting

- In **Investment casting**, a wax or suitable polymer pattern is coated by dipping into the refractory material slurry. Once the refractory material coating is hardened, then this dipping process is repeated several times to increase the coating thickness and its strength. Once the final coating is hardened the wax is melted out and molten metal is poured into the cavity created by the wax pattern. Once the metal solidifies within the mould, metal casting is removed by breaking the refractory mould.

Investment casting



source: Kalpakjian & Schmid

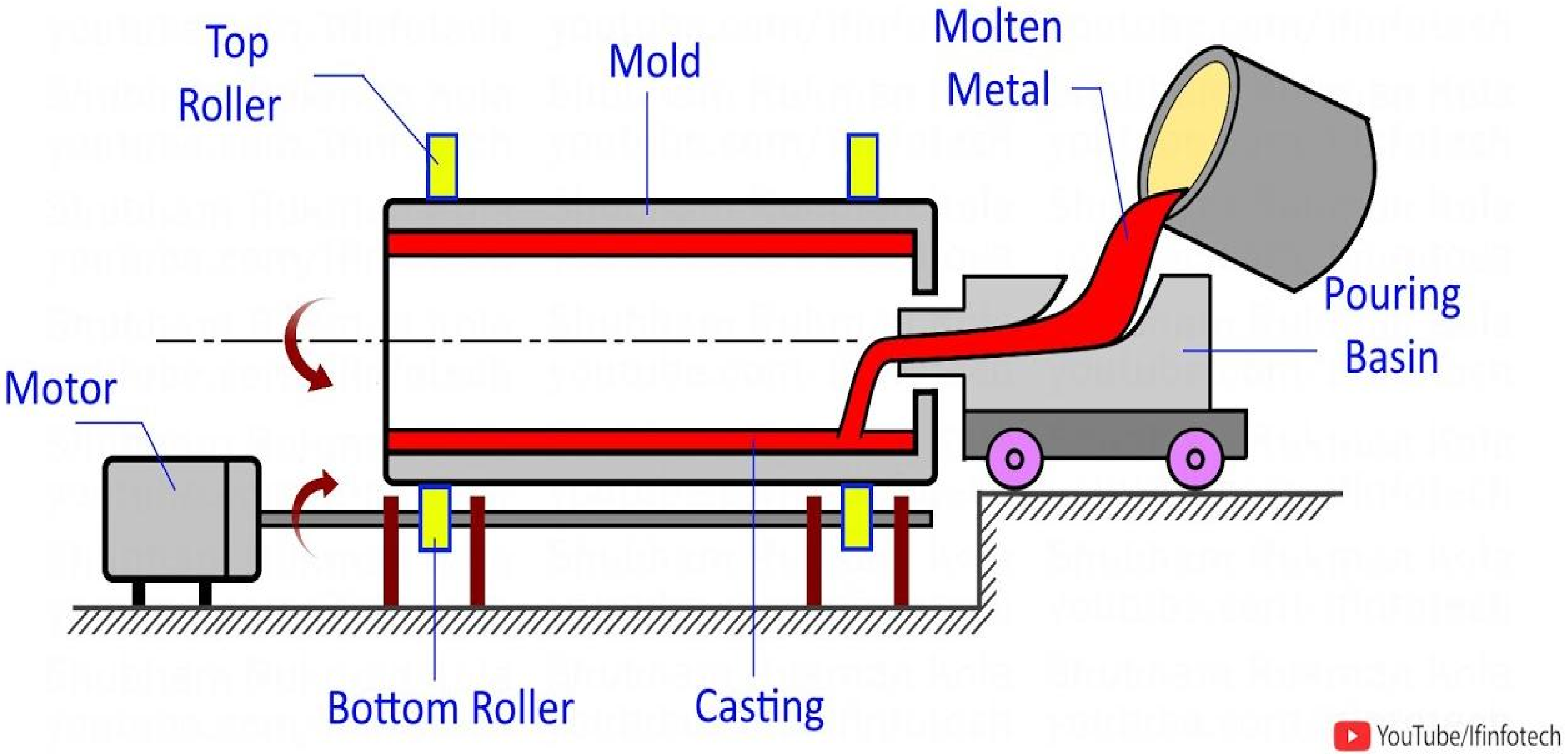
Advantages of Investment casting

- Parts with extremely complex shapes and intricate features can be cast as a single piece using investment casting
- With short length or shallow depth feature, thin sections down to 0.40 mm (0.015 in) can be cast without cold shut defects
- Lost wax casting has excellent dimensional accuracy and tighter tolerances of 0.075 mm (0.003 in) are easily achievable.
- Compared to similar manufacturing processes, Investment casting can achieve an excellent surface finish without any post-processing. Typically around 1.3 – 0.4 microns RMS Ra
- It offers almost unlimited freedom in terms of investment cast materials, but the most common materials used include Aluminium alloy, cast iron and non-ferrous alloys. The process is particularly attractive for high-temperature alloys.
- Draft on walls are not required but if a master die is used to make wax patterns then draft on the face would help the pattern making process easier.
- Since there are no parting lines, the cast would not have any flash. But the wax patterns might have parting lines from the master die.
- Excellent dimensional precision can be achieved in combination with very smooth as-cast surfaces. These capabilities are especially attractive when making products from the high-melting temperature, difficult-to-machine metals that cannot be cast with plaster- or metal mould processes.

Disadvantages of Investment casting

- Compared to other methods of metal casting such as Die casting and sand casting, lost wax casting involves many complex steps making the process relatively expensive. But some of the steps can be automated for certain products. It can be more expensive than die casting or sand casting, but per-unit costs decrease with large volumes.
- The high cost of dies to make patterns has traditionally limited investment casting to large production quantities
- The high cost is also due to specialised equipment requirements, costly refractory material, and high labour cost
- Parts are difficult to cast if they require cores, got holes smaller than 1.6 mm or deeper than 1.5 times the diameter

Centrifugal Casting Process



Centrifugal Casting Process

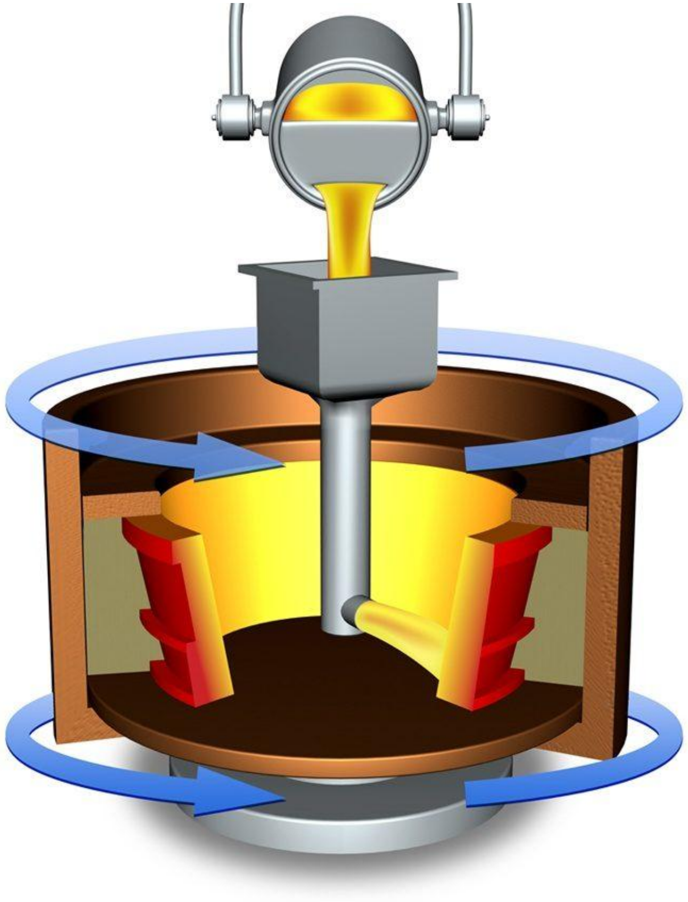
- Centrifugal casting is a process that delivers components of high material soundness. As a result, it is the technology of choice for applications like jet engine compressor cases, hydro wear rings, many military products, and other high-reliability applications. It has also proven to be a cost-effective means of providing complex shapes with reduced machining requirements and lower manufacturing costs as compared to forgings and fabrications.
- The centrifugal casting process steps begin with molten metal being poured into a preheated, spinning die. The die may be oriented either on a vertical or horizontal axis depending on the configuration of the desired part.
- By spinning a mold while the molten metal is poured into it, centrifugal force acts to distribute the molten metal in the mold at pressures approaching 100 times the force of gravity.

Types Of Centrifugal Casting

Vertical Centrifugal Casting

- Some manufacturers produce centrifugal components, including some with O.D shaping, in dies rotating about the vertical axis. These vertical castings may achieve that O.D. shaping by inserting graphite, sand, or ceramic molds into the die – resulting in significantly reduced post-processing, like machining or fabrication.
- Details on the outside surface of the casting may be modified from the true circular shape by the introduction of flanges or bosses to the inner diameter of the mold. The finished part need not be symmetrical but, in some cases, the casting mold does to maintain balance while spinning.
- The inside diameter and therefore the wall thickness of the casting are functions of the amount of metal poured into the rotating mold and the quantity machined away. When casting vertically, the height of the casting will typically be less than twice the width.

Vertical Centrifugal Casting

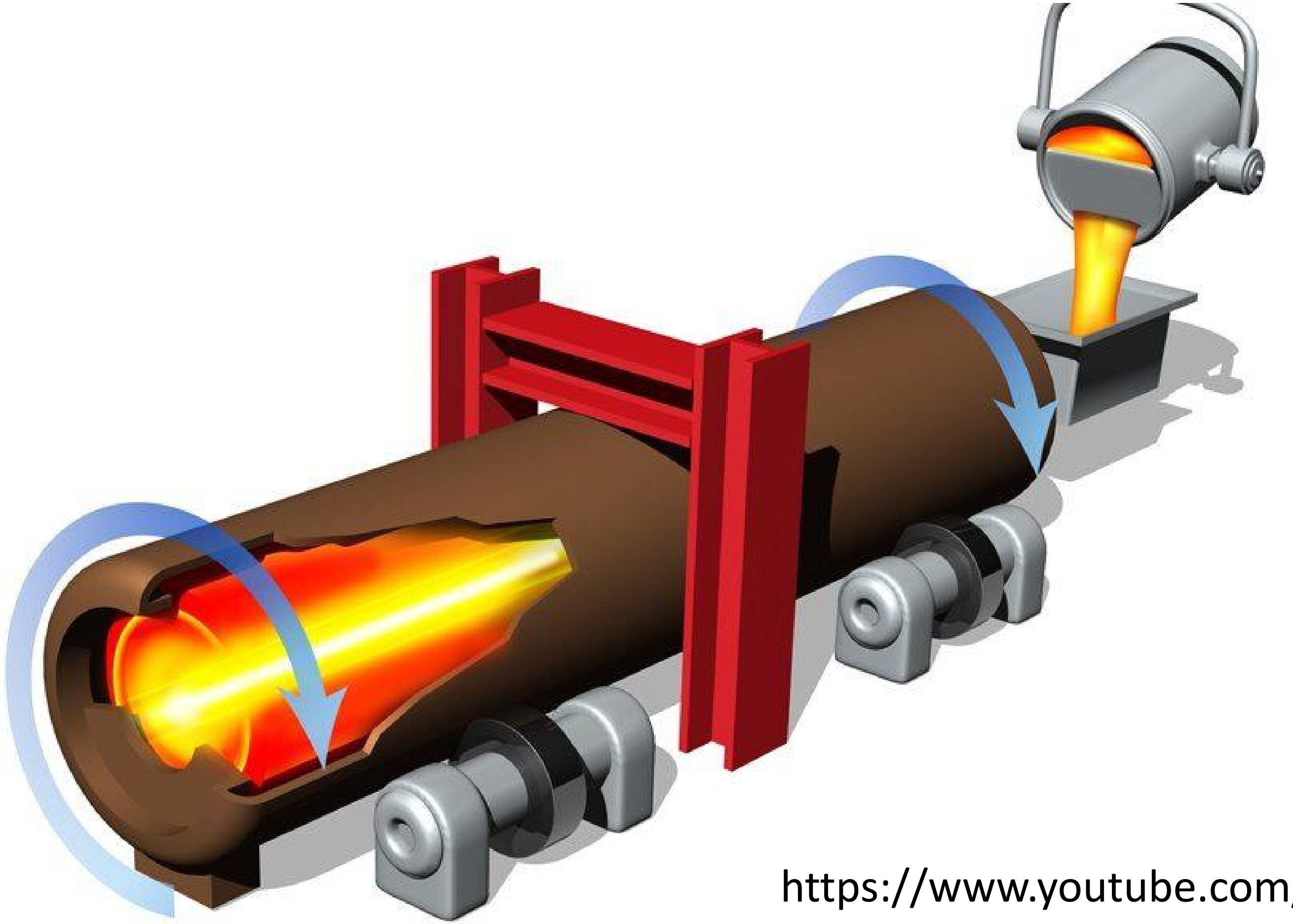


Types Of Centrifugal Casting

Horizontal Centrifugal Casting

- Some centrifugal casters produce only horizontal castings where the die rotates about the horizontal axis. This is a cost-effective method for producing high-quality tubular components.
- This process is especially suited for long cylindrical parts where the casting length is significantly longer than its outside diameter. This includes straight tube sections, long cylinders with end flanges, or short parts such as rings or flanges where multiple parts can be machined effectively from a straight cylinder.
- A long steel casting mold is spun at high speed while positioned horizontally. The rotational speed of the mold is high, to offset gravitational forces. Covers are fixed at each end of the mold to contain the molten metal and a pour funnel is used to deliver a specified weight of metal inside the mold.

Horizontal Centrifugal Casting



https://www.youtube.com/watch?v=pJVgAYsyl7o

https://www.youtube.com/watch?v=3G2sBqXkRT8

Advantages of Centrifugal casting process

- Castings acquire high density, high mechanical strength and fine grained structure
- Inclusions and impurities are lighter
- Gates and risers are not needed
- High output
- Formation of hollow interiors without cores

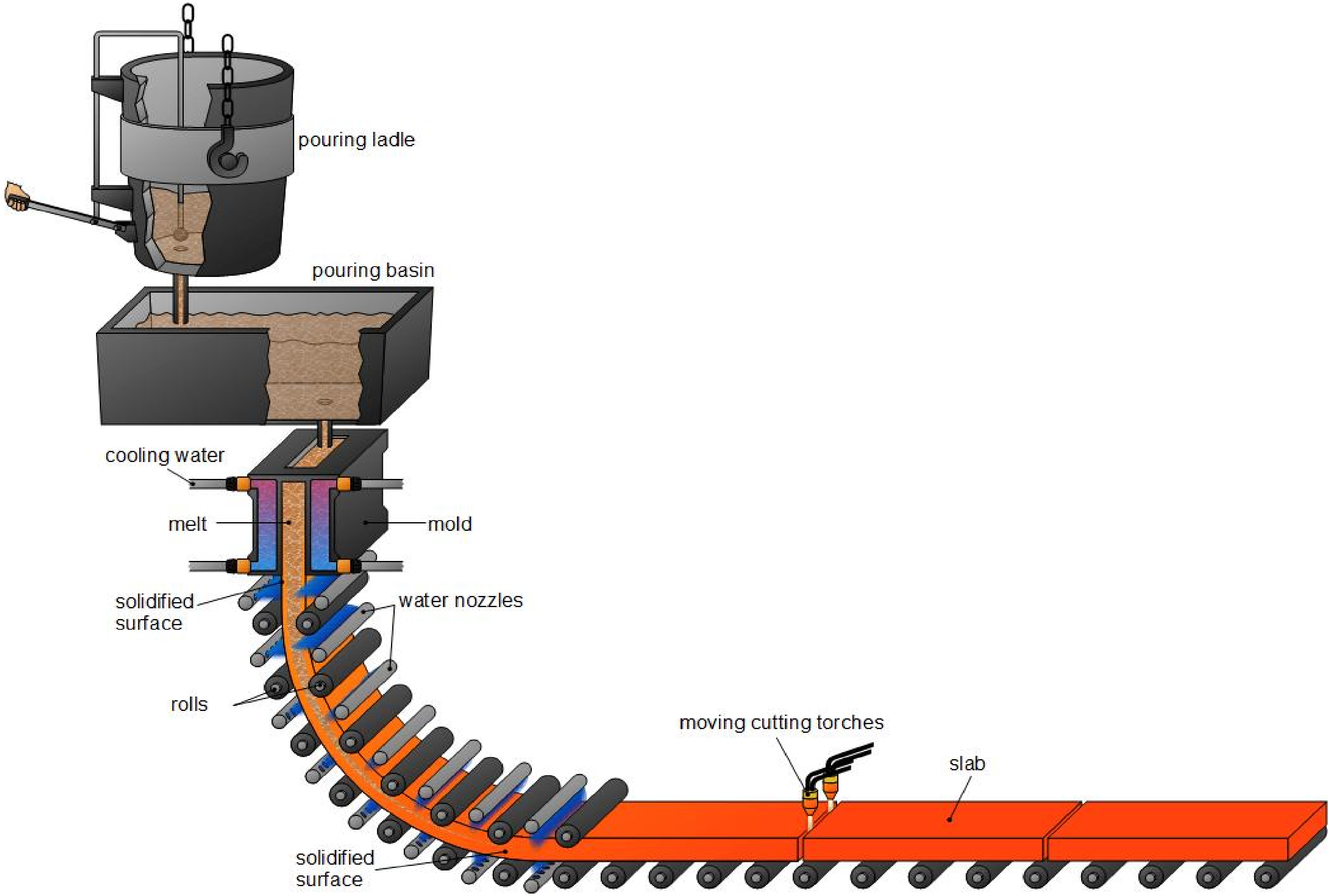
Disadvantages Centrifugal casting process:

- An inaccurate diameter of the inner surface of the casting.
- Not all alloys can be cast in this way.

Continuous casting

- Continuous casting is a manufacturing process that allows metals and metal alloys to be shaped then solidified without interruption. Metal is poured into a mold and rapidly chilled to ensure a uniform grain structure within the metal. Most often, these shapes are tubes and solids, but can also include squares, rectangles, and other irregular shapes as requested. This method improves quality and is more cost-efficient than other options, such as sand casting.
- Continuous casting of steel was first introduced in the 1950s as an alternative method of steel manufacturing. It is now a standard manufacturing method. Here's how the process works.

Continuous casting



The process

- Molten metal is ladled or fed into a mold of the shape required.
- Heat is extracted from the metal by placing cooled water around the mold. The metal is given its basic shape (from the mold) and is partially solidified.
- Semi-solid metal is then sent through a guide that will stretch the material to a thickness desired by the customer. The metal continues cooling in this stage
- Fully solidified metal is sent through straighteners to achieve the final dimensions.
- The metal product is withdrawn and cut to the needed length by saws

Advantages of Continuous Casting

- Continuous casting has many advantages. For starters, with other casting methods, it is difficult to cast metal into long, tubular forms. With continuous casting, you can make long tubes in a variety of shapes and sizes. Here are some of the other advantages to consider:
- Continuous castings are perfect for pressure applications. They are consistently homogeneous and dense.
- Less machining stock is needed.
- Less material is wasted than some other casting methods.
- These castings are straight and concentric, meaning there is no deviation. You get the same product every time.
- Suppliers often maintain stock of standard products, available to distributors on demand.
- Cost advantages can be offered for standard shapes and sizes.

Disadvantages of Continuous Casting

- There are a few limitations to consider when looking at continuous casting. The biggest is the cost of setup. Due to both the high cost of creating a mold and the time spent setting up the machine for each project, it is not practical to use this method for small quantities or for special shapes of a product. It also isn't economical to use this method with special metal alloys in smaller quantities.
- Another thing to consider is the shapes that can be cast. Continuous casting is limited to more simple shapes that have a stable cross-section. This method is not a good option for some of the more tedious, difficult casting projects.