

Ministry of Higher Education and Scientific Research

University of Ghardaia

Faculty of Science and Technology

Department of hydraulics and civil engineering

Basic technology cours

Target group: Second-year, specializing in civil engineering; hydraulics and energy mechanics

Materials

Plastic



Composites



Ceramics



Metals



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Introduction

Basic technology refers to fundamental technological knowledge and practices that form the foundation for more advanced technologies. It encompasses essential methods and systems necessary for production and development in various industries.

This course material is intended for second-year undergraduate students (LMD) in hydraulics, civil engineering, and mechanical engineering. It is divided into four chapters, the content of each chapter meeting the requirements of the second-year undergraduate program as defined by the National Pedagogical Committee for the Science and Technology field.

This course will enable students to acquire knowledge of the processes for obtaining and manufacturing parts and the techniques for their assembly.

Introduction

Material refers to any substance of natural or artificial origin that humans utilize or design to create objects, construct buildings, or manufacture machines.

Materials are categorized based on their origin, such as their properties, which can be mechanical (like flexibility or rigidity), chemical (such as water permeability or impermeability), or physical (including electrical conductivity...).

Typically, materials are organized into broad categories: metallic materials, plastic materials, ceramics, and composite materials

1.1 Metals and alloys

In metallurgy, the designation of metals and alloys refers to the standardized naming of metallic materials, often used on part drawings

A. Metal

A metal is a material known for its shiny appearance and its ability to conduct heat and electricity efficiently

A pure metal is considered an element because it consists solely of one type of atom

In the natural world, metals are seldom located in their pure form. Typically, they are combined with other materials within ores found in the Earth's crust. After these ores are mined, they undergo a series of processes to separate the various substances they contain

B. Alloys

An alloy is a pure metal that has been intentionally combined with one or more additional elements. Depending on the number of added elements, it can be classified as binary, ternary or quaternary, indicating the presence of two, three, or four components, respectively.

1.1.1. Metallurgical symbols
Table 1. Metallurgical symbols

Element	Chemical symbols	Metallurgical symbols
Aluminum	Al	A
Boron	B	B
Tin	Sn	E
Magnesium	Mg	G
Cobalt	Co	K
Manganese	Mn	M
Nickel	Ni	N
Silicon	Si	S
Titanium	Ti	T
Copper	Cu	U
Zinc	Zn	Z

1.1.2. Structure of metals and alloys

Observations of metals and alloys reveal that they possess an internal organization known as structure

Many metals, much like other solids, typically exhibit cubic (such as CC and CFC) or hexagonal (HC) crystal structure.

The alloys are created by crystallizing a combination of two or more metals, occasionally incorporating non-metallic elements as well

An alloy is composed of several distinct solid phases. A phase represents a structurally uniform portion of the system, which is separated from other parts by a clearly defined physical boundary. Each phase possesses its own unique structure and inherent properties. We identify:

- Ferrous alloys (ferro alloys)
- Non-ferrous alloys (Non-ferro alloys)

1.1.3. Ferrous metals and their alloys

1.1.3.1. The iron-carbon alloy:

Iron, known as the most affordable base metal, exists in three allotropic forms.

- The first, α iron (ferrite), has a body-centered cubic structure and is stable up to 906°C.
- The second form, γ iron (austenite), is stable between 906 and 1400°C with a face-centered cubic structure.
- Finally, δ iron is stable from 1400 to 1528°C, returning to a body-centered cubic structure.
- Carbon, which melts at 3500°C, also has three allotropes: graphite, diamond, and carbon black. It is a crucial component of steels and cast irons, second only to iron in importance.

A. Steels

Steel is a versatile material offered in various distinctive qualities and chemical compositions. In steels, the carbon content is less than 2.1%.

- **Types of steels**

- General Purpose Steel (S)
- Mechanical Construction Steel (E)
- Unalloyed Steel (C)
- High Alloy Steel (X)
- Low Alloy Steel (Nb)
- High Speed Steel (HS)

B. Cast iron

In metallurgy, cast iron is an alloy of iron and carbon with a carbon content of between 2.1 and 6.7% for cast iron.

- **Types of cast iron**
 - Lamellar graphite cast iron (L)
 - Spheroidal graphite cast iron (S)
 - Black-heart malleable cast iron (MB)
 - White-heart malleable cast iron (MW)

1.1.4. Non-ferrous Alloys

A. Alloys Aluminum

Alloys Aluminum alloys designed for casting are primarily composed of aluminum and are meant to be shaped using casting methods. These alloys are commonly referred to as "light alloys" due to the lightweight nature of the metals used in industrial applications

- **Main properties:**

Excellent conductor of heat and electricity - Low density: 2.7 kg/dm^3

- Melting point: 658°C
- Low Young's modulus: $70,000 \text{ N/mm}^2$ ($70,000 \text{ MPa}$ or $7,000 \text{ daN/mm}^2$)
- Stiffness coefficient per unit mass is comparable to that of steel
- Low elastic limit
- High elongation at break for thin sheets, foils, and paper
- Good corrosion resistance when an alumina layer forms, as it prevents further corrosion of the aluminum

Conversely, when aluminum is associated with a more electropositive metal like steel or copper alloys, the protective alumina layer is compromised, leaving the aluminum expose.

- **The addition elements are few in number:**

Copper, silicon, magnesium, manganese, titanium and associations of:

- Magnesium + silicon,
- Zinc + magnesium,
- Zinc + magnesium + copper.

B. Copper alloys

Copper alloys are a group of materials primarily composed of copper, known as cupro- alloys. They are generally recognized for their excellent resistance to corrosion

The primary categories of these alloys are:

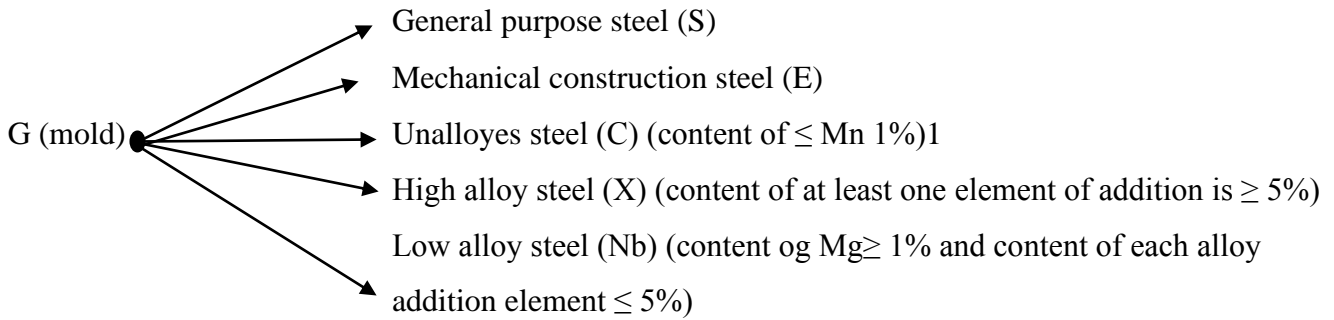
- Pure copper (contains at least 99% copper)
- Electrolytic copper ETP (electrolytic tough pitch),
- Thermal copper FRHC (fire refined high conductivity), FRTP (fire refined tough pitch),
- Copper deoxidized with phosphorus DHP (deoxidized high residual phosphorus), DLP (deoxidized low residual phosphorus),
- Oxygen-free copper OF (oxygen free), OFHC (oxygen free high conductivity), OFE (oxygen free electronic grade);
- Low-alloy coppers: less than 5% of addition elements;
- brass: copper-zinc,
 - copper + zinc: binary brasses,
 - copper + zinc + lead: leaded brasses,
 - copper + zinc + others: complex brasses;
- Bronzes: copper-tin,
- Copper + tin + zinc: chrysocales;
- Cuproaluminiums, or aluminium bronzes: copper-aluminium;
- Cupronickels: copper-nickel;
- Hickel silvers: copper-nickel-zinc;
- Cuprosilicones: copper-silicon;
- Cuproleads: copper-lead;
- Billons: copper-silver.

1.1.5. Symbolic designation

A. Designation of metallic materials

A.1. Designation of ferrous materials (steel and cast iron)

A.1.1. Steels



Re: the elatic limit In MPa 1 MPa = 1 N/mm²

Table 2. Designation of steels according to their types

Steel	Designation					
General Purpose	<table border="1" style="margin: auto;"> <tr> <td style="padding: 5px;">S</td> <td style="padding: 5px;">Re</td> </tr> </table>				S	Re
S	Re					
Mechanical Construction	<table border="1" style="margin: auto;"> <tr> <td style="padding: 5px;">E</td> <td style="padding: 5px;">Re</td> </tr> </table>				E	Re
E	Re					
Unalloyed Steel	<table border="1" style="margin: auto;"> <tr> <td style="padding: 5px;">C</td> <td style="padding: 5px;">% C × 100</td> </tr> </table>				C	% C × 100
C	% C × 100					
High Alloy Steel	X	% C × 100	Symbol of elements in descending % order	% in the same order		

Low Alloy Steel		% C × 100	Symbol of the addition elements in descending % Order	% × factor (in the same order)
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Table 3: Multiplication factors for the different addition elements (for low-alloy steels)

Addition elements	Multiplication factors
Cr, Co, Mn, Si, W	4
Al, Be, Cu, Mo, Nb, Pb, Ta, Ti, V, Zr	10
Ce, N, P, S	100
B	1000

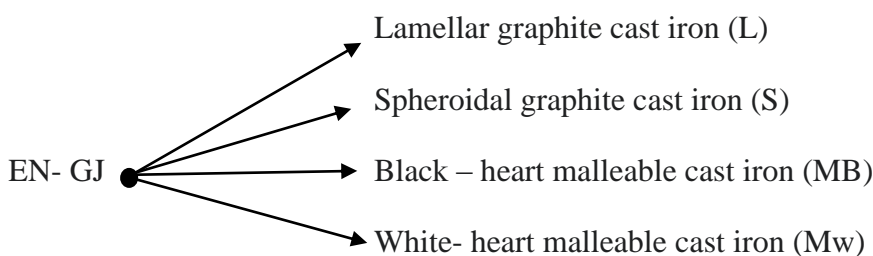
Example: S235 /E300/ GE300/ C25 /X 5 Cr Ni 18 – 10 / 47 Cu Ni Mo 7-5 / HS 6.5 - 4 - 3 -11

- **High speed steel (HS):** the designation successively includes the symbols following the letters HS. The numbers indicating the values of the alloying elements in the following order:

Tungsten (W) / Molybdenum (Mo) / Vanadium (Va) / Cobalt (Co). Each number represents the average content.

Example: S235 /E300/ GE300/ C25 /X 5 Cr Ni 18 – 10 / 47 Cu Ni Mo 7-5 / HS 6.5 - 4 - 3 -11

A.1.2. Cast iron



Rr: Tensile strength in MPa 1 MPa = 1 N/mm²

A%: Percentage of elongation after rupture

EN: European standard GJ: graphite cast iron

Table 4: designation of cast iron according to their types

Cast iron	designation
Lamellar graphite	EN- GJL- Rr
Spheroidal graphite	EN- GJS- Rr-A%
Black-heart malleable	EN- GJMB- Rr- A%
White-heart malleable	EN- GJMW- Rr- A%

A.2. Designation of non-ferrous materials

Table 5: Designation of non-ferrous materials

base metal symbol	symbol of 1 st addition element	% of 1 st addition element	symbol of 2 nd addition element	% of 2 nd addition element

A.2.1. Copper alloy

Table 6: Types of copper according to their mixtures

Copper + Zinc	Brass
Copper + Tin	Bronze
Copper + Aluminum	Cupro-aluminum
Copper + Nickel	Cupro nickel

Example: Cu Al 36 Pb 3

A.2.2. Aluminum alloy (cast (B); wrought (w))

Table 7: Types of aluminum alloys according to their mixtures

Aluminium + Silicon	Alpax
Aluminium + Copper	Duralium
Aluminium+ Magnésium	Duralinox

Example: Al Si 32 Pb 13

1.2. Plastic

1.2.1. Definition

A plastic A mixture whose basic constituent is a resin, or polymer with which we associate **adjuvants** (redesign, plasticizing, stabilizing, antioxidants) and **additives** (pigment and dyes, flame retardant, lubricants, fungicides)

1.2.2. Main Properties

Plastics offer numerous advantages, including:

- Low mass density: Ranging from 830 to 2300 kg/m³.
- Excellent Chemical Resistance: High resistance to corrosion.
- Versatile Quality: Available in various shapes and colors.
- Cost-Effectiveness: Generally low production costs.
- Electrical and Thermal Insulation: Effective insulators for both electricity and heat.

However, their applications may be limited in certain areas, such as:

- Temperature Resistance: Limited performance at extreme temperatures.
- Mechanical Strength: May not withstand high mechanical stress.
- Dimensional Stability: Potential for changes in shape under varying conditions.
- Long-Term Performance: Characteristics may degrade over time.

1.2.3. Classification

For the user, plastics are classified into two main categories:

A. Thermoplastics

Thermoplastics, when exposed to heat, transition into a viscous or molten state. Upon cooling, they solidify and revert to their original form. This thermal behavior is similar to that of metals.

B. Thermosetting Plastics

When subjected to heat, thermosetting plastics reach a viscous state (injection temperature in

the mold). They then undergo an irreversible internal chemical transformation, resulting in a permanent hardening of the material.

thermal behavior is comparable to that of clay, which hardens when exposed to heat.

Note:

Elastomers: have a viscoelastic behavior similar to that of rubber

Foams: are materials, either thermoplastic or thermosetting, characterized by a cellular structure and a range of variable properties

Example of main plastics

Thermoplastic: HDPE: high density polyethylene	LDPE: low density polyethylene
PP: polypropylene	PVC: polyvinyl chloride (rigid (u), flexible (p))
Thermosetting: EP: Epoxy	PUR: polyurethane
	UP: polyester

1.3. Composites

1.3.1. Definition

A composite material is formed by combining multiple immiscible materials of different types, whose properties complement one another. This results in a heterogeneous material that exhibits superior performance compared to its individual components.

In a composite material, two main elements are distinguished:

- **Reinforcement:** This serves as the structural backbone of the part, bearing most of the applied forces.
- **Matrix:** This component binds the reinforcements together, distributes the forces throughout the material, and provides protection to the reinforcements.

1.3.2. Types of Matrices

- Organic: (e.g., epoxy (EP) plastic, unsaturated polyester (UP), polyamide (PA), polyoxymethylene (POM), polycarbonate (PC), etc.)
- Mineral: (e.g., carbon, ceramics, etc.)
- Metallic: (e.g., aluminum, titanium, lead)

1.3.3. Types of Reinforcements

- Organic: (e.g., glass fiber, aramid fiber, etc.)
- Mineral: (e.g., carbon fiber, ceramic fiber, etc.)
- Metallic: (e.g., boron fiber, alumina fiber, etc.)

1.3.4. Different Reinforcement Structures

- Particles
- Short fibers
- Long fibers
- Multiaxial weaving
- Braiding
- Three-dimensional assembly

1.3.5. Main Properties of Composites

The properties of a composite material are influenced by several factors:

- The nature of the matrix
- The nature of the reinforcement
- The geometry of the reinforcement structure
- It can be noted that:

Composites can achieve equal performance while significantly reducing the weight of components.

- They are highly resistant to the initiation of fractures.
- They exhibit excellent fatigue resistance.
- They provide good corrosion resistance.
- They are largely unaffected by fatigue-corrosion phenomena.

1.4. Ceramics

In everyday language, the term "ceramic" refers to objects made from clay that have been

fired at varying temperatures. Historically, the art of ceramics predates that of glass and metalworking, dating back to the Neolithic period. Ceramics exhibit diverse properties based on the composition of their materials and their firing temperatures. For instance, we can distinguish between pottery, earthenware, porcelain, and other types.

A broader definition of ceramics describes them as non-metallic and inorganic materials produced through the application of high temperatures. These elevated temperatures induce an irreversible transformation within the raw material, imparting new properties to the resulting ceramic, such as enhanced strength, wear resistance, heat resistance, and insulating capabilities.

For many years, ceramics were primarily used to create art objects, pottery, and kitchenware. However, the unique properties of these materials have inspired engineers to explore industrial applications for ceramics. This has led to the development of technical ceramics, which are utilized as supports for heating elements, rolling balls, cutting tools, electrical insulators, and even as reinforcements in metallic composite materials.

A manufacturing process is a method, a technique by which an object is manufactured. There are various methods to acquire mechanical parts, and the role of a machining technician involves selecting the most appropriate manufacturing process to the part to be manufactured. Specifically:

- the simplest to implement
- The fastest
- The least expensive and which ensures the quality and the requested rate.

2.1. By fusion foundry

The main foundry materials are :

- Main foundry alloys
 - Zinc alloy
 - Aluminum alloy
 - Copper alloy
 - Cast iron and alloyed cast iron
- Main foundry sands
 - Green sand
 - Cores chemical process sands
 - Coreing process sand

2.1.1. The casting

Casting allows complex parts to be obtained by pouring molten metal into a mold. Two main families of processes:

- Non-permanent mold processes
- Permanent mold processes

Table 8. Main difference between permanent and non-permanent molds

	Characteristics	Advantage	Disadvantages
Non permanent molds	The mold is destroyed to extract part	Production of complex part shapes production of small series and prototypes	limited production rate Mold production time longer than casting

Permanent moles	The mold often metallic, is reused for several series of part	High productin rate respectability of thr geometry of to perts	More limited shape because the part must be able to be unmolded
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A. Casting methods

A.1. Sand molding

Casting involves placing a model or pattern plate into sand-filled frames, then pouring the alloy into the impression left by the mode. This process offers several advantages :

- Ability to produce complex and large parts, with recesses thanks to the use of cores
- Usable for prototyping, series of a few units to a few hundred
- Average surface finish and average dimensional precision

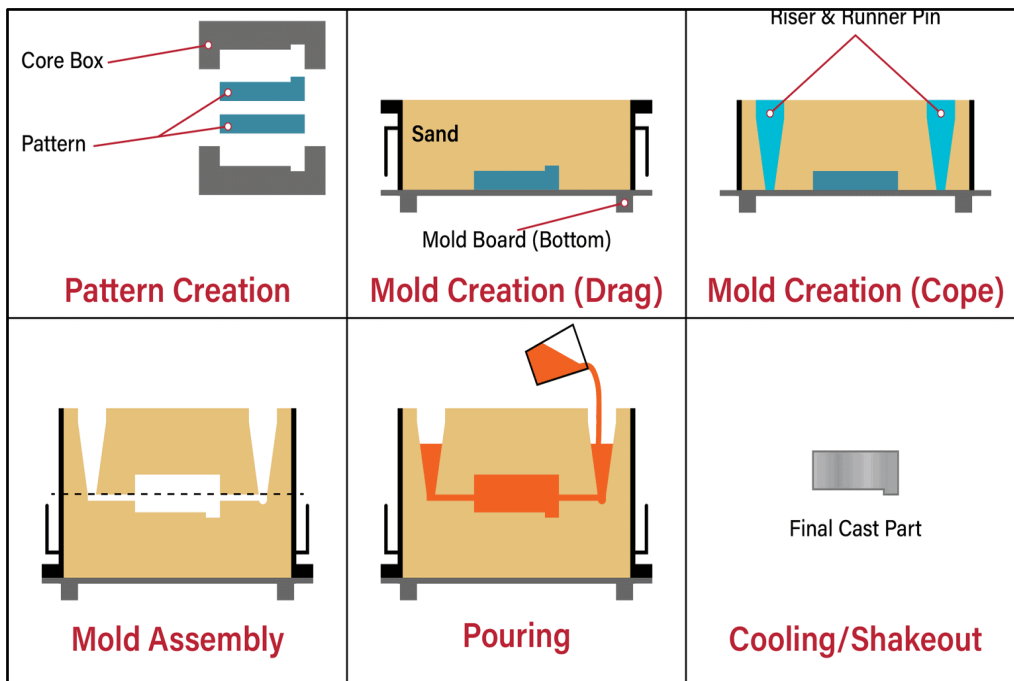


Figure1. Sand casting process

➤ <https://www.youtube.com/watch?v=3DesU9GatWU>

A.2. Shell molding

Shell molding (also known as shell-mold casting) is a precision casting process that uses a resin-bonded sand to form a thin, hardened "shell" as the mold. It is essentially an evolution of sand casting that offers much better dimensional accuracy and a smoother surface finish. The shell molding process offers :

- Permanent mold Casting in Steel Alloys

- High Production Capacity: Capable of producing several thousand parts.
- Superior Surface Finish: Ensures excellent surface quality for all components.
- Enhanced Mechanical Properties
- Delivers robust mechanical characteristics for durability and performance

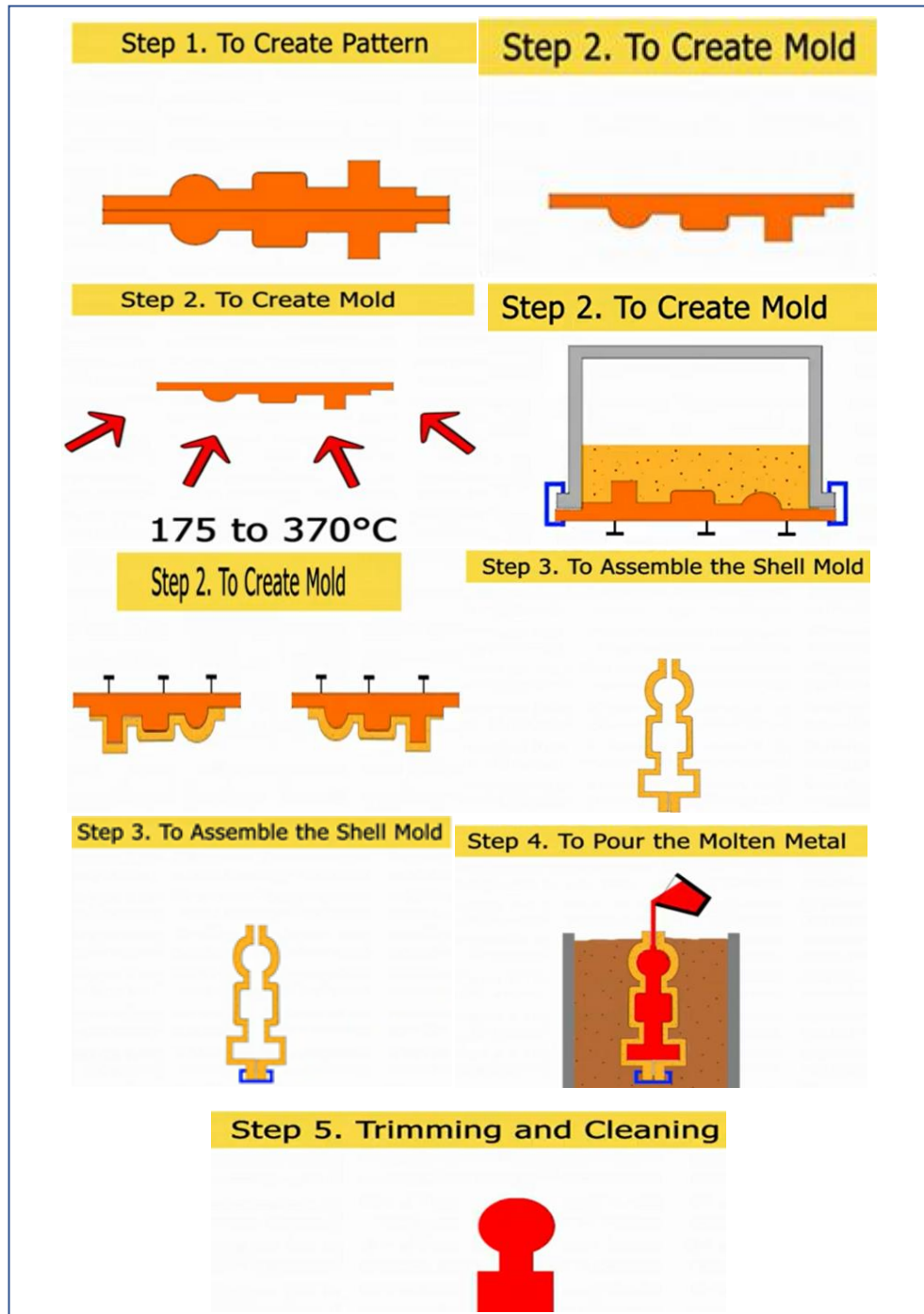


Figure2. Shell molding in casting process

A.3. Pressure casting

Pressure casting is a manufacturing process where molten metal (or resin) is forced into a mold under high pressure to create precise, strong, and repeatable metal or plastic parts.

- Principle similar to shell casting, except that the alloy is injected into the mold via a piston or cylinder
- Technology used in large series
- Good surface condition of parts
- Possibility of producing thin-walled parts

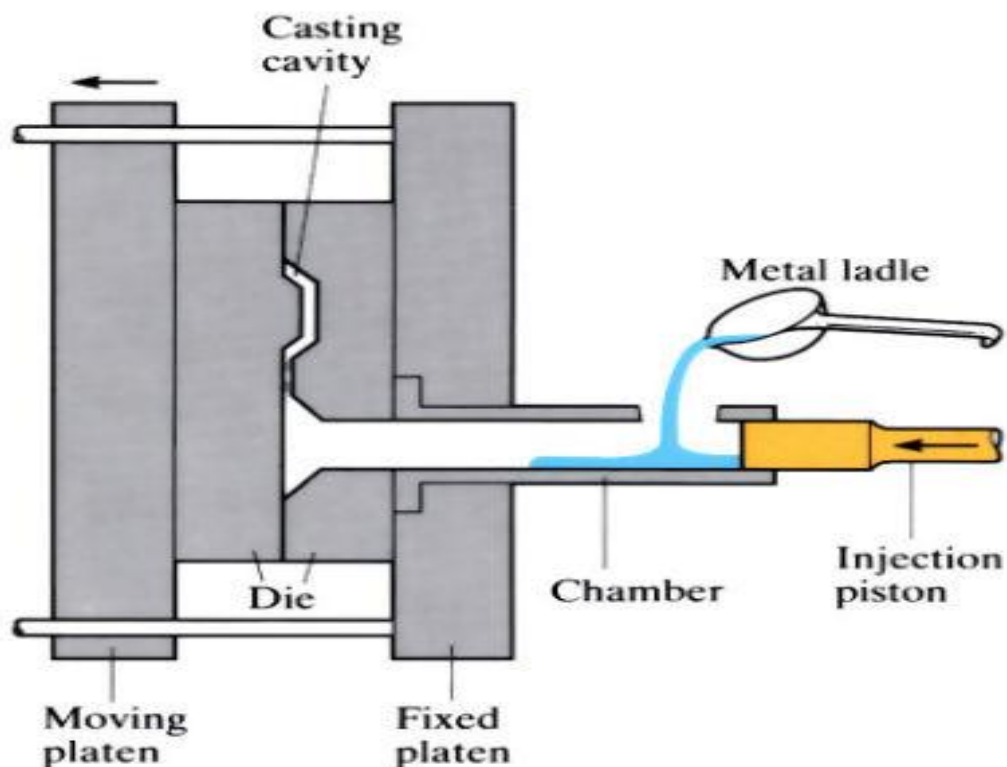


Figure 3. Pressure casting component and process

➤ https://www.youtube.com/watch?v=73_s7nUk

2.2. By plastic deformation

Deformation manufacturing processes consist of plastically deforming the material until the desired shape is obtained. These processes may occur: hot or cold.

2.2.1. Processes may occur hot

A. Forging

Forging is basically involves plastic deformation of material between two dies to achieve desired configuration. It can be manual or mechanical

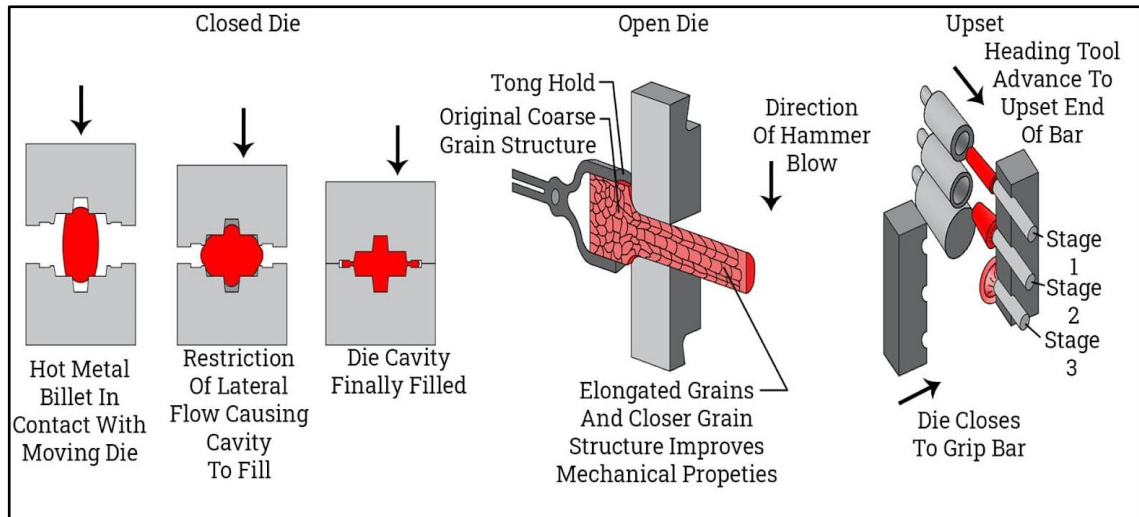


Figure 4. Forging process

Mechanical forging

➤ <https://www.youtube.com/watch?v=LBFPwctQII0>

Manual forging

➤ https://www.youtube.com/shorts/ffiCR_vtVwA

B. Stamping

Stamping is a metal shaping process where a workpiece is placed into a die and then subjected to force, typically through hammering, to adopt the die's shape. This technique can be categorized into two main types: pressure stamping, which applies gradual force, and shock stamping, which uses a sudden impact to achieve the desired form. Stamping offers all the typical advantages of the forging manufacturing process. The most important are:

- A good surface finish
- Improved mechanical properties
- Recyclable burrs
- Improved metal strength due to grain alignment along potential stress zones

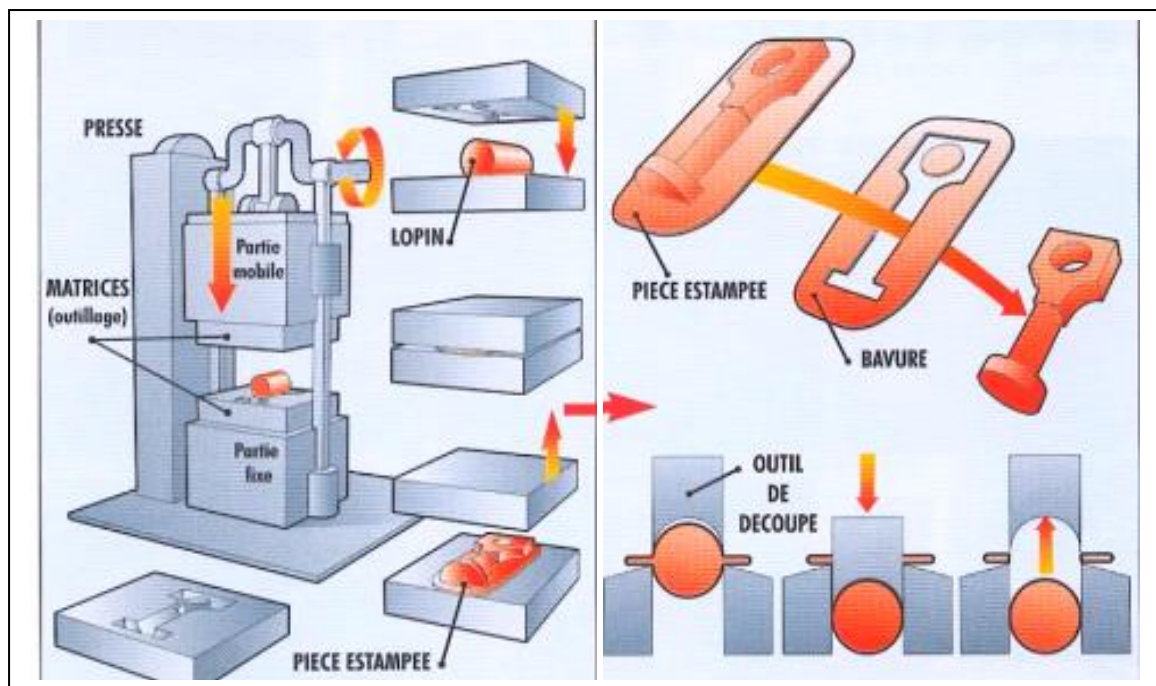


Figure 5. Stamping process

Shock stamping

➤ <https://www.youtube.com/watch?v=jCzJpGYVIGY>

Pressure stamping

➤ <https://www.youtube.com/watch?v=73KCUNqZY>

2.2.2. Processes may occur cold and hot

A. Rolling process

Deformation process in which work thickness is reduced by compressive forces exerted by two opposing rolls. The rollers sometimes have a specific shape in order to modify the shape of the part produced.

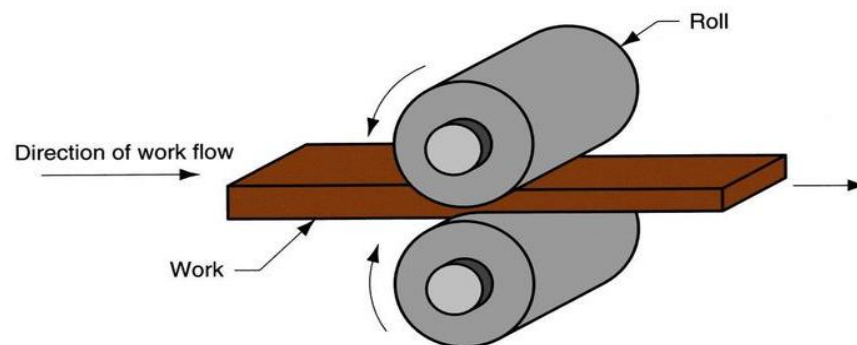


Figure 6. Rolling process

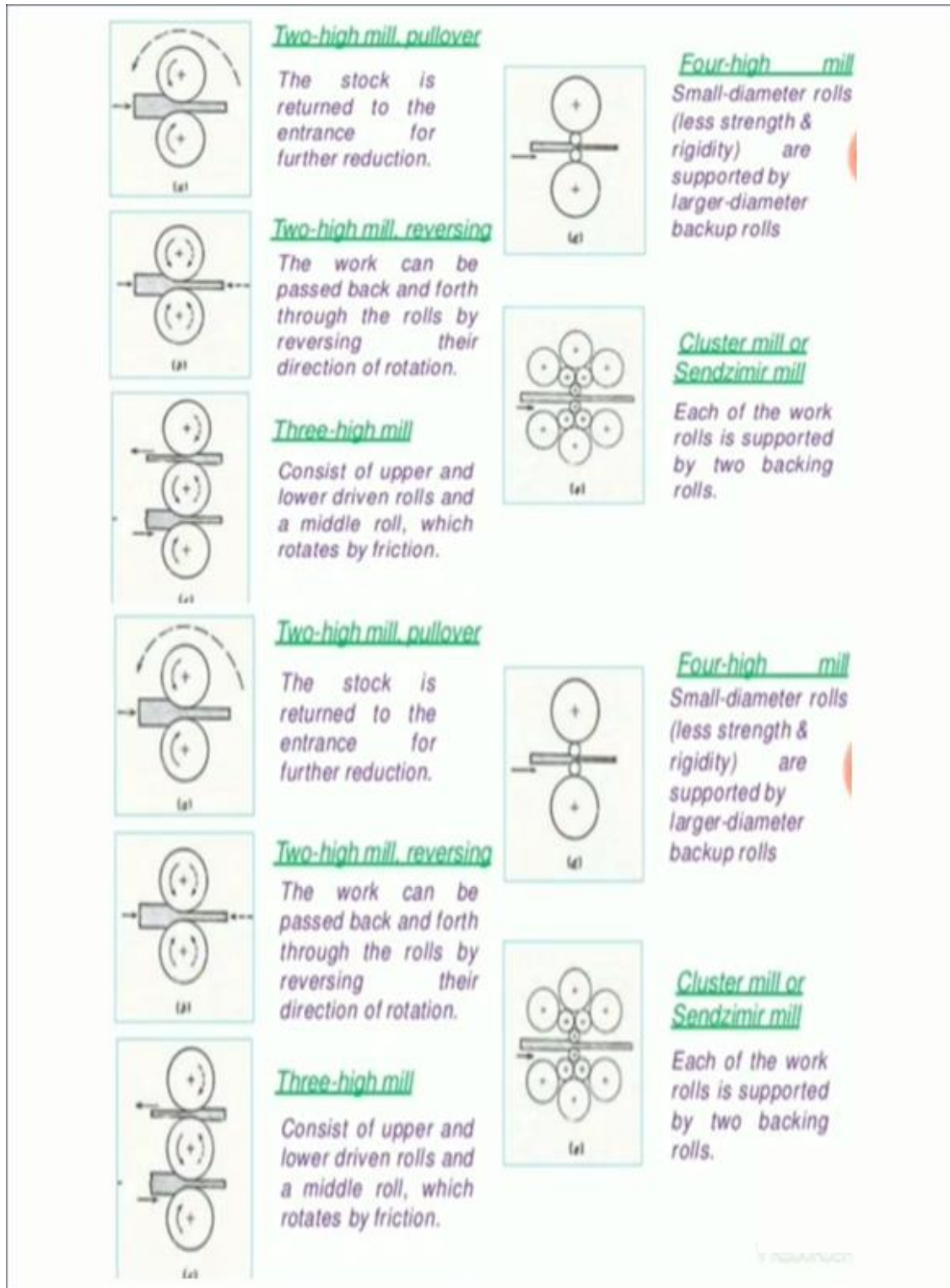


Figure 7. Typical arrangement of rollers for rolling mills

Cold rolling

➤ <https://www.youtube.com/watch?v=jCzJpGYVIG>

Hot rolling

➤ <https://www.youtube.com/watch?v=EFLUMf8sr>

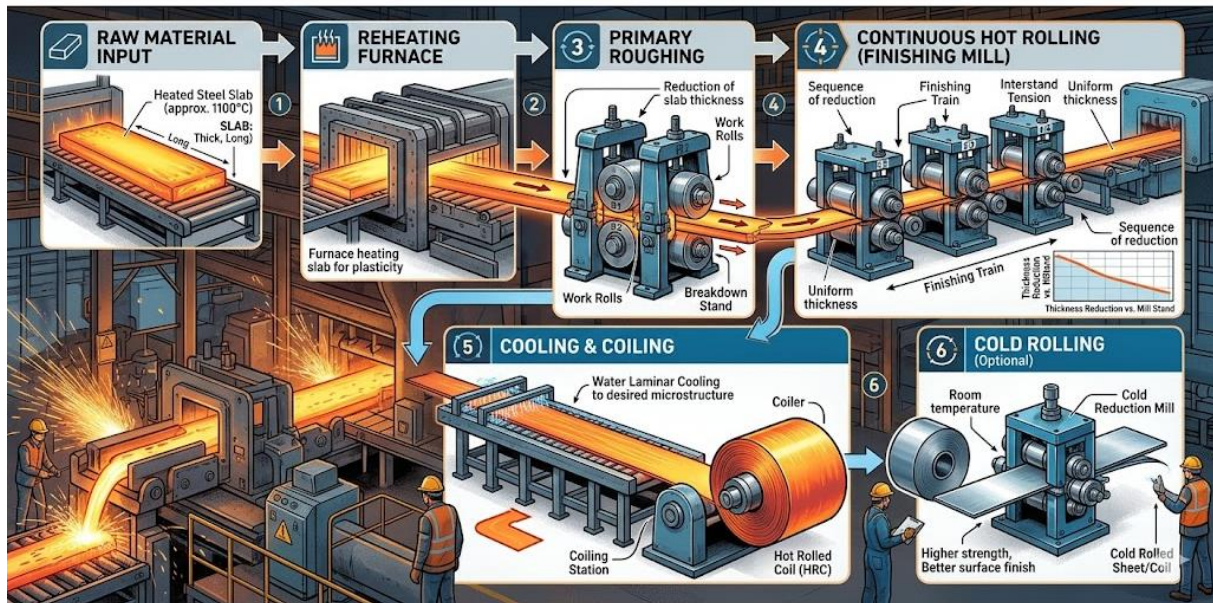


Figure 8. The Metal Rolling Process: From Slab to Product

- **Differences between hot rolling and cold rolling**

- Advantages

Hot rolled steel, having a higher tolerance, allows for greater malleability; while cold rolled steel is limited to certain limited shapes, such as flat, square and round.

- Applications

Hot rolled steel is mainly used in:

- Metal buildings
- Railway tracks
- Heavy vehicle parts
- Building structures
- Other uses not requiring precise shapes

Cold rolled steel is mainly used in

- Machine parts
- Metal furniture
- Filing cabinets
- Tables
- Exhaust pipes
- Chairs
- Household appliances

- Shelves and other similar products

B. Extrusion

Extrusion is a process to create a specific shaped object by pushing a material through a die. The die is a little disk with an opening of a specific size and shape. When the material is put under pressure through the die, it will create a desired shape. Often the die is made of steel. There are two methods of extrusion: hot and cold.

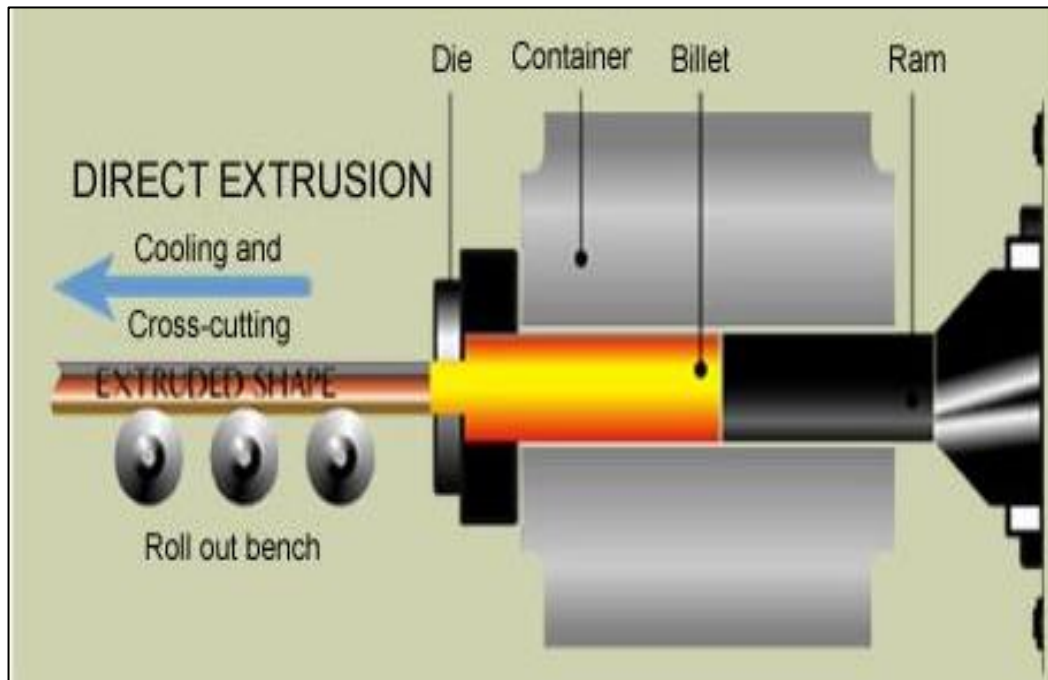


Figure 9. extrusion process and component

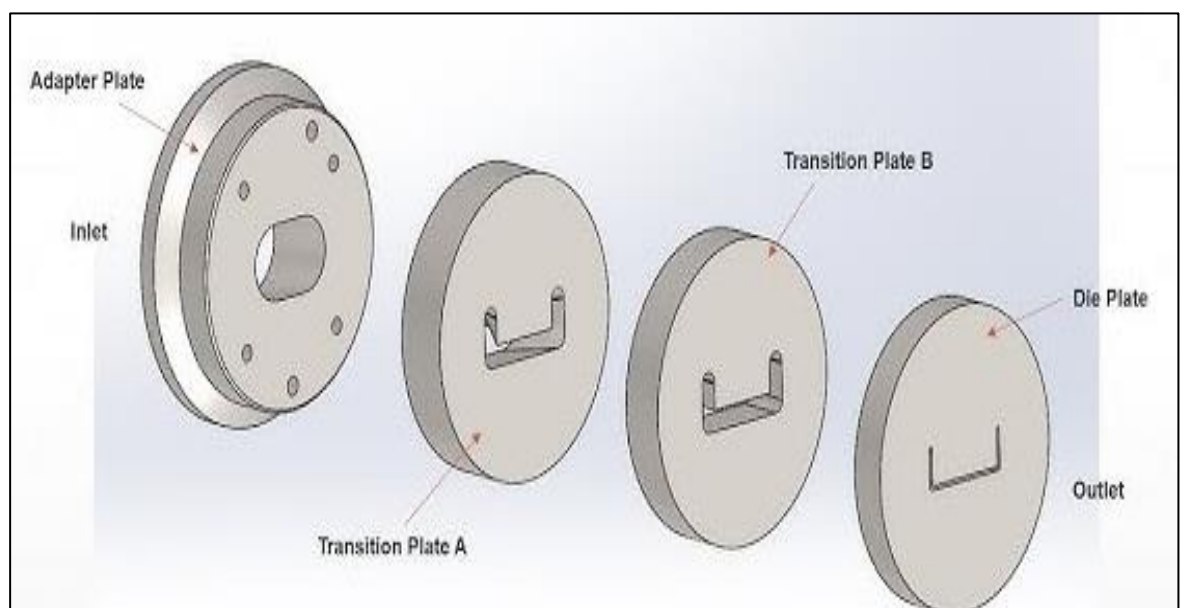


Figure 10. Die assembly for plastic extrusion

Cold extrusion

➤ <https://www.youtube.com/watch?v=Y75IQksBb0M>

Hot extrusion

➤ <https://www.youtube.com/watch?v=ETz2WiX6tMI>

C. Deep drawing

Deep drawing is a metal forming process for creating seamless, sheet metal parts that are closed on one end and have a depth greater than their radius. Deep drawn parts achieve their shape by drawing metal into a cavity rather than by stretching or thinning over a die, so the original sheet thickness remains essentially the same from start to finish. A deep drawn part can be recognized by its depth and its smooth, radiused corners. Examples range from cans, pots, kegs, and compressed gas cylinders to eyelets, sinks, and automotive body panels. Simple parts can be drawn to their finished shape in a single step while complex shapes, including parts that are especially deep, may require multiple steps. Deep drawing typically is used in combination with other techniques like blanking and piercing to create a finished product. In some cases, all steps can be completed using a single press.

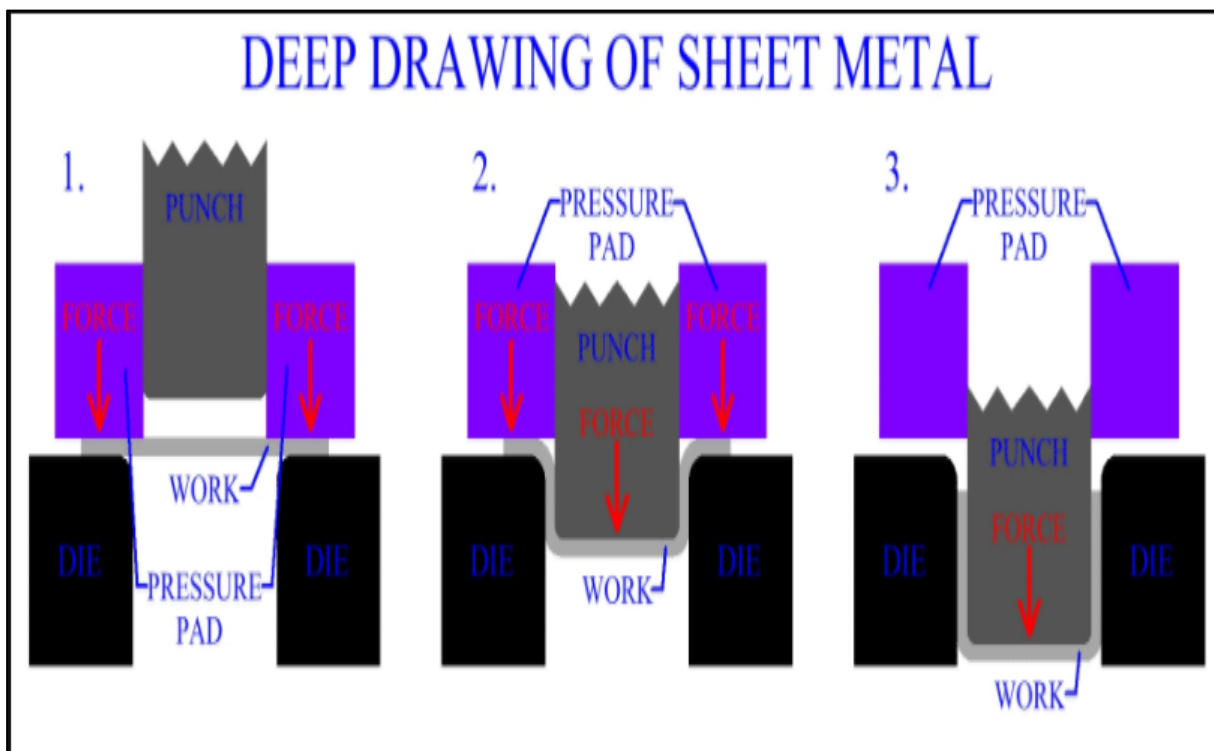


Figure 11. Deep drawing process

Hot deep drawing

➤ <https://www.youtube.com/watch?v=7E7pqyiuGX0>

Cold deep drawing

➤ <https://www.youtube.com/watch?v=8TJareY7bS8>

2.2.3 Processes may occur cold

A. Wire drawing

Wire drawing is a cold plastic deformation process by which the diameter of a rod or a wire is reduced and its length is increased by pulling the workpiece through a calibrated hole of a conical die. In drawing, the cross section of a long rod or wire is reduced or changed by pulling it through a die called a draw die. Thus, the difference between drawing and extrusion is that in extrusion the material is pushed through a die, whereas in drawing it is pulled through it. Although the presence of tensile stresses is obvious in drawing, compression also plays a significant role because the metal is squeezed down as it passes through the die opening. For this reason, the deformation that occurs in drawing is sometimes referred to as indirect compression. Drawing is a term also used in sheet metalworking. The term wire and bar drawing is used to distinguish the drawing process discussed here from the sheet metal process of the same name. Rod and wire products cover a very wide range of applications, including shafts for power transmission, machine and structural components, blanks for bolts and rivets, electrical wiring, cables.

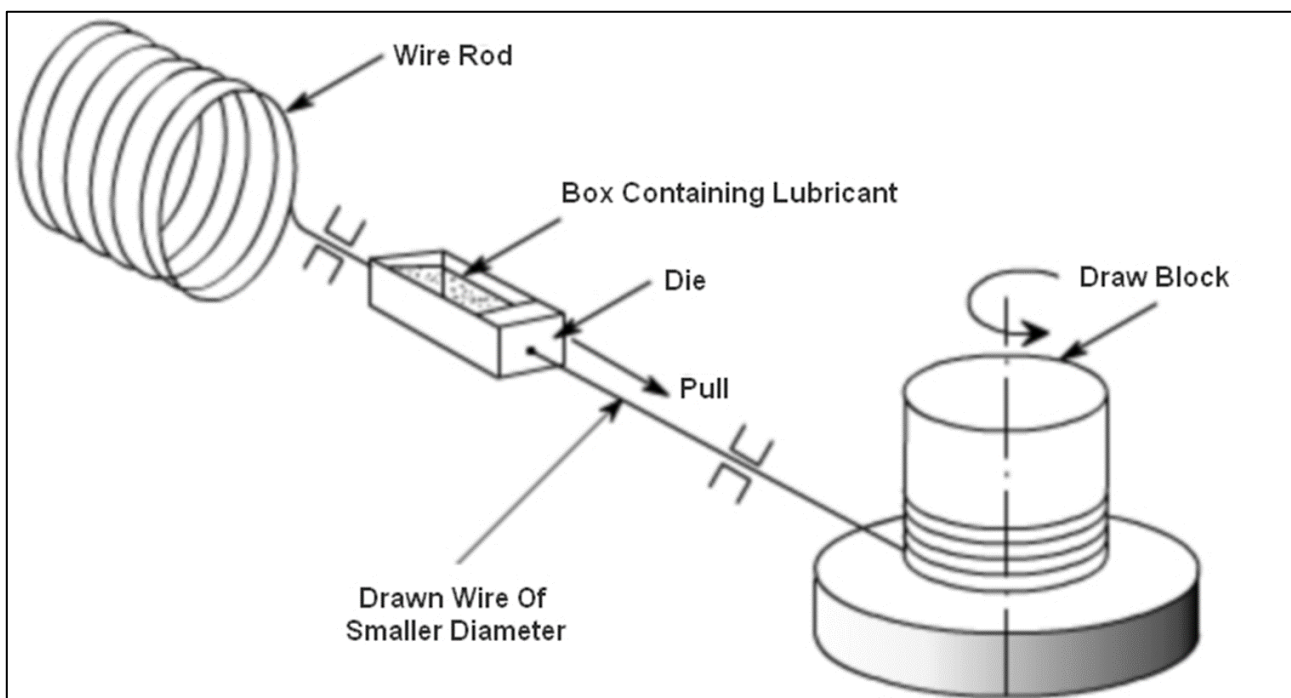


Figure 12. Wire drawing process



Figure 13. Real photo of die and wire machine

➤ <https://www.youtube.com/watch?v=JSVz-RC6pje>

B. Bending

The metal is generally placed in a machine called a folder press. Most companies specializing in metal bending are capable of working with a variety of different metals, including:

- Steel;
- Galvanized steel;
- Stainless steel;
- Aluminum;
- Copper;
- Brass.
- Advantages
 - Speed and Efficiency: This process allows for the quick production of parts. Modern machinery, such as CNC press brakes, can create numerous parts in a short amount of time, making it ideal for mass production.
 - Précision: Also, it can achieve high levels of precision, especially with advanced CNC technology. This ensures that parts meet strict tolerances, which is crucial for applications requiring exact specifications.
 - Répétabilité: Once set up, bending machines can produce identical parts consistently. This repeatability is enhanced by automation, suitable for lights-out operations.
 - Rentabilité: Bending is generally an economical process, especially for high-volume production. It reduces material waste and minimizes the need for additional machining or finishing processes.

- Polyvalence: Moreover, it can accommodate a wide variety of shapes and materials, including different types of metals like steel, aluminum, and copper alloys. This versatility makes it suitable for various industries.
- Reduced Complexity: By creating complex shapes from a single piece of material rather than multiple parts with joints, bending simplifies assembly and reduces potential failure points.
 - Disadvantages
- Thickness Limitations: Thicker materials often require larger bend radii, which can limit the complexity of the bends that can be achieved. However, tight bends are generally better suited for thinner sheets.
- Noise and Dust: The bending process can generate significant noise and produce metal shavings or dust, which may pose challenges in terms of workplace safety and comfort.
- Safety Concerns: Operating bending machinery carries inherent risks, including potential injuries from moving parts or heavy materials. Proper training and adherence to safety guidelines are essential to mitigate these risks.
- Material Stress: Bending can induce stress at the bend point in some materials, potentially leading to cracking or deformation if not managed properly.
-

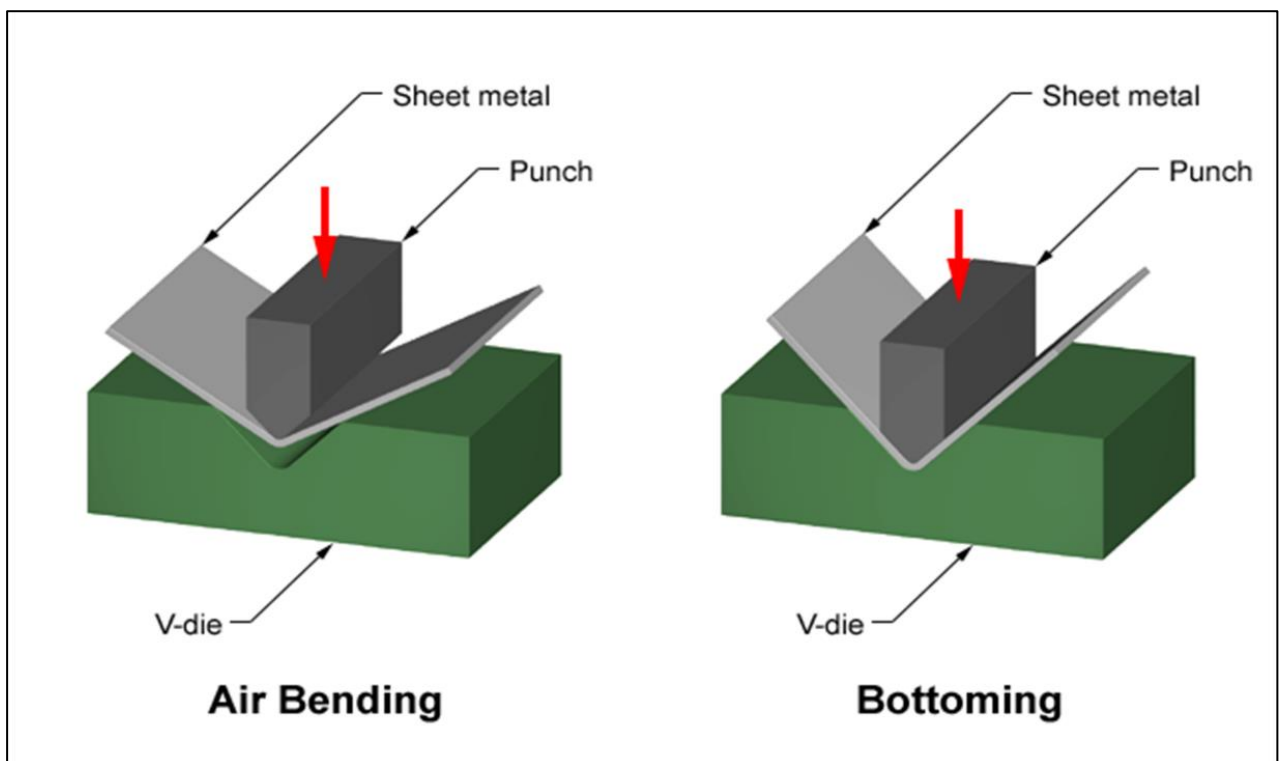


Figure 14. bending process

C. Cutting

Cutting is an operation where a piece of metal is cut according to a profile or specific dimensions. There are many cutting techniques. They are chosen according to the nature and size of the materials to be worked. These processes are:

- Oxycutting
- Waterjet cutting
- Laser cutting
- Plasma cutting

C.1. Oxycutting (Oxy-fuel cutting)

Oxy-fuel cutting is a thermal cutting process for materials. This technique uses the heat of a flame produced by a mixture of oxygen and acetylene using a torch similar to that used for oxyacetylene welding. The torch has a central nozzle through which oxygen escapes and concentric holes from which acetylene emerges.

Combustion gas mixture [1] (figure 15) is burned at the cutting nozzle with the purpose of heating the material to the ignition temperature. Pure oxygen gas is supplied through the center of the die [2], which supplies the additional energy needed to carry out the actual cutting. This cutting beam [3] helps to melt and burn the material, and thus creates a cut in the workpiece [4]. Material residues is pushed away from the section of the oxygen gas in the form of a slag stream [5].

The oxygen purity and outflow rate, which is largely influenced by nozzle design, greatly affects gas cutting results.

What fuel gas is chosen depends on several factors such as thickness of the workpiece and the time for heating. Cutting with multiple parallel cutting heads

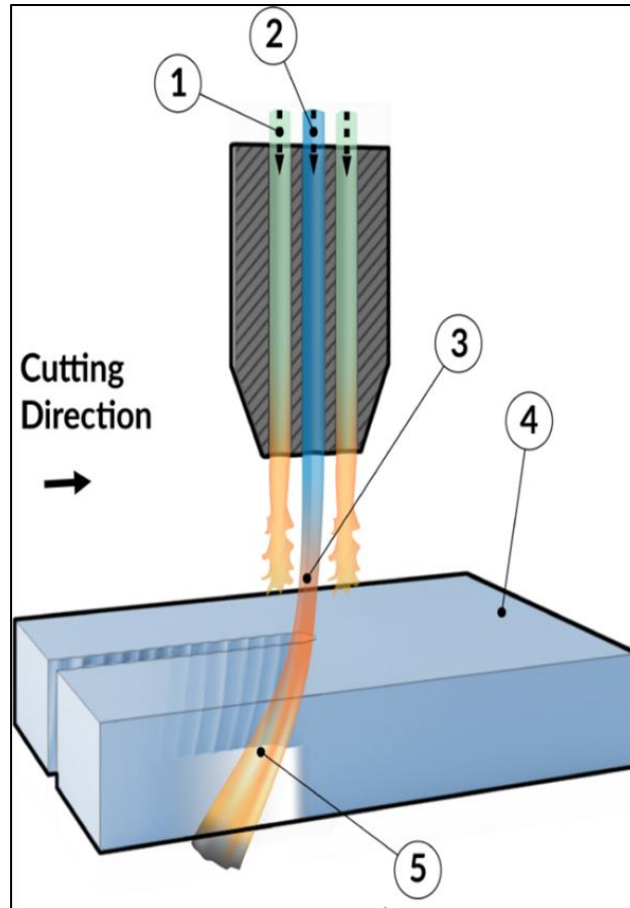


Figure 15. oxy-cutting process

Step 01. <https://www.youtube.com/watch?v=EoqcZRTYHII>

Step 02. <https://www.youtube.com/watch?v=G7IpMINO3FA>

Step 03. <https://www.youtube.com/watch?v=-cy-49TXatg>

Step 04. https://www.youtube.com/watch?v=Ack3H_pwyG8

C.2. Water jet cutting

The principle of this technique consists of projecting a stream of water at a very high speed, between 600 and 900 m/s through a nozzle with a small diameter of between 0.05 and 0.5mm. To cut the material, the water jet pressure needs to reach up to 4000 bars. The cutting process works by tearing the material apart.

For more difficult or harsh materials, an abrasive is added to the water jet.

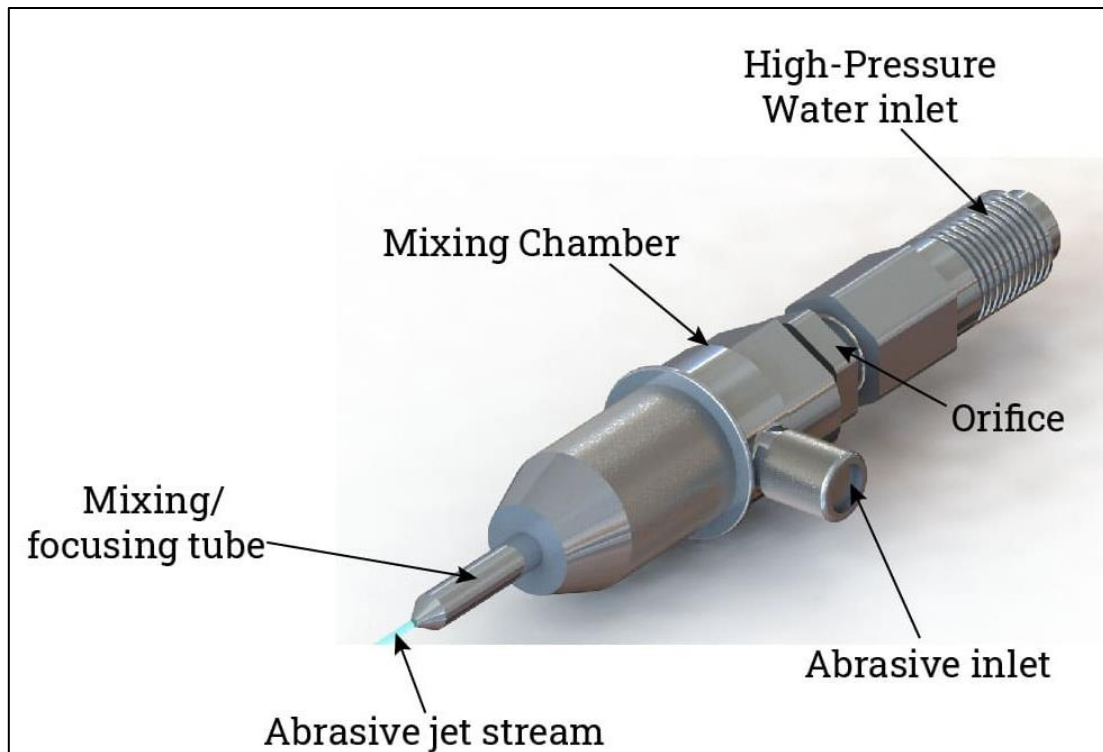


Figure 16. Water jet cutting head

https://www.youtube.com/watch?v=5XZ6oLpV_KM

C.2. Laser cutting

Laser cutting is a manufacturing process that involves cutting material using a large amount of energy generated by a laser and concentrated on a very small surface area.

- The profile file of the part to be manufactured is uploaded into the machine, allowing the laser to trace the cutting path.
- Material selection is based on strength and thickness considerations.
- The laser then follows the 2D plan to cut the material until the part is complete.
- Once finished, the part is retrieve

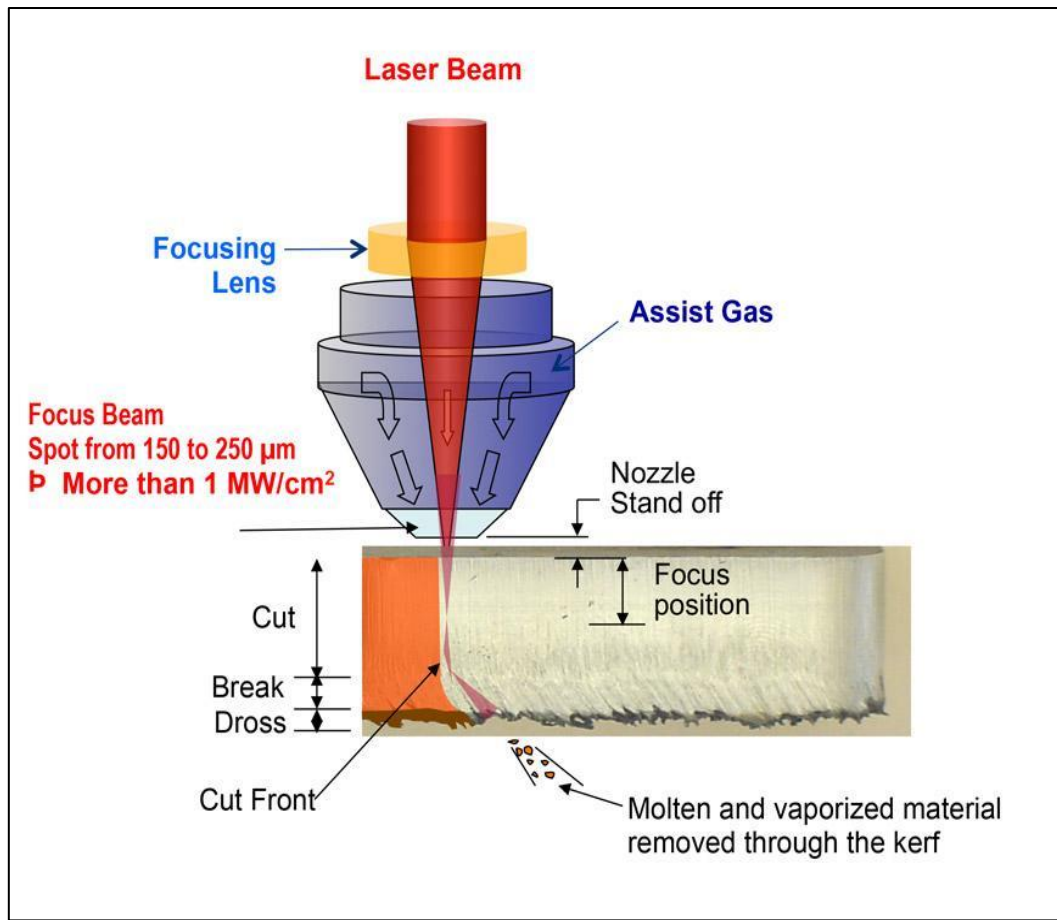


Figure 17. Laser cutting operation

➤ <https://www.youtube.com/watch?v=3lLFX9Xu-0>

C.3. Plasma cutting

The basic principle is that the plasma arc is formed between the electrode and the work piece through a constricting fine bore copper nozzle. This will increase the speed and temperature of the plasma exiting the tip. The temperature of the plasma is in excess of 15000°C and the speed can approach that of sound. This plasma gas flow in conjunction with the high temperature enables a deeply penetrating plasma jet to cut through the work piece material and at the same time molten material is blown away from the cut.

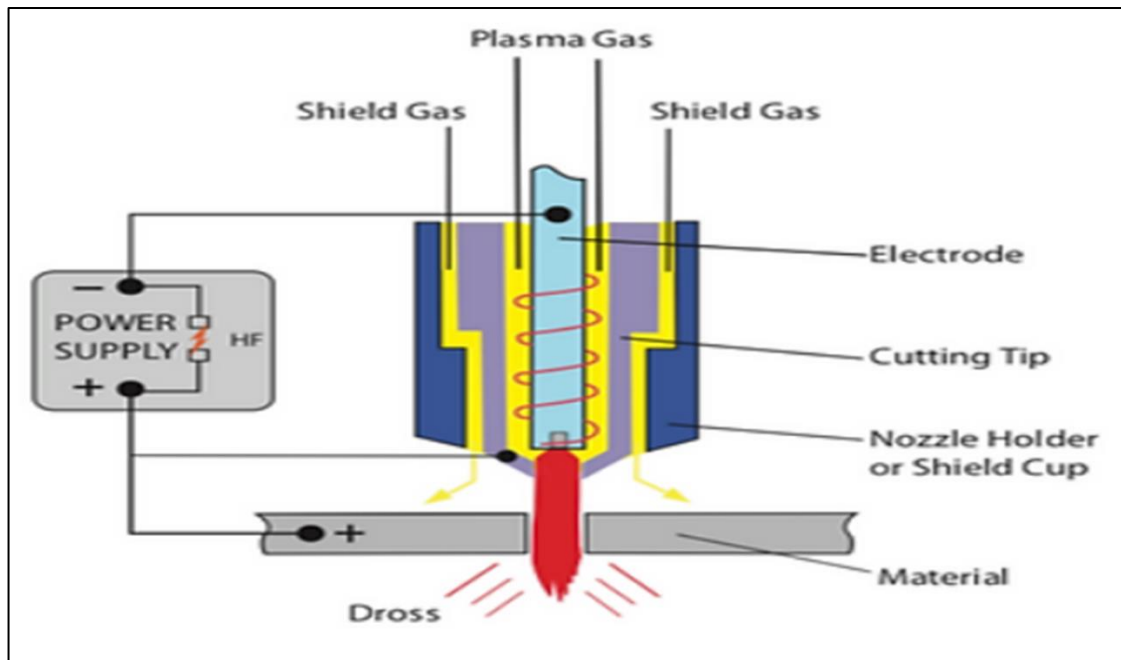


Figure 18. Plasma cutting operation

2.3. Sintering and powder metallurgy

This process consists of compression and sintering to obtain a final part adapted to specific needs. From the agglomeration of very fine powders, a tablet is produced with a shape very close to the desired one. We then seek to control the cohesion of the powder with a sintering heat treatment. This technique is often used when certain materials are difficult to fuse or not very plastically deformable.

It is used specifically in specific families of parts:

- Those where we are looking to obtain metallic products with controlled porosity of complicated shapes;
- That composed of refractory metals having good resistance to heat,
- That of alloys that cannot be obtained in foundries, in particular tungsten or certain magnetic materials such as soft magnetic metal-ferrite composites.
- We thus find cermets composed of "coarse" ceramic particles distributed in a metal matrix.
- That of electrical contact materials. Examples include contact pads made from silver or copper
- That of friction materials that make up brake pads or clutch discs

A. The process involves several stages:

- **Starting with the development of powders.**

The grains can range in size from 1 to 1000 microns, achieved through mechanical grinding of hard metals like molybdenum (Mo) and chromium (Cr). Thus the production can come from a liquid phase by atomization of aluminum or copper. The atomization process is defined as a drying operation which consists of transforming a liquid sprayed in the form of droplets in reaction with a hot gas into powder.



Figure 19. Metallic powder

- **Powder compaction:**

This operation is mandatory in order to reduce porosity. A uniaxial pressure between 200 and 1500 MPa is applied to the powder. The compacted part is then ejected from the tooling, it is then a “green part”, which has a certain mechanical consistency and can be handled (with care).

- **Powder sintering**

This step consists of forming while respecting the continuity of the solid. It is a process activated by atomic diffusion in the solid state at a temperature of 60% to 80% of that of fusion for a variable duration depending on the material studied. This energy is activated between contact surfaces of the powder grains and the shape of the pores is deformed until it is completely reduced.

*Overall, the process must be very controlled due to the permanent risks of oxidation.

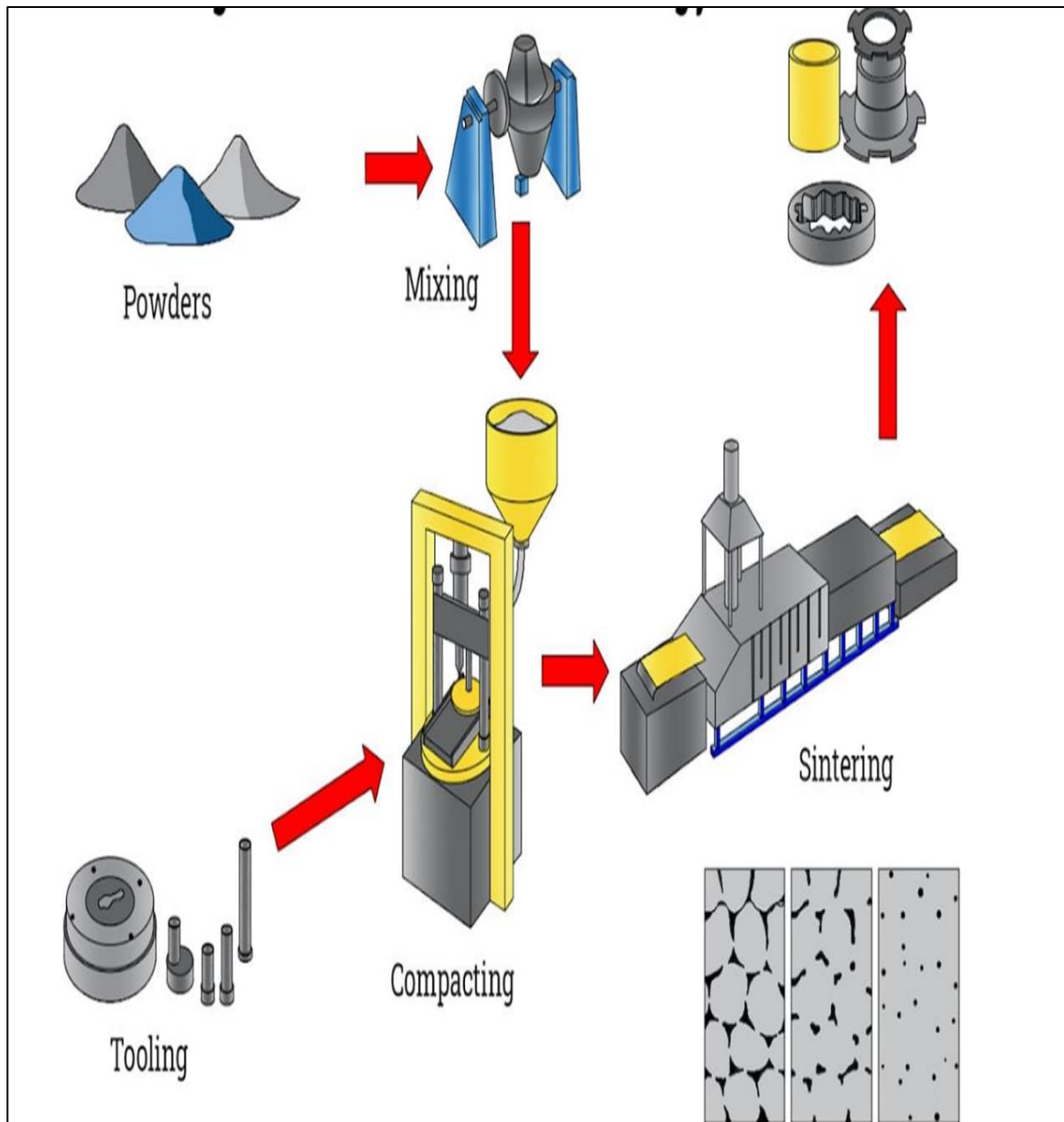


Figure 20. Stages of the powder metallurgy process

➤ <https://www.youtube.com/watch?v=N4-kfSD6XJI>

2.4. Profiles and Pipes

The concept of pipes means sections with a closed structure, generally with a circular cross-section and a constant and symmetrical wall thickness along the entire length of the tube.

Steel pipes: These are generally made of galvanized steel sheets, which are well protected against corrosion. The sheet is cut to the right size according to the specifications provided by the recipient, then rolled to the desired diameter and welded or welded along the edges. The tubes are produced using the diagonal rolling method.

Aluminium pipes: The pipes made from it are produced by extrusion, while being processed until the required diameter, shape and length are obtained.

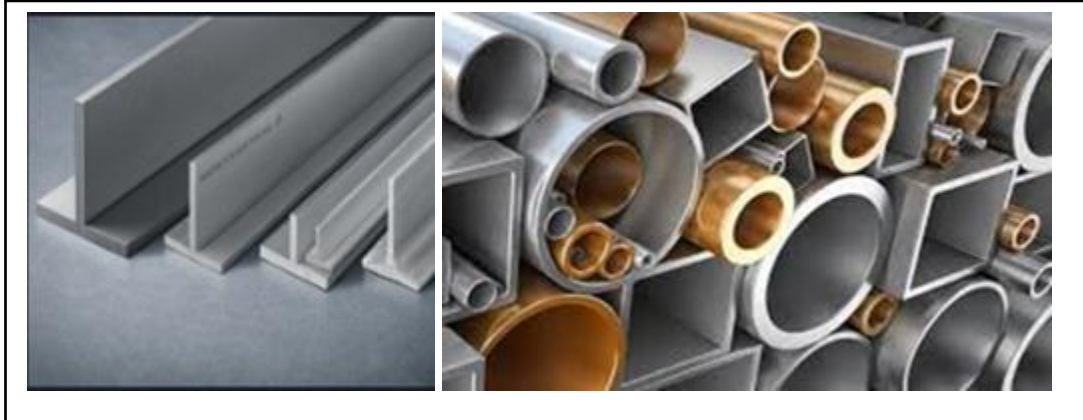


Figure 21. Profiles and Pipes

By rolling method

➤ https://www.youtube.com/shorts/PWBrg_nLwok

By extrusion method

➤ <https://www.youtube.com/watch?v=cfbRrkMsv4k>

Material removal machining is therefore that which removes or cuts the material from a part with a tool giving rise to this excess material, which is separated from the part with the same tool. There are two categories :

- Non-traditional
 - Traditional

- **Advantages of material removal machining**

- Delivers exceptionally tight tolerances, ensuring high dimensional accuracy.
- Produces parts with sharp corners and precise details.
- Maintains the inherent mechanical properties of the material.
- Offers versatile operational capabilities.
- Cost-effective compared to alternative manufacturing processes.
 - **Limitations of machining by material removal**
- Produces surplus material that can be challenging to recycle.
- Typically, the size of the part is constrained.
- Certain machining processes necessitate additional deburring to achieve a polished finish.
- Often requires significant time.

3.1 Traditional methods

3.1.1. Turning

Turning is a machining process in which a cutting tool removes material from the surface of a rotating workpiece to create cylindrical shapes. This process is typically performed on a lathe, where the workpiece is spun at high speeds while the cutting tool moves along its length or across its diameter.

Machines used for turning operations are called lathes. The types of lathes used in industry are very numerous. They are distinguished from each other by :

- Their shapes,
- Their dimensions,
- Their machining precision,
- Their powers,

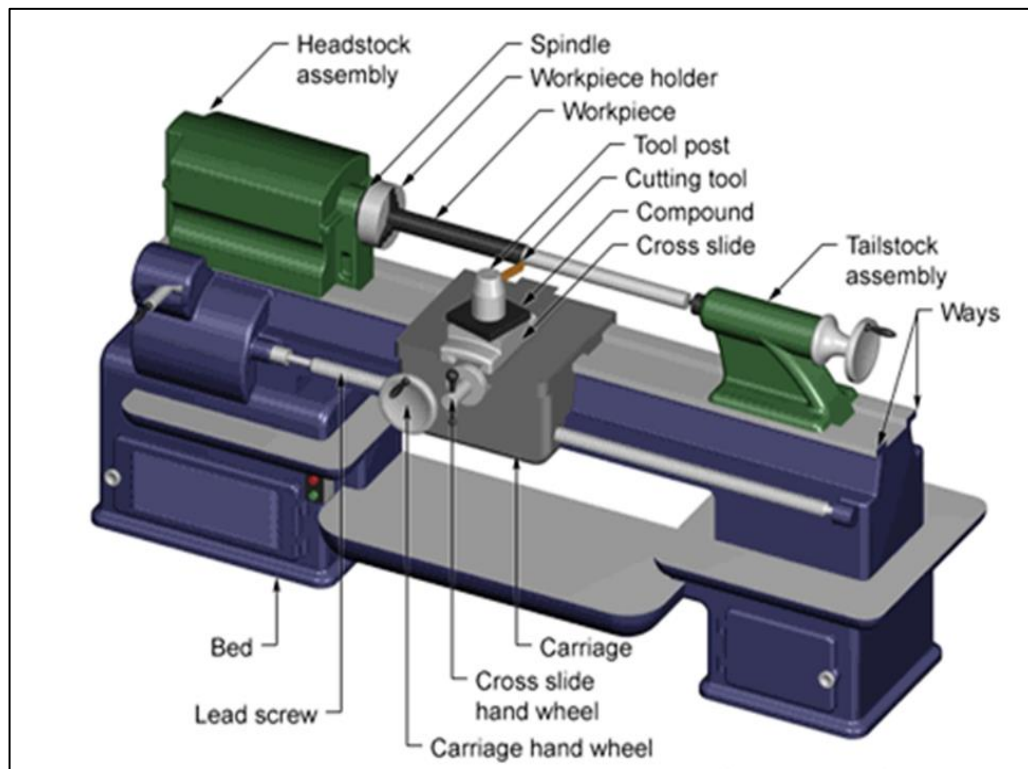


Figure 22. turning machine

A. Terminology of the main organs of the lathe

Tailstock assembly: the tailstock assembly is the rear section of the machine that is attached to the bed. The purpose of this assembly is to support the other end of the workpiece and allow it to rotate, as it's driven by the spindle. For some turning operations, the workpiece is not supported by the tailstock so that material can be removed from the end.

Carriage: the carriage is a platform that slides alongside the workpiece, allowing the cutting tool to cut away material as it moves. The carriage rests on tracks that lay on the bed, called "ways", and is advanced by a lead screw powered by a motor or hand wheel.

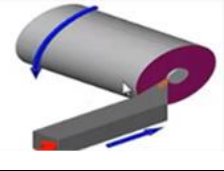
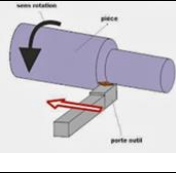
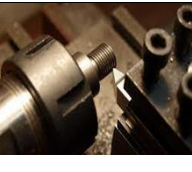

Cross slide : the cross slide is attached to the top of the carriage and allows the tool to move towards or away from the workpiece, changing the depth of cut. As with the carriage, the cross slide is powered by a motor or hand wheel.

Compound : the compound is attached on top of the cross slide and supports the cutting tool. The cutting tool is secured in a tool post which is fixed to the compound. The compound can rotate to alter the angle of the cutting tool relative to the workpiece.

B. Turninig operation

The following table.7 summarizes all the turning operations :

Table 7. Turning operation

Operation turning	Corresponding photo
<p>Facing: A single-point turning tool moves radially, along the end of the workpiece, removing a thin layer of material to provide a smooth flat surface.</p>	
<p>Turning : A single-point turning tool moves axially, along the side of the workpiece, removing material to form different features.</p>	
<p>Drilling: a drill enters the workpiece axially through the end and cuts a hole with a diameter equal to that of the tool.</p>	
<p>Thread: a single-point threading tool, typically with a 60 degree pointed nose, moves axially, along the side of the workpiece, cutting threads into the outer surface.</p>	
<p>Boring : a boring tool enters the workpiece axially and cuts along an internal surface to form different features, such as steps, tapers, chamfers, and contours. .</p>	
<p>Grooving: a single-point turning tool moves radially, into the side of the workpiece, cutting a groove equal in width to the cutting tool.</p>	
<p>Chamfering: Operation which consists of machining a small cone in order to remove an angle.</p>	
<p>Cut-off (parting): similar to grooving, a single-point cut-off tool moves radially, into the side of the workpiece, and continues until the center or inner diameter of the workpiece is reached,</p>	

knurling : a knurling tool is used to press a pattern onto a round section. The pattern is normally used as a grip for a handle.

Apprentice engineers often manufacture screwdrivers. These have patterned handles, to provide a grip and this achieved through the technique called knurling.



C. Advantages of the Turning Process

The advantages of the turning process are as follows:

- All Materials Are Interchangeable.
- Tolerance is Excellent.
- The Lead Time is Short.
- There is No Need for a Highly Skilled Operator.
- The Pace of Material Removal is Adjustable

D. Disadvantages of the Turning Process

The disadvantages of the turning process are as follows:

- Only Rotatable Components Are Permitted.
- Parts May Need Many Procedures and Machines.
- Expensive Equipment.
- Tool Wear is Significant.
- It Creates a Substantial Amount of Scrap

Turning operation overview

<https://www.youtube.com/watch?v=-J3wN1ruDZM>

3.1.2. Milling

Milling is a type of machining process that uses a rotating cutter to remove material in a controlled manner from a workpiece. This subtractive manufacturing technique aims to turn the workpiece into the required shape. The main working part of a milling machine is the rotary cutting tool. This cutting tool is responsible for the material removal process. Milling machines can utilize both single-point and multi-point cutting tools.

The cutting tool in milling moves perpendicular to the rotational axis. For instance, if the cutting is rotating in the X-Y plane around the Z-axis, the movement of the cutter also occurs

in the X-Y plane. The workpiece meets the cutter at the rotating tangent, resulting in the material removal process.

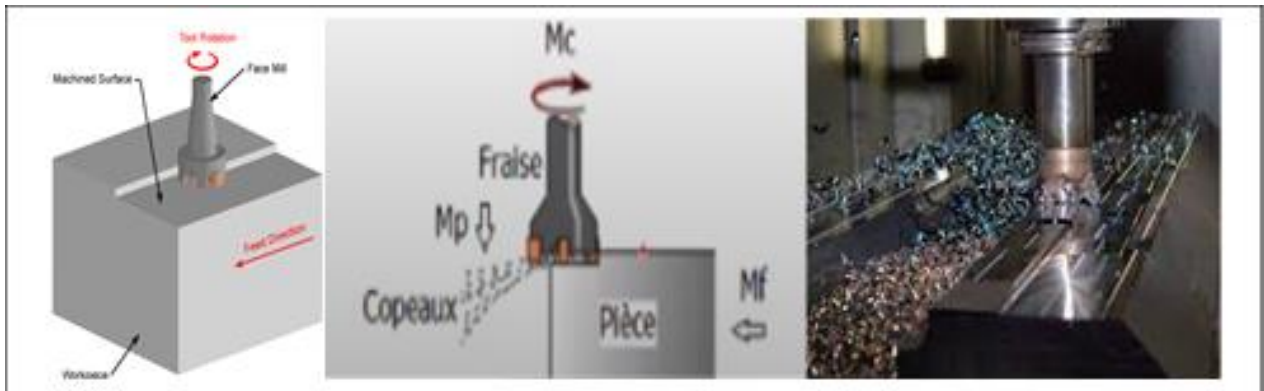


Figure 23. Milling

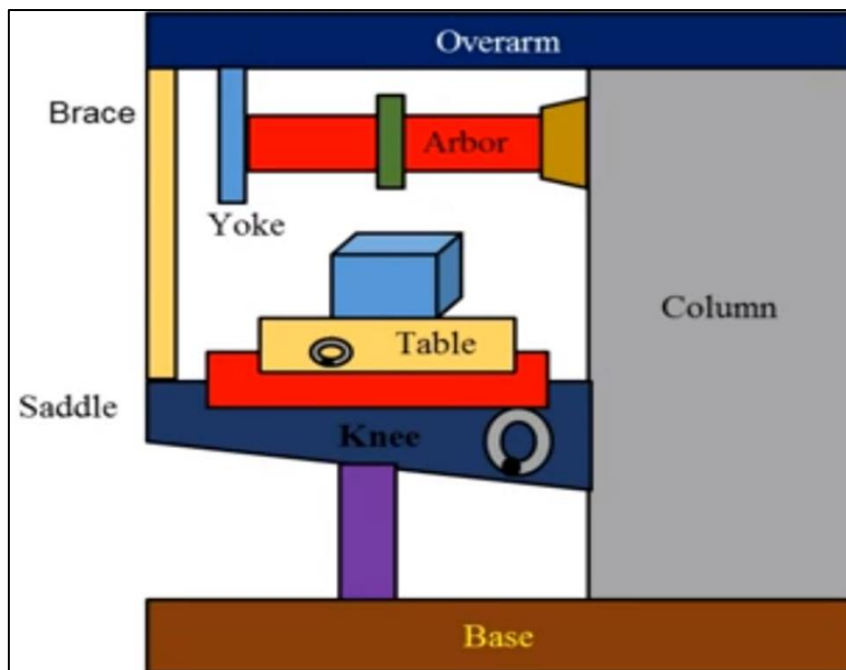


Figure 24. Components of milling machine

A. Classification of milling machine

A.1. According to nature of purpose of use

- **General purpose** : most versatile commonly used mainly for piece or small lot production.
- **Single purpose** : thread milling machine cam milling machines and slitting machine which are generally used for batch or lot production.

- **Special purpose** : these are used for lot or mass production, e.g duplication mills die sinkers, short thread milling etc.

A.2. According to configuration and motion of the work holding table/ bed

- Knee type
- Bed type
- Planer type
- Rotary type

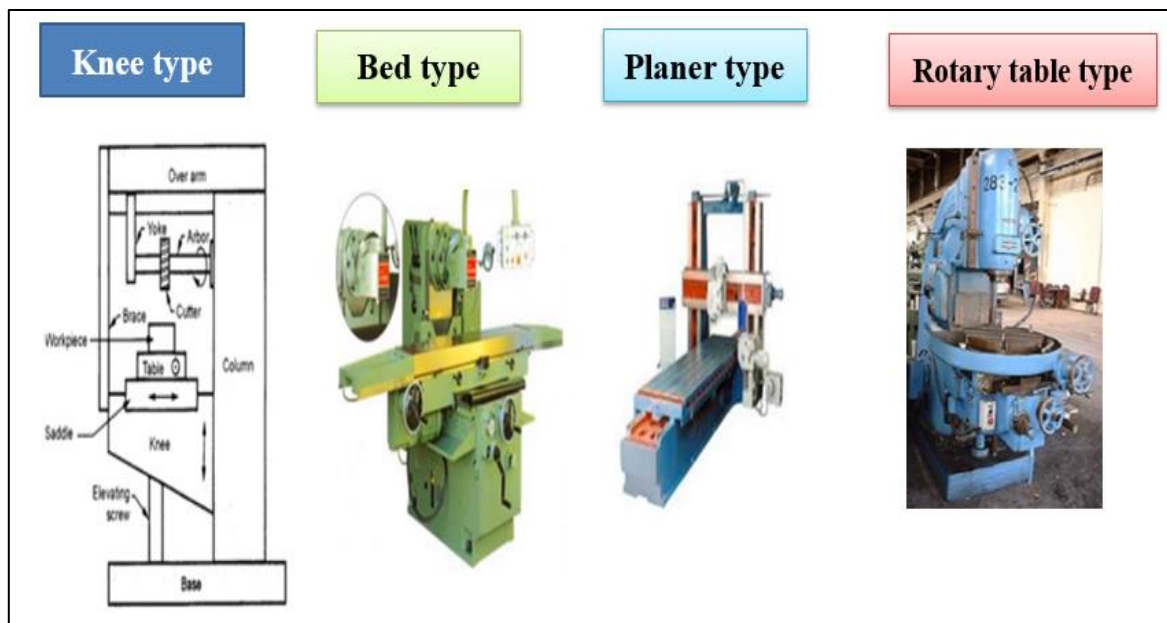


Figure 25. Types of milling machine

A.3. According to automation and production rate

- Hand mill
- Planer and rotary table
- Tracer controlled copy milling machine
- Milling machine for short thread milling

A.4. According to the orientation of the spindle

- Horizontal milling machine
- Vertical milling machine
- Universal milling machine
- CNC (stands for Computer Numerical Control) milling machine

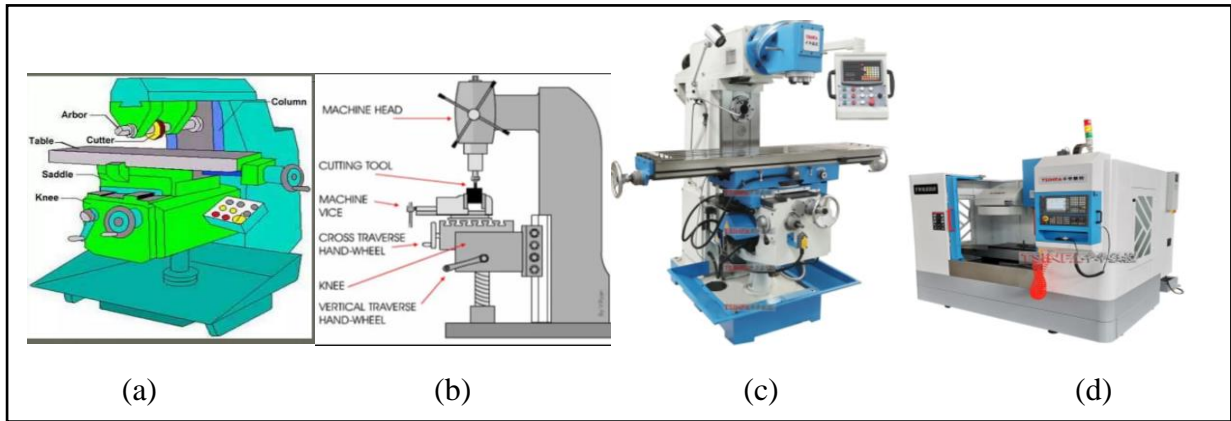
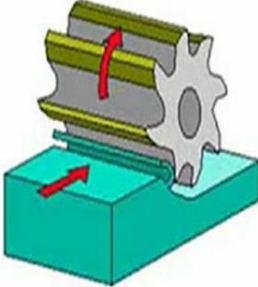
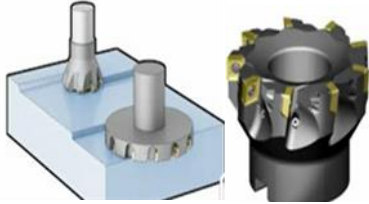


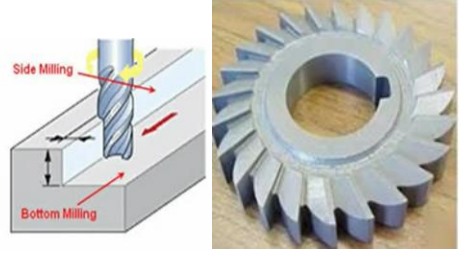

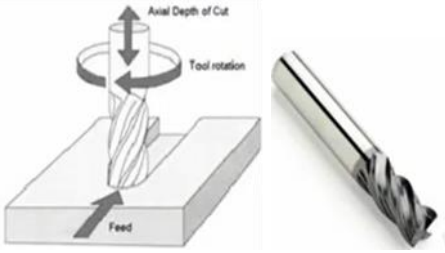
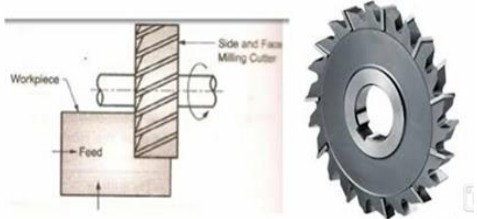

Figure 26. Milling machine type. (a)Horizontal milling machine ; (b) Vertical milling machine ; (c)Universal milling machine ; (d) CNC milling machine.

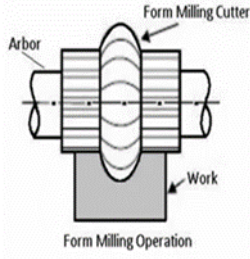

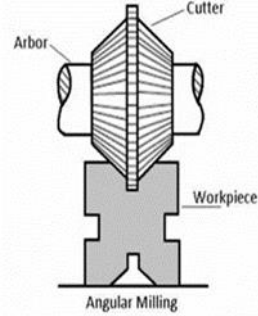
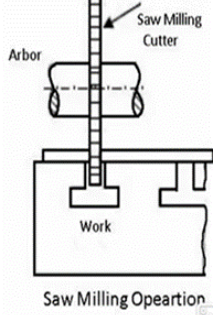
B. Milling operation

The following table 09 summarizes all the milling operations :

Table 09. milling operation

Milling operation	Corresponding photo
<p>Plain milling is performed to produce a plain horizontal surface parallel to the axis of rotation plain milling cutter.</p> <p>The operation is also know as slab milling</p> <p>To perform the operatio, the work and the The cutter are secured properly on the machine</p> <p>The depth of cuti s set by rotation the vertical feed screw of the table. And the machine is started after selecting the right speed and feed</p>	
<p>The face milling is the simplest milling machine operations.</p> <p>This operation is perfomed by a face milling cutter rotated about an axis perpendicular to the work surface.</p> <p>The operation is carried in plain milling, and the cutter is mounted on a stub arbor to design a flat surface.</p> <p>The depth of cuti s adjusted by rotation the crossfeed screw of the table</p>	

<p>The side milling is the operation of producing a flat vertical surface on the side of a workpiece by using a side milling cutter</p> <p>The depth of cut is set by rotating the vertical feed screw of the table</p>	
<p>The straddle milling is the operation of producing a flat vertical surface on both sides of a workpiece by using two cutters on the same arbor.</p> <p>Distance between the two cutters is adjusted by using suitable spacing collars.</p> <p>The straddle milling is commonly used to design a square or hexagonal surfaces</p>	
<p>The end milling is the operation of producing a flat surface which may be vertical, horizontal or at an angle in reference to the table surface.</p> <p>The cutter used is an end mill. The end milling cutters are also used for the production of slots, grooves or keyways.</p> <p>A vertical milling machine is more suitable for end milling operation.</p>	
<p>side and face milling machining is done by the teeth on the flat as well as cylindrical surface of the cutter, finished surfaces are perpendicular as well as parallel to the axis of the cutter</p>	
<p>The profile milling is the operation of reproducing an outline of a template or complex shape of a master die on a workpiece.</p> <p>Different cutters are used for profile milling. An end mill is one of the widely used milling cutters in profile milling work.</p>	

<p>The forme milling is the operation of producing the irregular contour by using form cutters</p> <p>The irregular shape may be convex ; concave, or of any other shape. After machining, the formed surface is inspected by a template gauge</p> <p>Cutting rate for form milling is 20% to 30% less than that of the plain milling.</p>	 <p>The diagram shows a cross-section of a form milling operation. A cylindrical 'Form Milling Cutter' is mounted on an 'Arbor' and is cutting into a 'Work' piece. The resulting surface has a specific irregular shape. The caption below the diagram is 'Form Milling Operation'.</p>
<p>The gang milling is the operation of machining several surface of work simultaneously by feeding the table against a number of cutters having the same different diameters mounted on the arbor of the machine</p>	 <p>The diagram on the left shows a 'Gang Milling Operation' with a 'Plain Milling Centre' and 'Side and Face Milling Cutters' on an 'Arbor' cutting a 'Workpiece'. To the right is a photograph of a machine with multiple cutters on an arbor. The caption below the diagram is 'Gang Milling Operation'.</p>
<p>The angular milling is the operation of angular surface on a workpiece other than at right angles of the axis of the milling machine spindle. The angular groove may be single or double angle and may be of varying included angle according to the type and contour of the angular cutter used. One simple example of angular milling is the production of V-blocks</p>	 <p>The diagram shows an 'Angular Milling' operation. A 'Cutter' is mounted on an 'Arbor' and is cutting into a 'Workpiece' to create an angular groove. The caption below the diagram is 'Angular Milling'.</p>
<p>Saw-milling is the operation of production narrow slots or grooves on a workpiece by using a saw-milling cutter. The saw-milling also performed for complete parting-off operation. The cutter and the workpiece are set in a manner so that the cutter is directly placed over one of the T-slots of the table</p>	 <p>The diagram shows a 'Saw Milling Operation'. A 'Saw Milling Cutter' is mounted on an 'Arbor' and is cutting into a 'Work' piece. The caption below the diagram is 'Saw Milling Operation'.</p>

Milling operation over view

➤ <https://www.youtube.com/watch?v=AxHexqN0Hr0>

3.1.3. Drilling

The term drilling means "obtaining a hole by Machining". This hole can be made by a drill bit on a drill, a bit on a crankshaft (hand drill), cutting, etc.

When drilling holes in a material a number of factors should be considered including:

- Material being drilled
- Hole size
- Hole quality.
- Speed /Feed required
- Depth of hole
- Need for coolant
- Capacity of drilling machine
- Method of work holding.
- Orientation of drill (horizontal , vertical drilling...)

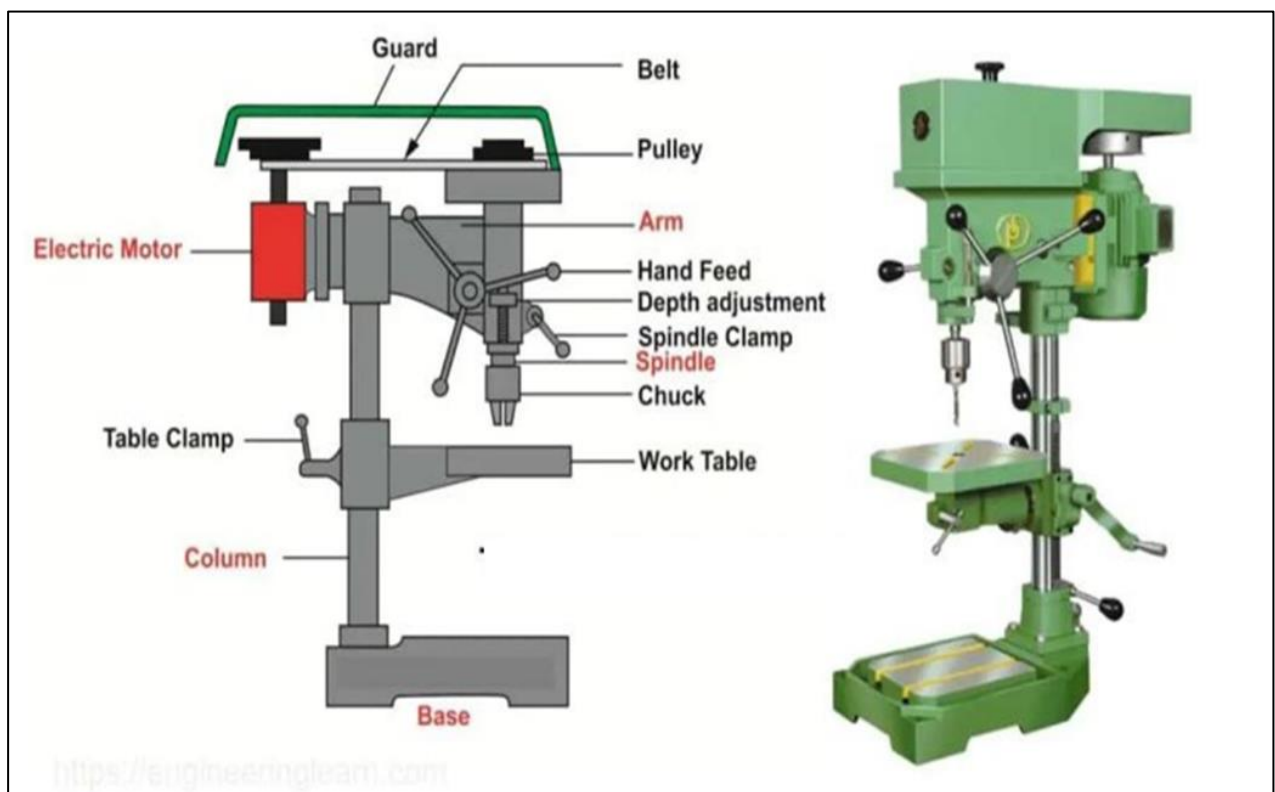


Figure 27. Drilling machine

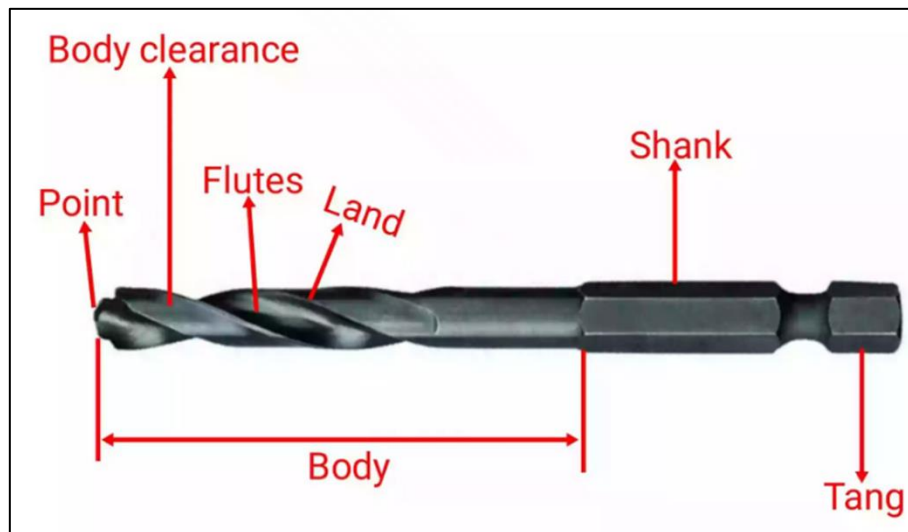


Figure 28. Twist drill (bit drill) component

A. The classification of drill bits

A.1. Depending on their shape, we distinguish:

- Cylindrical drills: extra-short, short, long and extra-long series;
- Drills with conical shank or Morse taper (used for series work): long series, short series and extra-long series;
- Reaming drills: with cylindrical shank and conical shank.

A.2. Depending on their helix angle, drills are classified into the following categories :

- Normal helix : for general drilling;
- Long helix : for metals with fragmented chips ;
- Short helix : for metals with continuous chips.

A.3. Depending to the shape of shank:

- Hex shank
- brace shank
- Triangle shank
- straight shank
- Morse taper shank
- SDS shank



Figure 29. Classification of drill bits depending to the shape of shank

A.4. Depending to the work piece:

- Masonry drill bit
- Metal drill bit
- wood drill bit



Figure 30. Drill bit depending work piece

3.1.4. Adjustment

Adjustment encompasses a range of actions aimed at enhancing mechanical parts. This includes:

- Removing Visual Defects
- Removing Burrs
- Optimizing Adjustments

After these processes, the parts are assembled to create a fully functional mechanical assembly, ensuring the efficiency in operation.

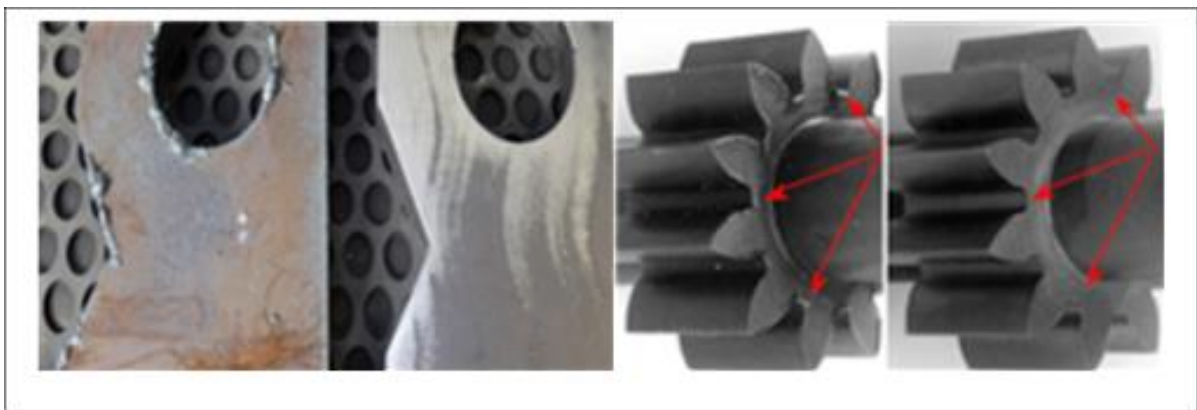


Figure 31. Adjustment effect

A. Adjustment categories

There are two categories of adjustment:

- Corrective Adjustment
- Completion Adjustment

A.1. Corrective Adjustment

Corrective adjustment refers to the actions taken to rectify any discrepancies or defects in mechanical components.

This process involves:

- Identifying Issues: Detecting misalignments, tolerances, or defects in parts.
- Implementing Corrections: Making necessary modifications to restore components to their intended specifications.
- Testing for Accuracy: Verifying that adjustments have effectively resolved the issues and that components operate as intended.

A.2. Completion adjustment

Completion adjustment involves finalizing the assembly process to ensure optimal functionality. This includes:

- Final Tuning : Making last-minute adjustments to achieve precise alignment and performance.
- Quality Assurance Checks : Conducting thorough inspections to ensure all components meet required standards.

Adjustment overview

➤ <https://www.youtube.com/watch?v=q2sWXotdAE0>

3.2. Non-Traditional methods

3.2.1. Electrochemical machining processes (ECM)

Electrochemical machining, commonly designated ECM, removes material by anodic dissolution with a rapidly flowing electrolyte. The process is shown schematically in Figure. It is basically a de-plating process in which the tool is the cathode and the work piece is the anode; both must be electrically conductive.

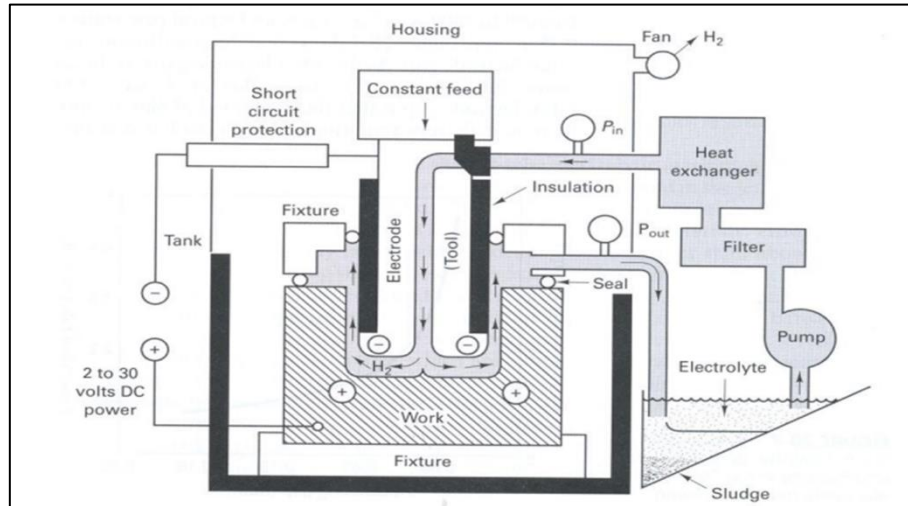


Figure 32. Schematic of electrochemical machining process (ECM)

The electrolyte, which can be pumped rapidly through or around the tool, sweeps away any heat and waste product (sludge) given off during the reaction. The sludge is captured and removed from the electrolyte through filtration. The shape of the cavity is defined by the tool, which is advanced by means of a servomechanism that controls the gap between the electrodes (i.e., the inter electrode gap) to a range from 0.254 mm. The tool advances into the work at a constant feed rate, or penetration rate, that matches the de-plating rate of the work piece. The

electrolyte is a highly conductive solution of inorganic salt - usually NaCl, KCl, and NaNO₃ - and is operated at about 24 to 65°C with flow rates ranging from 16 to 60 m/sec. The temperature of the electrolyte is maintained through appropriate temperature controls. Tools are usually made of copper or brass and sometimes stainless steel.

The behavior of the ECM process is governed by the laws of electrolysis (the use of electrical current to bring about chemical change). Faraday's first law of electrolysis states that the amount of chemical change (material removed) during electrolysis is proportional to the charge (number of electrons) passed.

3.2.2. Electrical discharge machining (EDM)

EDM processes remove metal by discharging electric current from a pulsating DC power supply across a thin inter electrode gap between the tool and the work piece as shown schematically in Figure. The gap is filled by a dielectric fluid, which becomes locally ionized at the point where the inter electrode gap is the narrowest-generally, where a high point on the work piece comes close to a high point on the tool. The ionization of the dielectric fluid creates a conduction path in which a spark is produced. The spark produces a tiny crater in the work piece by melting and vaporization, and consequently tiny, spherical "chips" are produced by resolidification of the melted quantity of work piece material.

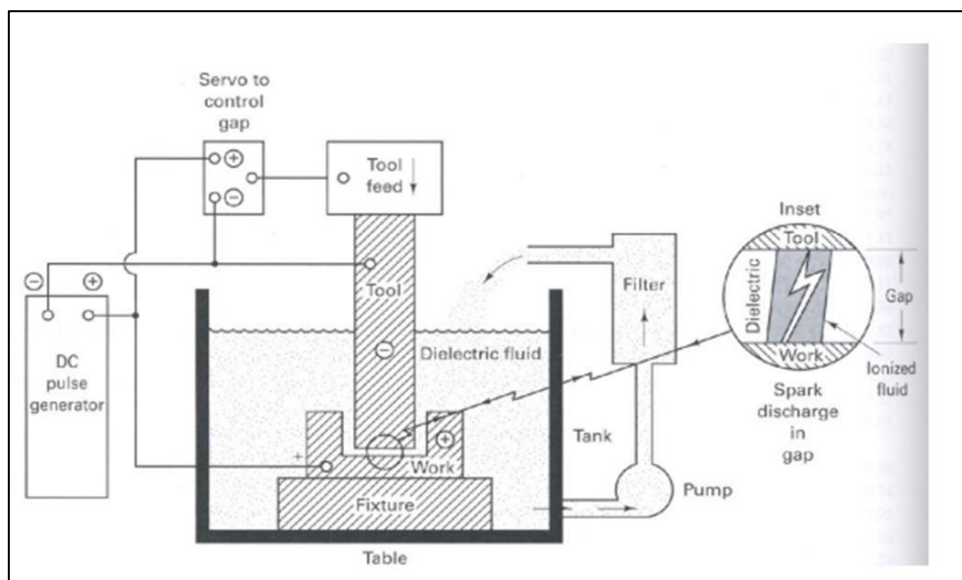


Figure 33. EDM or spark erosion machining of metal, using high-frequency spark discharge dielectric, between the shaped tool (cathode) and the work (anode). The table can make X-Y movements.

Bubbles from discharge gases are also produced. In addition to machining the work piece, the high temperatures created by the spark also melt or vaporize the tool, creating tool wear. The dielectric fluid is pumped through the inter electrode gap and flushes out the chips and bubbles while confining the sparks. Once the highest point the work piece is removed, a subsequent spark is created between the tool and next highest point, and so the process proceeds into the work piece. Literally hundreds of thousands of sparks may be generated per second. This material removal mechanism, is described as spark erosion.

Two different types of EDM exist based on the shape of the tool electrode used. In ram EDM, also known as die-sinking EDM or simply EDM, the electrode is a die in the shape of the negative of the cavity to be produced in a bulk material. By feeding the die into the work piece, the shape of the die is machined into the work piece. In wire EDM, also known as electrical discharge wire cutting, the electrode is a wire used for cutting through-cut features, driving the work piece with a computer numerical controlled (CNC).

4.1. Definition:

Assembly technique is process of connecting multiple elements to create a unified whole.

4.2. Classifications of assembly processes:

Assembly processes are classified into 3 families:

- Mechanical
- Thermal
- Chemical

4.3. Types of assembly:

Each means of assembly can be defined by five criteria:

4.3.1. Complete or partial assembly:

- Complete assembly: no movement possible between the assembled parts.
- Partial assembly: movement(s) possible between the assembled parts.

4.3.2. Dismountable (non-permanent, removable) or non-dismountable (permanent) assembly:

- Dismountable assembly: it is possible to remove the connection without damaging the parts or the connected elements.
- Non-dismountable (permanent) assembly: it is impossible to remove the connection without causing damage to the parts or the connected elements.

4.3.3. Elastic or rigid assembly:

- Elastic assembly: a displacement of a part causes the deformation of an elastic element (spring, rubber).
- Rigid assembly: the assembly is not elastic in any direction of displacement.

4.3.4. Assembly by obstacle or by adhesion:

- Assembly by obstacle: an element obstructs the movement between two parts.
- Assembly by adhesion: the assembly is obtained by the phenomenon of adhesion due to friction between the parts.

4.3.5. Direct or indirect assembly:

- Direct assembly: the shape of the linked parts is in direct contact. There is no intermediate element.
- Indirect assembly: the assembly requires one or more intermediate elements.

4.4. Assembly techniques:

4.4.1. Bolting

Bolting is a method of dismountable mechanical assembly. Bolts are used to create a continuous connection between elements or to ensure the full transmission of forces from one part to another of a construction.

In bolting, the term screw corresponds to a complete thread while the correct term is bolt body when the threaded part is partial.

- - **A fixing screw**; commonly called a screw, is a mechanical part, comprising a threaded rod and a head; it is intended to achieve the fixing of one or more parts by pressure. There are several screw head profiles, two of which are known:

* **Slotted profile screw head**: the face of which is obtained using a flat screwdriver.



Figure 34. Slotted profile screw head

***Screw head consisting of two perpendicular slots**; also called “Phillips” profile, which is screwed in using a cross-head screwdriver.



Figure 35. Screw head with two slots

* Bolt: bolt = screw + nut, the parts to be assembled have a smooth hole, the tapped hole is in the nut

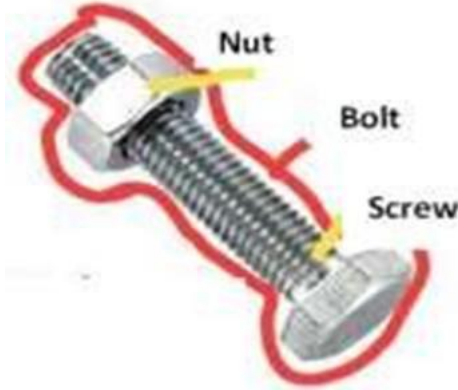


Figure 36. Bolt



Figure 37. Bolt head

* **Stud:** is a mechanical member in the form of a rod allowing an “indirect, complete, rigid, removable” connection to be made between a part equipped with the stud and one or more others crossed by the stud and locked by a nut.



Figure 38. Stud

***Nut:** The nut is a mechanical part receiving a threaded rod (screw) to ensure a connection between two parts.

Table 10. the different types of nut

Single nut	
Wing nut	
Cap nut	
Self-locking nut	
Castle nut	
Lock nut	

4.4.2. Riveting

Rivet: is a fastener in the form of a smooth cylindrical rod with a head at one end. The other end will deform to hold the object to be fixed on both sides. We distinguish the aluminum rivet, steel rivet, copper or brass rivet. It allows assembling hard materials (metal, steel) on materials.

*Riveting two objects

To fix two objects using the rivet, you will need riveting pliers, a drill, rivets and tips corresponding to the rivet

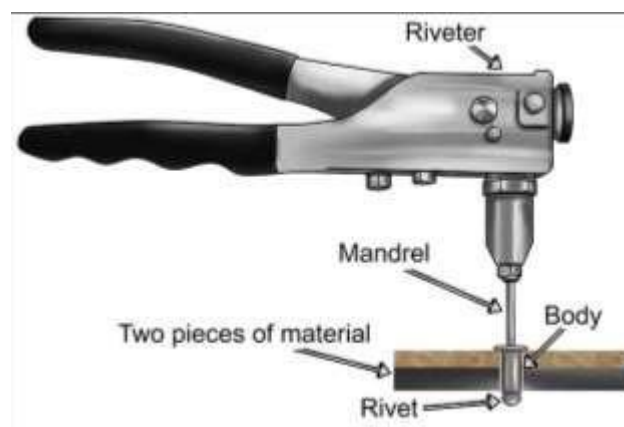


Figure 39. riveting components

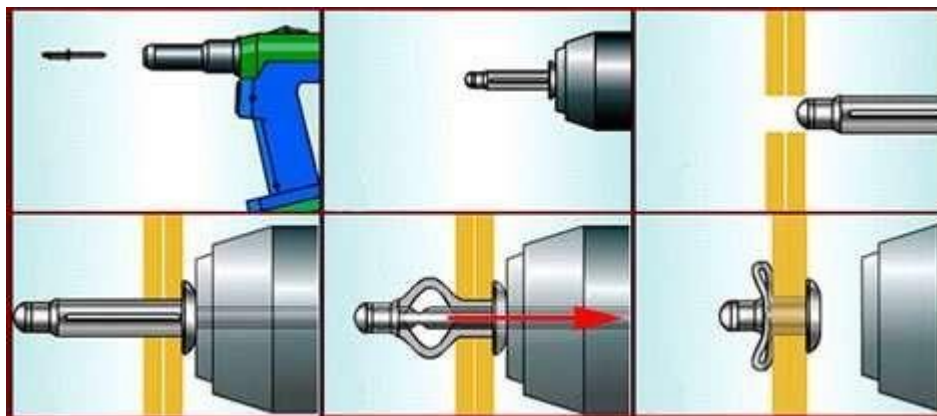


Figure 40. The riveting steps

*Riveting steps:

- Drill the hole
- Screw the tip onto the rivet gun. Tighten it with the wrench.
- Insert the rivet nail onto the tip.
- Operate the rivet gun until the nail breaks



Figure 41. The different types of rivets

*The blind rivet: is a non-removable fastening system, also called "stem break". There are many types of blind rivets.



Figure 42. Typical standard / pop rivet



Figure 43. Blind rivets types

4.4.3. Welding

Welding is a process by which metal parts or plastic materials are joined by heating and melting the parts in contact in order to create a joint with the same properties as the material constituting the assembled parts.

Basically, three elements are necessary to make a weld:

- A heat source such as an arc, a flame, pressure or friction. Most often, this heat comes from an electric arc. The arc corresponds to the physical space between the end of the electrode and the base metal. This space generates heat due to the resistance linked to the passage of the current and the rays of the arc. The arc melts the metals and allows them to melt.
- Protection, by using a gas or another substance to protect the weld from the air at the time of its creation. The oxygen present in the air makes welds fragile and porous.
- A filler material, which corresponds to the material used to join the two parts.

***Different welding processes**

There are several different welding processes, and each one corresponds to a specific use. Here is a list of the most common:

- Shielded metal arc welding (SMAW), also called manual shielded arc welding (MMAW)
- Gas tungsten arc welding (GTAW), or TIG welding
- Flux-cored arc welding (FCAW)
- Gas metal arc welding (GMAW, MIG, and MAG)
- Plasma arc welding (PAW), plasma cutting (PAC), and plasma gouging
- Submerged arc welding (SAW)
- Resistance spot welding or spot welding
- Air carbon arc cutting (AAC) and carbon arc gouging with an air jet
- Gas welding, cutting (OFC), and heating (composite fuel mixtures oxygen-acetylene [oxyacetylene] or oxygen-propane [oxy-propane] are most commonly used).

Table 11. The main hazards associated with welding

DANGERS	Welding Processes and Related Operations			
	Plasma processes (PAW and PAC) and air carbon arc cutting	SMAW, GTAW, GMAW, and FCAW processes	SAW processes	Gas processes
Ergonomic problems	✓	✓	✓	✓
Electric shocks	✓	✓	✓	X
Intense light	✓	✓	(✓)	✓
Ultraviolet radiation	✓	✓	(✓)	X
Toxic fumes and gases	✓	✓	(✓)	✓
Heat, flames, burns	✓	✓	✓	✓
Noise	✓	X	X	X

Legend:

- X : indicates absence of danger.
- ✓ : indicates presence of danger
- (✓) : indicates danger in the absence of flux powder

4.4.4. Collage

Collage: an ancestral, modern and sustainable means of assembly

Assemblage de pièces grâce à un contact intime avec un adhésif. Selon le type d'adhésif les liaisons seront interatomiques ou intermoléculaires.

The condition of: the surface; the shape and the cleanliness are essential for the mechanical strength of this type of assembly.

An adhesive is a generally organic material that provides the bond between two materials that are of the same nature or of different natures. In the first case, the assembly produced will be said to be homogeneous, in the second case, we will speak of a heterogeneous assembly.

General conclusion

In conclusion, this educational guide for the "Basic Technology" course has provided a comprehensive study of the integrated technical chain for manufacturing mechanical parts : from raw material selection to final assembly, including forming and machining methods.

The four chapters of this program have allowed us to develop a global vision of engineering, structured around the following key points :

- Materials

We have established a clear distinction between metals, polymers, and composite materials, emphasizing that technical designations serve as the universal language. This language enables engineers to precisely identify the material that guarantees both the performance and longevity of a product.

- Part Manufacturing (Without Material Removal)

This section explored how materials acquire their initial shape through traditional techniques such as foundry (casting), forging, and rolling, as well as modern technologies like powder metallurgy. These methods ensure high productivity and robust mechanical properties.

- Precision Machining (With Material Removal)

This section highlighted the vital importance of turning, milling, and drilling operations to achieve the extreme precision required by technical drawings. Mechanical systems cannot function effectively without precise surface finishes and exact dimensions.

- Assembly Technology

We concluded this program by studying methods for transforming individual parts into a complete, functional system. Through welding, bolting, and riveting techniques, we have gained an understanding of how structures and machines are built.

The objective of this publication was not merely to list techniques, but to establish an engineering framework linking materials, manufacturing methods, and costs.

This guide serves as a foundation for mastering industrial technologies, designed to help students align their technical skills with their long-term career aspirations.

Best of luck to all our dear students !

BASIC TERM		
Chapter 01		
English	French (Français)	Arabic (العربية)
Alloys	Alliages	سبائك
Black-heart malleable cast iron	Fonte malléable à cœur noir	حديد صب مرن ذو قلب أسود
Cast iron	Fonte	حديد صب (فونط)
Ceramics	Céramiques	سيراميك / خزف
Composites	Composites	مواد مركبة
Copper alloys	Alliages de cuivre	سبائك النحاس
Elastomers	Élastomères	مرنات / إلاستومر
Ferrous metals	Métaux ferreux	معادن حديدية
Forms	Formes	أشكال
General Purpose Steel	Acier d'usage général	فولاذ للأغراض العامة
High Alloy Steel	Acier fortement allié	فولاذ عالي السبائك
High Speed Steel	Acier rapide	فولاذ القطع السريع
Iron-carbon alloy	Alliage fer-carbone	سبيكة حديد-كربون
Lamellar graphite cast iron	Fonte à graphite lamellaire	حديد صب غرافيتي رقائقي
Low Alloy Steel	Acier faiblement allié	فولاذ منخفض السبائك
Matrix	Matrice	مادة الأساس / قالب
Mechanical Construction Steel	Acier de construction mécanique	فولاذ الإنشاءات الميكانيكية
Metals	Métaux	معادن
Non-ferrous Alloys	Alliages non-ferreux	سبائك غير حديدية
Plastic	Plastique	بلاستيك

Reinforcement	Renfort	تسليح / تقوية
Spheroidal graphite cast iron	Fonte à graphite sphéroïdal	صب غرافيتي كروي حديد
Steels	Aciers	الفولاذ
Unalloyed Steel	Acier non allié	فولاذ غير سببكي
Thermoplastics	Thermoplastiques	لدائن حرارية
Thermosetting Plastics	Plastiques thermodurcissables	لدائن صلبة بالحرارة
White-heart malleable cast iron	Fonte malléable à cœur blanc	حديد صب مرن ذو قلب أبيض
Chapter 02		
Bending	Pliage	ثني
Casting	Moulage / Fonderie	سباكة / صب
Cutting	Découpage / Coupe	قطع
Deep drawing	Emboutissage profond	سحب عميق
Extrusion	Extrusion	بثق
Forging	Forgeage	حدادة (طرق)
Fusion foundry	Fonderie par fusion	سباكة بالصهر
Laser cutting	Découpage laser	قطع بالليزر
Non-permanent mold processes	Procédés en moules non permanents	عمليات القوالب غير الدائمة (المستهلكة)
Oxycutting	Oxycoupage	قطع بالأكسجين والغاز
Permanent mold processes	Procédés en moules permanents	عمليات القوالب الدائمة
Plasma cutting	Découpage plasma	قطع بالبلازما
Plastic deformation	Déformation plastique	تشويه لدني
Pressure casting	Coulée sous pression	صب تحت الضغط
Processes may occur cold	Procédés pouvant s'effectuer à froid	عمليات يمكن أن تتم على البارد

Processes may occur hot	Procédés pouvant s'effectuer à chaud	عمليات يمكن أن تتم على الساخن
Processes may occur cold and hot	Procédés pouvant s'effectuer à froid et à chaud	عمليات يمكن أن تتم على البارد والساخن
Profiles and Pipes	Profilés et Tubes	مقاطع وأنابيب
Rolling process	Laminage	عملية الدرفلة
Sand molding	Moulage en sable	صب في القوالب الرملية
Shell molding	Moulage en carapace	صب في القوالب القشرية
Sintering and powder metallurgy	Frittage et métallurgie des poudres	التلييد وميتالورجيا المساحيق
Stamping	Estampage / Matriçage	كبس / صك
Water jet cutting	Découpage au jet d'eau	قطع بنفث الماء
Wire drawing	Tréfilage	سحب الأسلاك
Chapter 03		
Adjustment	Ajustement	ضبط / تكييف
Bed type	Type à banc fixe	طراز ذو فرش ثابت
Boring	Alésage	توسيع الثقوب / التجويف
Brace shank	Queue à vilebrequin	ساق مخدد
Carriage	Chariot	عربة
Chamfering	Chanfreinage	شطب الحواف
CNC milling machine	Fraiseuse à commande numérique	آلة فرز بالتحكم الرقمي
Completion Adjustment	Ajustement de finition	ضبط الإنهاء
Compound	Composé	مركب
Corrective Adjustment	Ajustement correctif	ضبط تصحيحي
Cross slide	Chariot transversal	راسم عرضي

Cut-off	Tronçonnage	قطع / فصل
Drill bits	Forets / Mèches	لقم الثقب
Drilling	Perçage	ثقب
Electrical discharge machining	Usinage par électro-érosion	التشغيل بالتفريغ الكهربائي
Electrochemical machining processes	Procédés d'usinage électrochimique	عمليات التشغيل الكهروميكانيكية
Facing	Dressage	تسوية الوجه
Grooving	Rainurage	تحزيز / عمل أخاديد
Hand mill	Fraiseuse manuelle	مفرزة يدوية
Hex shank	Queue hexagonale	ساق سداسي
Horizontal milling machine	Fraiseuse horizontale	آلة فرز أفقية
Knee type	Type à console	طراز نوركبة
Knurling	Moletage	تحزيز (تحشين)
Long helix	Hélice longue	حلزون طويل
Masonry drill bit	Foret à béton / maçonnerie	لقمة ثقب الخرسانة
Metal drill bit	Foret à métaux	لقمة ثقب المعادن
Milling	Fraisage	فرز
Milling machine for short thread milling	Fraiseuse pour filetage court	آلة فرز لولبة قصيرة
Morse taper shank	Queue à cône Morse	ساق مخروطي مورس
Non-Traditional methods	Méthodes non-traditionnelles	طرق غير تقليدية
Normal helix	Hélice normale	حلزون عادي
Planer and rotary table	Raboteuse et table rotative	مقشطة وطاولة دوارة
Planer type	Type raboteuse	طراز مقشطة
Plain milling	Fraisage en bout	فرز بسيط (سطحي)

Rotary type	Type rotatif	طراز دوار
Tailstock assembly	Ensemble de la poupée mobile	مجموعة الغراب المتحرك
Thread	Filetage / Filet	سن اللولب
Traditional methods	Méthodes traditionnelles	طرق تقليدية
Triangle shank	Queue triangulaire	ساق مثلثي
Turning	Tournage	خراطة
Single purpose	À usage unique / Spécialisée	وحيدة الغرض
Special purpose	À usage spécial	خاصة الغرض
Saw-milling	Fraisage à la scie	فرز بالمنشار
Short helix	Hélice courte	حلزون قصير
SDS shank	Queue SDS	ساق SDS
Side and face milling	Fraisage combiné (disque)	فرز جانبي ووجهي
Straight shank	Queue droite	ساق مستقيم
Tracer controlled copy milling machine	Fraiseuse à copier	آلة فرز ناسخة بالناسخ
The angular milling	Fraisage angulaire	فرز زاوي
The end milling	Fraisage en bout	فرز طرفي
The face milling	Fraisage de face	فرز وجهي
The form milling	Fraisage de forme	فرز تشكيلي
The gang milling	Fraisage en train	فرز تجمعي
The profile milling	Fraisage de profil	فرز جانبي
The side milling	Fraisage latéral	فرز جانبي
The straddle milling	Fraisage double (entretoise)	فرز مزدوج متساوي
Universal milling machine	Fraiseuse universelle	آلة فرز عامة

Vertical milling machine	Fraiseuse verticale	آلة فرز رأسية
Wood drill bit	Mèche à bois	لقمة ثقب الخشب
Chapter 04		
Assembly by obstacle or by adhesion	Assemblage par obstacle ou par adhérence	تجميع بالعائق أو بالالتصاق
Assembly technique	Technique d'assemblage	تقنية التجميع
A fixing screw	Une vis de fixation	برغي تثبيت
Blind rivets	Rivets aveugles	برشام أعمى
Bolt	Boulon	مسمار / بولون
Bolting	Boulonnage	تثبيت بالبراغي
Cap nut	Écrou borgne	صامولة غطاء (مغلقة)
Castle nut	Écrou à créneaux	صامولة تاجية
Collage	Collage	لصق
Complete or partial assembly	Assemblage complet ou partiel	تجميع كلي أو جزئي
Direct or indirect assembly	Assemblage direct ou indirect	تجميع مباشر أو غير مباشر
Dismountable assembly	Assemblage démontable	تجميع قابل للفك
Elastic or rigid assembly	Assemblage élastique ou rigide	تجميع مرن أو صلب
Lock nut	Contre-écrou	صامولة قفل
Non-dismountable assembly	Assemblage non démontable	تجميع غير قابل للفك
Nut	Écrou	صامولة
Pop rivet	Rivet aveugle (Pop)	مسمار برشام (بوب)
Rivet	Rivet	مسمار برشام
Riveting	Rivetage	تبرشيم
Self-locking nut	Écrou autobloquant	صامولة ذاتية القفل

Screw	Vis	برغي
Screw head	Tête de vis	رأس البرغي
Single nut	Écrou simple	صامولة مفردة
Stud	Goujon	مسمار تثبيت (بدون رأس)
Welding	Soudage	لحام
Wing nut	Écrou à oreilles	صامولة مجنحة

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