

# Manufacturing Process

CUTM1604

Credits 3: Theory-2+ Practice -1

Basket IV- Core Basket

Prof. Dillip Kumar Mohanta

# Objectives

(What, Why and How)

1. Materials
2. Manufacturing Process
3. Process Planning
4. Product Design

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Period 1	1 H																		2 He
Period 2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
Period 3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
Period 4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
Period 5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
Period 6	55 Cs	56 Ba	* 71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
Period 7	87 Fr	88 Ra	* 103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og	
			* 57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb			
			* 89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No			

Russian chemist [Dmitri Mendeleev](#) in 1869

# Common Engineering Materials

**Material:** Materials are physical substances used as inputs to production or manufacturing.

**Material Science:** Systematic Study of Materials.

**Systematic study:** Study of their structure, properties, characterization, processing, performance

**Metallurgy:** Study of metals

# **MATERIAL CLASSIFICATION**

**Most engineering materials are classified into one of the following types:**

**Metals (ferrous, non-ferrous) and Alloys**

**Ceramics**

**Composites**

**Organics**

**Semiconductors**

**Advanced/Biomaterials**

# **MATERIAL CLASSIFICATION**

## **Metals**

**These are broadly used in industries.**

**These are extracted from the ores of oxides and sulphides.**

**Metals readily give up electrons to form metallic bonds.**

**Characteristics: luster, hardness, elasticity, strength, ductility, malleability, good electrical & thermal conductivity, machinability, castability.**

**Examples: iron, copper, aluminium, zinc, etc.**

# **MATERIAL CLASSIFICATION**

## **Ceramics**

**They contain oxides, nitrides, carbides, silicates of various metals.**

**These are inorganic, non-metallic substances.**

**These are strong in compression but weak in tension.**

**Characteristics: brittleness, rock-like appearance, high temperature resistance, hardness, corrosion resistance.**

**Examples: sand, glass, brick, cement, plaster, abrasives, etc.**

# **MATERIAL CLASSIFICATION**

## **Organics:**

**These are the derivatives of carbon having long molecular chain.**

**Characteristics: light weight, soft, combustible, poor conductors of heat and electricity, non-corrosive.**

**Examples: rubber, plastics, paper, fuels, wood, lubricants, adhesives, paints.**



# **MATERIAL CLASSIFICATION**

## **Composites:**

**These are composed of two or more materials. So they have much superior properties than any one of the constituent materials.**

**Characteristics: durable, low maintenance, strength, non-corrosive, high temperature strength.**

**Examples: fiber glass, cement concrete, plywood, etc.**

# **MATERIAL CLASSIFICATION**

## **Semiconductors:**

**These are the substances whose electrical conductivity lies in between conductors and non-conductors.**

**These are used in ICs, transistors, diodes, etc.**

**At high temperature suitable impurities are added to make them conductors.**

**Examples: silicon, germanium, lead sulphide.**

# ALLOY

## WHAT IS AN ALLOY?

An alloy is a mixture of two or more elements, at least one of which is a metal.

Alloy= (main metal, or parent metal, or base metal) + Alloying agents or elements

Alloy= Metal + Metal or Non-metals

## HOW ARE ALLOYS MADE?

1. Solid solution ( Heating, melting & Mixing)
  2. Powder metallurgy
  3. Ion implantation

# ALLOY

## WHAT IS THE ADVANTAGE OF ALLOY?

Compared to pure materials/metals, alloys can be stronger, more resistant to damage and more versatile.

# COMMON EXAMPLES OF ALLOY

<b>Alloy</b>	<b>Components</b>	<b>Applications</b>
<b>Steel (general)</b>	Iron (80–98%), carbon (0.2–2%), plus other metals such as chromium, manganese, and vanadium.	Metal structures, car and airplane parts, and many other uses.
<b>Steel (stainless)</b>	Iron (50%+), chromium (10–30%), plus smaller amounts of carbon, nickel, manganese, molybdenum, and other metals	Jewelry, medical tools, tableware.
<b>Cast iron</b>	Iron (96–98%), carbon (2–4%), plus silicon.	Metal structures such as bridges and heavy-duty cookware.

# COMMON EXAMPLES OF ALLOY

<b>Alloy</b>	<b>Components</b>	<b>Applications</b>
Babbitt metal ("white metal")	Tin (90%), antimony (7–15%), copper (4–10%).	Friction-reducing coating in machine bearings.
Brass	Copper (65–90%), zinc (10–35%).	Door locks and bolts, brass musical instruments, central heating pipes.
Bronze	Copper (78–95%), tin (5–22%), plus manganese, phosphorus, aluminum, or silicon.	Decorative statues, musical instruments.
Gunmetal	Copper (80–90%), tin (3–10%), zinc (2–3%), and phosphorus.	Guns, decorative items.

# COMMON EXAMPLES OF ALLOY

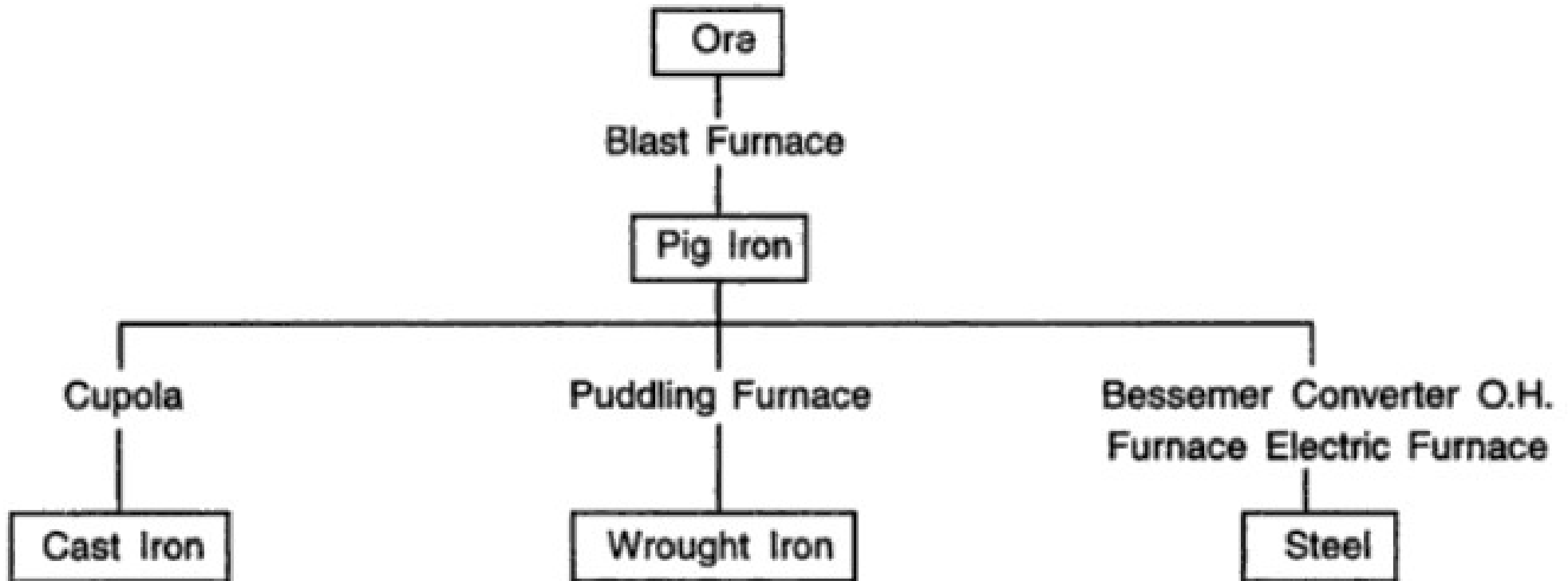
<b>Alloy</b>	<b>Components</b>	<b>Applications</b>
Super alloys	Typically (but not always) nickel-based: nickel (45–70%), chromium (14–30%), plus smaller amounts of various other metals (common ones such as iron, molybdenum, and copper, or more unusual ones like rhenium, hafnium, and ruthenium) and nonmetals (for example, silicon, carbon, or phosphorus).	Protective, high-temperature materials widely used in aerospace engine applications where aluminum and steel are unsuitable. Examples include the Inconel family, Waspaloy, Hastelloy alloys, and the CMSX alloys (such as CMSX-4).
White gold (18 carat)	Gold (75%), palladium (17%), silver (4%), copper (4%)	Jewelry.

# STEEL

1. Steel is an alloy of iron and Carbon.
2. The carbon content of steel is between 0.002% and 2.14% by weight.
3. Classification of Steels:
  - a) Plain Carbon Steel ( Mild Steel, Medium Carbon Steel, High Carbon Steel)
  - b) Alloy Steel ( Nickel Steel, Chromium Steel, etc.)
  - c) Stainless steel (Austenitic SS, Martensitic SS, etc.)
  - d) Tool Steel (HSS)



# STEEL



# CARBON STEEL

1. **Carbon steel** is a steel with carbon content from about 0.05% up to 2.1% by weight.
2. Increase in carbon percentage content, the hardness, strength of steel increases but ductility, malleability, weldability and MP decreases.
3. Chromium, cobalt, molybdenum, nickel, niobium, titanium, tungsten, vanadium, zirconium, Copper, Silicon, Manganese are also added with less quantities to get desired alloying effect.

# CARBON STEEL

TYPE	% Carbon	Properties	Application
Low-carbon steel	0.05–0.30	Low hardness and cost. High ductility, toughness, machinability and weldability	Rod, Bar, angles, gears, nail, rivet, chain, pipes
Medium-carbon steel	0.30 – 0.60	Low hardenability, medium strength, ductility and toughness	Axles, connecting rod, hacksaw, screw, nut-bolt, shaft
High-carbon steel	0.60 – 0.15 or more	High hardness, strength, low ductility	spring, saw, die & punch, taps, hand tools, hammer, chisel

# CARBON STEEL

S. no.	CAST IRON	WROUGHT IRON	MILD STEEL (LOW CARBON STEEL)	HARD STEEL (HIGH CARBON STEEL)
1.	It contains 2 to 5% carbon.	Purest form of iron containing 0 to 0.25% carbon.	Contains 0.08 to 0.35% carbon.	Contains 0.55 to 1.3% carbon.
2.	It is hard and brittle	Tough and more elastic than cast iron.	Tough and more elastic than wrought iron.	Tough and more elastic than mild steel.
3.	Can neither be forged nor welded.	Can be easily forged and welded.	Can be easily forged and welded.	Can be easily forged and welded.
4.	It has crystalline, coarse granular structure.	It has fibrous structure (bluish colour).	It has fibrous structure (Bright).	It has fine granular structure.
5.	It can be hardened by heating and sudden cooling but cannot be tempered.	Can neither be hardened nor tempered.	Can be hardened and tempered but not easily.	Can be hardened and tempered easily.
6.	Neither malleable nor ductile.	Very malleable and ductile.	Malleable and ductile.	Brittle and less ductile.
7.	Does not rust easily.	Rust more rapidly than cast iron.	Rusts readily.	Rust rapidly.
8.	Cannot absorb shocks.	It can withstand sudden and excessive shocks.	It absorbs shocks.	It absorbs shocks.
9.	Melting point = 1200°C.	Melting point = 1530°C.	Melting point = 1400°C.	Melting point = 1300°C.
10.	It cannot be magnetised.	It can be temporarily magnetised.	It can be permanently magnetised.	It can be permanently magnetised.
11.	Tensile strength is least.	Tensile strength is better than cast iron.	Tensile strength is better than cast iron and wrought iron.	Tensile strength is better than cast iron, wrought iron and mild Steel.

# ALLOY STEEL

1. When other desired properties are required, some other alloying elements are added to Carbon steel to get alloy steel.
2. The alloying elements may be Cr, Ni, Mn, Mg, P, S, W etc.

## **Purpose of Alloying**

1. To improve hardness, toughness and tensile strength.
2. To improve wear resistance.
3. To improve corrosion resistance.
4. To improve ability to retain shape at high temperature.
5. To improve machinability.
6. To improve ability to resist distortion at elevated temperature.
7. To impart a fine grain size to steel.
8. To improve elasticity.
9. To improve case hardening properties.
10. To improve cutting ability.

# ALLOY STEEL/EFFECTS OF ALLOYING ELEMENTS

ALLOYING ELEMENT	EFFECT
Carbon	Hardness, Strength, MP
Nickel	Toughness, strength, corrosion resistance
Chromium	Corrosion Resistance, Strength
Cobalt	Thermal resistance, toughness
Silicon	Softness, Ductility, Elasticity
Tungsten	Heat Resistance, wear resistance
Copper	Corrosion Resistance, Strength
Aluminium	Ductility, Malleability, Deoxidizer
Sulphur	Hardness, brittleness
Manganese	Hardness
Phosphorus	strength, increases resistance to corrosion and improves machinability

# CUTTING TOOL MATERIALS

Cutting tool materials are materials that are used to make cutting tools which are used in machining (drill bits, tool bits, milling cutters, etc.)

The common cutting tool materials are:

Carbon Steel

High Speed Steel

Carbide or Cemented Carbide

Ceramic

Cubic Boron Nitride

Diamond





# CARBIDE TOOL MATERIALS

1. Tools are made by a powdery metallurgy process.
2. The two basic groups of carbides used for machining are **Tungsten carbide (WC)** and **Titanium carbide (TiC)**.
3. Tungsten carbide (WC) is a composite material consisting of tungsten-carbide particles bonded together in a cobalt matrix/ binder. WC is also called cemented carbide.
4. **More is the cobalt % less is the hardness but more toughness.**
5. Tungsten carbide tools are commonly used for machining steels, cast irons and abrasive nonferrous materials.
6. Titanium carbide (TiC) has a higher wear resistance than tungsten but is not as tough.
7. **Cutting Speed Range 60-200m/min; Temperature- 1000 degree centigrade; Hardness 90HRC.**
8. **Carbide tools may be alloyed, uncoated and coated.**

# COATED CARBIDE TOOL MATERIALS

## Why Coatings are required?

Coatings of single layer or multiple layers of different thickness are done on the surface of a tool insert to improve its properties.

## What is coated cemented carbide cutting tool material?

Coated cemented carbide combines cemented carbide with a coating.

What are the coated carbide types?

CVD and PVD

## What is cermet cutting tool material?

The name cermet combines the words ceramic and metal. Originally, cermet was a composite of TiC and nickel. Nickel is the binder.

## CVD-Coated

CVD stands for Chemical Vapor Deposition. The CVD coating is generated by chemical reactions at temperatures of 700-1050°C.

## PVD-Coated

Physical Vapor Deposition (PVD) coatings are formed at relatively low temperatures (400-600°C). The process involves the evaporation of a metal which reacts with, for example, nitrogen to form a hard nitride coating on the cutting tool surface.

# COATED CARBIDE TOOL MATERIALS

ASPECTS	CVD	PVD
Definition	Chemical Vapour Deposition	Physical Vapour Deposition
Layer/film	Thicker	Thinner
Process Temperature	450- 1050 degree centigrade	250-450 degree centigrade
Coating Materials	TiC, TiN, TiCN, Diamond, CrC, Al <sub>2</sub> O <sub>3</sub>	TiN, TiCN, TiAlN, AlCrN, CrC, CrN
Coating Material Form	Gas	Solid
Cutting Edges	Normal	Very Sharp
Operation	Roughing	Finishing
Main Property	Wear Resistance	Toughness

# COATED CARBIDE TOOLS



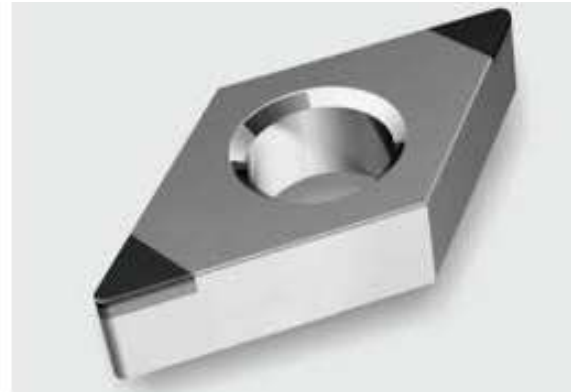
# CERAMIC/CEMENTED OXIDE TOOLS

1. Most common ceramic materials are aluminum oxide and silicon nitride.
2. Tools are made by powder metallurgy- sintering process.
3. Ceramic tools are chemically inert and possess resistance to corrosion. They have high compressive strength.
4. They are stable up to temperature 1400°C. They are ten times raster than HSS.
5. The friction between the tool face and chip are very low and possess low heat conductivity, usually no coolant is required. They provide the very excellent surface finish.
6. Cutting Speed- 300-600 m/min; Temperature- 1400°C ; Hardness - up to HRC 93
7. The high hot hardness, compressive strength, wear resistance, and chemical inertness of ceramics promised success.
8. General limitations of ceramics include their thermal shock resistance and fracture toughness.
9. **Ceramics** are used for high speed semi- and final finishing of ferrous and some non-ferrous materials.



# CBN TOOLS

1. It is the second hardest material after diamond.
2. They are generally used in hand machines.
3. They offer high resistance to abrasion and use as an abrasive in grinding wheels.
4. Speed 600-800m/min  
Hardness - higher than HRC 95



# DIAMOND/PCD TOOLS

## What is polycrystalline diamond cutting tool material?

PCD is a composite of diamond particles sintered together with a metallic binder. Diamond is the hardest, and therefore the most abrasion resistant, of all materials. As a cutting tool material, it has good wear resistance but it lacks chemical stability at high temperatures and dissolves easily in iron.

1. It is the hardest material known and it is also expensive.
2. It possesses very high thermal conductivity and melting point Diamond offers excellent abrasion resistance, low friction coefficient and low thermal expansion.
3. It is used in machining very hard material such as carbides, nitrides, glass, etc.
4. Diamond tools give a good surface finish and dimensional accuracy. They are not recommended for machining steel



# SiAlON TOOLS

1. They are formed when silicon nitride ( $\text{Si}_3\text{N}_4$ ), aluminium oxide ( $\text{Al}_2\text{O}_3$ ) and aluminium nitride (AlN) are reacted together.
2. **SiAlONs** are ceramics based on the elements silicon (Si), aluminium (Al), oxygen (O) and nitrogen (N).
3. SiAlONs also have high wear resistance, low thermal expansion and good oxidation resistance up to above  $\sim 1000^\circ\text{C}$ .
4. The hot hardness, fracture toughness and thermal shock resistance of fully dense SiAlON makes it well suited to use in cutting tools.
5. SiAlONs have also replaced cemented carbide tools when machining nickel based superalloys/ HRSA.



*SiAlON wear guides*



seals and bearings.





# PLASTICS

Plastics are synthetic or semi-synthetic and attractive organic compounds.

Properties:

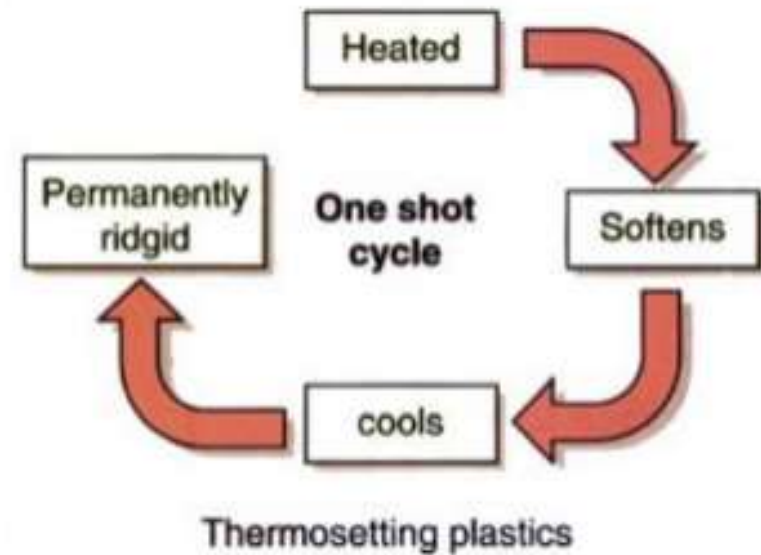
1. Light Weight
2. Good Strength & Rigidity
3. Good Toughness
4. High moldability
5. Heat, corrosion, chemical and electrical resistance
6. Good colorability
7. Brittleness

# TYPES OF PLASTIC

- A) Thermosetting Plastics/ thermosets
- B) Thermoplastic

## Thermosetting Plastics

- 1. Phenol-formaldehyde
- 2. Urea-formaldehyde
- 3. Polyster
- 4. Bakelite
- 5. Vulcanized rubber



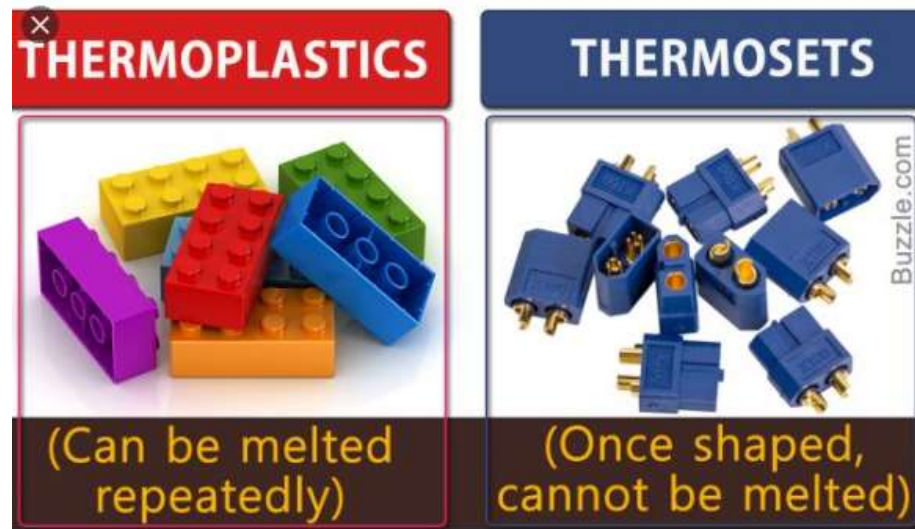
Once heated, thermosetting plastics can be moulded, shaped and pressed into shapes. Once set they cannot be reheated since they are permanently set.

# TYPES OF PLASTIC

- A) Thermosetting Plastics/ thermosets
- B) Thermoplastic

## Thermoplastics

- 1. Acrylonitrile Butadiene Styrene (ABS)
- 2. Polystyrene (PS)
- 3. Polyvinyl chloride (PVC)
- 4. Polycarbonate
- 5. Polyethylene
- 6. Polyamide (PA)/nylon
- 7. Teflon



# TYPES OF PLASTIC

<b>THERMOSETTING PLASTICS/ THERMOSETS</b>	<b>THERMOPLASTIC</b>
Thermosetting plastics are synthesized by condensation polymerization.	Thermoplastic can be synthesized by the process called addition polymerization.
Can't be reshaped and reused	Can be reshaped and reused
Thermosetting Plastic is processed by compression moulding, reaction injection moulding.	Thermoplastic is processed by injection moulding, extrusion process, blow moulding, thermoforming process, and rotational moulding.
Thermosetting plastics have high melting points and tensile strength.	Thermoplastics have low melting points and low tensile strength.

# TYPES OF PLASTIC



## Thermoplastics



# TYPES OF PLASTIC/ Thermosets



# PLASTIC MOLDING PROCESSES

1. Compression Molding
2. Transfer Molding
3. Injection Molding
4. Blow Molding
5. Vacuum forming
6. Casting
7. Extrusion Molding

# Generic plastic materials

## **Conductive polymers**

Intrinsically Conducting Polymers (ICP) are organic polymers that conduct electricity. While plastics can be made electrically conductive. Nevertheless, this is a developing field.

## **Biodegradable plastics**

**These** are plastics that degrade, or break down, upon exposure to: sunlight or ultra-violet radiation, water or dampness, bacteria, enzymes or wind abrasion.

## **Bioplastics**

These are plastic materials produced from renewable biomass sources, such as vegetable fats and oils, corn starch, straw, woodchips, sawdust, recycled food waste, etc



# Generic plastic materials

