

CONCEPTS OF
MECHANICAL
ENGINEERING – I
(25ME111)

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WEEK 02

- Classification of Engineering Materials Ferrous Materials
- Cast Iron- Types of cast iron- Grey, White, and Malleable. Properties, composition and applications of cast iron.
- Steel –Types, Designation of steel, Types -Plain Carbon Steel- Low (0.15 0.25%C), Mild (0.25%C), Medium (0.25-0.65%C), High Carbon (0.65 1.5%C), Properties, composition and applications of steel.
- Alloy Steel- Tool Steel, Tungsten steel, Stainless-Steel, High-Speed Steel, Properties, composition and applications of alloy steel.

Introduction

The ferrous metals i.e., steels and its alloys are extensively used in engineering industries due to their following characteristics:

1. Good resistance of corrosion.
2. Strength to weight ratio.
3. Excellent mechanical properties and
4. Excellent magnetic properties.

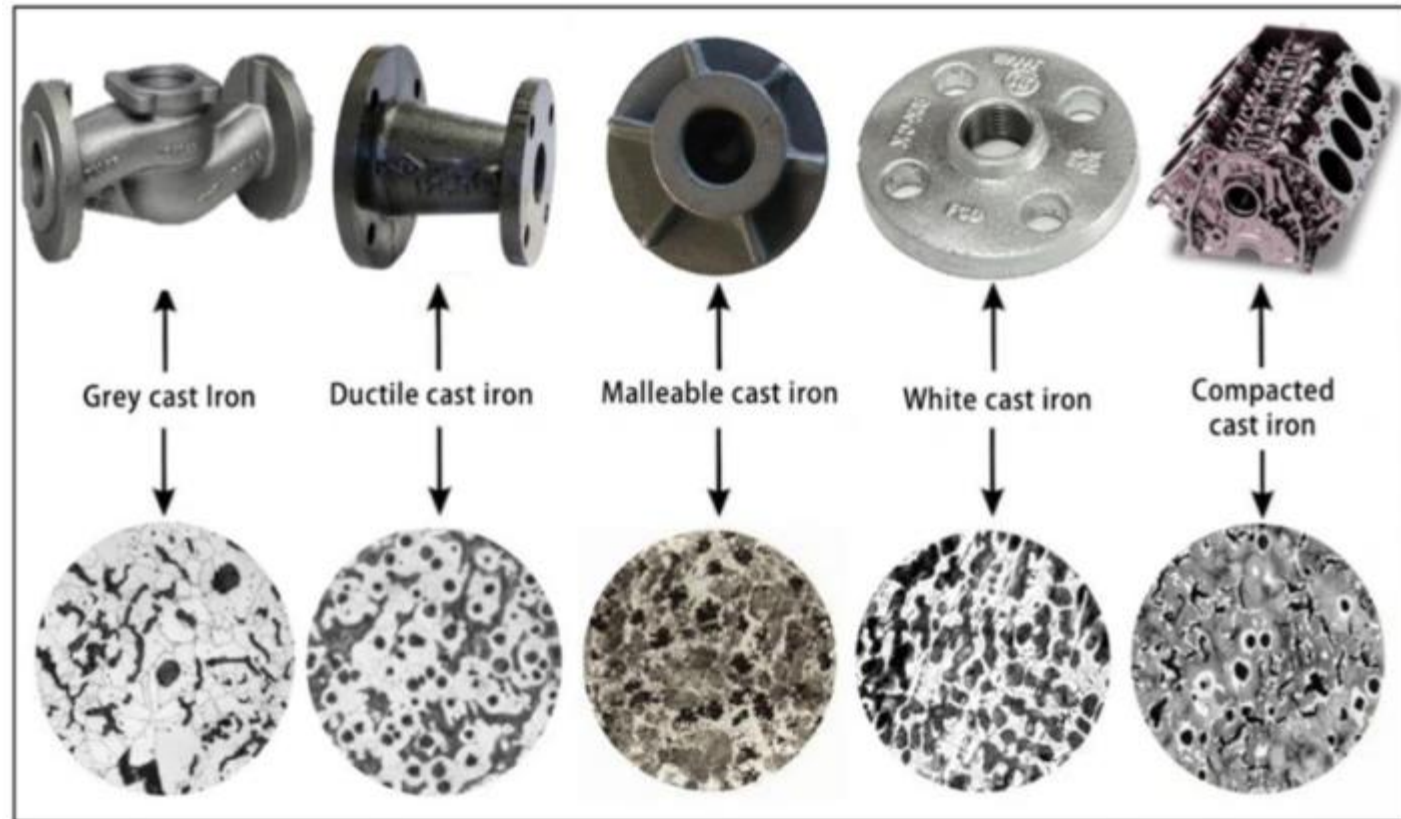
Cast Iron:

- Cast iron is a eutectic alloy of iron and carbon.
- It has relatively **low melting point**, therefore it can be melted very easily.
- It requires **less fuel and more easily** operated in furnaces.
- The **carbon content** of the cast iron varies from 2% to 4.5%.
- It also contains small amounts of silicon, sulphur, manganese and phosphorus.



TYPES OF CAST IRON

1. White cast iron
2. Gray cast iron
3. Nodular cast iron
4. Malleable cast iron
5. Chilled cast iron
6. Molted cast iron
7. Alloy cast iron.



Gray Cast Iron

It is an ORDINARY COMMERCIAL CAST IRON and it has the following compositions:

- ❖ Carbon 3% to 3.5%
- ❖ Manganese 0.4% to 1%
- ❖ Silicon 1% to 2.75%
- ❖ Phosphorus 0.15% to 1%
- ❖ Sulphur 0.02% to 0.15% and remaining is iron.



The gray colour of this cast iron is due to the fact that the carbon is present in the form of free graphite which acts as a lubricant, due to this reason, it is very suitable for those parts where the sliding action is desired.

<i>Properties:</i>	<i>Applications:</i>
❖ It has a low tensile strength.	❖ Gray cast iron is widely used for:
❖ High compressive strength.	❖ Machine tool bodies.
❖ No ductility.	❖ Automobile cylinder blocks.
❖ It can be easily machined.	❖ Pipes and pipe fittings.
	❖ Agricultural implements.

White Cast Iron

It is a particular variety of cast iron, which shows a white fracture. It has a following compositions:

Carbon	2% to 2.3%
Manganese	0.1% to 0.4%
Silicon Phosphorus	0.85% to 1.2%
Sulphur	0.05% to 0.2%
And remaining is iron.	0.12% to 0.35%



The white colour of cast iron is due to the fact that the carbon is in the form of carbide known as **cementite** and it is the hardest constituent of iron. This cementite is caused by quick cooling of molten iron.

Applications.

It is used for inferior casting and in place where hard casting is required.

It is used for car wheels.

It is used as raw material for the production of wrought iron and malleable cast iron.

Properties.

High tensile strength

Low compressive strength

It is hard

It cannot be machined

It is white in colour.

Malleable Cast Iron

- ❑ The malleable cast iron is obtained from white cast iron by a suitable heat treatment process i.e. by annealing.
- ❑ The annealing process separates the combined carbon of the white cast iron into nodules of free graphite.
- ❑ It is a ductile in nature and may be bent without breaking or fracturing the section. Its tensile strength is higher than the gray cast iron and has an excellent machining qualities.

Malleable Iron



Ductile Iron



COMPOSITION:		PROPERTIES:	APPLICATIONS:
Carbon	2.3-2.7%	It is highly ductile.	It is used for the following:
Silicon	1.0-1.75%	Can be bent without fracture.	Hubs of wagon wheels.
Manganese	0.15-1.25%	High tensile strength than gray CI.	Small fittings for railway rolling stock.
Sulphur	0.02-0.20%	Excellent machinability.	Brake supports.
Phosphorus	0.02-0.15%		Parts of agricultural machinery.
			Pipe fittings.
			Door hinges, locks, etc.

Steels

Steel is an alloy of iron and carbon with carbon content up to a maximum of 1.4%. The carbon occurs in the form of iron carbide.

Iron carbide increases the hardness and strength of the steel.

The other elements like silicon, sulphur, phosphorus and manganese are also present to impart the desired properties.

Types of Steels:

Steels can be classified into the following:

- 1) Plain carbon steels
- 2) Alloy steel
- 3) Tool steels
- 4) High speed steel
- 5) Heat resisting steel
- 6) Stainless steel
- 7) Free cutting steels
- 8) Spring steels.



Plain Carbon Steels



Definition:

- ❖ It can be defined as a steel which has its properties mainly due to its carbon content and does not contain more than 0.5% of silicon and 1.5% of manganese.
- ❖ The plain carbon steels contains the carbon varying from 0.06% to 1.4%. These steels are strong, tough, ductile and used in expensive materials.
- ❖ They can be cast, worked, machined and heat treated to a wide range of properties. Plain carbon steel has a poor atmospheric corrosive resistance, but it can be protected easily by painting, enamelling or galvanizing.
- ❖ The strength and hardness of the steel increases *with an increase in* carbon content.
- ❖ The ductility and toughness decreases with an increase in the carbon content.

Types of Plain Carbon Steels and their Compositions:

Following are the different types of plain carbon steels:

Dead mild steel	0.06% to 0.12% carbon.
Low carbon or mild steel	0.10% to 0.25% of carbon
Medium carbon steel	0.25% to 0.55% of carbon
High carbon steel	0.55% to 1.4% of carbon

Properties of Plain Carbon Steels:

Following are the properties of plain carbon steels:

- ❖ These are highly ductile and soft.
- ❖ These are harder and tougher.
- ❖ Poor atmospheric corrosive resistance.
- ❖ They can be easily forged.
- ❖ They can be easily welded and machined.

Types of Steels	Applications or Uses
Dead mild steels	Nails, rivets, plates, chains, stampings etc.
Low carbon steels or mild steels	Chain links, nails, rivets, ship hulls, car bodies, bridges, cams, light duty gears etc.
Medium carbon steels	Axles, connecting rods, gears, wheels for trains and rails etc.
High carbon steels	Clutch plates, razor blades, scissors, knives, files, punches, dies etc.

Alloy Steel

Definition:

The alloy steel can be defined as the steel in which elements other than carbon are added in sufficient quantity in order to obtain special properties is known as alloy steel.

These steel contain carbon together with small amounts of manganese and silicon.

The alloying of steel is generally done to increase its strength, hardness, toughness, resistance to abrasion and wear and to improve electrical and magnetic properties. The various alloying elements are nickel, chromium, molybdenum, cobalt, vanadium, manganese, silicon and tungsten.

Purposes of Alloying:

The alloying elements are added to accomplish one or more of the following:

- ❖ To impart a fine grain size to steel.
- ❖ To improve casehardening properties.
- ❖ To improve elasticity;
- ❖ To improve corrosion and fatigue resistance.
- ❖ To improve hardness, toughness and tensile strength.
- ❖ To improve machinability.
- ❖ To strengthen the ferrite.
- ❖ To improve high or low temperature stability.
- ❖ To improve cutting ability.
- ❖ To improve wear resistance.
- ❖ To improve ductility.

TOOL STEELS

These are the steels for making the tools and dies which are required for cutting, forming, shaping and blanking of materials.

Tool steels should have high resistance, greater wear resistance, greater toughness, high thermal conductivity, high impact strength, low coefficient of friction, etc.

Tool steel is typically composed of iron and carbon with additions of alloying elements like chromium, tungsten, molybdenum and vanadium.

The carbon content usually ranges from 0.1% to 1.6%.

Properties:

Following are the properties of tool steel:

- 1) Excellent wear resistance.
- 2) Greater toughness.
- 3) Hard material.
- 4) High thermal conductivity.
- 5) It withstand high temperature.
- 6) Good impact resistance.
- 7) Low co-efficient of friction.
- 8) Good machinability.
- 9) Good corrosive resistance.



Composition:

Carbon	0.1% to 1.6%
Chromium	0.5 to 15% or more
Molybdenum	0.1 to 1.5% or more
Vanadium	0.1 to 2% or more
Tungsten	0.1 to 5% or more

Applications:

It is used for cutting tools (e.g. drill bits, lathe tools)

Used for making dies and moulds for shaping materials.

Used for making forming dies.

Used for stamping and forming tools.

Used for hot working tools.

TUNGSTEN STEEL

Tungsten steel is a composite material made of tungsten and other alloying elements, such as carbon, cobalt, molybdenum and chromium. **It is also known as cemented carbide.**

Composition:

Tungsten	2% to 18% of alloy by weight
Cobalt	0 to 20% depends on type of alloy.
Carbon	0.6% to 0.8%
Molybdenum	Depends on type of alloy, varies up to 70%
Chromium	4%
Vanadium	less than 0.5% but can be high in high speed steels.



PROPERTIES

- ☐ Tungsten steel is extremely hard and wear resistant.
- ☐ It is very strong and improves the strength of steel at higher temperature.
- ☐ Resistant to corrosion.
- ☐ It has high melting point, 3422°C making is suitable for higher temperature.
- ☐ It is very dense material i.e. 19.3 g/cm³.

Applications

It is used for making permanent magnets.

It is used for making high speed cutting tools and high speed machineries.

Used for making nozzles for rocket engines.

Used for making micro drill bits.

Used for making filaments for light bulbs.

Used for making heating elements.

Used for making electrodes and engine parts.

Stainless Steel

A stainless steel is a group of iron based alloy which when heat treated and finished, resists oxidation and corrosive attack from corrosive media.

It contains a minimum of approximately 11% of chromium a composition that prevents the iron from rusting and also provides heat resistant properties.

A typical composition of stainless steel (i.e. 316 Austenitic stainless steel)

Carbon	-0.08%
Manganese	-2.00%
Phosphorus	-0.045%
Sulphur	-0.030%
Chromium	-16 to 18%
Silicon	-0.75%
Nickel	-10 to 14%
Molybdenum	-2 to 3%
Nitrogen	-0.10%



PROPERTIES

- ❖ Excellent corrosion resistance.
- ❖ High strength.
- ❖ High durability.
- ❖ Good temperature resistance.
- ❖ High tensile strength.
- ❖ Greater toughness
- ❖ Good resistance to oxidation.

APPLICATION

- Used for making cookware, cutlery etc.
- Used for making medical equipment's.
- Used for making scissors, gears and springs.
- For making ball bearings, cutting and dental equipment's.
- For manufacturing bars, sheets, strips, pipes, wires, etc.
- Used for plumbing fittings.
- Used for kitchen utensils.

HIGH SPEED STEEL (HSS)

High speed steel is a special alloy steel typically containing.

Composition:

Tungsten	18%
Chromium	4%
Vanadium	1%
Carbon	0.6 to 0.8%

Sometimes it also contains cobalt or molybdenum.

These are used for cutting metals at a much higher cutting speed than ordinary carbon tool.

These steels have a valuable property of retaining their hardness even when heated to red hot.



High Speed Steel

PROPERTIES

It has an excellent toughness.

Exceptional hardness.

Good wear resistance.

Ability to maintain its cutting properties at higher temperatures.

Excellent machinability.

Good regrindability.

Good corrosion resistance.

APPLICATIONS

- ❖ For making cutting tools like drills, taps and milling cutters.
- ❖ For making Lathes, planer and shaper tools.
- ❖ Used for saw blades.
- ❖ Used for broachers and gear cutters.
- ❖ Used for punches and dies.
- ❖ Used for rolling equipment's.
- ❖ Used for medical instruments like surgical blades and dental tools.
- ❖ Used for manufacturing the aerospace components.
- ❖ Used for manufacturing automotive parts etc.

Week 02 Review Questions

1. What is cast iron? Write the types of cast iron.
2. Write the composition of gray cast iron.
3. What are the properties and applications of gray cast iron?
4. What is the composition of white cast iron?
5. What are the properties and applications of white cast iron?
6. What is malleable cast iron? Write its properties.
7. What are the properties and applications of malleable cast iron?
8. What is steel? List the types of steel.
9. Write the properties of plain carbon steel.
10. List the different plain carbon steel with their composition.
11. What are the applications of plain carbon steel?
12. What is alloy steel? List the purpose of alloying.
13. What are the purposes of alloying?
14. What is tool steel? List the types of tool steel.
15. What is tungsten steel? List the types of tungsten steel.
16. What are the properties and applications of tungsten steel?
17. What is tungsten steel? Write its composition.

