Wrought Iron

- Wrought iron is the purest form of iron containing less than 0.02% C with a small percentage of finely divided slag, distributed uniformly through out the metal
- It is produced from pig iron by remelting it in the puddling furnace
- It is soft, malleable, ductile and tough
- Composition: C – 0.02% (max.)
  Si – 0.02 to 0.1%
  S – 0.008 to 0.02%
  Mn – 0.01 to 0.02%
  P – 0.05 to 0.2%

Material Science & Metrology

Mechanical S3 - Module 1

Vijesh pm

Wrought Iron

Properties:

- It is never cast
- It can be easily cold worked and welded
- It is soft, malleable, ductile and tough
- Due to the presence of slag in wrought iron, it is corrosion resistant
- It cannot be heat treated for changing it's physical properties
- It possess good impact strength and fatigue resistance

To study

- Crystal structure and classification of engineering materials
- Phase diagrams, Fe-C phase diagram
- The importance of TTT diagram
- Classify different types of steels based on the carbon content
- The different ferrous alloys, its properties use and applications

Steel

Classification:

- Steels may be classified, according to composition into two groups
  - a. Plain carbon steels (Unalloyed steels)
  - b. Alloy steels

Wrought Iron

Uses:

- Wrought iron is used for making
  - bolts and nuts
  - rivets
  - chains
  - crane hook
  - railway coupling
  - pipe and pipe fittings
  - plates, sheets, bars
  - boiler tubes

Plain Carbon Steel

- Steels which have it's properties mainly due to carbon content are called plain carbon steels
- Carbon is the principal determinant of many performance properties
- Carbon content -

Increases	Decreases
strength and hardness	softness and ductility
	machinability & weldability
	thermal & electrical conductivity
	magnetic permeability
	corrosion resistance

Steel

- Steel is an alloy of iron and carbon, with carbon content varying upto 2%
- The main difference between cast iron and steel is that , steel never contains graphite or free carbon in it
- In steel, the major portion of the carbon exists in cementite(iron carbide) and a small portion in ferrite
- Besides C, other elements present in steel are Si, Mn, S, P etc.

Plain Carbon Steel

Classification:

- The plain carbon steels are usually classified on the basis of carbon content. They are

1. Low carbon steels – 0.08 to 0.3% C
    a. dead mild steel – 0.08 to 0.15% C
    b. mild steel – 0.15 to 0.3% C
2. Medium carbon steels – 0.3 to 0.8% C
3. High carbon steel – 0.8 to 1.5%

Plain Carbon Steel

- Even though the iron-carbon alloys upto 2% C content are classified as steel, for industrial applications iron-carbon alloys with C content only upto 1.5% are considered as steel.
- If the C content s increased above 1.5%, there is a chance for the formation of graphite in it's structure. When graphite is formed, it is called by the name cast iron.

Plain Carbon Steel

Classification:

Types of steel	Carbon content	Uses
Dead mild steel	0.05-0.15%	Chains, stampings, rivets, nails, seam welded pipes, tin plate, automobile body steel, and material subjected to drawing and pressing.
Mild steel	0.15-0.30%	Structural steels, Machine and structural work, universal beams, screw, gears, drop forgings, free cutting steel, case hardening steel, shafting and forgings.
Medium carbon steels	0.30-0.80%	Connecting rods, shafting, axles, crank hooks forging, crank shafts, gears, die-block rotors, tyres, skip wheels, Loco tyres, rails, wire ropes, Drop hammer dies, saws, screw-drivers, Band saws, anvil faces, hammers, wrenches, laminated springs, cable wires, large dies for cold presses.

Plain Carbon Steel

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Ferrous metals

8.	Cannot absorb shocks.	Can stand sudden and excessive shocks.	Absorbs shocks.	Absorbs shocks.
9.	Fair tensile strength and good compress-ive strength.	Better tensile strength and compressive strength less than cast iron.	Tensile strength is better than cast iron and wrought iron, while comp-ressive strength better than wrought iron but less than cast iron.	Both tensile and compressive strength better than cast iron, wrought iron and mild steel.
10.	Becomes soft in salty water.	Stands salty water better than cast iron.	Not much affected by salty water.	Not much affected by salty water.
11.	It is used for making bed plates, columns, rail chairs, brackets, drain pipes, water pipes and machine parts not subjected to heavy shocks.	It is used for making rolled iron joints, angle iron, crane hooks, chains, rail-way couplings etc.	It is used for all kinds of structural work in bridges and buildings, for making channels, rails, angle iron, rivets, bolts, wire and for making sheets.	It is used for dies, cutlery and edge tools.

Plain Carbon Steel

Classification:

High carbon steels	0.80-1.50%	Cold chisels, shear blades, punches, rocks drills, Axles, knives, drills, taps, screw ring dies, Ball bearings, files, broaches, razors, boring and finishing tools, metal cutting tools for lathe, planer and slotter, mandrels, drawing dies, gauges, etc.

Alloy Steel

- Steels in which elements other than carbon are added in sufficient amounts to produce improvements in properties are known as alloy steels
- The various alloying elements are Ni, Cr, Mo, W, V, Mn, Si and Co
- These elements may be used separately or in combination to produce required properties in steel

Ferrous metals

S.No.	Cast Iron	Wrought Iron	Mild Steel	High Carbon Steel
1.	It contains 3 to 4% carbon.	Purest form of iron containing 0.02 to 0.03% carbon.	Contains 0.15 to 0.30% carbon.	Contains 0.80 to 1.5% carbon.
2.	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 be hardened by heating and sudden cooling but cannot be tempered.	Can neither be hardened nor temp-ered.	Can be hardened and tempered but not easily.	Can be hardened and tempered readily.
4.	Can neither be forged nor welded.	Can be easily forged and welded.	Can be readily for-ged and welded.	Cannot be easily forged and welded.
5.	Cannot be magneti-sed.	Can be temporarily magnetised.	Can be permanently magnetised.	Can be permanently magn-etised.
6.	Neither malleable nor ductile.	Very malleable and ductile.	Malleable and duct-ile.	Brittle and less ductile than mild steel.
7.	Does not rust easily.	Rusts more rapidly than cast iron.	Rusts readily.	Rusts rapidly.

Alloy Steel

Cobalt improves hardness, toughness, tensile strength, thermal resistance and magnetic properties. It also acts as a grain refiner.

Manganese increases strength and toughness, imparts hardness accompanied by brittleness, and high degree of hardness.

Silicon acts as a ferrite strengthener and improves elastic limit. It improves magnetic permeability and decreases hysterisis losses. Higher percentage of silicon gives rise to corrosion resisting alloys.

Molybdenum increases wear resistance, thermal resistance, hardness, ability to retain mechanical properties at elevated temperatures and helps to inhibit temper brittleness. When added with nickel, it also improves corrosion resistance.

Tungsten increases hardness, toughness, wear resistance, shock resistance, magnetic reluctance and ability to retain mechanical properties at elevated temperatures.

Alloy Steel

The reason for alloying various elements in steel are

1. To improve various mechanical properties like tensile strength, toughness, impact strength, ductility, hardness etc.
2. To improve corrosion resistance
3. To improve electrical and magnetic properties
4. To improve hardenability
5. To improve weldability and machinability
6. To improve resistance to abrasion and wear
7. To retain physical properties at high temperature
8. To control grain size

Alloy Steel

Vanadium is a powerful deoxidizer, a strong carbide former, inhibits grain growth and is very expensive.

Boron increases hardenability and is, therefore, very useful when alloyed with low carbon steels.

Aluminium is basically used as a deoxidiser. It promotes the growth of fine grains, helps in providing a high degree of hardness through nitriding by forming aluminium nitrides.

Titanium is a strong carbide former, effectively inhibits grain coarsening and acts as a grain refiner. In order to prevent the precipitation of chromium carbides, titanium is added to stainless steels.

Copper increases resistance to atmospheric corrosion and also acts as a strengthening agent. It's proportion normally varies from 0.2 to 0.5%.

Alloy Steel

Effects of alloying elements:

In order to select the alloy steel that is best suited for a given design, the effects of primary alloying elements must be taken into account. They are :

Nickel improves toughness, tensile strength, ductility, corrosion resistance and deep hardening.

Chromium improves tensile strength, corrosion resistance, toughness and hardenability.

Alloy Steel

Important alloy steels

2. **High Speed Steel(HSS)**: The different types of HSS are

   a) **18-4-1 HSS**: 18% W, 4% Cr and 1% V with 0.72% C

   It is considered to be one of the best all purpose tool steel with greater abrasive resistance. It is widely used for drills, lathe, planner and shaper tools, dies and punches etc.

   b) **Molybdenum HSS**: 6% Mo, 6% W, 4% Cr and 2% V with 0.85% C

   This steel has high hardenability, improved toughness and cutting ability

Alloy Steel

Important alloy steels

1. **Silicon steel**:

   Steel with 2% Si, 1% Mn and 0.4 to 0.6% C has very good elastic limit & toughness and used for springs

   Low and medium carbon steels containing 5% Si have good magnetic permeability and low hysteresis loss, they are used in transformers, motors and generators

Alloy Steel

Important alloy steels

2. **High Speed Steel(HSS)**: The different types of HSS are

   c) **Cobalt HSS**: 20% W, 4% Cr, 2% V and 12% Co with 0.8% C

   It has increased red hardness, wear resistance and is used for heavy cutting operations at elevated temperatures

   This is also known as super high speed steel

Alloy Steel

Important alloy steels

2. **High Speed Steel(HSS)**:

   This steel is used for high speed cutting operations

   They operate at cutting speeds 2 to 3 times higher than for carbon tool steels and retain their hardness up to 600^0C

   Most of the HSS contain W as the chief alloying element

   Other elements like Cr, Mo, Co and V may be preent in some proportion

Alloy Steel

Important alloy steels

3. **Spring Steel**:

   Spring steels should possess maximum strength, high elastic limit, high toughness and high fatigue strength & shock resistance

   Steel containing 1.6 to 2% Si, 0.5 to 0.6% C, 0.8 to 1.1% Mn is extensively used as a high quality modern spring material

   They are used for motor car laminated and coil springs, automobile and air craft engine valve springs etc.

Alloy Steel

Important alloy steels

4. **Stainless Steel(SS)**:

Assignment 1:

Write about

- Stainless steel(SS)
- Composition of SS
- Properties and uses of SS
- Types of SS (Ferritic SS, Martensitic SS, Austenitic SS) and their applications