- Tool structures bed and frame
- Gas and water pipe underground purposes
- Cylinder block and head for I.C engine.
- Ingot moulds
- Piston ring.
- Rolling mill, etc.

2.**Malleable cast iron** –it is iron base alloying of carbon and chromium and nickel and chemical composition is C -2-3% ;Si -0.6 -1.3 % ; Mn -0.2 -0.6 % ; P 0.15% ; S 0.10% .

Malleable cast iron is fame ferrite and perlite matrix.

Property –

- Hard and brittle
- High strength
- High yield strength
- Low coefficient of thermal expansion.
- Good wear resistance.
- Good vibration damping.

Application

-automotive industry.
-Gear case
-crankshaft.
-rear axle housing
-universal joint
-Railroad
-electrical line

3.**Nodular cast iron**- it is iron base alloying of carbon and fame a perlite matrix ferrite(white) surrounded by graphite nodules(slow cooling). And chemical composition is C-3.2 -4.2%; Si -1.1 -3.5% ; Mn-0.08% ; P -0.08 % ; S -0.2%.

Property –

-good machinability
-damming capacity intermediate between cast iron and steel.
-good wear resistance.
-good castability.

Application

-Pipes
-Valves
-Pumps
-Steel mill
-IC engines
-Power transmission equipment.
-Construction machinery, etc.

4.**White cast iron** – it is iron base alloying the carbon and rapidly cooling, and fame iron carbideFe_3C .chemical composition is-

C -1.8 -3.6 % ; Si -0.2 -0.8 % ; Mn -0.2 -0.8 % ; P – 0.18% ; S -0.10%.

Property –

- Good abrasive resistance.
- Hard and brittle.
- Not machinable.

Application

- Power transmission equipment.
- Construction machinery
- automotive industry.

1.1.2 Ferrous Alloys (Steel)

Ferrous alloys have included steels and cast irons. Steel is an alloy of iron and carbon. The biggest disadvantage of many ferrous alloys is low corrosion resistance but steel have high mechanical property. Carbon is an important alloying element in all ferrous alloys. In general, higher levels of carbon increase strength and hardness, and decrease ductility and weld ability. Various types of steel use in engineering works they are following types.

1- Plain carbon steel 2. Stainless steels 3..High speed steel

1. **Plain Carbon Steel** – A plain Carbon steels is alloy of iron and carbon and carbon contain from 0.10 -1.2% basically just mixtures of iron and carbon. They may contain small amounts of other elements, but carbon is the primary alloying ingredient. The effect of adding carbon is an increase in strength hardness and malleability .Most carbon steels are plain carbon steels, of which there are several types.

Low-Carbon Steel /Mild steel

Low-carbon steel has less than about 0.30% carbon. It is characterized by low strength but high ductility. Some strengthening can be achieved through cold working, but it does not respond well to heat treatment. Low-carbon steel is very weld able and is inexpensive to produce. They are following types-

(i) Dead mild steel – Percentage of carbon is 0.05-0.15% ; use – wire ,sheet ,rivets, screw, etc.
(ii) Mild Steel – percentage of carbon is 0.15 -0.30 % ; use making sheet and strips, camshafts, forging connecting rod, railway axles .

Medium-Carbon Steel

Medium-carbon steel contains between about 0.30% to 0.70% carbon. It can be heat treated to increase strength, especially with the higher carbon contents. Medium-carbon steel application is very about percentage of carbon

- Containing percentage of carbon is 0.30-0.40% ; use –connecting rod ,wires and rod ,gear shafts, key stock small and medium forging.
- Containing Percentage of carbon is 0.40-0.50%; use - Railway coach, axles crank pin, crankshaft etc.

- Containing Percentage of carbon is 0.50 – 0.70 %; use –die blocks, set screw, valve springs; clutch discs; drop forging, etc .

High-Carbon Steel

High-carbon steel contains between about 0.70% to 1.40% carbon. It has high strength but low ductility. Its application base on percentage of carbon :

- Containing percentage of carbon is 0.7 -0.8 % ; Use –wrenches ,jaws for vices , shear blades wheels for railway ,automatic clutch discs.
- Containing percentage of carbon is 0.8 -0.9 % ; Use –clutch discs ,punches and dies ,circular saws ,rock drills ,machine chisels
- Containing percentage of carbon is 0.9 -1.8 % ; Use – seed disc ,pins, key , shear blades ,punches and dies.
- Containing percentage of carbon is 1.0 -1.1 % ; use –machine tool ,taps , mandrels ,railway springs , etc.
- Containing percentage of carbon is 1.1 -1.2 % ; Use –thread metals dies ,Twist drills ,taps etc.
- Containing percentage of carbon is 1.2 -1.3 % ;Use –files ,reamers ,metal cutting tools etc.
- Containing percentage of carbon is 1.3 -1.4 % Use – wire drawing , metal cutting saws , tool for turning ,etc.

Alloy Steel

alloy steels, also commonly called alloy steels, contain less than about 8% total alloying ingredients and content of alloying elements exceeds one or more of the limit.(Mn -1.60% , Si -0.78% ,CU -0.59% . alloy steels are typically stronger than carbon steels and have better corrosion resistance. Chemical composition is –

C-0.2 -0.4%; Si – 0.3 -0.6 %; Cr -0.4 -0.6 %;

Mn-0.3 -1.0%; Ni -0.4 -0.7%; Mo -0.15 -0.3%;

Some alloy steels are designated as high-strength low-alloy (HSLA) steels. What sets HSLA steels apart from other low-alloy steels is that they are designed to achieve specific mechanical properties rather than to meet a specific chemical composition.

Purpose of allowing.

- Improve corrosion resistance
- Improved machinability.
- Improve toughness.
- Improve high and low temperature stability.
- Better hardenability.
- Grain size control.

Allowing elements and effect on mechanical property-

Carbon – effect – hardness

-Machinability

- Tensile
- strength
- Melting point

Nickel steel - effect – increases toughness. C-0.36% ; Ni -3.6%

-lower critical temperature.

-Strengthens steel.

Chromiun steel – hardenability. C -0.36% ; Ni -1.24% ; Cr -0.65%;

- resistance to abrasion and wear.

Silicon steel - effect – improve oxidation resistance . C-0.10% ;Mn -0.65% ;Si -1.2%

- Strengthens low alloy steels.
- deoxidizer.

Titanium - effect – long heating.

- Hardness and hardenability.

Molybdenum steel - effect – hardenability. C -0.27% ; Mo - 0.85% ;

- Fine grained.
- Creep strength.
- Increases corrosion resistance.

Vanadium steel - effect – fine grain. C-0.27% ; V -0.25 %

- Hardenability.
- Impart strengths and toughness.
- Hardening.

Tungsten steel - effect – increases the hardness. C-0.60% ; Cr – 1.75% ; Tungsten – 2.5%.

- Fine grain.
- Heat resists. Strengths.

Manganese steel - effect – strengths and hardness. C-0.17-0.49% ; Mn -1.5-2% ;S -0.32%

- Lower ductility and weld ability.

Copper - effect – Increases corrosion resistance.

- Strengths.

Boron - effect – Hardenability.

Aluminium - effect – deoxidizer.

- Fine grain.

Cobalt - effect – increases the hardness.

-increases the heat resistance.

- Hardenability.

- increases tensile strengths, fatigue strengths.

Vanadium - effect – powerful carbide form.

Tool Steel[1]

Tool steels are primarily used to make tooling for use in manufacturing, for example cutting tools, drill bits, punches, dies, and chisels. Alloying elements are typically chosen to optimize hardness, wear resistance, and toughness. Composition of tool steel is following types –

1.W-high speed steel (T) – T_1 –C-0.7 ; Cr-4 ;V-1 ; W-18 ;

T_4 –C -0.75 ; Cr -4 ; V -1; W-18 ; Co-5 ;

T_6 - C-0.8 ; Cr -4.5 ; V-1.5 ; W-20 ; Co -12 ;

2.Mo –High speed steel(M) –M_1 –C -0.8 ; Cr-4 ; V-1; W-1.5; Mo -8 ;

M_2 – C-0.8 ; Cr-4 ; V-1.5; W-1.5; Mo -8 ; Co-12 ;

3.high C, high Cr steel (D) - D_2 – C-1.5 ; Cr -12 : Mo-1;

D_5 – C-1.5 ; Cr -12 : Mo-1; Co-3 ;

D_7 – C-2.35 ; Cr -12 : Mo-1; V-4;

4. Air hardening steel (A) – A_2 - C-1.1 ; Cr -5.5 ; Mo-1.1;

A_7- C-2.25 ; Cr-5.4 ; V-4.5; W-1.1; Mo -1.1 ;

A_9 - C-0.56; Cr-5.1; V-1.1; W-1.1; Mo -1.5 ; Ni-1.6

5.Oil hardening steel(O) –O_1 - C-0.9 ; Mn -1.4 ; Cr-0.5; W-.4; Mo -1.1 ;