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Sub: Non Ferrous Metallurgy
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A) Properties of Pure Aluminium (Al)

(1) Pure aluminium is a very soft & ductile material (2) It is has god good strength (3) Strength to weight ratio of aluminium is high (4) Al has excellent corrosion resistance properties.(5) It has good thermal conductivity (6) It has excellent electrical conductivity. (7) Aluminium has FCC crystal structure.

B) Duralumin alloy (Al-4.5%Cu):

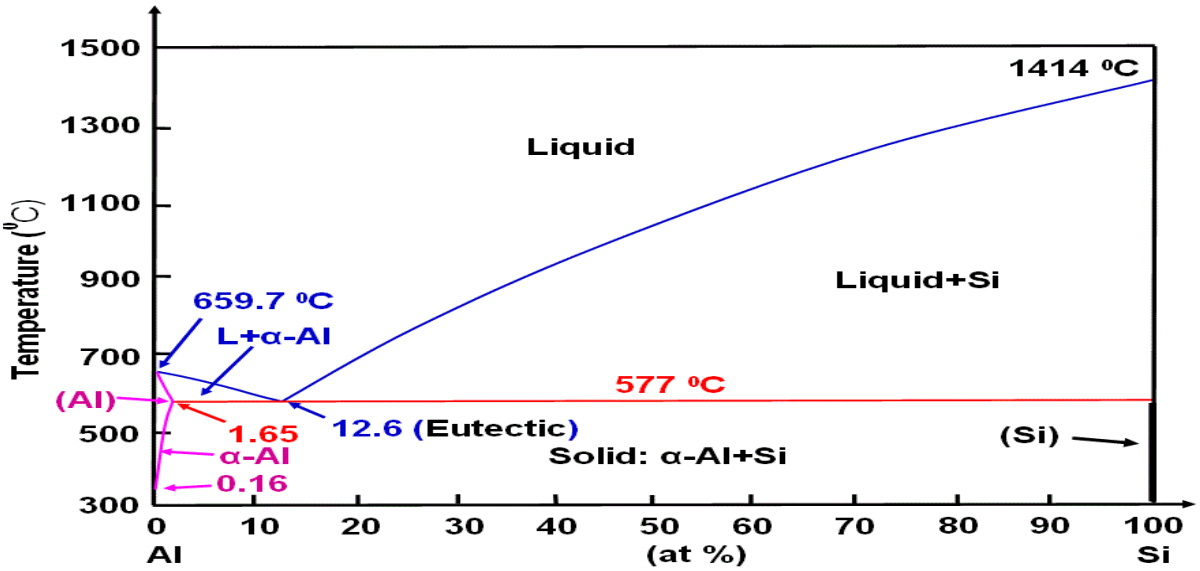
Duralumin is one of the important Aluminium alloy and it is widely used in various industries. Composition, properties and application of the duralumin alloys are given below:

Composition: 3.5- 4.5 % Cu + 0.5% Mg + 0.5% Mn + Balance Aluminium (above 90%)

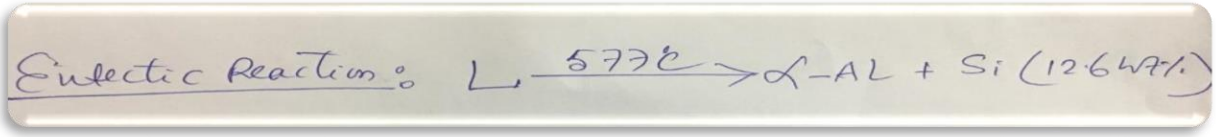
Properties: (1) It's a light weight material (2) It is very tough and highly ductile in nature (3) Strength to weight ratio of duralumin is very high (4) Its is a good conductor of heat and electricity (5) Duralumin has excellent corrosion resistance properties (6) It has good machinability. So machining of the duralumin items can be done easily.

Application/Uses: (1) It is widely used in Aircraft industry as aeroplane body, wings and various other parts due to its high strength to weight ratio as well as corrosion resistance properties (2) Duralumin are used in making surgical instruments and electric cables (3) It is used for making automobile and locomotive parts due to its high ductility and electrical conductivity.

C) Al-Si binary phase diagram:



Melting point of Al and Si is 660 deg C & 1414 deg C respectively. Phases present in the above phase diagram is α-Al, pure Si, pure Al and Liquid. Aluminium-Silicon alloys form a eutectic at 12.6 wt% Silicon and the eutectic temperature is 577 deg C. Eutectic point is the lowest possible melting temperature. Al-Si alloy is very important casting alloy and it has excellent corrosion resistance properties and good weldability. Al-Si casting is widely used as automobile components.



D) Properties of pure Si:

Following are the properties of pure silicon.

1) Pure silicon is a hard, dark gray solid type metalloid (having properties of both metal and non metal)
2) Crystal structure of pure silicon is Diamond cubic.
3) Melting point of silicon is very high (1414 deg C)
4) Silicon is an intrinsic semiconductor in its purest form. Due to its semiconducting nature, it is widely used in semiconductor as transistors, chips, photovoltaic cells, IC circuit etc.
5) Silicon is the principal component of glass, cement and ceramics.

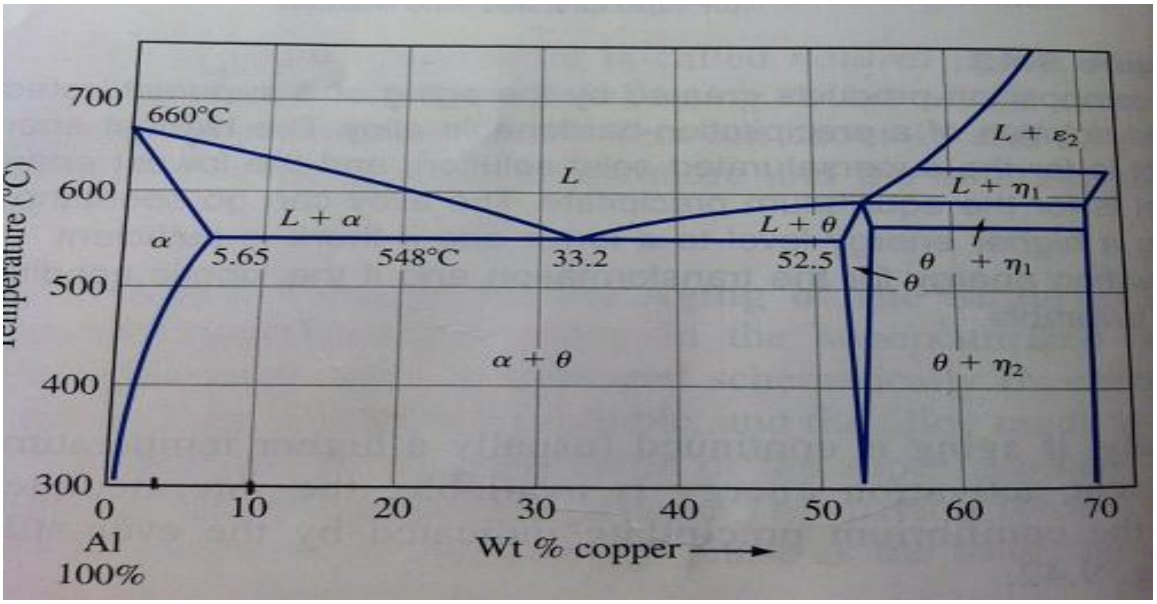
E) Properties of pure Cu:

Following are the properties of the pure copper.

(1) Excellent heat conductivity. (2) Excellent electrical conductivity (3) Good corrosion resistance. (4) Good bio fouling resistance. (5) Good machinability. (6) Copper can retain mechanical and electrical properties even at low temperature. (7) Copper is non magnetic in nature. (8) Copper has FCC crystal structure.

F) Al-Cu binary phase diagram:

Melting point of Al & Cu is 660 deg C & 1085 deg C respectively. Above Al-Cu phase diagram is useful to understand the precipitation strengthening in Al-Cu alloys. Here two solids are completely soluble in their liquid state but partially soluble in the solid state. Aluminium forms solid solution with copper in which copper has maximum solubility of 5.65 wt% at 548 deg C. With cooling further precipitation of α phase (Al rich phase) takes place, this is known as precipitation hardening. But within 0.5 to 5 wt% Cu, there will be two phases (α + θ). Where θ is nothing but $CuAl_2$ precipitate. Eutectic reaction for this binary phase diagram takes place at 33.2 wt% of Cu and at 548 deg C.



Al-Cu binary phase diagram

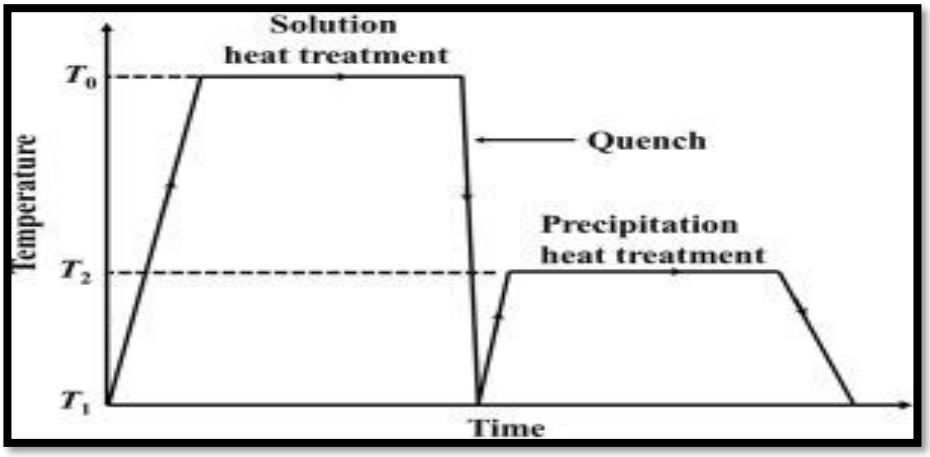
G) Heat treatable Al-Cu alloys:

Aluminium alloys are mainly classified as heat treatable and non heat treatable. The main criterion for heat treatment is whether the alloy will precipitate or not on heat treatment. And this one is known as precipitation hardening. The main alloying elements responsible for precipitation is copper, magnesium and zinc.

The major aluminium alloy which are heat treatable is Al-Cu alloy, Al-Cu-Mg alloy etc. An Al-Cu alloy which is heat treatable is commercially designated as 2XXX series. Main alloying element is copper. This alloy requires solution heat treatment as well as ageing process to obtain the optimum properties like strength, hardness and ductility.

Heat treatment of aluminium-copper alloys is a three-step process:

a) Solution heat treatment: dissolution of soluble phases
b) Quenching: development of super saturation by solutes
c) Age hardening: precipitation of solute atoms either at room temperature (natural aging) or elevated temperature (artificial aging or precipitation heat treatment). For Al-Cu alloy precipitation of CuAl2 phases takes place.



Sketch showing the heat treatment steps for Al-Cu alloy.

H) Properties of Antifriction material:

Antifriction materials are usually used for machine parts like bearing, bushing and others. A good antifriction material should have following properties:

(a) It should have low coefficient of friction.
(b) Should have low adhesion
(c) It should have good wear resistance
(d) Antifriction material should have good thermal conductivity.
(e) It should have good bonding property.
(f) It should deform easily
(g) Should be resistant to corrosion in lubricating medium.
(h) It should have low melting point.
(i) It should have high fatigue resistance.

I)Babbitt Materials:

The term "Babbit" is commonly used to describe any kind of white material which is used as bearing material. Babbitt material is used as a thin layer which covers the entire bearing surfaces. A good babbitt material should have the following properties: (a) Low coefficient of friction (b) High compressive strength (c) High fatigue strength (d) low thermal expansion (e) High thermal conductivity (f) Relative bonding between babbitt material coating and bearing surface should be good.

Babbitt material can be classified into two families: (a) Tin based Babbitt (b) Lead based Babbitt
Lead based Babbitt composition: 10-15% antimony + 10% Tin + 80-90% Lead

Tin based Babbitt composition: 3-8% copper + 4-14% antimony + 80-90% Tin.
Typical composition of the lead based Babbitt material is: 10-15% antimony + 10% Tin + 80-90% Lead
Copper and antimony increases the strength and hardness of the tin based Babbitt material. Increase the amount of this alloying elements beyond the limit decreases cracking resistance and fatigue strength.
.Tin based Babbitt is suitable for high speed or hard to lubricate bearing. But lead based bearing is used for low speed or heavy load bearing application.

Uses: Babbitt materials are used as Bearing , bushing etc in Machineries.

J) Tin Based Babbitt Material:

Tin based Babbitt materials are widely used as antifriction bearing material. It contains more than 80% of tin. The material may also contain small parts of antimony, lead and copper. Typical composition is: 3-8% copper + 4-14% antimony + 80-90% Tin. Following are the properties of the tin based Babbitt material:

a) It has low wear resistance. (b) It has low coefficient of friction. (c) It has excellent thermal conductivity than lead based Babbitt material. Because of high thermal conductivity it helps to carry away heat generated inside the bearing. (d) high load bearing capabilities

Compare to lead based Babbitt material, tin based Babbitt is more costly and used widely. Tin based Babbitt is suitable for high speed or hard to lubricate bearing. Copper and antimony increases the strength and hardness of the tin based Babbitt material. Increase the amount of this alloying elements beyond the limit decreases cracking resistance and fatigue strength. Due to high load bearing capabilities, tin-based Babbitt bearings can be used in compressors, electric motors, heavy machinery, and marine work.

K) Lead-Based Babbitt material:

Lead-based Babbitt is another common bearing material as it contains 75% or more of lead alloy. Most commonly-used, lead-based Babbitt will also contain tin as well as antimony. Typical composition of the lead based Babbitt material is: 10-15% antimony + 10% Tin + 80-90% Lead. Following are the typical properties of the lead based Babbitt material:

1) This material has excellent corrosion capabilities, which makes it ideal for shipboard applications and other work where there will be high humidity and moisture.
2) Like tin-based Babbitt, lead-based Babbitt also provides good frictional capabilities and can adhere well to both bronze or steel bearing surfaces.
3) Lead based material is usually used for low speed or less heavy load bearing application.

4) Lead-based Babbitt is an economical alloy as it can be used for general purpose machinery, line shafting, and machine shops. It can also be used in farm machinery, cement machinery, conveyors, elevator applications and steel mill machinery.

Short question & answer:

1) Pb-Sn alloys is known as - Solder alloy
2) Composition of soldering alloy- 63% Sn (tin) + 37% Pb (lead)
3) Alloy Ti+5% Al + 2.5% Sn – has good corrosion resistance.
4) Inconel contains- 75% Ni + 15% Cr + 9% Fe
5) Bell metal is - Alloy of Cu (78%) + Sn (22%)
6) Strength of Brass can be increased by addition of – Ni , Mn, Si alloying elements.
7) Melting point of Si – 1414 deg C
8) Crystal structure of Si- Dimond cubic
9) Crystal structure of Pb- FCC
10) Crystal structure of Mg, Zn – HCP
11) Monel is alloy of- Ni + Cu
12) Non ferrous alloys are always given age hardening heat treatment.
13) Composition of brazing brass – 59% Cu + 39% Zn + 0.5% Sn
14) Melting point of Cu-1085 deg C, Crystal structure of Cu-FCC
15) Melting point of Al – 660 deg C, Crystal structure of Al – FCC
16) Two aluminium industry –NALCO, Vedanta
17) Two copper industry –Hindustan copper, Vedanta
18) Two zinc industry – Hindustan zinc and Vedanta