Lecture # 2.1a

Engineering Materials

Engineering Materials

Introduction

It is necessary to choose a suitable material for use in machine element,

and the Choice of material depends very much on its properties, cost, availability and such other factors.

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Common Engineering materials are normally classified as Metals and non-Metals.

Metals may conveniently be divided into ferrous and non-ferrous metals.

Important ferrous metals for the design purpose are:

(i) cast iron

(ii) wrought iron

(iii) steel.

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Some of the important non-ferrous metals used in engineering design are:

(a) Light metal group such as Aluminium and its alloys, Magnesium and Manganese alloys.

(b) Copper based alloys such as brass (Cu-Zn), bronze (Cu-Sn).

(c) White metal group such as Nickel, Silver, White Bearing Metals eg. SnSb7Cu3, Sn60Sb11Pb, Zinc etc.

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Ferrous Materials

(i) Cast iron -

It is an alloy of iron, carbon and silicon

it is hard and brittle.

Carbon content may be within 1.7% to 3%

carbon may be present as free carbon or iron carbide Fe3C.

The Cast Iron is further categorized as:

(a) Grey cast iron

(b) White cast iron

(c) Malleable cast iron

(d) Spheroidal or nodular cast iron

(e) Austenitic cast iron

(f) Abrasion resistant cast iron.

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(a) Grey cast iron -

Carbon is present in the form of graphite.

This type of cast iron is inexpensive

It has high compressive strength.

Graphite is an excellent solid lubricant and this makes it easily machinable but brittle.

Some examples of this type of cast iron are FG20, FG35 or FG35Si15.

The numbers indicate ultimate tensile strength in MPa and 15 indicates 0.15% silicon.

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(b) White cast iron -

In these carbon is present in the form of iron carbide (Fe3C) which is hard and brittle.

The presence of iron carbide increases hardness and makes it difficult to machine.

Consequently these cast irons are abrasion resistant.

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(c) Malleable cast iron -

These are white cast irons rendered malleable by annealing.

These are tougher than grey cast iron

They can be twisted or bent without fracture.

They have excellent machining properties

They are inexpensive.

They are used for making parts where forging is expensive such as hubs for wagon wheels, brake supports.

Depending on the method of processing they may be designated as black heart BM32, BM30 or white heart WM42, WM35 etc.

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(d) Spheroidal or nodular graphite cast iron -

In these cast irons graphite is present in the form of spheres or nodules.

They have high tensile strength

They have good elongation properties.

They are designated as, for example, SG50/7, SG80/2 etc

where the first number gives the tensile strength in Mpa

and the second number indicates percentage elongation.

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(e) Austenitic cast iron -

Depending on the form of graphite present these cast iron can be classified broadly under two headings:

Austenitic flake graphite iron designated, for example, AFGNi16Cu7Cr2 and

Austenitic spheroidal or nodular graphite iron designated, for example, ASGNi20Cr2.

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(e) Austenitic cast iron -

These are alloy cast irons, and they contain small percentages of silicon, manganese, sulphur, phosphorus etc.

They may be produced by adding alloying elements viz. nickel, chromium, molybdenum, copper and manganese in sufficient quantities.

These elements give more strength and improved properties.

They are used for making automobile parts such as cylinders, pistons, piston rings, brake drums etc.

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(f) Abrasion resistant cast iron -

These are alloy cast iron, and the alloying elements render abrasion resistance.

A typical designation is ABR33 Ni4 Cr2 which indicates a tensile strength in kg/mm2 with 4% nickel and 2% chromium.

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(ii) Wrought iron -

This is a very pure iron where the iron content is of the order of 99.5%.

It is produced by re-melting pig iron

some small amount of silicon, sulphur, or phosphorus may be present.

It is tough, malleable and ductile and can easily be forged or welded.

It cannot however take sudden shock.

Chains, crane hooks, railway couplings and such other components may be made of this iron.

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(iii) Steel -

This is by far the most important engineering material

and there is an enormous variety of steel to meet the wide variety of engineering requirements.

It is an alloy of iron and carbon in which the carbon content can be less than 1.7%

and carbon is present in the form of iron carbide to impart hardness and strength.

Two main categories of steel are

(a) Plain carbon steel and

(b) alloy steel.

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(a) Plain carbon steel -

The properties of plain carbon steel depend mainly on the carbon percentages

and other alloying elements are not usually present in more than 0.5 to 1% such as 0.5% Si or 1% Mn etc.

There is a large variety of plane carbon steel and they are designated as C01, C14, C45, C70 and so on

where the number indicates the carbon percentage.

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Following are the categorization of plain carbon steels on the basis of carbon percentage:

Dead mild steel - upto 0.15% C

Low carbon steel or mild steel - 0.15 to 0.46% C

Medium carbon steel - 0.45 to 0.8% C.

High carbon steel - 0.8 to 1.5% C

Detailed properties of these steels may be found in any standard handbook but in general higher carbon percentage indicates higher strength.

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(b) Alloy steel -

In order to impart some desired properties, such as wear resistance, corrosion resistance, electric or magnetic properties etc, elements other than carbon are added in sufficient quantities .

The Chief alloying elements added are usually:

Nickel for strength and toughness,

Chromium for hardness and strength,

Tungsten for hardness at elevated temperature,

Vanadium for tensile strength,

Manganese for high strength in hot rolled and heat treated condition,

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(b) Alloy steel (Continue)-

Silicon for high elastic limit,

Cobalt for hardness and

Molybdenum for extra tensile strength.

Some examples of alloy steels are

35Ni1Cr60,

30Ni4Cr1,

40Cr1Mo28,

37Mn2.

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Stainless steel is one such alloy steel that gives good corrosion resistance.

One important type of stainless steel is often described as 18/8 steel where chromium and nickel percentages are 18 and 8 respectively.

A typical designation of a stainless steel is 15Si2Mn2Cr18Ni8 where carbon percentage is 0.15.

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Specifications of Steels

A number of systems for grading steel exist in different countries.

The American system is usually termed as SAE (Society of Automobile Engineers) or AISI (American Iron and Steel Industries) systems.

In this system the first digit indicates the chief alloying material.

Digits 1,2,3,4 5,6,7and 8 refer to carbon, nickel, nickel/chromium, molybdenum, Chromium, chrome/vanadium, tungsten and Silico/ Manganese respectively.

The second digit or second and third digits give the percentage of main alloying element and the last two digits indicate the carbon percentage.

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This therefore explains that SAE 71360 indicates an alloy steel with 0.6% carbon and

the percentage of main alloying material tungsten is 13.

In British system steels are designated by the letters En followed by a number such as 1,2…16, 20 etc.

Corresponding constituent elements can be seen from the standards

but in general, En4 is equivalent to C25 steel,

En6 is equivalent to C30 steel and so on.

References

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