Properties of steel and cement

Steel differs from wrought iron and cast iron, only in the percentage of carbon content. Steel contains more iron than wrought iron and less than that of cast iron. It is because of this reason that steel is considered to occupy a position between these two metals. However, the properties of steel, wrought and cast iron differ tremendously. Let's take a look at the physical properties of steel.

The physical properties of steel are totally different from its component elements viz. iron and carbon. One of the major properties of steel is the ability to cool down rapidly from an extremely hot temperature after being subjected to water or oil. Physical properties depend on the percentage composition of the constituent elements and the manufacturing process. A particular amount of carbon can be dissolved in iron at a specific temperature.

Cement is very costly these days. Cement used in construction is characterized as hydraulic or non-hydraulic. Hydraulic cement hardens because of hydration, chemical reactions that occur independently of the mixture's water content; they can harden even underwater or when constantly exposed to wet weather. The chemical reaction that results when the anhydrous cement powder is mixed with water produces hydrates that are not water-soluble. Non-hydraulic cements (e. g., lime and gypsum plaster) must be kept dry in order to retain their strength.

For mild steel, stainless steel and cast iron,

Mild steel is a type of steel alloy that contains a high amount of carbon as a major constituent. An alloy is a mixture of metals and non-metals, designed to have specific properties. To get what mild steel is, one must know what the alloys that are combined to make steel are. Steel is any alloy of iron, consisting of 0. 2% to 2. 1% of carbon, as a hardening agent. Besides carbon, there are many metal elements that are a part of steel alloys. The elements other than iron and carbon, used in steel are chromium, manganese, tungsten and vanadium. All these elements along with carbon, act as hardening agents. The ductility, hardness and mild steel tensile strength are a function of the amount of carbon and other hardening agents, present in the alloy.

Cast iron has the compressive strength, Compressive strength is defined as the ability of a material to withstand forces which attempt to squeeze or compress it. Cast iron structures show resistance to deformation and provide a rigid frame. However, if one part of the casting after the iron is poured into the molds, is very thin, and another very thick, then the problem of the structure breakdown becomes prominent.

Properties of wood products,

Wood and wood products are materials derived from trees and include timber, lumber, veneer, wood pulp, wood flour, pellets and chips. Wood products are cheaper than that of metals but they cannot be used in heavy duty columns, because of lower value of modulus of rigidity.

Ceramics,

The properties of ceramic materials, like all materials, are dictated by the types of atoms present, the types of bonding between the atoms, and the way the atoms are packed together. In general, most ceramics are hard, wear-resistant, brittle, refractory, thermal insulators, electrical insulators, nonmagnetic, oxidation resistant, prone to thermal shock, and chemically stable.

Glass,

Glass is material very cheap as per condition but modulus of rigidity is lower. So it is hard material but not a tough for absorbing shock.

ANS- 3

Here, as per given condition Kci > 30 Mpa.

There should be following materials from the chart 7.

Cu-alloy

Steel alloy

Ni-alloy

Ti-alloy

But from the chart 15 only steel fits the given criteria. From above materials the modulus of rigidity is given by,

E = 200 Mpa for cu-alloy.

E = 400 Mpa for Ni and Ti alloy.

E = 800-1000 Mpa for steels.

So steel has higher value of E and is cheaper than other materials and is easily available.

ANS- 4

We are told that choose practical alternative from chart.

So we decide to choose CI, Al-alloy and fiber with steel.

Here steel should be,

Stainless steel is a group of iron-based metal containing at least 10% chromium (alloy metals). The chromium oxide “ CrO” creates an invisible barrier (“ passive film”) to oxygen and moisture. Therefore the Chromium protects the iron against most corrosion or red-colored rust; thus the term “ stainless” steel.

The purpose of stainless steel is to provide hard steel material highly resistant to stain, rust and corrosion and resistance against:

– Adverse atmospheric conditions such as carbon dioxide, moisture, electrical fields, sulfur, salt, and chloride compounds

– Natural and artificially produced chemicals (e. g. ozone)

– Extremes of weather such as cold temperatures

And cast iron should be,

Iron is a lustrous, ductile, malleable, silver-gray metal (group VIII of the periodic table). It is known to exist in four distinct crystalline forms. Iron rusts in dump air, but not in dry air. It dissolves readily in dilute acids. Iron is chemically active and forms two major series of chemical compounds, the bivalent iron (II), or ferrous, compounds and the trivalent iron (III), or ferric, compounds.

Iron is the most used of all the metals, including 95 % of all the metal tonnage produced worldwide. Thanks to the combination of low cost and high strength it is indispensable. Its applications go from food containers to family cars, from screwdrivers to washing machines, from cargo ships to paper staples.

Fiber,

Fiber has property same as above material. Also, fiber is light weight. Thus many cars are made of fiber products. But the fiber products are costly and are not beneficial for high speed cars.

Al alloys,

Aluminum is a soft and lightweight metal. It has a dull silvery appearance, because of a thin layer of oxidation that forms quickly when it is exposed to air. The use of aluminum exceeds that of any other metal except iron. Pure aluminum easily forms alloys with many elements such as copper, zinc, magnesium, manganese and silicon. Alloys make it much stronger.

“ Finally we can choose CAST IRON material for car body.”

For car body usually steel is used but we are told that the steel body has been removed and different material should be used.

The material used in car body different from steel is cast iron.

Cast iron has high percentage of carbon which gives toughness to the body.

Mostly, car body is made from steel or Al-alloy. It is strong, paintable, and easy (relatively) to bend to the right shape. This doesn't mean it is the best material – many cars use Fiberglass, some use carbon fiber.

ANS- 5

The material for heat exchanger to extract heat from geo-thermally heated saline water at 120 C.

The following materials should be used:

Material (ranked by M1)

High Conductivity Coppers – have the best performance index but relatively poor corrosion resistance.

Brasses – Again, relatively poor corrosion resistance

Wrought Stainless Steel – A good choice, but steel is more dense than copper

Aluminum Bronzes – An economical and practical choice

Now from chart 1 the modulus E should be

E = 150 Gpa for Cu-alloy.

E = 200 Gpa for steel.

Also the fracture toughness is given by,

Kic = 100 – 150 Gpa for cu.

Kic = 200 Gpa for steel.

But for the heat exchanger the heat should be distributed from hot fluid to cold fluid so the material should not be dense.

If material is dense then the heat will not be given up to cold fluid properly.

Hence, Cu alloy is used here.

ANS- 6

Here, given that C- clamp for electronic components has temperature of 450C.

C -clamp has following criteria:

x – thickness

t – time

Î» – thermal conductivity

Ï – density

– Special heat capacity

Also given, and

Again, clamp has low thermal inertia and it reaches temperatures quickly. So the material has higher value of (diffusivity).

For getting higher value of it should have less dense material and low special heat capacity.

From above three materials obtained:

Al alloy having = 0. 902 S (J/9C)

CI having = 0. 450 S (J/9C)

Cu alloy having = 0. 385 S (J/9C)

Al alloy is not suitable according to the criteria because of higher and low melting point.

Here, Cu alloy is most suitable as it has less value than CI.

ANS- 7

Given that, and

Where, = Peak Stress

M = Moment

F = Force

I = Moment of Inertia

To eliminate the value of x from equations,

Now,

Substituting value of x,

But, M = FL

From this equation, the force depends on b, stress, length and I (Moment of inertia). The material should have high stress and less L.

Hence, suitable material for these criteria is CI (Cast Iron).

ANS- 8

The material for leaf spring is given here with code.

1. 55Si2Mn90

2. 50Cr1

3. 50Cr1V23

These all materials are used in hardened and tempered state.

The physical properties of some of these materials are given here.

50 Cr 1 ultimate tensile strength 1680-2200Mpa

Tensile yield strength 1540-1750Mpa

Brinell hardness number 461-601Mpa

50 Cr 1 v 23 ultimate tensile strength 1900-2200Mpa

Tensile yield strength 1680-1890Mpa

Brinell hardness number 534-601Mpa

55 Si 2 Mn 90 ultimate tensile strength 1820-2060Mpa

Tensile yield strength 1680-1920Mpa

Brinell hardness number 534-601Mpa

Here data given that 2 variables (B and T)

B = width

T = thickness

Also consider 2 constraints, Deflection and Stiffness.

The deflection depends on force (F), modulus (E), and MOI.

The max value of deflection is proportional to double power of length so the length should be less, otherwise it will fail under some of load.

The thickness (T) must be considerably high.

MOI also depends on the B and T.

The spring should of carbon steel.

Carbon steel property

composition – as per weight

C = 0. 37-0. 44%

Mn = 0. 60-0. 90%

P = 0. 04%

S = 0. 05%

Density (Ã-1000 kg/m3)= 7. 845 at T = 25 c

Poisson's Ratio = 0. 27-0. 30 at T = 25 c

Elastic Modulus (GPa) = 190-210 at T = 25 c

Tensile Strength (Mpa) = 518. 8

Yield Strength (Mpa) = 353. 4

Elongation (%) = 30. 2

Reduction in Area (%) = 57. 2

Hardness (HB) = 149 at T = 25 c

Impact Strength (J) = 44. 3

General material and characteristic of trucks given here,

Use a general Young's modulus of steel 200 kN/mm2. You will have a good approximation. The different alloys do not have huge variations (195-210 kN/mm2). The variation is more in other mechanical properties. As a rule of thumb the modulus will go up with higher melt temperature of the alloy.

Ductility is obtained by selecting a raw material that has inherent characteristics for ductility. Also, the combination of annealing and rolling used will affect this process. The size and arrangement of the carbide particles and the ferrite areas in the steel create the ductility. Production must be designed to bring about the carbide structure at the final size for the ductility required. High ductility simplifies the manufacture of the spring or form and also makes impossible parts possible to make.

Harden ability is really set in the original melting of the steel. This is done by varying the de-oxidation process which results in shallow hardening fine-grained steels or deep hardening coarse-grained steels.

ANS- 9

CES means that Closed Ecological Systems are ecosystems that do not rely on matter exchange with any part outside the system.

As per CES (COST ECOLOGYCAL SYSTEM) chart given here I would like to select following four materials.

WROUGHT IRON

ALUMINIUM ALLOY

CERAMICS

COPPER ALLOY

WROUGHT IRON

Wrought iron is an iron alloy with very low carbon content, in comparison to steel, and has fibrous inclusions, known as slag. This is what gives it a " grain" resembling wood, which is visible when it is etched or bent to the point of failure. Wrought iron is tough, malleable, ductile and easily welded. Historically, it was known as " commercially pure iron" however it no longer qualifies because current standards for commercially pure iron require a carbon content of less than 0. 008 %wt.

ALUMINIUM ALLOY

Aluminum alloys are alloys in which aluminum (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminum is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminum alloys yield cost effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminum alloy system is Al-Si, where the high levels of silicon (4. 0% to 13%) contribute to give good casting characteristics. Aluminum alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.

CERAMICS

A ceramic is an inorganic, non-metallic solid prepared by the action of heat and subsequent cooling. Ceramic materials may have a crystalline or partly crystalline structure, or may be amorphous (e. g., a glass). Because most common ceramics are crystalline, the definition of ceramic is often restricted to inorganic crystalline materials, as opposed to the non-crystalline glasses. The earliest ceramics were pottery objects made from clay, either by itself or mixed with other materials, hardened in fire. Later ceramics were glazed and fired to create a colored, smooth surface. Ceramics now include domestic, industrial and building products and art objects.

COPPER ALLOY

Copper alloys are metal alloys that have copper as their principal component. They have high resistance against corrosion. The best known traditional types are bronze; where tin is a significant addition, and brass, using zinc instead. Both these are imprecise terms, and today the term copper alloy tends to be substituted, especially by museums. Copper is somewhat costly than steels.

ANS- 10

We obtain following materials from the chart as per given conditions:

Aluminum, Balsa, ABS fins, Titanium, Magnesium, Polystyrene

ALUMINIUM

For the development and application of new aluminum alloys with properties and strength-to-weight ratios that make possible the design of future aircraft with improved payload and design safety margins. Airframe designers need lightweight materials that are strong, durable, damage-tolerant, and economical to fabricate. Aluminum alloy products have filled this need since the 1920s. Despite the advances in polymer matrix composites, manufacturers of airframes for passenger jetliners look to aluminum-base materials for the bulk of their needs.

BALSA

The best solution by far, is to use a poly/ABS fin with the inner portion of the fin cut out and replaced with balsa, thus getting the durability of a manmade material where it is needed and the lightness and stiffness of balsa. This is all extra work on initial construction but, it seems to be worth it due to less time spent repairing the rocket over its service life.

ABS fins

Fins may make with 2. 5 mm ABS cored with 1/8″ balsa for model rocket. It is not that tricky cutting out the core with a Dremel multi-purpose bit, but the fins were around 16 sq. in.–a decent size palette to work with, as your fin size decreases this method would get trickier. The resultant fin was noticeably lighter and stiffer than its pure ABS sibling. It saves approximately 28% of the total weight of EACH fin.–Definitely worth the extra effort in fin construction.

TITANIUM

Values for the pure element are found under the name Titanium, Ti. Grades 1, 2, 3, 4, 7, 11, and 12 and considered ‘ unalloyed’ titanium and have similar mechanical properties. Grades 1 through 4 allow increasing levels of impurities. Grades 7 and 11 have 0. 2% palladium added to improve titanium’s already excellent corrosion resistance. Grade 12 features 0. 8% Ni and 0. 3% Mo to improve the corrosion resistance at a lower cost than Pd. Titanium alloys generally feature higher strength than unalloyed titanium.

Magnesium

The density of the magnesium is about 2/3 of that of aluminum and a quarter of that of steel. Magnesium is the lightest among metallic materials which are being used practically. Although magnesium alloy has a higher density than plastics, its tensile strength and Young’s modulus per unit weight are higher than plastics. This enables to make a lighter part by using magnesium alloy than plastics. The thermal conductivity of magnesium alloy is much higher than that of plastics. Magnesium casings of electronic appliances can dissipate heat, which is generated in the electronic circuit, much more effectively than plastic casings.

POLYSTYRENE

Polystyrene is actually an aromatic polymer that is made from the monomer styrene. It is a long hydrocarbon chain that has a phenyl group attached to every carbon atom. Styrene is an aromatic monomer, commercially manufactured from petroleum. Polystyrene is a vinyl polymer, manufactured from the styrene monomer by free radical vinyl polymerization.