Metal Casting
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Module - 04
Common Cast Alloys
Lecture - 03
Copper, Zinc And Titanium Cast Alloys

Good morning friends, today let us learn about copper, zinc and titanium cast alloys. Copper, zinc and titanium cast alloys. So, first we will see the copper cast alloys.

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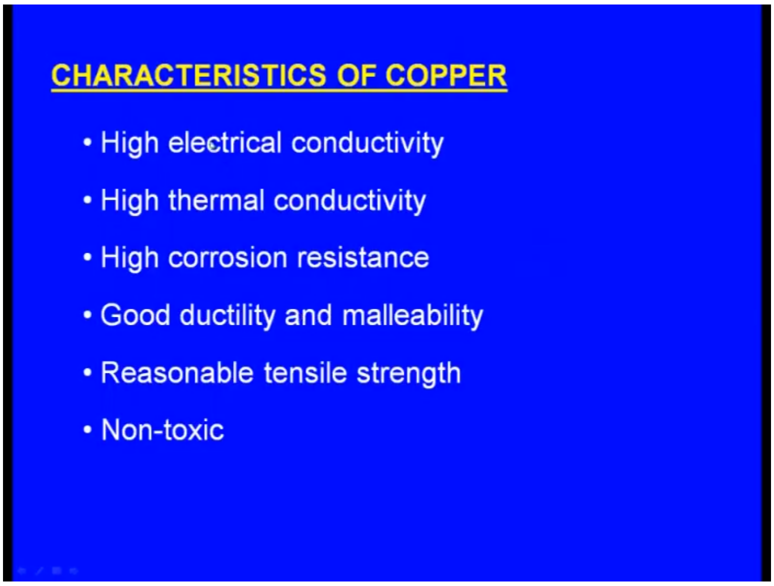

Now, the characteristics of copper what are the characteristics of copper one is high electrical conductivity. That we know very well, next one high thermal conductivity, next one high corrosion resistance, good ductility and malleability. Next one reasonable tensile strength and finally, it is non toxic. So, these are the characteristics of copper you can see all are favourable characteristics. That's why there is a lot of demand for copper in the industry not only the industry for the domestic applications. These are the physical properties of copper.

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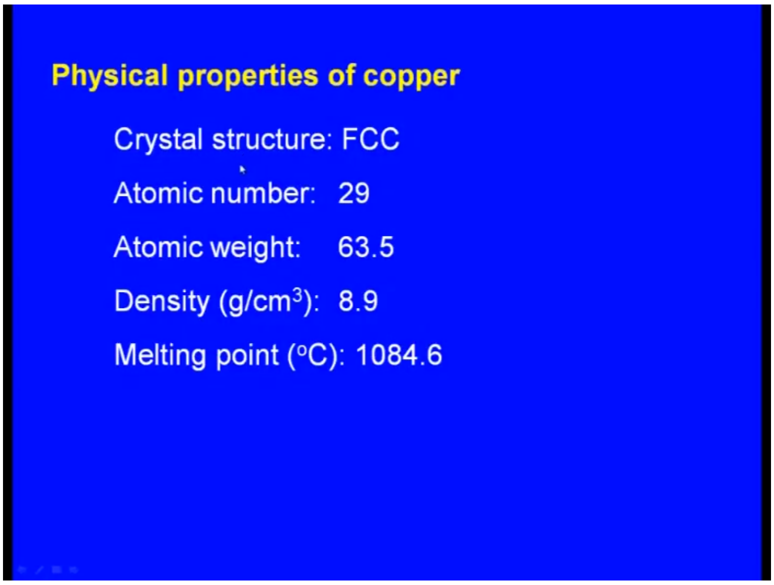

Crystal structure is FCC, face centred cubic system. Atomic number is 29. Atomic weight is 63.5. Density 8.9 grams per cc. Melting point is 1084.6 centigrade.

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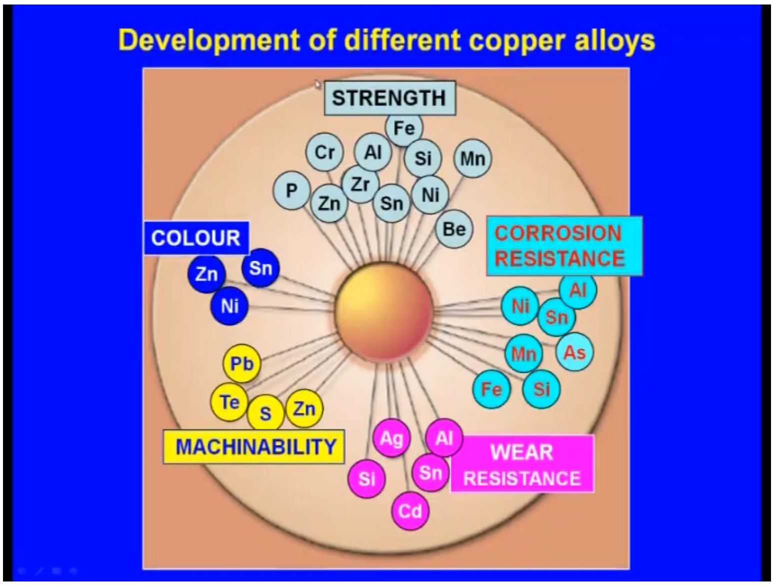

Now, this is the way the copper alloys have been developed with the different objectives. Now, you can see here there are what say five objectives are there. One is to an object to were strength has to be increased and another objective could be increase of the corrosion resistance or another objective could be increase of wear resistance or another objective could be increase of the machinability next one increase in the colour.

So, what is your objective besides the development of the copper alloy? If you are objective is to enhance the strength of the alloy then these alloying elements are to be added like phosphorus, zinc, zirconium, chromium, iron, aluminium, silicon, nickel, manganese, beryllium and so on and if your objective is to increase the corrosion resistance. Then we have to add these elements like nickel, aluminium, tin, manganese, iron, silicon, arsenic, and so on and if your objective is to increase the wear resistance of an alloy. Then these elements have to be added like aluminium, tin, cadmium, silicon, silver, and so on and if the objective is to increase the machinibility of the copper alloy. Then these elements are to be added lead, zinc, sulphur, and so on and if your objective is to increase the colour. Then these are the elements zinc, tin, nickel, and so on.

So, based on the objective or the purpose or the application different alloy alloying elements are added to the copper and the copper alloying is developed.

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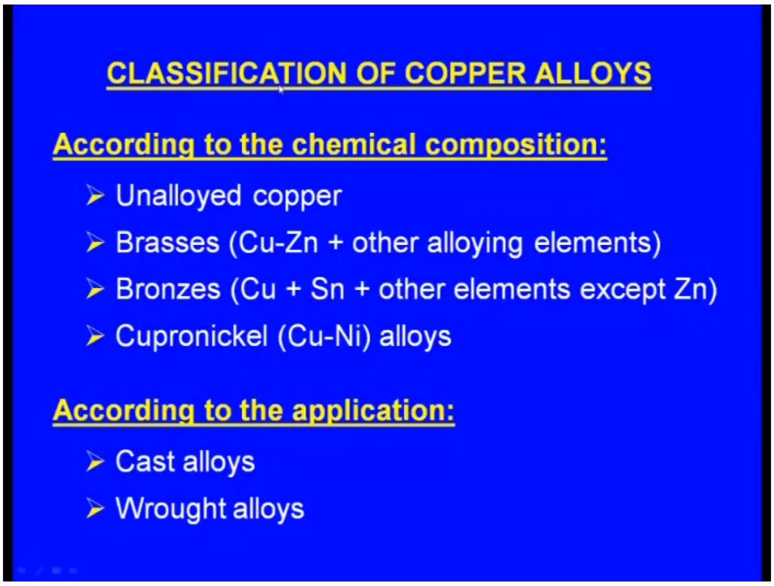

Now, this is the classification of the copper alloys. First classification is according to the chemical composition and the second composition is according to the application. First let us see the classification according to the chemical composition. Under that we have unalloyed copper. Next one we have brasses, brass means copper and zinc and other alloying elements. Next one bronzes means copper, tin and other alloying elements except zinc. Cupronickel that is copper and nickel alloy and here you can see brass means you can see copper is the base element and zinc is the main and the primary alloying element and in the bronze copper is the base element and tin is the primary alloying elements and it won't though other elements are present yes, but zinc won't be present.

And next classification is according to the application they can be classified as cast alloys and wrought alloys. Now, let us see the unalloyed copper. These are the characteristics of the unalloyed copper.

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One is good electrical and thermal conductivities, next one high corrosion resistance, easily fabricated, reasonable tensile strength, controllable annealing properties, good soldering and joining properties.

Now, you see these are the typical applications of the unalloyed copper and you can see here this is the copper finished parts.

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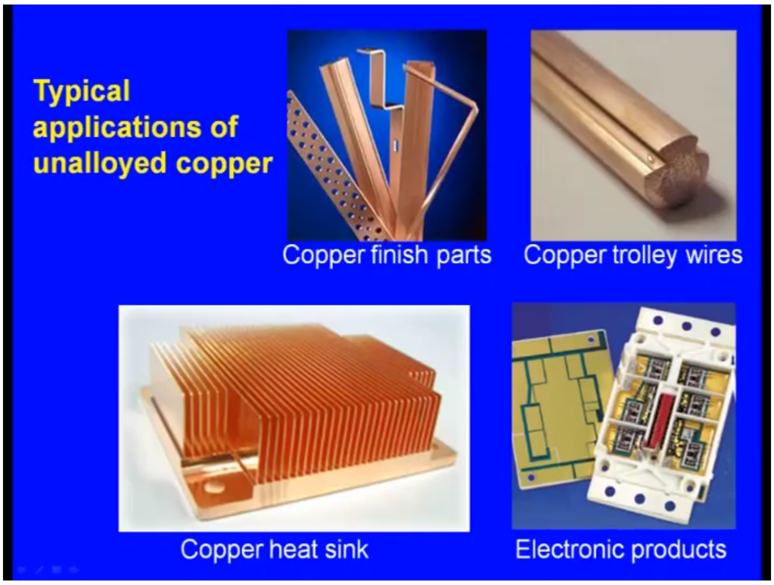

Copper trolley wires, electronic products, copper heat sink. So, in all these cases we use the unalloyed copper.

Next one under the what; say chemical composition we have another one is the brass. Brass means copper, zinc and other alloying elements will be there. But zinc is the primary alloying element.

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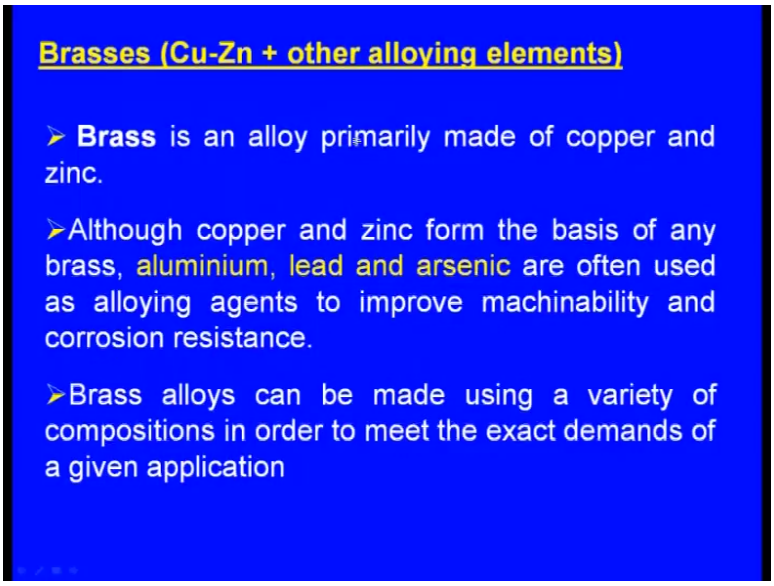

Brass now, brass is an alloy primarily made up of copper and zinc. Although copper and zinc form the basis of any brass, aluminium, lead and arsenic are often used as alloying agents to improve machinability and corrosion resistance. Brass alloys can be made using a variety of compositions in order to meet the exact demands of a given application. Now, these are the typical applications.

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Decorative items for its bright gold like appearance. Applications where low friction is required such as locks, gears, bearings, doorknobs, ammunition casings and valves. Next one plumbing and electrical applications. Next one musical instruments such as horns and bells for acoustic properties. So, these are all the typical applications of the brass. Now, we can see more applications.

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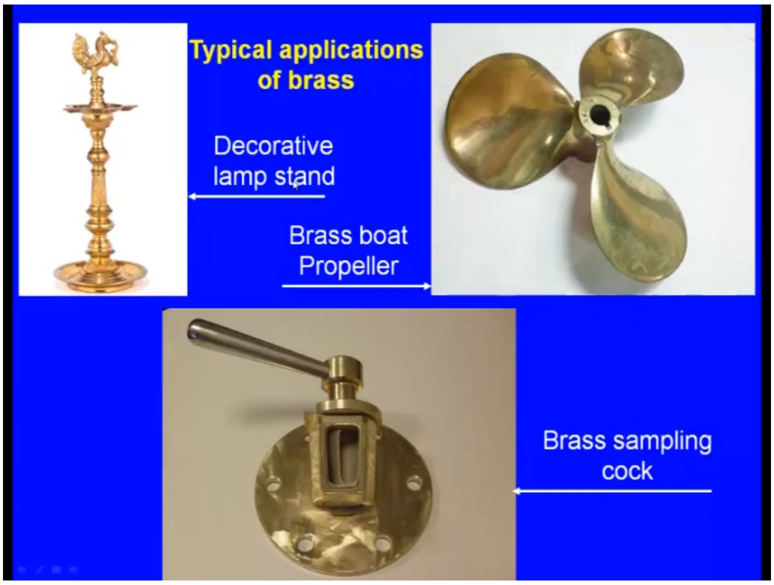

This is this is a decorative lamp stand you see this is made up of brass. Now this is a brass boat propeller. So, this is also made up of brass. Now this is a brass sampling cock and you can see here. So, this is also a brass alloy component.

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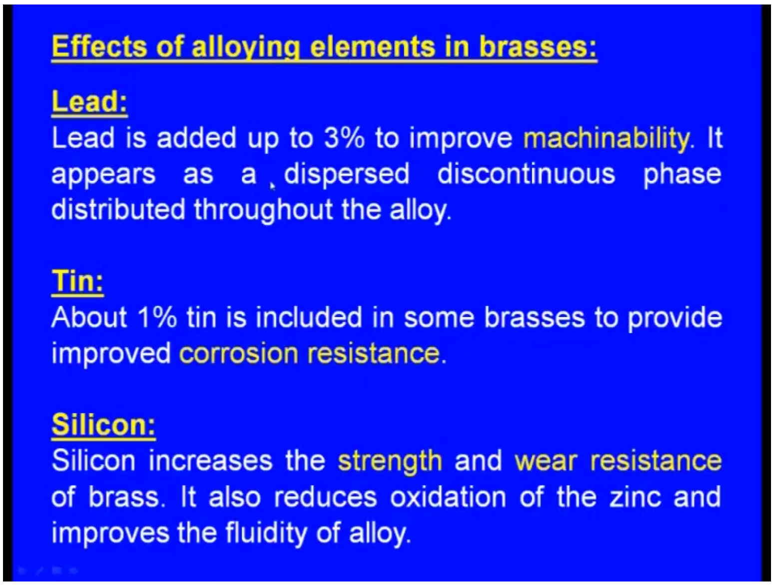

Now, let us see the effects of alloying elements in brasses. So, what happens when we add different alloying elements? First one is lead. Lead is added up to 3 percent to improve the machinability. So, this greatly improves the machinability. It appears as a dispersed discontinuous phase distributed throughout the alloy. So, the next alloying element is tin about 1 percent of tin is included in some brasses to provide improved corrosion resistance. So, tin improves the corrosion resistance. The next alloying element that appears in the brass is the silicon. Silicon increases the strength and wear resistance of brass. It also reduces oxidation of the zinc and improves the fluidity of the alloyed. So, wherever silicon comes into picture it improves the fluidity.

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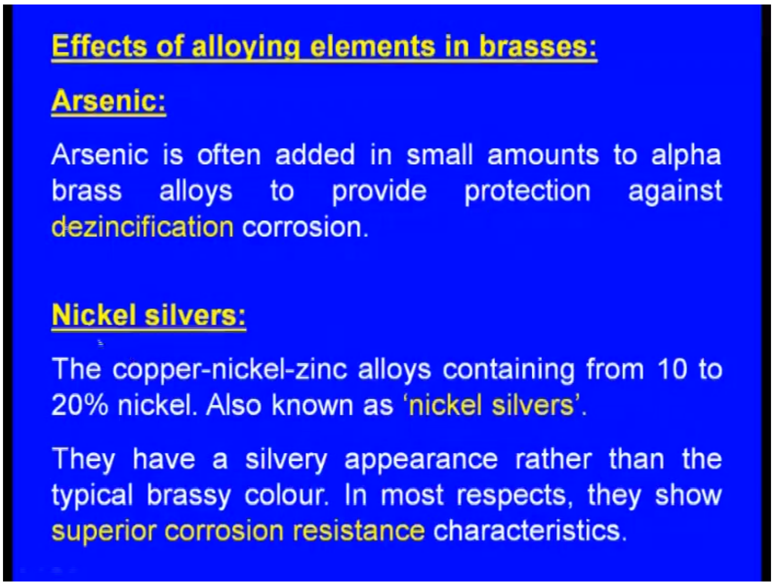

Next one other elements, next one is the arsenic. Arsenic is often added in small amounts to alpha brass alloys to provide protection against dezincification corrosion. Next one is the nickel silvers. The copper nickel zinc alloys containing from 10 to 20 percent nickel also known as nickel silvers. They have a silver appearance rather than the typical brassy colour. In most respects, they show superior corrosion resistance characteristics. Next let us see the different types of brasses.

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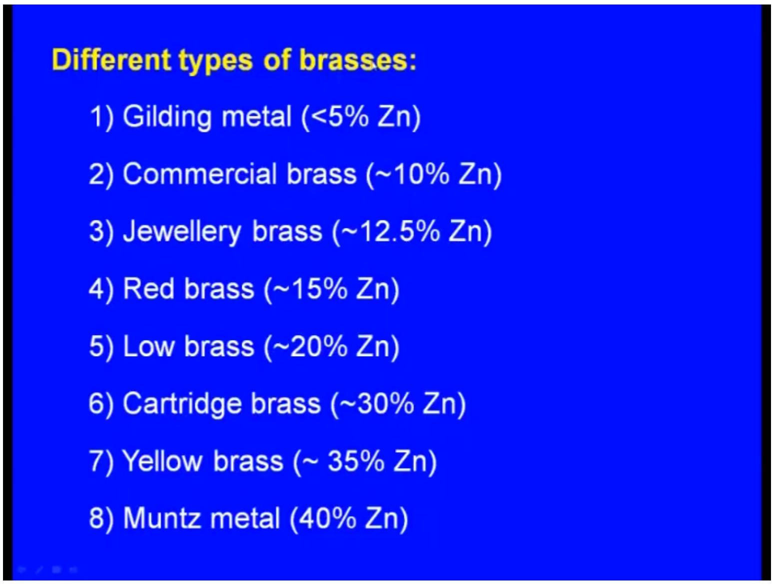

One is the gilding metal where the zinc content is less than 5 percent. Next one is commercial brass where the zinc content is less than ten percent or approximately 10 percent. Next one is jewellery brass in this case we have zinc around 12.5 percent. Next one we have the red brass in this case we have zinc around 15 percent. Next one we have the low brass in this case the zinc content is around 20 percent. Next one we have the cartridge brass in this case the zinc content is around 30 percent. Next one is yellow brass in this case the zinc content is around 35 percent. Next one; muntz metal where the zinc content is around 40 percent.

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Now, these are the typical applications of the brass.

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And you can see a safety clamp for high voltage systems made up of low brass. This is a brass cartridge, now flange made up of yellow brass.

Next let us see the bronzes. So, far we have completed unalloyed copper and brasses now we will see the bronzes.

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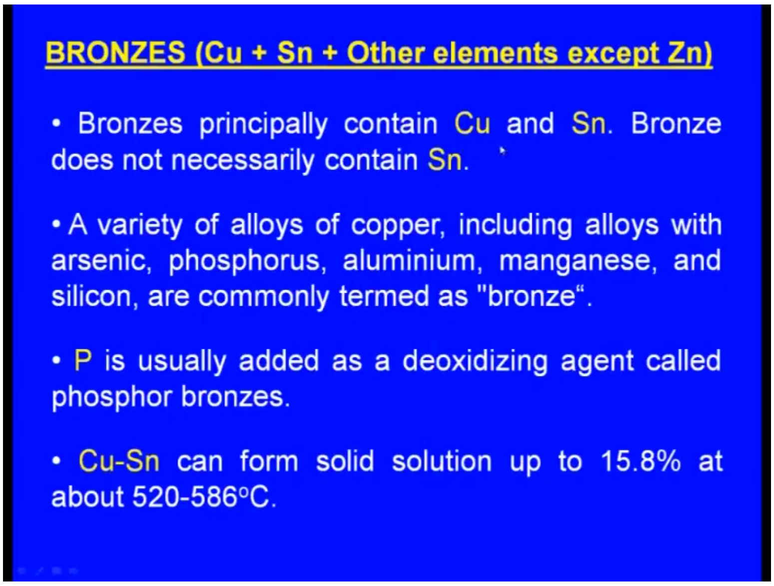

Bronzes are principally they principally contain copper and tin. Bronze doesn't necessarily contain tin. Generally, they contain copper and tin of course, copper is the base element and tin is the primary alloying element most of the cases. A variety of alloys of copper, including alloys with arsenic, phosphorus, aluminium, manganese, and silicon, are commonly termed as "bronze". Phosphorus is usually added as a deoxidizing agent called phosphor bronzes. Copper tin confirm solid solution up to 15.8 percent at about 520 to 586 degrees centigrade.

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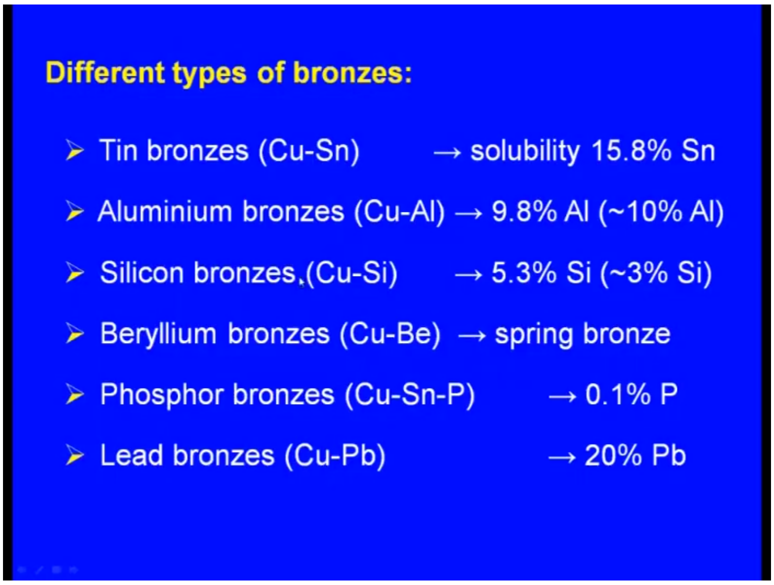

Now, let us see the different types of bronzes. Tin bronzes so that is copper tin, solubility is 15.8 percent tin. Next one aluminium bronze where there will be 9.8 aluminium and 10 percent that is about 10 percent aluminium. Next one silicon bronze it is 5.3 percent silicon. Beryllium bronze will be there. Next one phosphorus bronze and lead bronze.

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And here you can see this is a bronze gear.

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A high pressures flange for a sub-sea weapon system made up of aluminium bronze. It is a very what says typical component of the bronze.

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And silicon bronze. For door fittings.

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Phosphor bronze cables.

So, with this we are completing the bronzes. Finally, we will come to the cupronickel Cu-Ni.

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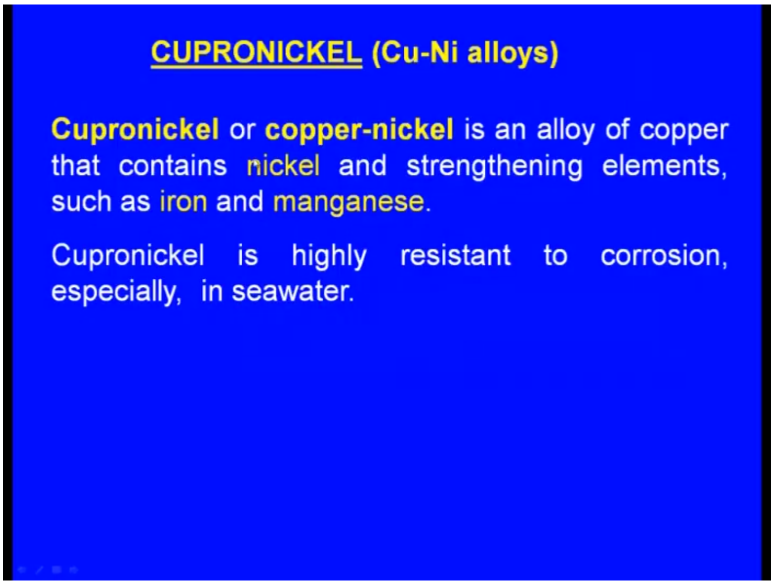

What is this cupronickel? Cupronickel or copper nickel is an alloy of copper that contains nickel and strengthening elements such as iron and manganese. Cupronickel is highly resistant to corrosion especially in sea water.

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Now, what are the applications of cupronickel. Piping in sea water, heat exchangers, condensers in sea water systems, marine hardware, propellers and crankshafts of tugboats, fishing boats and other working boats, strings for string instruments and so on.

So, these are the important applications of the cupronickel.

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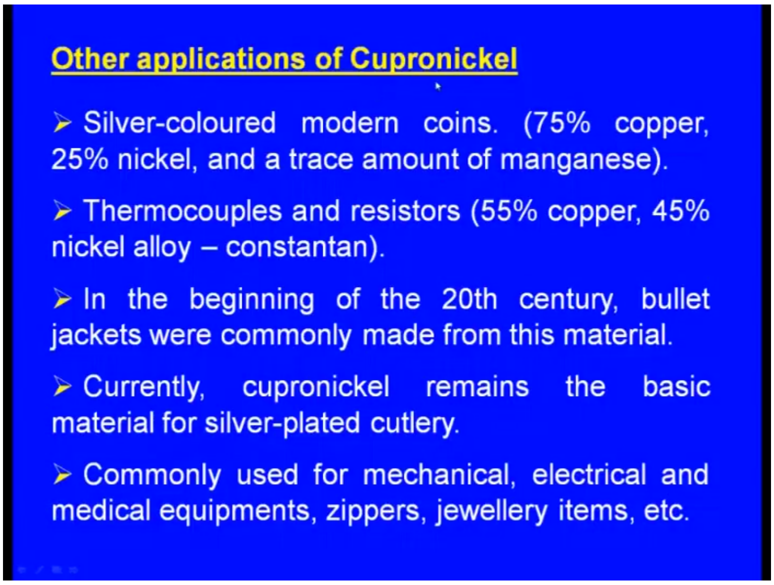

Other applications of cupronickel, Silver coloured modern coins. 75 percent of copper and 25 percent of nickel and a trace amount of manganese. Thermocouples and resistors 55 percent of copper, 45 percent of nickel alloy constantan and in the beginning of the twentieth century bullet jockets were commonly made from this material. Currently, cupronickel remains the basic material for silver plated cutlery and this is commonly used for mechanical electrical and medical equipments, zippers, jewellery items and so on.

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So, this are the cupronickel cutlery.

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Cupronickel flange. So, with this we are completing the a copper alloys. Next, let us see the zinc cast alloys.

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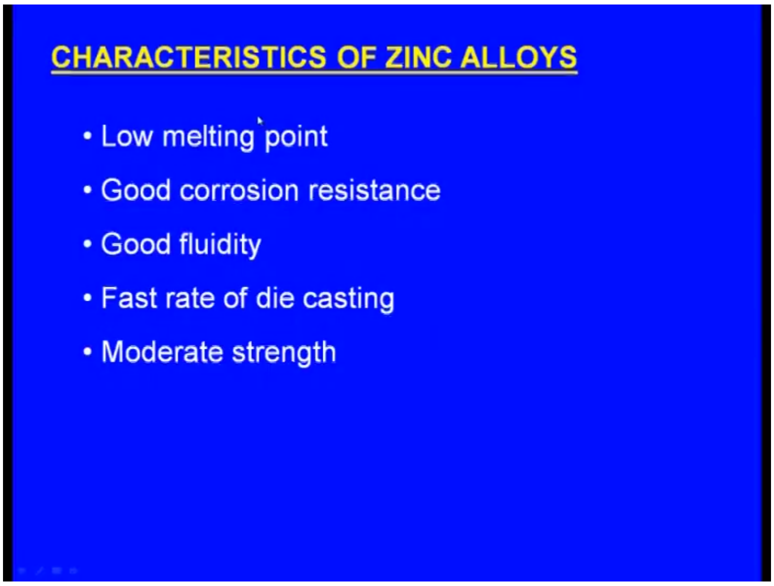

Now, what are the characteristics of zinc alloys? It has got no melting point, good corrosion resistance, good fluidity, fast rate of die casting and moderate strength.

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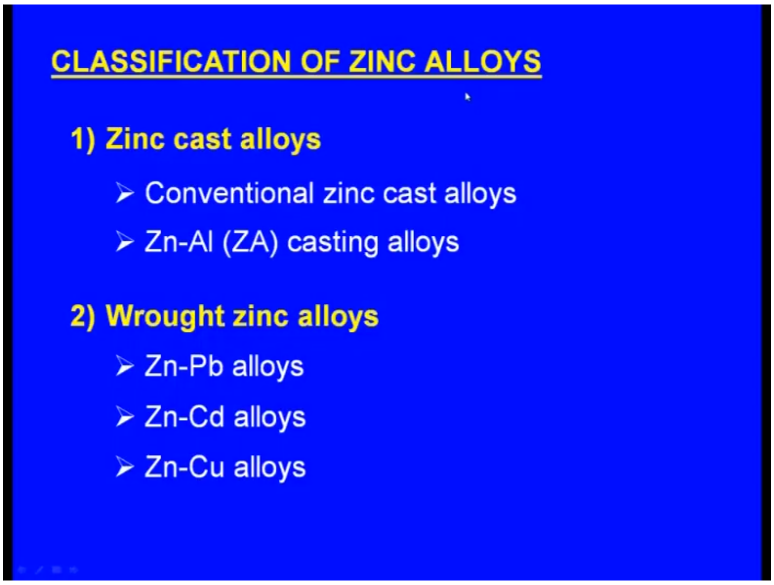

This is the classification of the zinc alloys. Broadly, they can be classified as zinc cast alloys and zinc wrought alloys. Now, we will be concentrating all these zinc cast alloys. So, they can be classified into further into 2 types. One is the conventional zinc cast alloys and zinc aluminium cast alloys. So, first let us see the conventional zinc cast alloys.

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Conventional zinc cast alloys are based on zinc and 4 percent aluminium and zinc 8 percent aluminium. Aluminium can form solid solution with zinc; at what say low quantity at 382 degree centigrade and gives eutectic reaction at 5 percent aluminium.

Now these are the characteristics of the zinc cast alloys. High castability, Easy finishing, Good mechanical properties, Free from intergranular corrosion.

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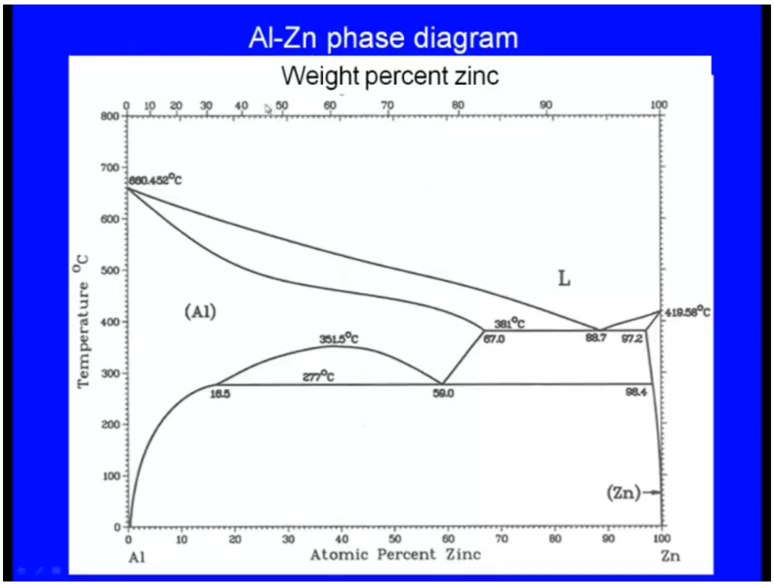

Now, let us see this is the aluminium zinc face diagram. Now, you see here so say this is the zinc what say 100 percent zinc and at this point you see. Maybe 10 per 90 percent zinc and 10 percent aluminium.

Here we can see an eutectic reaction means they reaction where having the lowest melting point and here you can see this is the may be this is 382 degree centigrade.

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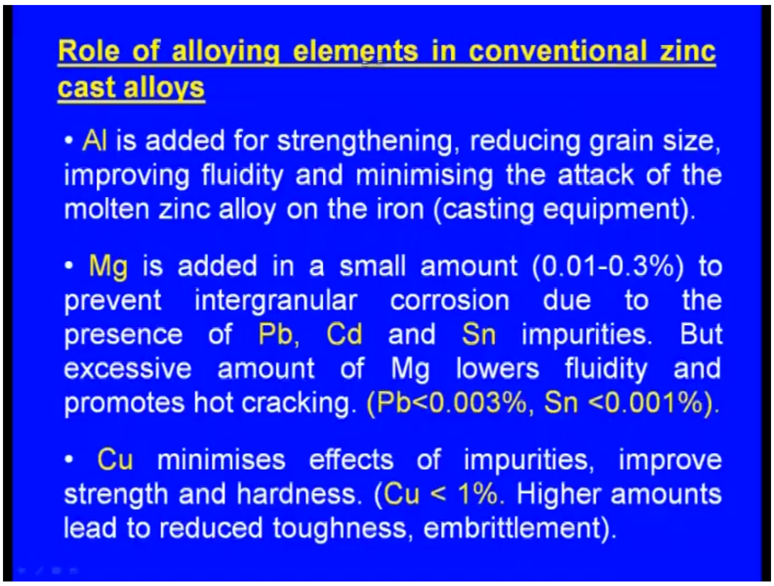

Role of alloying elements in conventional zinc cast alloys. Aluminium is added for strengthening, reducing grain size, improving fluidity and minimising the attack of the molten zinc alloy on the iron.

Next one magnesium is added in a small amount you see this amount 0.01 to 0.3 to prevent intergranular corrosion due to the presence of lead, cadmium, and tin impurities. But excessive amount of magnesium lowers the fluidity and promotes hot cracking. Next one copper minimises effect of impurities, improves improve strength and hardness. Copper should be less than 1 percent. Higher amounts of what say copper leads to toughness and embrittlement.

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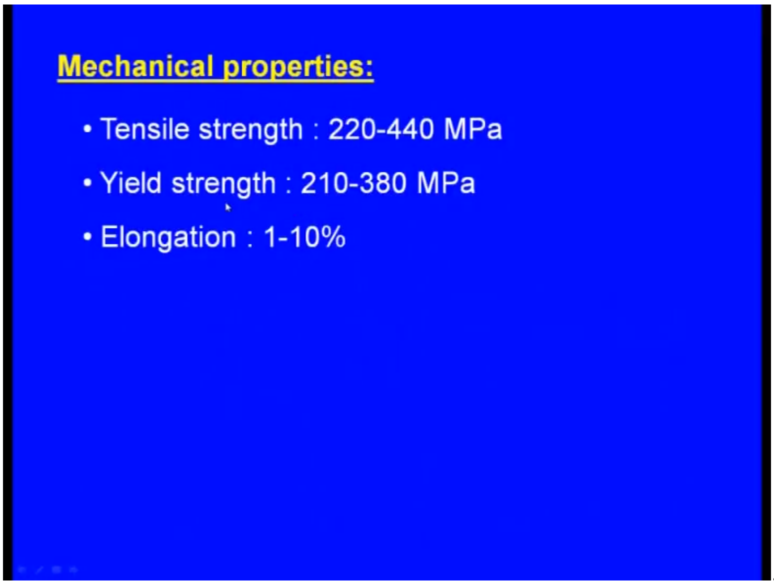

Next one mechanical properties you see tensile strength is between 220 to 440 mega Pascal, yield strength 210 to 380 mega Pascal and elongation is 1 to 10 percent.

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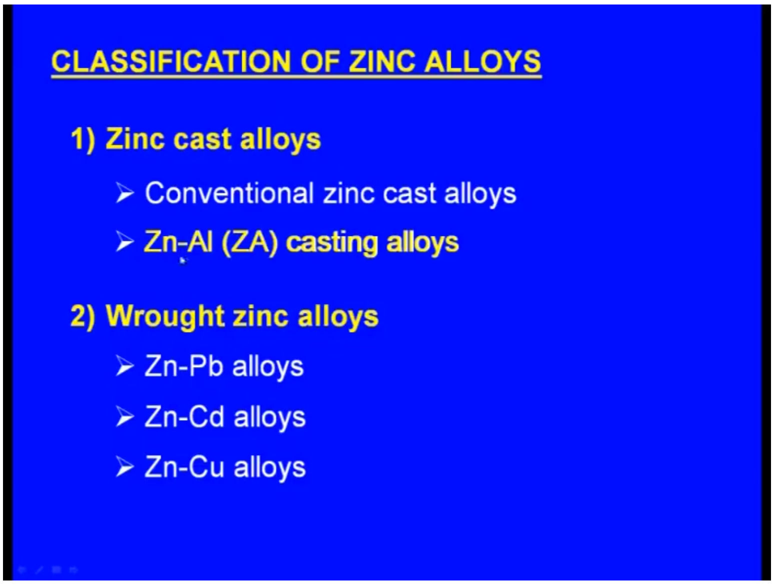

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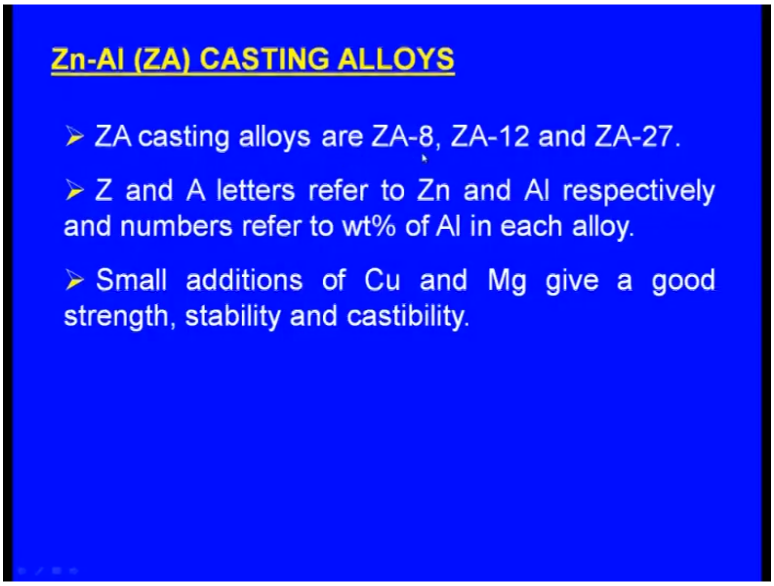

Next one let us see zinc aluminium ZA casting alloys. ZA casting alloys are ZA-8, ZA-12 and ZA-27 alloys. Z and A letters refer to zinc and aluminium respectively and number refer to the percentage weight of aluminium in each alloy. Small additions of copper and magnesium give a good strength, stability and castibility.

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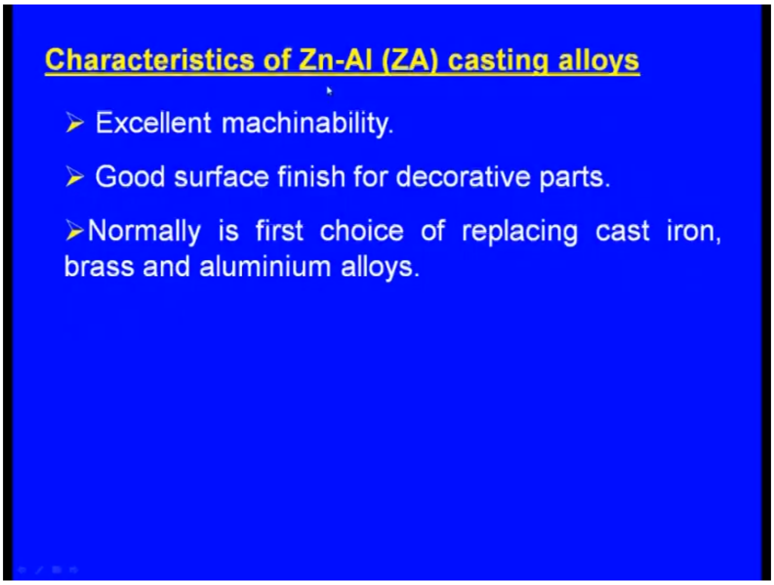

Characteristics of Zinc-Aluminium ZA casting alloys. They have excellent machinability. They have good surface finish for decorative parts. Normally is first choice of replacing cast iron brass and aluminium alloys.

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Applications of zinc cast alloys. Die castings. Used for auto mobile parts handles, locks, and so on. Used for making body hardware, light fittings, instruments and so on. Parts with thin walls and intricate shapes. Several mechanical and electrical components. Galvanic protection on steels. Decorative finish on several components.

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Now, this is a typical component produced with the zinc alloy what say alloy. Zinc alloy automotive engine block you see.

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Now, this is the zinc alloy automotive mould base.

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Zinc alloy automotive carburetor body. So, this the carburetor body which is used in the automobiles.

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Next one zinc alloy what say products for automobile applications miscellaneous applications.

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Next one typical ZA-27 products.

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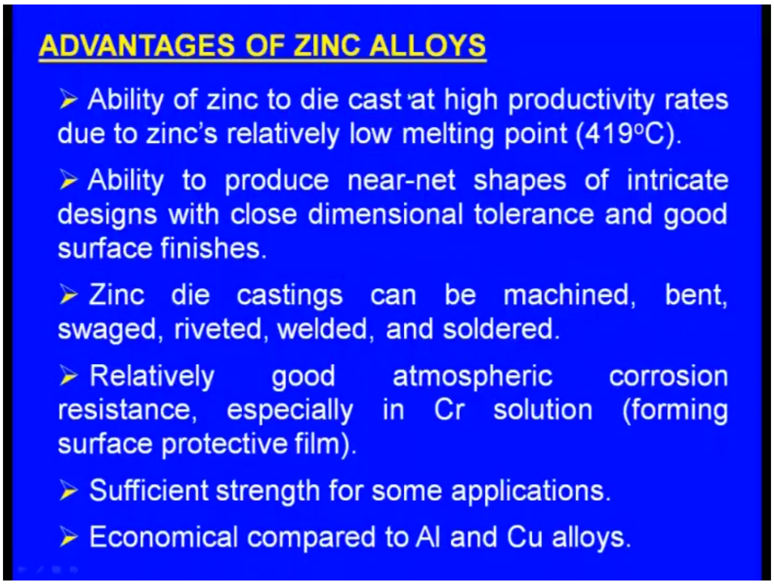

Advantages of zinc alloys. Ability of zinc to die cast at high productive rates due to zinc's relatively low melting point. So, you see the melting point 419 degree centigrade because of that it is easy to cast them using die casting process. Ability to produce near-net shapes of intricate designs with close dimensional tolerance and good surface finishes. Zinc die castings can be machined, bent, swaged, riveted, welded, and soldered. Relatively good atmospheric corrosion resistance, especially in what say chromium solution forming surface protective film. Surface what say sufficient strength for some applications. And finally, economical compared to aluminium and copper alloys.

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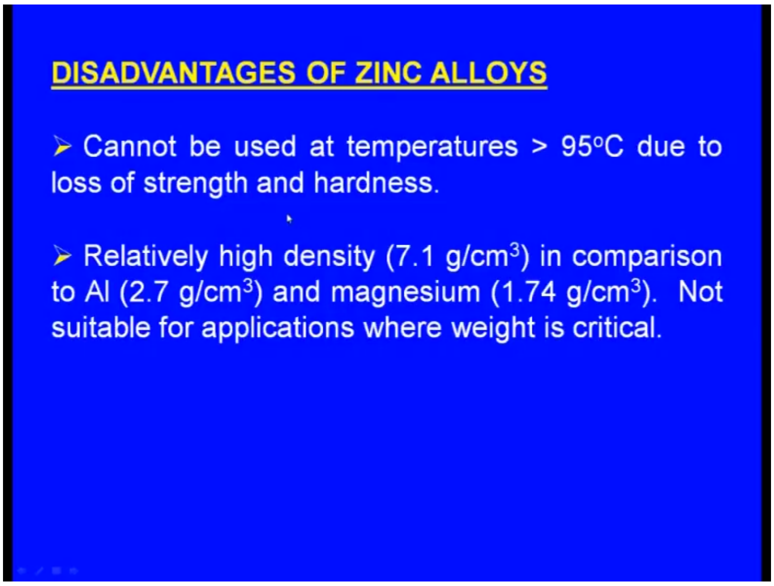

Next we will see the disadvantages of zinc alloys.

Cannot be used at temperatures greater than 95 degrees centigrade due to loss of strength and hardness. Relatively high density they have high density you see 7.1 grams per cubic what say centimetre in comparison to the aluminium 2.7 grams per what say cubic centimetre and magnesium 1.74 grams per centimetre cube. Not suitable for applications where weight is critical. So, with this we are completing the zinc alloys.

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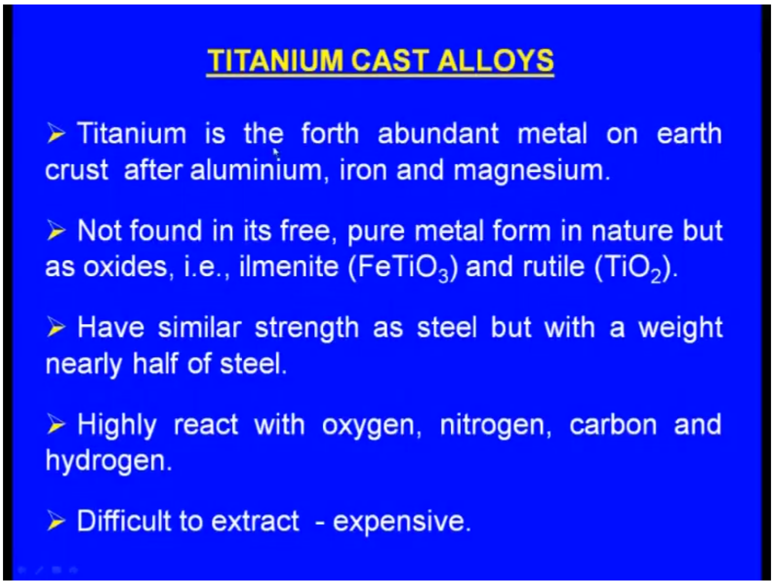

Next we will see the titanium cast alloys. Titanium is the forth abundant metal on the earth crust after aluminium, iron and magnesium. It is not found in its free, right pure metal in its nature, but it is available as oxides you see, it is available as oxides. It has got to similar strength as steel, but with a weight nearly half of steel. So, this is the greatest advantage. It is strength is similar to steel, but its weight is half of the steel. Highly it react highly with oxygen, nitrogen, carbon and hydrogen. Difficult to extract. So, this is what say difficult to extract, and that is how it is of production cost will be high.

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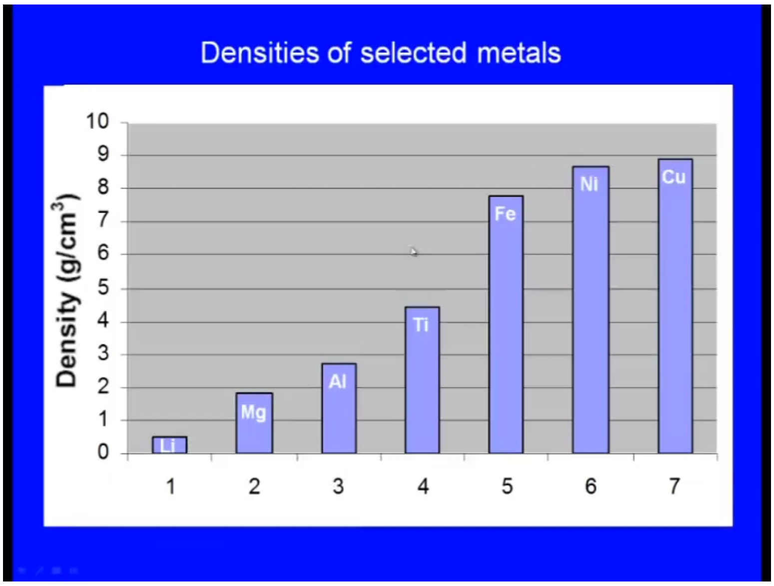

Now, these are the densities of the certain selected metals. Now, you see here seven metals are compared here and the y axis represents the density and the first one the first one is the lithium, second one is the magnesium, third one is the aluminium forth one is the titanium, fifth one is the iron sixth one is the nickel and seventh one is the copper. Now, among all these metals you see copper and nickel they are and iron they have a got the higher density, and lithium and magnesium have got the lowest density. Whereas, titanium's density is moderate now.

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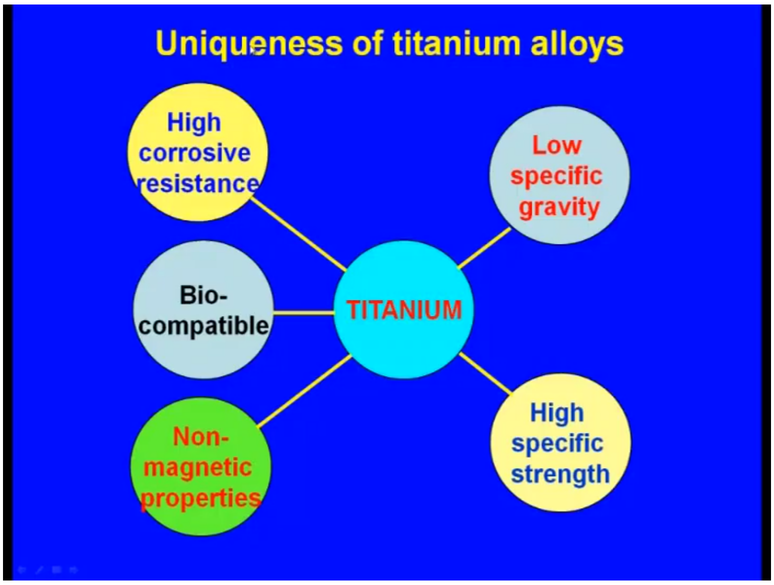

What is the uniqueness of titanium alloys? It has got several what say special characteristics.

Low specific gravity. Next one it has got high specific strength. Next one it is it has got non magnetic properties. Next one it is biocompatible, that is how it is used in the what say surgeries say human implants are made up of titanium alloys, why because it is biocompatible. Next one it is it has got the high corrosive resistance.

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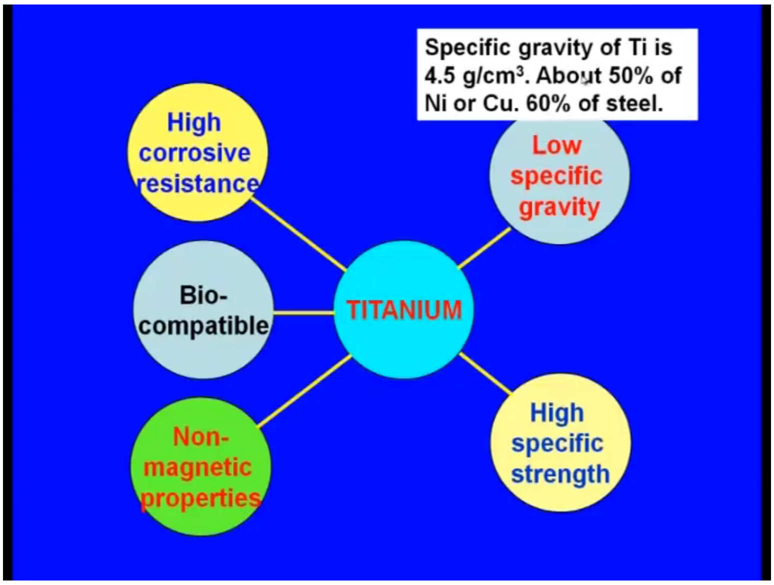

You see the specific gravity of titanium is 4.5 grams per centimetre cube. About 50 of nickel or copper or 60 percent of steel. So, its specific gravity is very less compared to nickel copper or steel.

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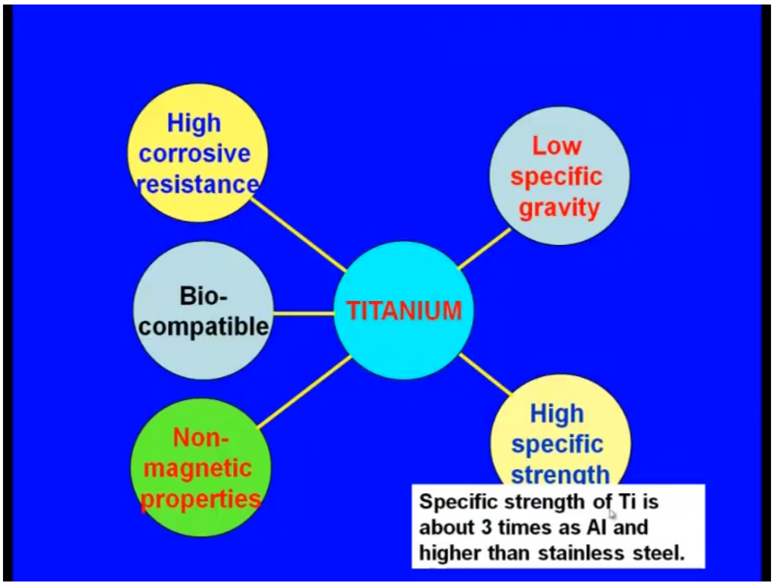

Next one what about the specific strength. Specific strength of titanium is about 3 times as aluminium and higher than stainless steel. So, that is again a great advantage.

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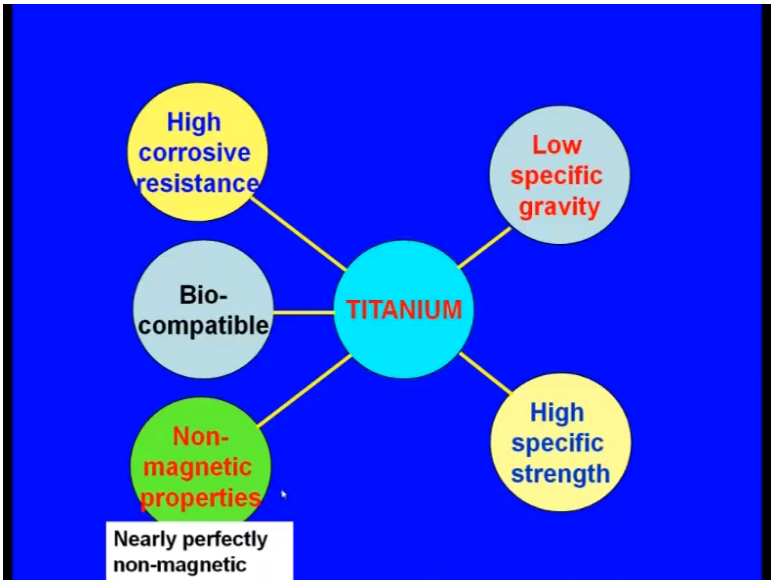

Next one nearly, perfectly nonmagnetic.

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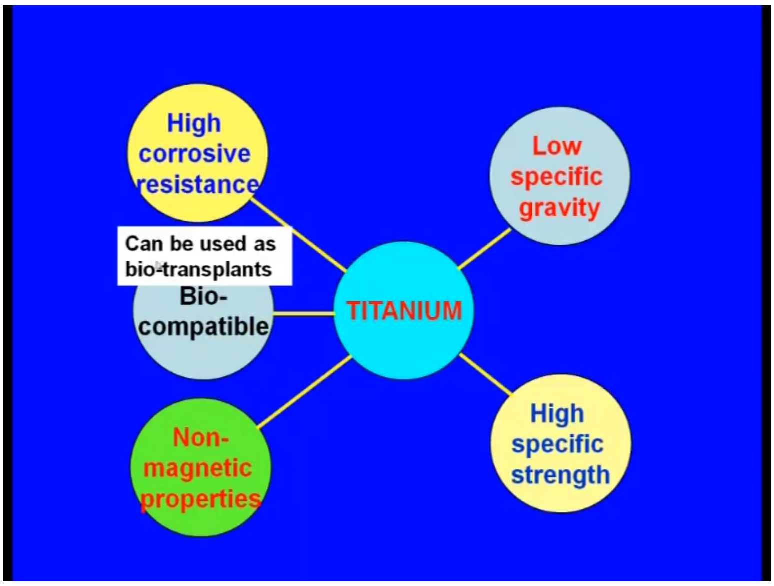

Next can be used as bio-transplants.

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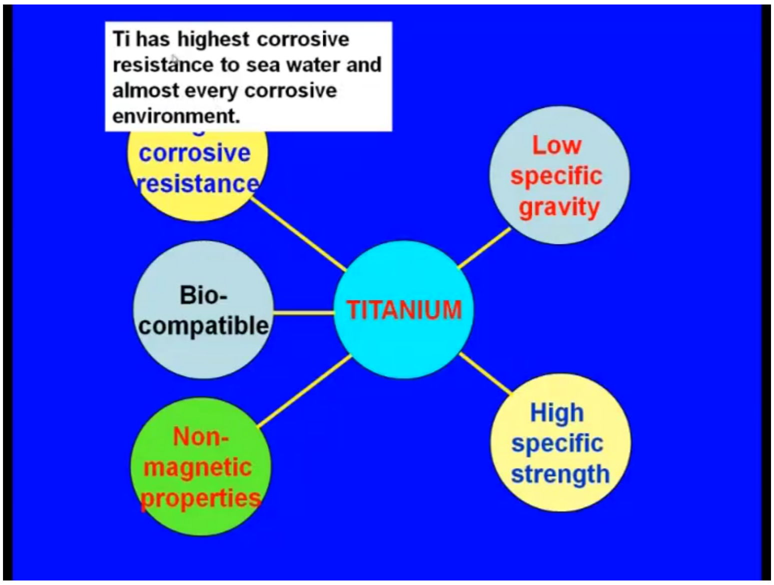

And finally, Titanium has highest corrosive resistance to sea water and almost every corrosive environment. Again this is a very good advantage.

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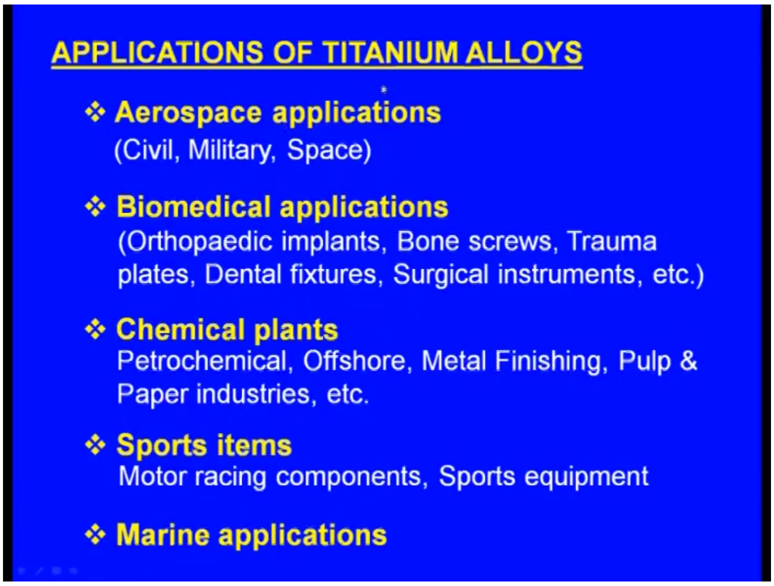

Now, these are the applications of the titanium alloys. Aerospace applications for making civil military and space components. For biomedical applications- Orthopaedic implants, Bone screws, Trauma plates, Dental fixtures and Surgical instruments and so on, all these are made up of the titanium alloys. Next one chemical plants- Petrochemical, Offshore, Metal Finishing, pulp and paper industries. In all these what say industries titanium alloys are used.

Next one sports items like motor racing components, Sports equipments. So, these are also made up of titanium alloys. And finally, marine applications also made up of titanium alloys.

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Now, this is a Golf sticks made up of titanium alloys you see. So, these are made up of titanium alloys.

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Next one titanium knee hinge joint and you can see here. So, this is the titanium joint. So, made up of titanium alloys.

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So, this is the Titanium hip joint you see. So, these are used for the hip replacement.

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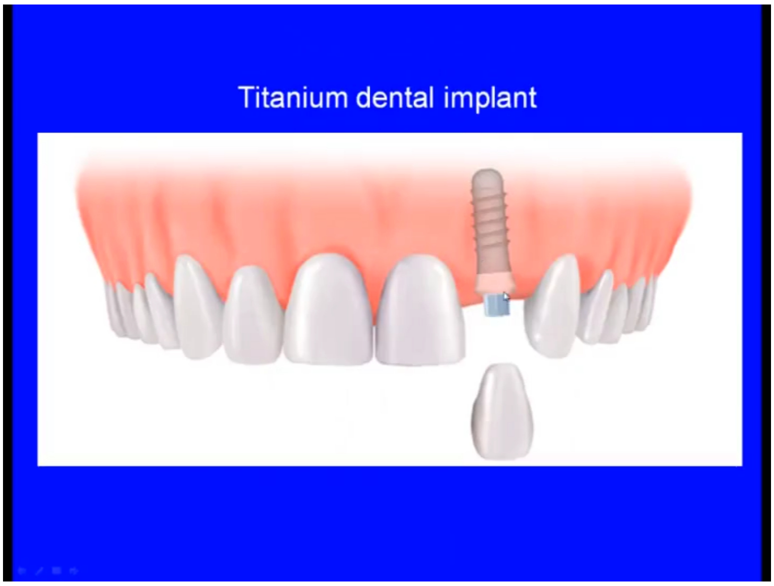

Titanium dental implants you see. So, these titanium dental implants are very useful in the dental what say surgery.

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Aircraft turbine blades made up of titanium alloys you see. This is the aircraft turbine blade.

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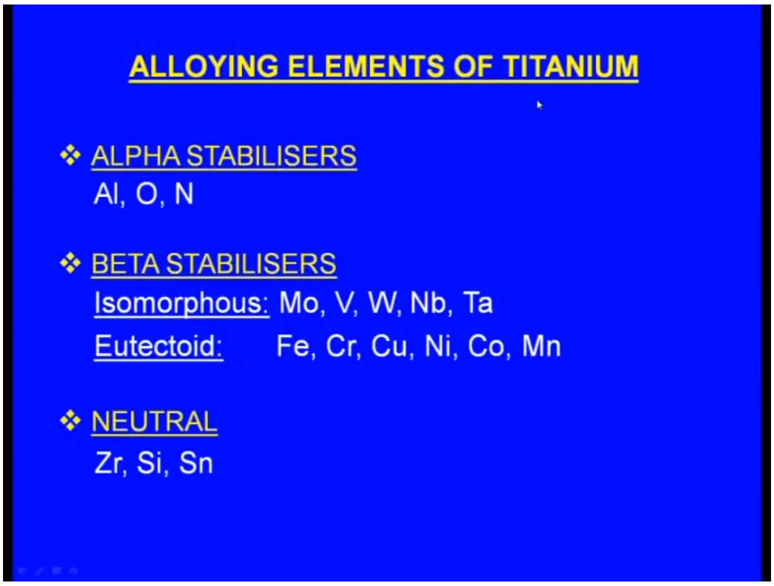

Alloying elements of titanium. One is the alpha stabiliser, second one is the beta stabiliser and third one is the neutral. Under the alpha stabiliser we have aluminium, oxygen and a nitrogen. Under the beta stabilisers we have molybdenum, vanadium, tungsten, tantalum and so on. Under the neutral we have zirconium, silicon and tin.

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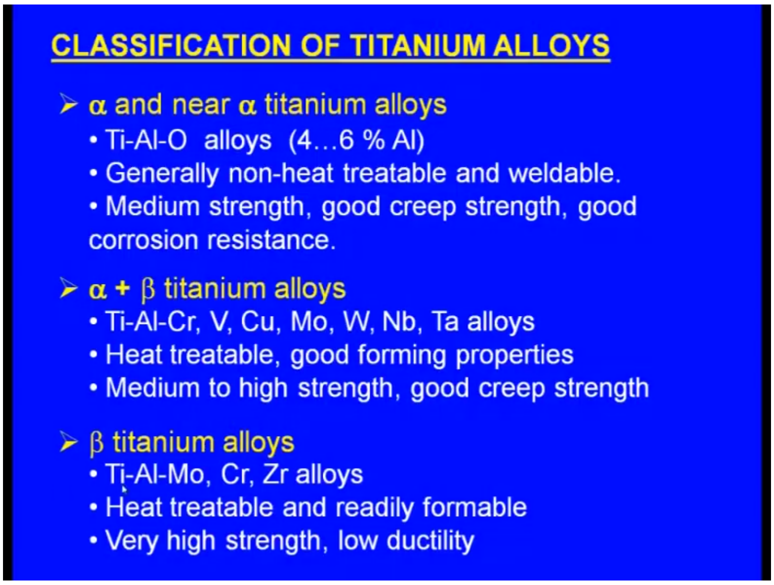

Now, this is the classification of the titanium alloys. Alpha and near alpha titanium alloys, alpha plus beta titanium alloys, beta titanium alloys. So, there are three types of titanium alloys. So, under the alpha under near alpha titanium alloys we have titanium-aluminium-oxygen alloys, where aluminium content will be 4 to 6 and they are generally non heat treatable and weldable. They have medium strength, good creep strength, good corrosion resistance. Under the alpha plus beta titanium alloys, we have titanium-aluminium-chromium, vanadium, copper, molybdenum, tungsten, tantalum alloys.

They are heat treatable, good forming properties. They have medium to high strength and good creep strength. Under the beta titanium alloys we have titanium-aluminium-molybdenum, chromium, zirconium alloys. Heat treatable and readily formable. They have high strength and low ductility.

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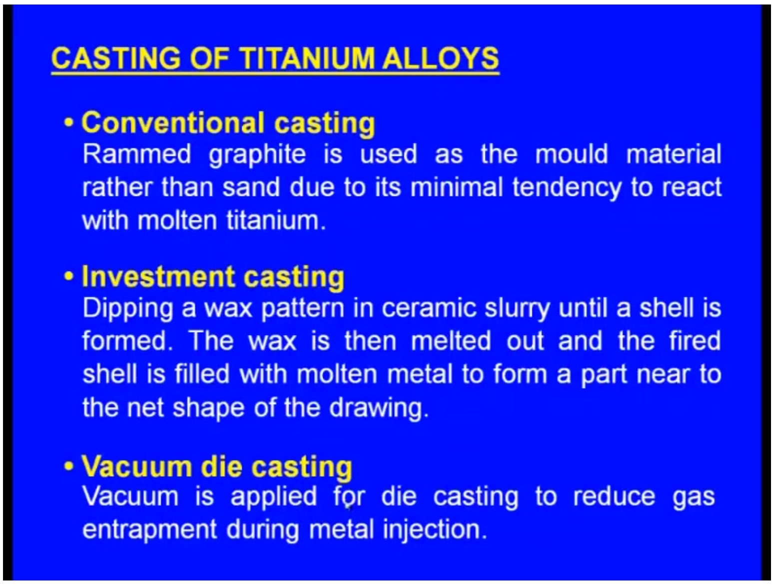

Casting of titanium alloys- Casting of titanium alloys is done in three ways. One is the conventional casting, second one is the investment casting and the third one is the vacuum die casting. In the conventional casting, we have to make the sand mode and we have to melt the metal and we have to pour the molten metal into the sand mode. So, that is the what say conventional casting. In the investment casting we have to make a wax pattern. So, parallelly we will be making a ceramic slurry.

The wax pattern will be dipped inside the ceramic slurry taken out and a stucco dry stucco we have sprinkled on that pattern. Then again it is dipped inside this slurry taken out and so, what say stucco is sprinkled. So, this process is repeated maybe six seven times till a thick shell is created around the wax pattern. Then the wax pattern inside the shell is drained out. Then the shell is what say dried and it is what say burnt for gaining additional strength. Then the molten metal will be poured inside the shell. So, that is the principle involved in the investment casting. So, the titanium alloys are also made by castings are also made using investment casting and titanium alloys can also castings can also be made by using vacuum die casting. Here in the conventional casting we use the rammed graphite and in the investment casting we use the yes wax pattern and we dip it inside the ceramic slurry and in the vacuum die casting. Vacuum is applied for the die casting to reduce gas entrapment during metal injection.

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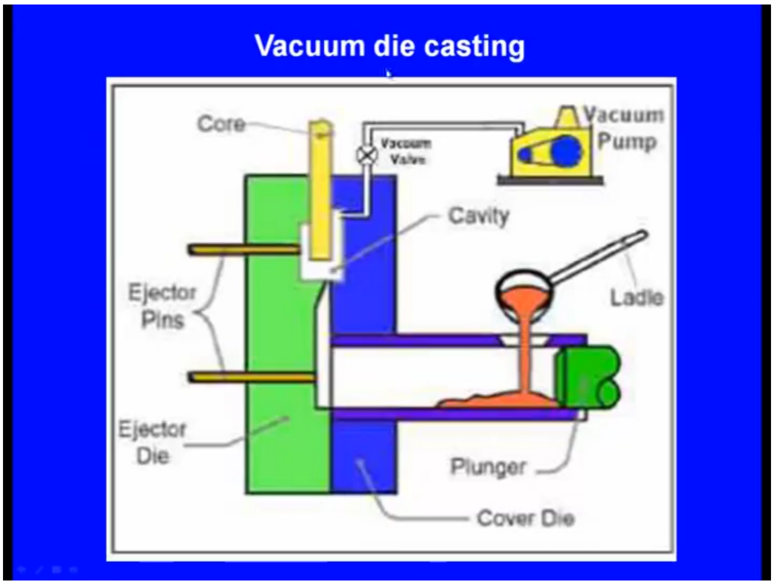

And here we can see this is the Vacuum die casting.

So, here you can see there is a what say cylinder and here we can see there is a plunger and here we pour the molten metal. After pouring the molten metal the plunger will be pushing the molten metal and this is the cavity and here you can see the cavity. The molten metal will be injected inside the cavity. So, it is possible that atmosphere or air present around the what say molten metal may react with the metal and the casting will be damaged oxidation takes place.

So, for that purpose we use the vacuum. So, that there won't be any what say air inside. Only molten metal is there. So, it is free from the oxidation.

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So, titanium castings are normally near net shape products with minimised metal waste. So, that is another what say advantage of the titanium castings. So, in this lecture friends we have learnt about the copper alloys, zinc alloys and titanium casting alloys. Three casting alloys we have completed in this lecture. So, we will meet in the next lecture.

Thank you.