Theory of Production Processes

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Lecture - 59
Weldability of Non-Ferrous Materials

Welcome to the lecture on Weldability of Non Ferrous Materials. So, we discussed about the ferrous materials among them especially we discussed about the steel and then we discussed about the cast iron. And then we also must have some knowledge about the weldability behaviour of the non ferrous materials also.

Because non ferrous materials are also of quite a good significance and they have quite a good unique properties as even as compared to the ferrous materials, especially about the machinability studies, then first of all cast ability studies because here you require the melting at smaller temperatures. Then they have some special properties like many a times they are used when you need a very high conductivity.

And then if you look at the strength to weight ratio that is the biggest advantage as compared to the ferrous components because the strength to weight ratio for many non ferrous materials are quite better as compared to the ferrous counter parts.

So, now we must also have certain ideas about the weldability aspects of non ferrous materials; especially to know that what are the challenges when we do welding, what are those points we need to concentrate to understand that how the weldability will change? So, that is what we are going to discuss today in the weldability of non ferrous materials.

So, among the non ferrous materials we will first try to concentrate on the material that is aluminium and its alloys. Now, aluminium alloys have certain characteristics which makes it a very important material. And as we know that it is a very silvery white metal and it has certain properties like it is light.

So, aluminium if you look at it has, it is a as third you know weight having weight as that of the steel. So, its density is about one third of that of the steel.

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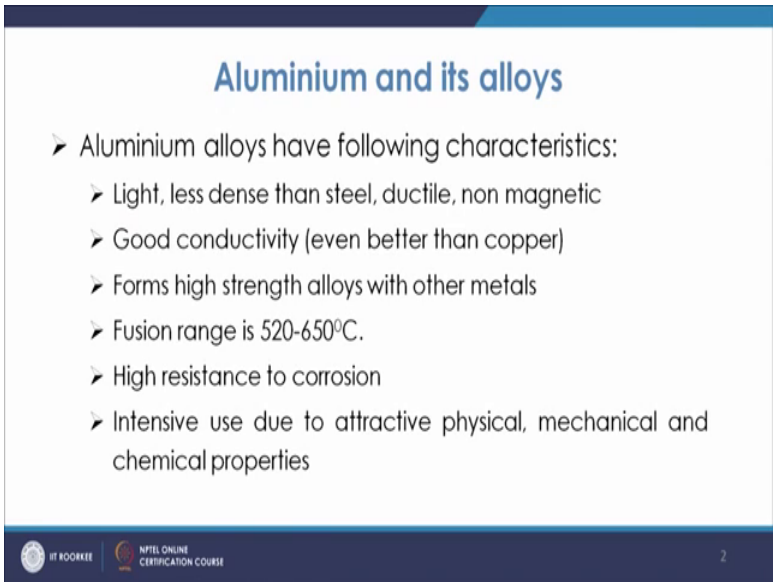

And very; so, then it is quite ductile and non magnetic then its conductivity is quite high even it is having better conductivity then the copper also, then a aluminium has the tendency to form the high strength alloys with other metals. Now, if you take the pure aluminium then pure aluminium is soft and it does not have much of the strength.

So, for engineering applications pure aluminium has not much of the use pure aluminium has its use wherever we require quite a good thermal conductivity. So, in that case we go for the aluminium, but if we try to have try to know about the strength of these alloys then. So, it has the tendency that it makes the alloy with different materials and yields into a very good properties, then the fusion range is about 520 to 650 degree centigrade. So, as we know that aluminium has also smaller melting point.

So, in that case that gives you another advantage because you have, to you know do you have the advantage in welding because the temperature requirement is quite smaller. The fusion range is something like 520 to 650 degree centigrade, it is highly resistant to corrosion and the thing is that because of its attractive combination of physical mechanical and chemical properties its uses are many. You have the use of aluminium alloys in many fields before that they also exhibit quite a good amount of toughness. So, you know they become stronger at temperatures below the ordinary atmospheric you know range.

So, that is these are the normal traits of the aluminium material. Now, if you talk about the uses of these aluminium alloys, now it its uses are many and they are normally used you should talk about the alloys because the advantage is that it gives you quite a good specific strength value. So, they are used in those industries where we need the strength, but at the lower weight. So, in that case it becomes a cheaper alternative, the same strength you get with larger weight then in that case you have to pay more.

So, we are using in the transportation industries because in the transportation industries we think of having a material which should be lighter. So, that you have energy efficient vehicles then also you go for using the structural framework then engine parts and decorative features are every, every in the every areas we try to use this aluminium components.

Then in the food industry also aluminium has extensive application like in refrigeration or storage containers, they are also made by this aluminium then you have also the use of aluminium in the cryogenic you know applications also. So, this way the aluminium is very much sought after material and its gaining the momentum in terms of its demand. Now, as the demand of these components in are increasing similar will be the trend for their you know these aspects like how to weld them, how to get a satisfactory weld in these cases.

So, these properties also suppose in one way or other the challenges may be many times are favourable you know favourable also there may be far as regards the welding aspect is considered.

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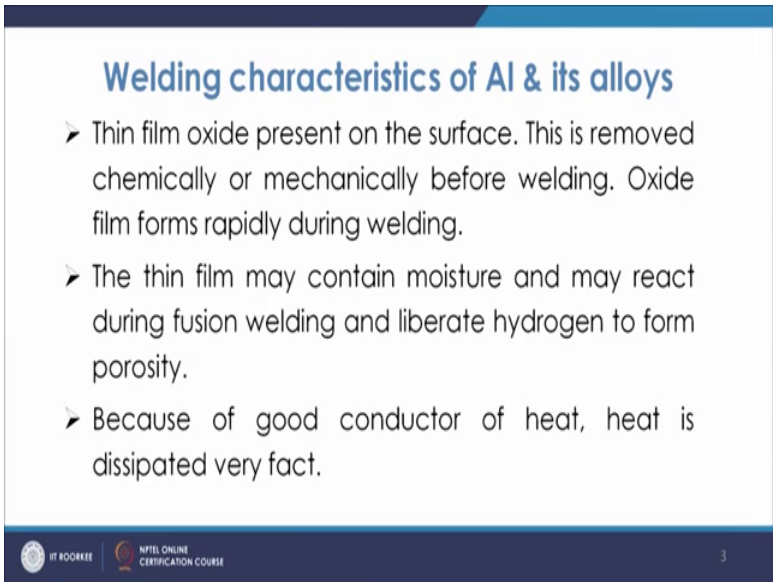

So, we are going to discuss something about the welding characteristics of aluminium and its alloys. Now, if you talk about the aluminium the important thing in the case of aluminium is that you have the thin oxide film which is present on the surface. As we know that in aluminium you have the oxide of aluminium l 2 o 3 on the surface and this is removed chemically or mechanically before welding, you have to remove them and the this oxide film basically rapidly forms during the welding also.

So, basically you have to have certain ways by which you can remove these you know oxide layers and for that you may have the use of a suitable flux in the case of welding and brazing. And also when we do I mean the arc welding. In that case you have to use the suitably the stick electrodes or thickly coated electrodes in the metallic arc welding, also when we go for the use of the DC welding or AC welding in those case we are using this DCRP to be very effective for the MIG welding and AC is used for the TIG welding.

So, basically what happens that in AC in the half the cycle that process is done and in half of the cycle it is not. So, the in the MIG welding when we use this DCRP then the oxide is removed by the arc cleaning action. So, because the aluminium base metal will be the negative poles. So, when we use the DCRP. So, that is reverse polarity.

So, electrode will be positive and work will be negative and in that case the there will be arc you know cleaning action. Now, the DC arc is used in the TIG welding then. So, in that case the TIG electrodes will be overheated. So, and the problem may be that when

the TIG electrodes will be overheated then the chances of melting or the you know problem will be there in the adequate melting.

So, what we do is in the case of you know TIG welding we go for the AC you know setup. So, in case of MIG welding we go for the DC reverse polarity because there itself they are the electrode itself has to deposit. So, that is getting accumulated, that is getting large portion of heat because this is reverse polarity. So, so electrode will be positive and in the case of a TIG you go for the AC welding. Now, the thin film may contain moisture and may react during fusion welding and liberate hydrogen to form the porosity this is another challenge because the thin film of oxide which is there. So, it may have moisture and then it may react during the fusion welding and liberate hydrogen to form the porosity.

So, this challenge is for the to be overcome in the case of welding, the another property of the aluminium is that as we have understood that it is a very good conductor of heat. So, being a very good conductor of heat the heat will be dissipated very fast and that see is a basically big challenge when we do the welding. So, for that there are certain you know measures which are to be taken so; that means, the thing is that when you are giving the heat input in that case being very very high conductor, it will quickly go away and it will be passing.

So, that way you will not have adequate heats they are retaining their so that you can do the fusion operation. So, for that you have to have the proper you know way to compensate that heat loss to the surroundings. Now, for that when we do the gas welding in that case you can have the nozzle of larger diameter. So, that will give you the large amount of heat in that case similarly, when you go for the use of current then the current values should be somewhat larger then the normal arc welding processes.

So, wherever we are doing the arc welding as compared to that you will have to go for little bit larger value of the current, then we can also do like when we have thicker work pieces then we can preheat that and then you do it. So, that the rate of heat transfer in a particular time will be smaller. So, these are the precautions which you will have to take for taking care of these properties. Another challenge with aluminium is that you have it has a very high coefficient of linear expansion.

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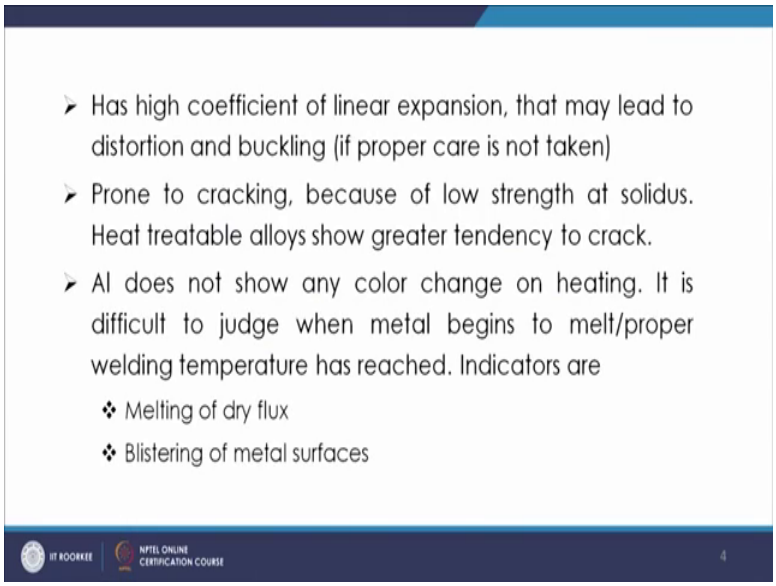

So, once you have the high coefficient of linear expansion than the chances of istortion and buckling will be higher because as the temperature increases the expansion will be the chances of expansion will be more. So, if you are not taking proper care. So, in that case you will have the chances of buckling or distortion will be there more then aluminium also has prone to cracking because of its low strength and the solidus and especially the heat treatable alloys. So, aluminium as we know that it makes alloys with large amount of material and some of them are the heat treatable materials and some of them are not heat treatable.

So, the alloys which are heat treatable they, so the larger tendency to crack. So, so whenever you have the tendency to crack in that case you will have to do the suitable pre or post weld heat treatment. So, that the chances of cracking will be smaller , the another challenge which we face with aluminium is that in the case of ferrous component. We know that what is the temperature what might be a temperature when the melting is going on, but in this case it does not show any change in the color.

So, that is the challenge. So, you will have to by experience only people can know that where is the what is the stage of welding with the welding is going on or it has been finished or the temperature. So, basically there are only certain indications when you have the melting of the flux or the blistering of metal surfaces, by only that the experienced you know persons who are working on welding. So, they can only get to

know that what is the state of the welding process whether welding process has been over or it is still going on.

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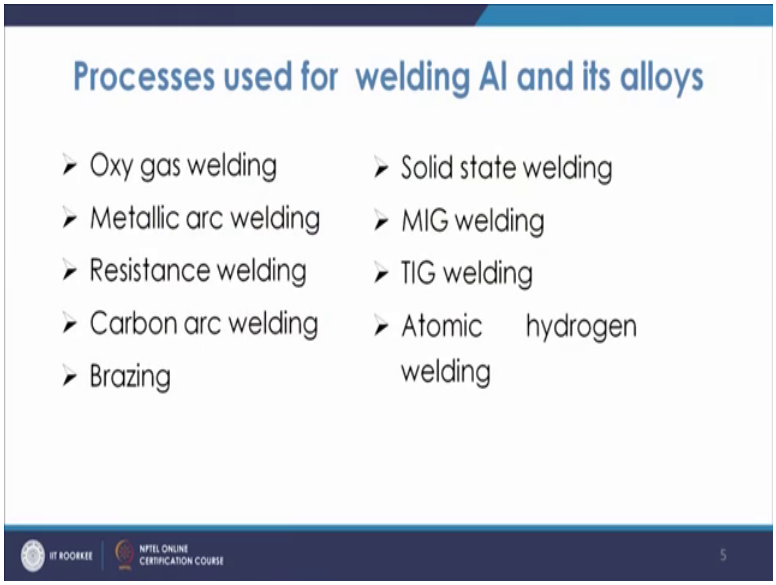

The process which are used for the welding aluminium and its alloys are like oxy gas welding then you have metallic arc welding, resistance welding, carbon arc welding, brazing solid state welding, MIG welding, TIG welding atomic hydrogen welding. So, these are normally the methods which are used for welding of the aluminium and its alloys, then the next material which we are going to discuss will be the copper and its alloys.

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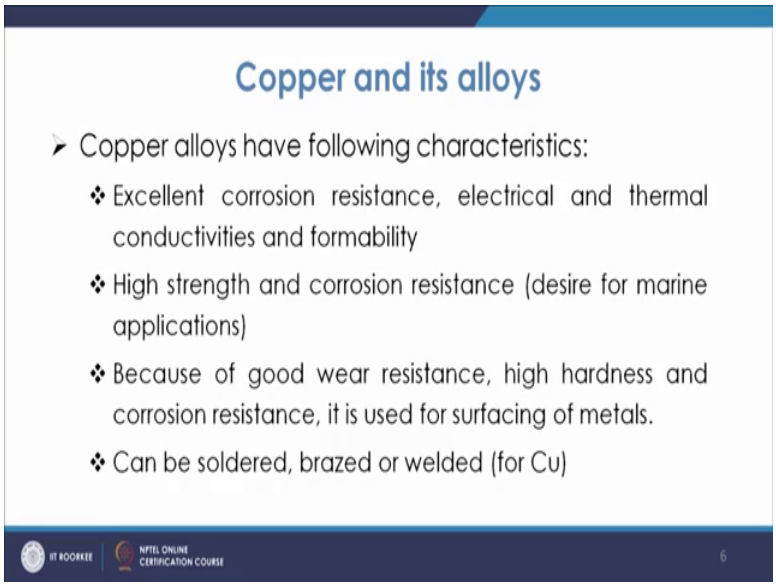

So, copper is again one of the very important non ferrous material which has extensive use and because of because it has very good properties. So, we will discuss first of all its property and then the challenges related to the welding behaviour of this material. So, copper alloys now they have very good corrosion resistance electrical and thermal conductivity and formability.

So, good corrosion resistance as we know that it has very good electrical and thermal conductivity. So, the for that it is used in the electrical appliances thermal conductivity is quite good. So, many a times we use it for making even moulds in certain very very rapidly cooling or chilling you know casting processes.

So, like continuous casting or so, so it has a very good electrical and thermal conductivity and also the formability. Now, high strength and corrosion resistance makes it very suitable for use in the marine applications. So, that is required when we go for components to be used in the marine applications, because of good wear resistance high hardness and corrosion resistance it is also used for the surfacing of metals many a times and as far as its weldability is concerned it can be soldered braised and welded. So, this way now copper as we see that it has a very good you know combination of properties as regards its use in the engineering, you know applications are concerned, apart from that it has a very good resistance to fatigue and abrasion. So, that is another thing then also it can be used because it gives a very good appearance.

So, pleasing appearance once polished. So, also used for that decorative purposes or other purposes, very good it has the machinability. We know that its melting point is little bit higher among the non ferrous materials, but it is quite smaller as compared to steel. So, the melting point is pure copper is close to 10 83 degree centigrade.

So, it is quite smaller and somewhat even smaller than the gray caster and also. So, this makes copper a very suitable material apart from that copper has the advantages with copper is that it can alloy with different types of you know elements and its alloys are mostly used like you have the brass is the high copper, you have many high copper alloys are there brass is there also.

So, that way you have many materials as alloys which are very very popular which are the copper based alloys, coming to the talking about the welding characteristics of copper and its alloys.

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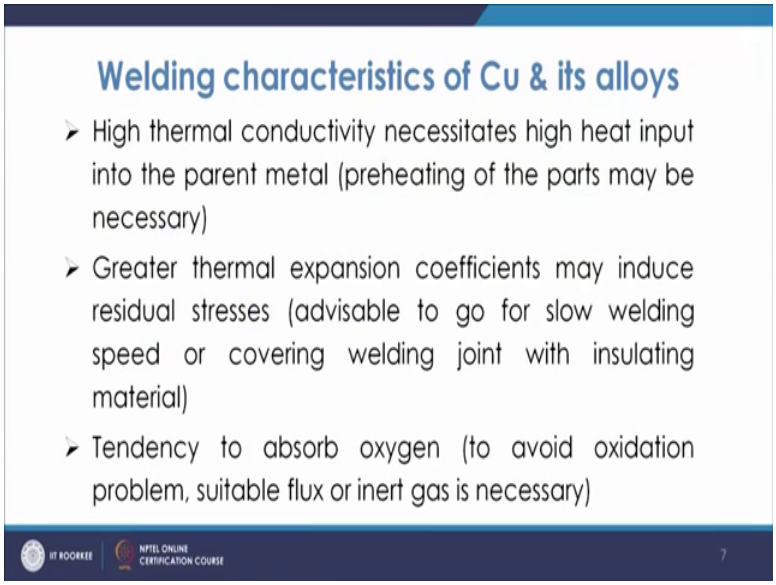

So, now the again the challenge with copper is that since its thermal conductivity is quite high. So, you need very high heat input into the parent metal and for that even the preheating is required because the thermal conductivity being very very high, the rate of heat transfer also the rate of heat being extracted will be quite fast.

So, that way you will have to go for the preheating of the parts in those cases, also just like aluminium phases it has also very high thermal expansion coefficient. So, that if the

thermal expansion coefficient is larger in that case that may induce the residual stresses certainly because once you have the more expansion and then if you have the restraint then the residual stresses will develop and. So, and that we also should have the aim that this value of the residual stresses should not be more than certain limit.

So, we so, we advise the advice is that you should we should go for the slow welding speed or the or when we are welding, in that case while cooling we should cover the welding joint with insulating material like asbestos. So, that is what we do in the case of the copper, also another challenge which or another problem which we get with the copper is that it has a high tendency to absorb oxygen. Now, this oxygen, so that way you will have the oxidation problem and it has to be avoided. So, to avoid this oxidation problem suitable flux or inert gas is necessary. So, this, for avoiding this problem what we do is we can use the suitable flux or even the inert gases. So, that is what we do to see that they do not observe the oxygen in the case of the welding of copper.

Now, another thing which we see with the copper the challenge is that it remains in the fluid state for larger time, now it is I mean in other words it is considerably more fluid than other metals and that is why you need to have the greater welding speeds for the copper.

So, otherwise that creates a problem as compared to that of that for the steel and also what we do is we also do some you know back a plate or we use some stripper plates or so while doing the welding for the copper. The different processes which are used for copper is the TIG, MIG gas welding, brazing and soldering.

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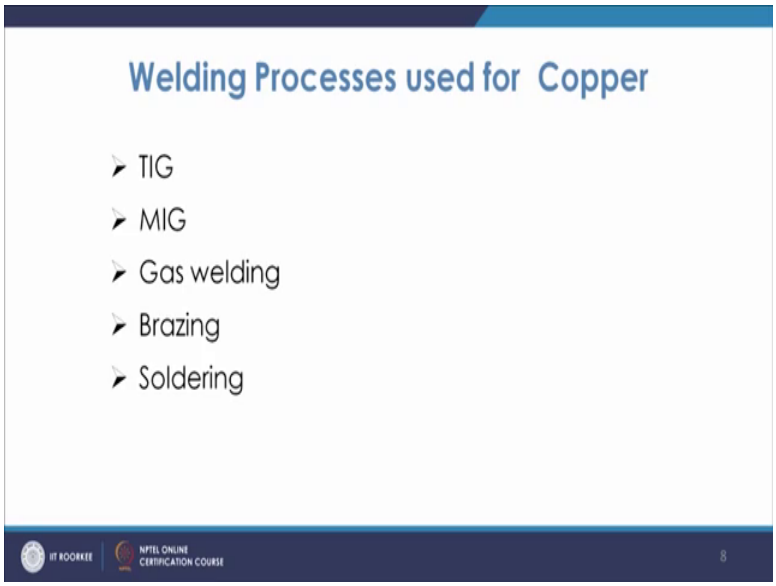

So, you have the different welding parameters will be there in the case of TIG or MIG or so also the when we do this TIG welding then you have some advantages what we get otherwise like when we do the arc welding with TIG then we are basically the oxidized coppers are obtained in that case you can use other welding processes also like MIG or gas. But then brazing and soldering is another these are the 2 most commonly used methods which are used for these joining of these copper parts and they give some wiggles in brazing you have the temperature of the braze metal will be close to 450 I mean more than that.

So, 600 or 700 also. So, in that case it gives a very good substitute of welding the copper base materials which gives quite a good strength.

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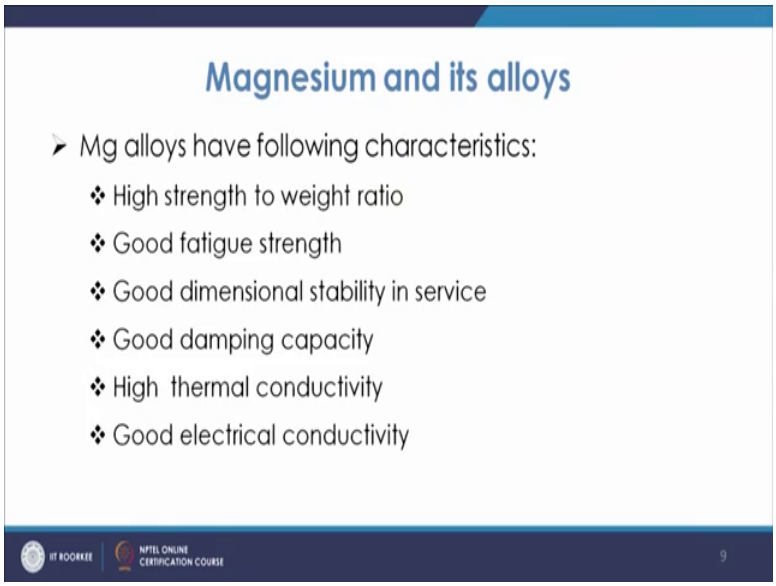

Now we will move to the another variety of material and that is magnesium and its alloys, now magnesium as you know in the recent times magnesium is going to be a very lucrative material as far as the you know its properties are concerned, if you look at its property you see that it has a very high strength to weight ratio.

So, it has, it gives you a very very high strength to weight ratio its density is quite smaller even lighter than aluminium and the specific strength becomes quite high the there is a good fatigue strength with the magnesium alloys you have good dimensional stability in the service good damping capacity high thermal conductivity good electrical conductivity and you have.

So, these are basically the different properties which you have with magnesium alloys. Now, depending upon its properties it has the use in many sectors and mostly we are going to make the airframes in aircraft in industry, is mechanism has a very good use because its alloys has a very good use because of very lightweight of magnesium. Then you have in the engines gearboxes or you know there are many places where you use then in the transmission pumps or differentials all these places also they, they are used they are also used in the material handling equipment also in the you know moving parts of the textile machines and printing equipment.

So, there are enough use of this component, now talking about the weldability behaviour or welding characteristics of the magnesium alloys.

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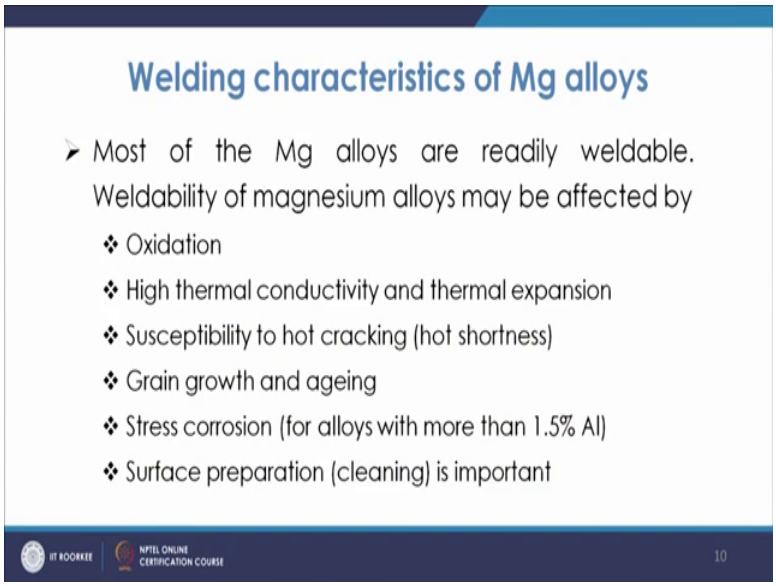

Now, most of the magnesium alloys are readily weldable. So, they have good weldability properties, but then you know you have many challenges and you have some parameters which affect its welding characteristics and the important of ones are like one is oxidation. So, oxidation is the problem because magnesium all itself is very much prone to you know I mean, I mean it has a quite good affinity towards oxygen. So, you will have to do the welding in such an environment that it does not have a contact with oxygen.

So, this is to be seen then it has a very high thermal conductivity and the thermal expansion. So, again because of that the similar problems are with you when the materials like aluminium or copper. So, you will have to have the preheat and post heat post weld heat treatment to be provided or you will have to have the cooling in a control atmosphere.

So, that the adverse effect of the thermal expansion is not with not you know faced then susceptibility to hot cracking that is hot shortness. So, this is another problem in the case of the magnesium, grain growth and ageing. So, what happens that when the alloy is welded in the work hardened condition in that case the grain growth and ageing occurs in the heat affected zone and if that happens then that imparts not a favourable you know situation that does not lead to a favourable situation for the material because grain growth being taking place that will be making the properties inferior.

So, basically what we do is that many a times for even removing this for lowering these chances of oxidation we use suitable fluxes, then for you know if there is grain growth or ageing in that case you will have to you know you have to see that they should not occur that that happens mainly because of the temperature.

So, otherwise they will be lowering the overall strength of the weld pool, stress corrosion cracking is the another you know phenomena which is seen in the case of magnesium alloys and that is typically more prominent when the they are making the alloys with aluminium and aluminium is more than 1.5 percent. So, that is also important in those cases, surface preparation or cleaning is important because many a times the these magnesium surface are painted.

So, that is why when you do the welding this aspect is to be kept in mind that the surface must be prepared they must be cleaned properly. The different processes which are used for magnesium alloys are TIG, MIG that is tungsten inert gas, metal inert gas, resistance welding, gas welding, brazing, pressure and forge welding or EBW electron beam welding.

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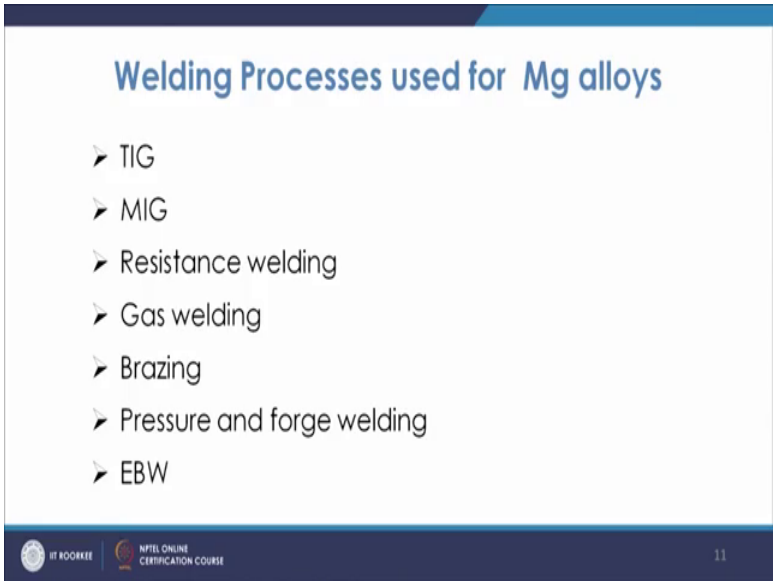

These are the different processes which are used for the magnesium alloys welding, certainly every welding will have you will have the optimized set of parameters which will give you more satisfactory weldings. But the aspects which are to be looked into are

basically related to this higher thermal conductivity and then oxidation and then grain growth ageing and all that that is to be you know incorporated, that is to be looked after.

Thank you very much.