Fundamentals of Surface Engineering: Mechanisms, Processes and Characterizations

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Lecture-44
Surface Modification Techniques: Weld Surfacing Process

Hello I welcome you all in this presentation related with the subject fundamentals of surface engineering and we are talking about the methods where in a layer of the good material is applied on the surface of the substrate so that the required a change in mechanical properties and tribological properties can be realised. Now in this presentation basically will see that different surface modification processes which are related with the weld surfacing basically it is about the weld surfacing processes

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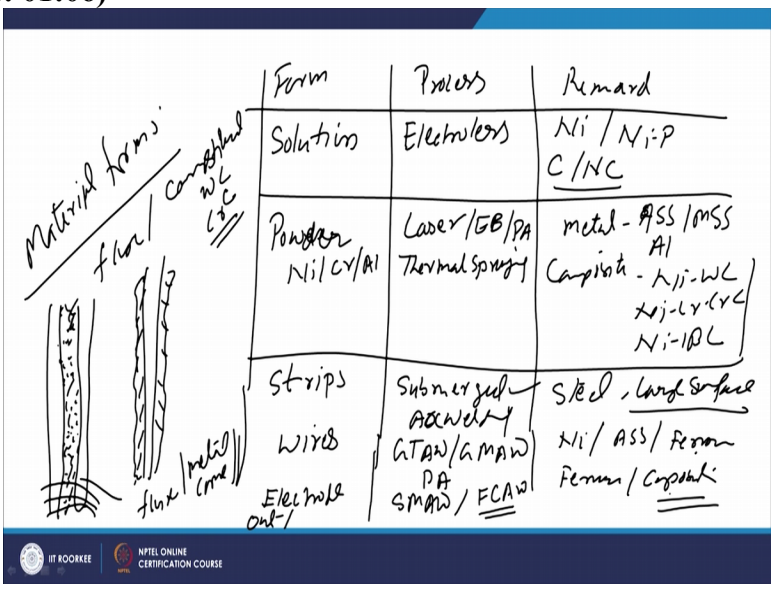

And will be starting this presentation with the different materials which are used. Material forms which are used for surfacing by developing a layer of the required quality of the material. So, materials can be used in variety of forms for example here the first column we have form. Form may be in form of solution like the elements to be deposited in form of layer are used in form of solutions and this is primarily used in a process which is called like electroless process.

And it is used for depositing the depositing layer of like say the Nickel or the Nickel Phosphorus kind of the compounds. It can be used for depositing the coatings of such kind of materials on both conducting and non electrical conducting materials. So, it is not necessary that the work

piece material has to be electrical conducting; it can be used to for depositing the coatings of the required material on to both the conducting and non-conducting kind of the materials.

Then we have another form of the material which is like in powder form. The material which is to be applied is available in powder form is can be like the Nickel or chromium or aluminium or any other suitable material like aluminium silicon carbide oxide. Whatever we have to deposit apply on to the substrate that is available in powder form. And it is used with them like say it can be used with the laser or electron beam or plasma arc welding process.

It can also be used in case of the thermal spray processes like oxy fuel is spray process HVOF or detonation gun kind of processes. Then this is very widely used for depositing the like the layer of the required metal in form of likes a austenitic stainless steel, martensitic stainless steel or application of the like a the aluminium a layer; at the same time it is also used for developing the layer of composites.

For example Nickel Tungsten Carbide, Nickel Chromium, Chromium carbide and Nickel Boron Carbide kind of the; composite layers can also be developed using these processes where in the material to be applied on the substrate is in form of powder. Then it can be in form of the strips like thin strips. And this is particularly used in case of the submerged arc or submerged arc welding process especially when it can be used like ferrous metals and Steels.

Especially when the large surface area is to be covered, so if very wide area of the surface is to be modified then material form of strips is used in case of the submerged arc welding process then we can use wires. Wires of the different diameters like 1.6 to 2.5 like that and it can be used in the processes like non consumable as well as console processes. For example gas tungsten arc welding, gas metal arc welding or plasma arc welding process.

So, at the heat source like arc the wire is fed for fusion and getting it mixed with them fused base metal to form a bead on plate. So, this can be used for or developing the and the claddings and coatings of Nickel or austenitic stainless steel or ferrous metals different category of ferrous metals like high carbon steels and other layers also can be deposited as per the requirement of the surface modification.

Then one more form is there which is like electrode where metallic wires covered with the coatings. So, this is a like a when the coating is applied outside of the electrode this is typically

used in case of the shielded metal arc welding process. But there can be another variant where the metal in form of the tube is filled with the flux. So, for the flux with the presence of the flux which will help to provide which will be providing them a required protection as well as formation of the slide?

And apart from that it can also be used the flux is can be mixed with the required constituents like we can add tungsten carbide chromium carbide powder mixture. So, after getting mixed with them with the base metal as well the tube which will be fusing it will be forming the carbides or it will also be it will be forming the composite weld servicing layer or it will be leading to the modification of the chemical composition of the weld which is being developed by incorporating the elements to be introduced with the flux itself.

So, electrode can be in the two forms where coating is applied outside or inside so this is called like flux code or it is also called metal code electrodes. So, in case of the metal code electrode we introduce, we feel in besides the flux we are also include the constituents in form of in the powder form of the elements that we want to introduce your constituents that you want to introduce may in form of chromium or Nickel or any other element that we want to add in the bead on plate.

Or we can add the suitable constituents in form of carbides, fluorides etcetera. So, that they can be incorporated in bead on plate weld so like shielded metal arc welding will be using that the electrodes where flux is applied outside and flux cored arc welding will be using the electrodes where the flux and the other constituents are filled inside the tubular electrode and this can be used for developing the layers of all ferrous metals or developing the composite layers.

So, this is about the description of the various forms in which the material is applied and where this kind of the methods can be applied like all those processes where arc is to be established like inshield metal arc welding, gas tungsten arc welding, submerged arc welding, flux cored arc welding in all those cases it is necessary that work piece is having the enough electrical and thermal conductivity.

So, that arc can be established while in case of the laser welding it is not necessary in case of electron beam welding it is not necessary that the work piece is electrical conducting.

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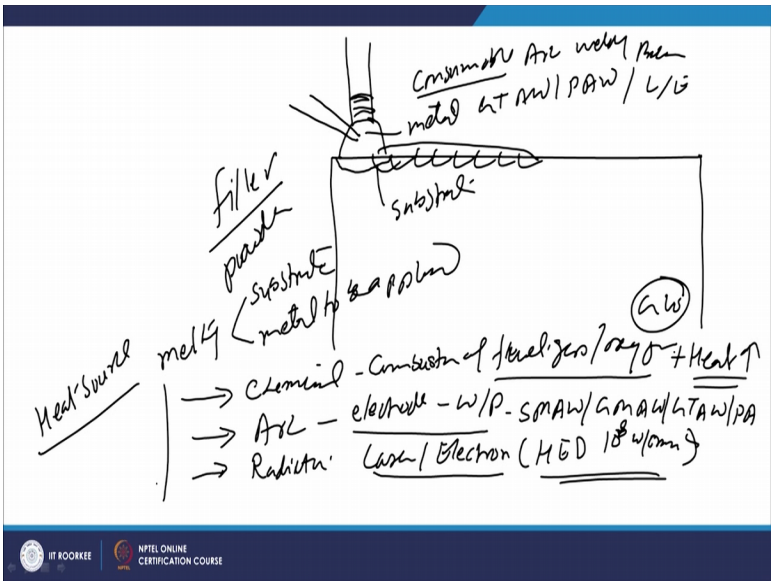

And now will be talking about the way by which the beads are deposited like this is a substrate and so using the suitable source of the heat. Heat is applied on to the surface of substrate this will be melting the substrate up to certain depth. Now our heat source can itself provide them metal to be applied in case of the consumable arc welding processes or if the electrode is not providing like non consumer arc welding processes.

In case of say gas tungsten arc welding, plasma arc welding or our laser or electron beam in both cases in all those cases are the heat source our source will be providing just heat and metal to be applied on to the surface of substrate has to be fed from outside. So, as you get this is the heat source and facilitating the melting of the substrate. So, either melting of the electrode or the filler itself will be providing or we have to feed it from outside.

So, this feeding can be in form of the filler or it can be in form of the powder. So, this heat source will be facilitating the melting of the substrate as well as the melting of the metal to be applied. So, the metal to be deposited will be applied in form of filler strip or the powder in the zone of the heat source. So, that the melting of both substrate as well as the material to be applied can be facilitated and after the development of the weld bead required surface modification can be achieved.

Now this heat source is important for melting of both substrate and as well as metal to be metal to be applied on to the substrate. So, heat source and now the heat can come from the various sources like it can come in form of the chemical energy through the combustion of fuel

gas and oxygen mixture. So, the fuel gas like a propane or acetylene will be mixed with the oxygen and it will be burnt to produce the heat through the exothermic reaction.

So, that will be providing the heat, there is another source of heat that is the arc. Suitable arc is established either between the consumable electrode or non consumable electrode like tungsten and that source of heat is used. So, here it is either between the electrode which is consumable or non consumable and the work piece, arc is established. This will you facilitating the melting of the substrate as well as if the electrode is consumable than itself will be consumed or otherwise we have to feed it from outside in the arc zone.

So, that the melting of the metal to be applied can be facilitated, now depending upon the processes are the different energy density is observed like chemical. In case of the chemical energy for the combustion of the fuel gas and oxygen is used this approach is used in case of the gas welding and arc is used as a source of heat in case of; like number of processes like shielded metal arc welding and gas metal arc welding, gas tungsten arc welding, plasma arc welding, flux cored arc welding etcetera.

In all these cases arc is established between the electrode and work piece work which has to be electrical conducting then only the arc can be established. Then there is another source of heat that is that is about the radiation energy where both laser and electron beams are used. Both these provide very high energy density processes ranging up to 10 to the power 8 watt per mm square. So, such high energy density helps to melt the surface layer very quickly and the metal which is to be applied.

So, the processes fast it allows good control over the heat input good control over the quality due to the limited dilution fast cooling rate facilitating the fine grain structure. Even some of the cases amorphous structure is also produced. So, if we see these three processes because the source of the heat is different.

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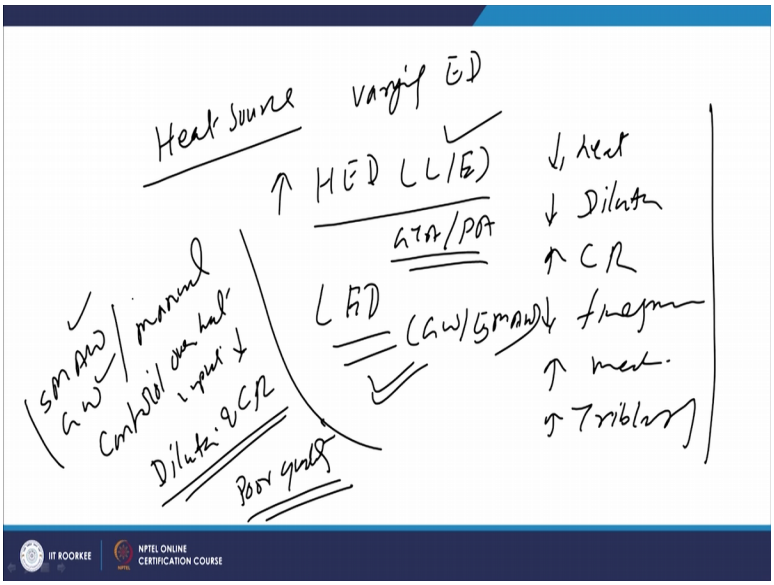

And that is why we get very different heat source are having the very different varying energy density is associated with them. As we have talked earlier if the process is of the high energy density like a laser or electron beam then it will be requiring the less heat for melting purpose and then it will be leading to the reduced dilution, to be leading to the increased cooling rate which internal leading to the fine grain structure and so improved mechanical properties improved tribological properties.

So, this is these are the benefits of the high energy density process and the reverse happens when the use the low energy density processes like a gas welding or shielded metal arc welding which offer significantly lower energy density compared to the high energy process like laser and electron beam. Further in between the energy density are offered by like GTAW and the plasma arc. So, quality is also in between the best quality is offered by this kind of process with regard to dilution and the structure.

While the poor quality afford by the gas welding and shield metal arc welding processes regard to the structure of dilution etcetera and so, performance of the weld surfacing or the surfacing which will be achieved. Now in general if we see where ever we use like that shielded metal arc welding or gas welding kind of processes. There we do not have very good control over the heat input and the melting of the substrate.

Because mostly these are the manual processes, so the control over heat input is less. And since the heat input is not well controlled so the dilution and cooling rate both are not controlled properly and that is why we get the poor quality of the modified surfaces which are developed in

the SMA and GMAW process. So, it is very important that heat input and protection is properly and achieved for developing the sound weld surfacing. So, that good quality modified surfaces can be generated.

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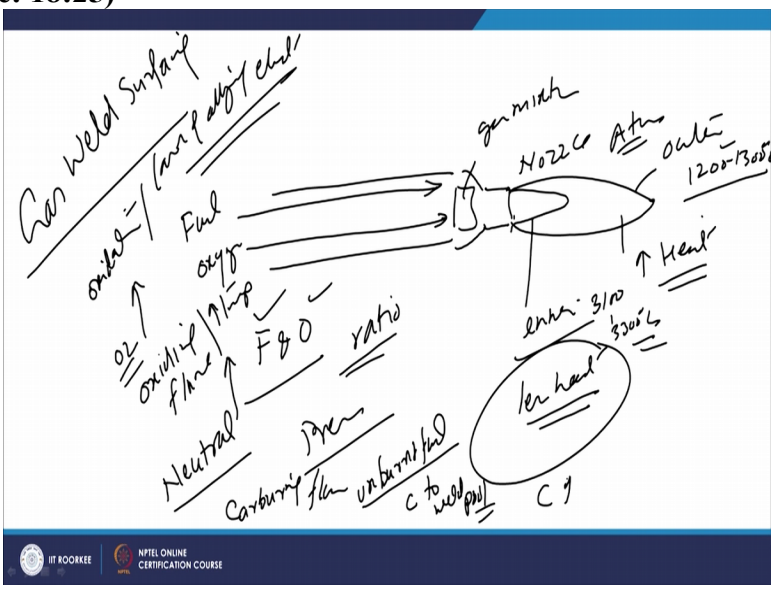

Now will be talking is specifically about some of the processes like gas weld surface. So, like; as the name reflects in case of the gas weld surfacing, we feed the two different gases like the fuel gas and oxygen and both are fed and then they are mixed in a chamber. So, fuel gas mixture gas both cases are mixed in addition allowed to, come out. So, this is where the nozzle of the torch exists to the gases will be coming out of this.

And here we have to fire it, so when we fire the fuel gas mixture we get a like a flame having this kind of the cone shaped. So, there can be a the flame can have the two or three different cones depending upon the fuel and Oxygen gas proportions or gas ratio the frame structure can have two or three cones. So there is one outer cone and there is one in a cone. In outer cone temperature is low light around 1200 to 1300 degree centigrade.

All though outer cone is called; is the zone where the secondary combustion takes place and increased amount of the heat is generated. So more heat is generated in our cone while in case of the inner cone the less heat is generated this is the zone where primary combustion takes place. So, less heat is generated but if we see the outer cone area surface area which is exposed to the ambient atmospheric gases the area is large and other gases in the atmosphere gases are at low temperatures.

So, the flame temperature outside flame temperature is low that is 1200 to 1300 degree centigrade. While inner core where despite of having the less heat generation, since its area is less as well as it is covered around the hot flame of the temperature 1200 to 1300 degree centigrade. So, the temperature of the cone is higher despite of generation of the less heat and this temperature can vary from 3100 to 3300 degree centigrade depending upon the pressure of Oxygen and the fuel mixture which is being used.

In general increase of pressure of the oxygen increases the heat generation and temperature. On the other hand increase of the oxygen content also helps to increase the temperature of the inner cone. So, the fuel and oxygen gas mixtures all the type of fuel also affects like spleen offers the maximum temperature while other propane and butane kind of fill gasses offers lower temperature like 26, 2800 Degree centigrade.

So, the maximum temperature is significantly affected by the type of fuel gas which is being used, this is one aspect. So, we always expect that there is approximately equal amount of; equal portion of the both fuel and oxygen gas mixture is used for producing the neutral flame where whole of the fuel gas is completely burn by the oxygen which is available. If the oxygen is more than it leads to production of the oxidising flame.

Oxidizing flame offers the higher temperature as compared to the neutral flame. And if the fuel gas is more as compared to the oxygen then incomplete combustion leads to the development of the carburizing flame. Now important is here that here, it will be having excess oxygen and here it will be having the axis of the un-burnt fuel which is basically hydrocarbon. So, carburising flame transfers to the weld pool or weld surfacing.

While oxidizing oxidising flame tend to cause the oxidation of the alloying elements in the molten pool and so there can be possibility for the oxides as well as loss of alloying elements. It is always preferred that the neutral flame otherwise carbonizing flame will tend to modify the chemical composition of the bead which is being deposited through the carburizing flame picture composition of modification primary happens in terms of the increase of the carbon content.

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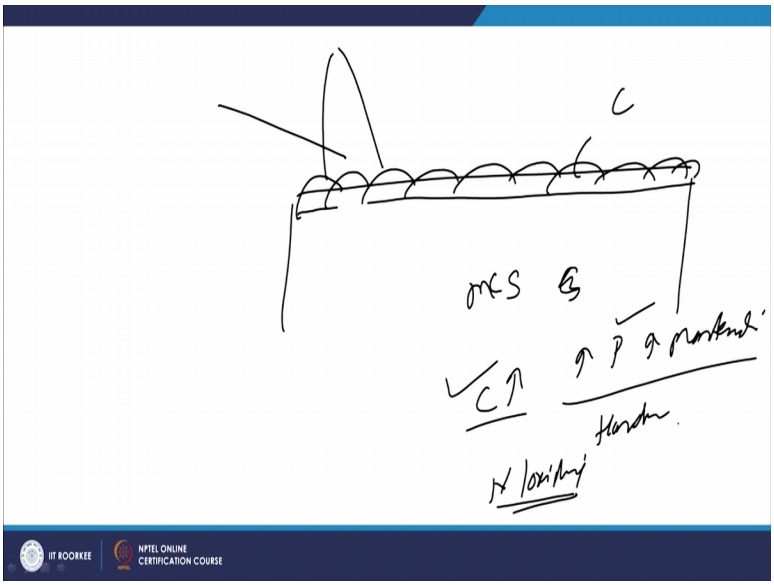

So, like say if this is the medium carbon steel which is being modified with the help of gas flame and we are feeding the electrode and a bead, weld bead is being developed like this so the composition of this weld bead will be richer in carbon content if you are using carburizing and we know that increase in carbon content in the steel in general leads to the increase the percentage of the perlite, increased percentage of martensite as per the kind of cooling rate.

And both these factors will be increasing the hardness of the weld surfacing as compared to the case when we use the neutral or oxidizing flame. So, carburizing flame leads to the enrichment of the carbon content which will be increasing the fraction of the perlite because increasing carbon content will increasing the perlite under the low cooling rate conditions and in the cooling rate is high enough to form the martensitic transformation.

Then it will lead to the formation of somewhat higher carbon martensite this is one of the implications related with the use of carburizing flame. Now we will see what kind of the metals systems which are deposited using the gas.

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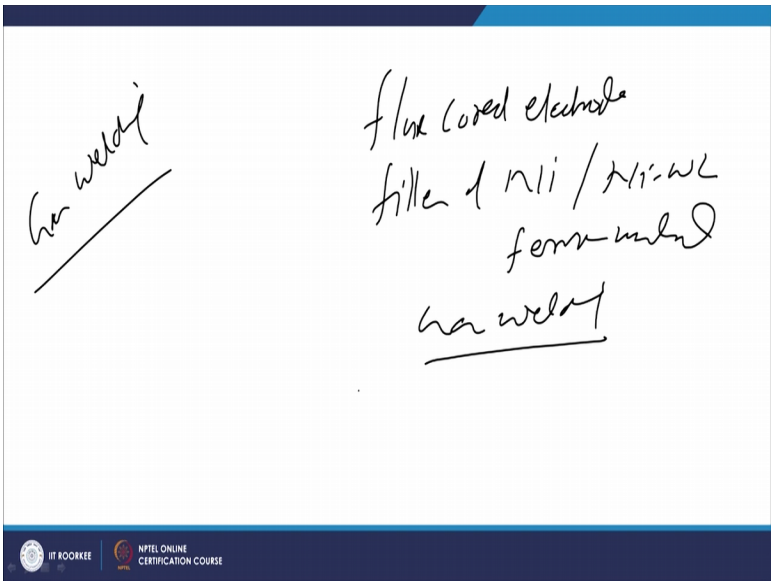

So, like the flux cored electrodes and the fillers of Nickel or Nickel Tungsten carbide or other ferrous metals these can be deposited using the gas welding process since the equipment for the gas welding is very simple very cost effective. So, it can be used effectively for the surfacing of the small areas and the system is very easy so it can be applied even by the semi skilled workers also.

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Now will see the another a surface modification process by the welding that is called shielded metal arc welding process, shielded metal arc welding process basically talks about in general structure of the process it uses consumable electrode having the metallic core wire. This is core wire made of metal to be applied for the weld surfacing and around that we have the flux coating.

This flux coating is thermally decomposed by the heat of the arc this is arc zone use when we use the suitable polarity or like say we use in AC equal amount of heat will be generated and if we use DC; so, when we use the DC and two third of DC with the work piece is connected to the negative terminal and electrode is connected to the positive terminal. So, less heat on the work piece side will be leading to the limited melting of the substrate and more melting of the electrode.

So, the heat of the like 66% of the heat generation on the electrode side and 33% of the heat generation in the work piece side, so more heat generation will be leading to the faster melting of the electrode as well as this will also be used for thermal decomposition of the coatings which is

already there. This flux will be providing the inactive gases which will be forming a cover around the arc to protect the molten pool from the condemnation by the atmospheric gases.

And so the formation of the undesirable inclusion oxides nitrates etcetera can be avoided. So, this is the internal structure so there is work, there is a power source where in basically the positive terminal connected to the electrode and negative terminal connected to the work piece are given. The connection of this kind is made this is called reverse polarity DCRP reverse polarity or DC electrode positive where electrode is connected to the positive terminal of the power source.

It helps to melt the electrode at faster rate in limited melting of the substrate. So, that the dilution can be controlled in better way but the problem with this is that electrode is controlled manually. So, the heat being applied per unit length is not well controlled and that is why the dilution at one section may be low at another section it may be high and that is why the shield metal arc welding process offers somewhat less control over the heat input as well as dilution.

So, and the dilution in this case may be like 15% with proper control of the process it can be reduced but if the process less controlled then it will be on the higher side. Now I will summarise this presentation, in this presentation basically I have talked about the gas welding process and the shield metal arc welding process and how this can be used effectively for surface modification.

So, that the weld bead on plates can be developed the for realising the required set of the properties which can help in improving the surface properties and improve the life of tribological components, thank you for your attention.