Fundamentals of Surface Engineering: Mechanisms, Processes and Characterizations

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Lecture-46
Surface Modification Techniques:
Weld Surfacing II

Hello I welcome you all in this presentation related with the subject fundamentals of surface engineering and we are talking about the weld surfacing processes, we have talked about the weld surface using the gas welding, Shield metal arc welding and the submerged arc welding. And now in this presentation basically we will be taking of the two weld surfacing processes that is the gas metal arc welding and flux cored arc welding.

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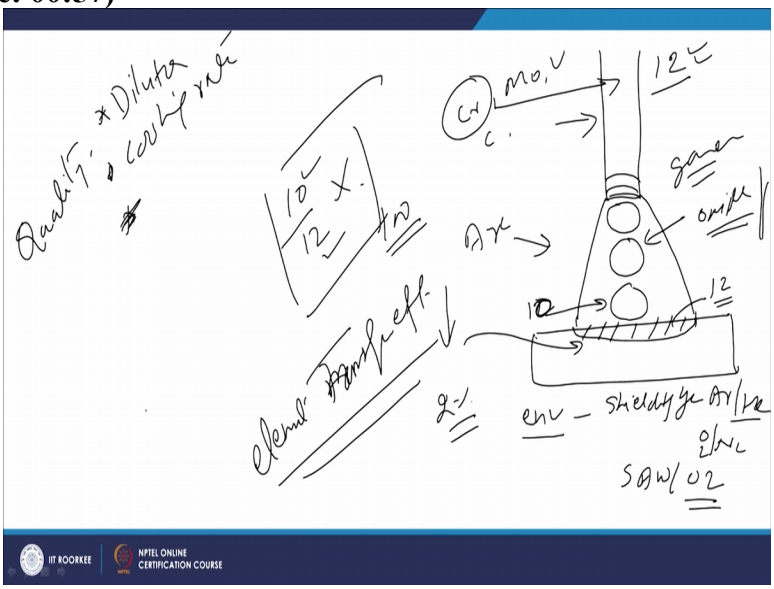

And we have seen that the performance of the quality of the surfacing is affected by the dilution and the cooling rate which is experienced by the weld metal during this solidification. And apart from this there can be other compositional degradation during the surfacing. So, what are those I will talk little bit about that. Let us say there is one material which is to be deposited on the surface of the substrate to achieve the required set of the properties.

So, in case of this weld surface in processes what is happening we are establishing the arc which is being used to melt the material to be applied. When the material melts obviously it is transferred to the arc gap to the substrate where it will be deposited in form of the bead on plate.

So, since the high temperature molten metal drops when they interact with the gases present in the arc environment.

They get oxidized and form other compounds and that is why whatever elements we had in the electrode like chromium, molybdenum, vanadium, carbon etcetera. Part of these elements are little amount of these elements get gets oxidized and so what we get at the end on in the weld surfacing that is somewhat lesser than what we had in the electrode or in the material which was being used to get deposited on to the surface of the substrate.

And this reduction in the amount of elements which are actually being made available in the weld surfacing is due to the one technical factor which is called element transfer efficiency. Element transfer efficiency so means if there is a particular amount of the element present in the electrode say it is 12% but when we deposit the amount reaching is just 10%. So, these reduction of the 2% is attributed to the loss of the alloying element due to the interaction with the gases which are present are with the molten metal.

And this is attributed and this is quantified in terms of the element transfer efficiency. If whole amount of the alloying element is transferred into the weld surfacing like if earlier we had 12 and weld surfacing. We also we are also getting 12 then element transfer efficiency will be 100% otherwise there will be drop in element transfer efficiency like this. Earlier we had 12 and now it is actually reaching 10. So, there will be reduction in transfer efficiency so that is what we can simply calculate.

And this element transfer efficiency to a great extent influenced by the environment through which the molten metal will be crossing to get transferred into the weld pool. So, if there are protective shielding gases like Argon and Helium then such kind of the interactions are very limited. But if lot of the oxygen, nitrogen kind of the gases are present in our environment and elemental transfer efficiency will be low. Especially in case of the SAW where oxygen content in the arc environment is too high that will be reading leading to the significant drop in the element transfer efficiency.

And that is why element transfer efficiency becomes critical parameters in case of the SAW process. It will also be important other processes but that element transfer efficiency in other

process maybe high especially in the inert shielding gases are used. Now in continuation with the welding process which are being used for the weld surfacing;

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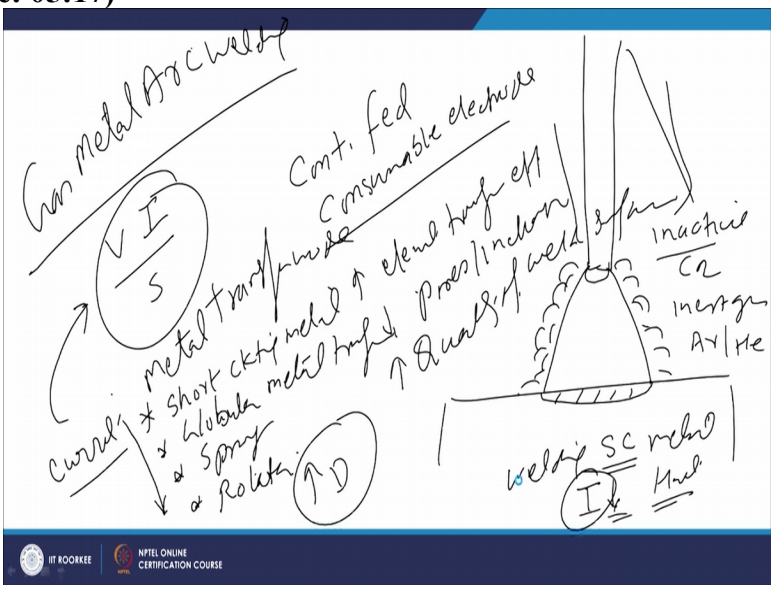

We will be talking about the gas metal arc welding. So, like a submerged arc welding process gas metal arc welding process also uses the continuously fed consumable electrode and that is why there is no need to stop the process. The process and we are able to deposit a large amount of the molten metal without making a; without interrupting the process. So, at the same time the protection to the pool of the weld surfacing; molten pool of the weld surfacing is given by the either inactive gases like carbon dioxide or inert gases like Argon or Helium. So, the protection to the molten metal is very good.

And that is why we get the high element transfer efficiency and reduced possibilities and incidences for pores and inclusions. And both these factors internal improve the quality of the weld surfacing deposited by the GMAW process. As far as the heat input is concerned in this is a process it is simply calculated using VI by S formulation but in order to reduce the heat input while developing the same good quality of the weld surfacing advanced variants of the processes have been developed.

There is one more important thing which we can notice is that the way by which metal is being transferred from the electrode tape to the substrate. So, here there the way by which transfer takes place is called metal transfer mode. So, there are 4 common modes of the metal transfers metal transfer one is called short circuiting metal transfer, globular metal transfer, spray transfer

and rotational transfer and these are transfers will be taking place for increasing value of the current, we know that when the current value is increased.

We find the increase in net heat input for given welding parameters like welding voltage and the welding speed. So, increase in the current value will be leading to the increased heat input which intern will be increasing the dilution. Therefore it is always preferred that for weld surfacing the short circuit mode of the metal transfer is used with the help of the minimum possible current value. So, the metal is melted at the electrode tape and it is transferred to the pool using the minimum possible heat input because of the lower value of the current.

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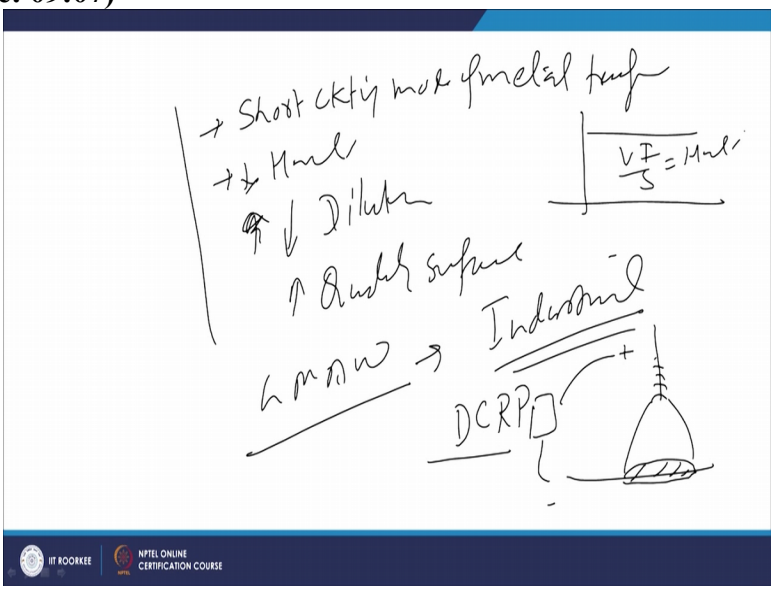

So, whenever short circuiting mode of metal transfer is used it helps since it is achieved using the minimum possible heat input and therefore it helps in reducing the dilution tendency. It decreases the dilution and the protective environments of the inert gases are inactive gases helps in developing quality weld surface. So, that is why GMAW variant is found extremely good for developing the weld surfacing at the industrial level for production of the many useful components.

Now in the conventional GMAW process we use the DCRP polarity. So, in DCRP polarity the electrode is connected to positive terminal and substrate is connected to the negative terminal of the power source. And so the more of the heat is generated on the electrode side and less on the work piece side this just facilitates the melting little melting of the substrate. While at the high rate of the melting is achieved on the electrode side.

So, we can achieve the higher deposition rate of the weld surfacing. In this case the welding current as a function of time remains constant and VI by S calculation is simple to determine the H net value.

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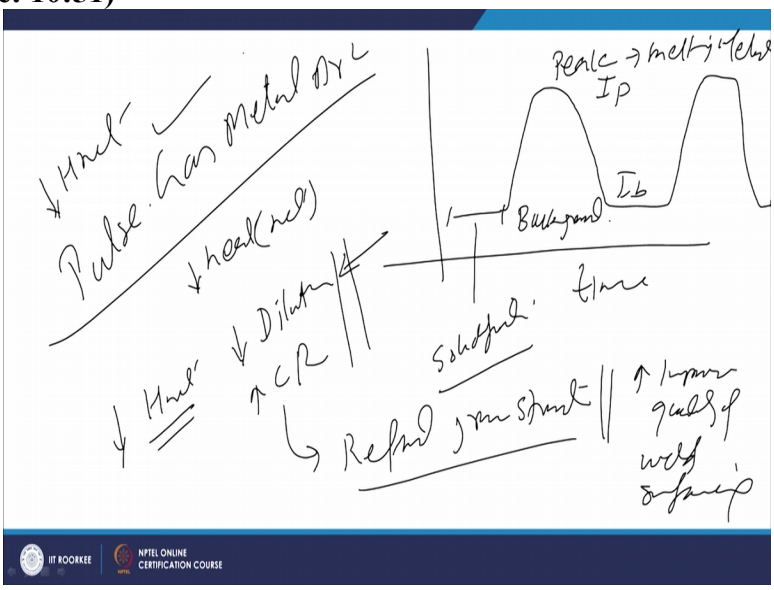

But in an effort to reduce the H net further other variants of the GMAW process has been developed these are called pulse gas metal arc welding. So, in case of the pulse metal arc and gas metal arc welding variant the current value is fluctuated or cutting in controlled way it is regulated between the background current level then higher level than lower level then again like this. The current value is regulated in very controlled way. So, when the current value is the lower level it facilitates the solidification.

And when the current increases is this one is called peak current and this one is called background current. Background current just helps to maintain the arc stable while peak current facilities of the melting of electrode so that it can be transferred. So, such kind of the peak current and background current fluctuations actually helps in reducing the heat input or net heat input for depositing the metal of the required quality. Since the heat input is reduced use of; by using the pulse is this in turn help in decreasing the dilution level and increasing the cooling rate.

So both these factors are favourable with regard to the quality there will be reduced degradation in the composition of the substrate of the weld surfacing while in case of; while in higher cooling rate will be leading to the refined grain structure and which; and therefore since the reduction in heat reduction in heat input is decreasing the dilution. Decreasing the composition of modification and increase in cooling rate is helping to refine the grain structure and both these

factors in combination help to improve the quality of weld surfacing and that is why the pulse variant of the GMAW process helps in developing the quality a surfacing.

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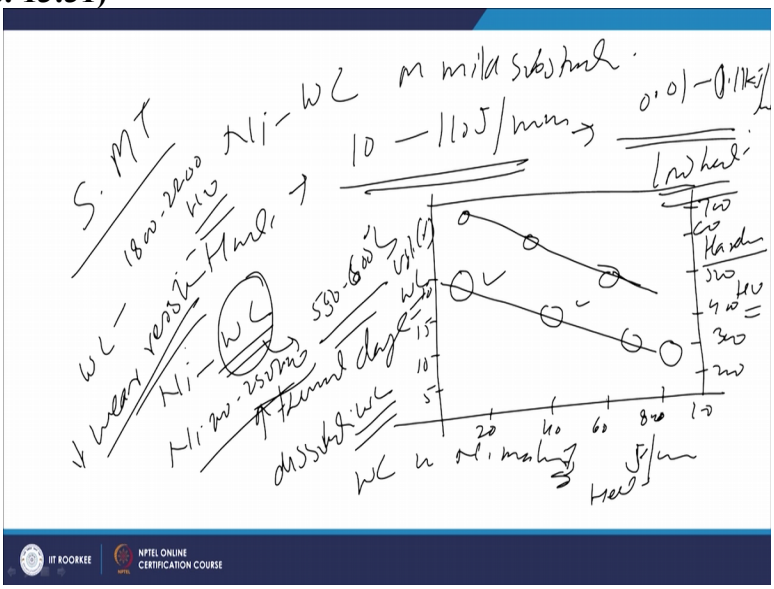

There is one a typical example wear shorts circuiting mode of the metal transfer was used for depositing the nickel tungsten carbide weld surfacing on the mild steel substrate using the current values in such a way that net heat input H net was ranging from 10 to 110 joule per mm this is very low heat input because normally the heat input is expressed in terms of the kilo joule in that case to be like .01 to 2.11 kilo joule per mm. This is very low heat input value and its effect on the quality of the weld surfacing was achieved.

So, in this case basically like say since the nickel and tungsten carbide, tungsten carbide particle they started decomposing especially above the 550 to 600 centigrade. So, high attempt means exposure of the tungsten carbide particles at high temperature for longer period increases the thermal damage and this thermal damage basically is in form of the dissolution of the tungsten carbide particles. So, the reinforcement of the WC in nickel matrix will be reducing and this inturn will be degrading the quality of the weld surfacing.

So, in this study basically the study was made to see how the change in the net heat input was leading to the variation in the like 20, 40, 60, 80, 100 joule per mm H net value and the try to observe how does the volume fraction of the tungsten carbide particles was changing. And how the hardness of the weld surfacing does was changing. So, variation in the volume fraction was found to decrease like say 5, 10, 15, 20 it was found to decrease like this, like from 20 to 10% it was reduced.

When the heat input was the fraction of the tungsten carbide particles was high and the increase of heat input the fraction tungsten particle was reduced and this was attributed to the dissolution of the WC tungsten carbide particle with the increase of the heat input. On the other hand hardness was also found to be consistent with the variation in the tungsten carbide particles where in hardness was reduced from say 700 Hv to 500 Hv 700, 600, 500, 400, 300, 200 Hv.

And the drop in the hardness was notice up to the 500 level with increase of the heat input under that is what this and this reduction in the hardness was attributed to be reduction in the volume fraction of the tungsten carbide particle, tungsten carbide particle are the hardness constituents of hardness 1800 to 2200 HV value depending upon the kind of tungsten carbide particle which is there in otherwise nickel matrix is completely soft term with 200, 250HV values.

So, if WC tungsten carbide particle fraction particle value is decreasing with the increase of heat input that will be certainly reducing the hardness and which in turn will be leading to the reduction into the wear resistance. So, it is important to consider the welding parameters are selected in such way that the thermal degradation to the constituent is limited, limited transfer efficiency is quite good.

So, that the good quality weld surfacing can be achieved, now will see a there is another example related with the use of the gas metal arc welding process for developing the weld surfacing of the AS.

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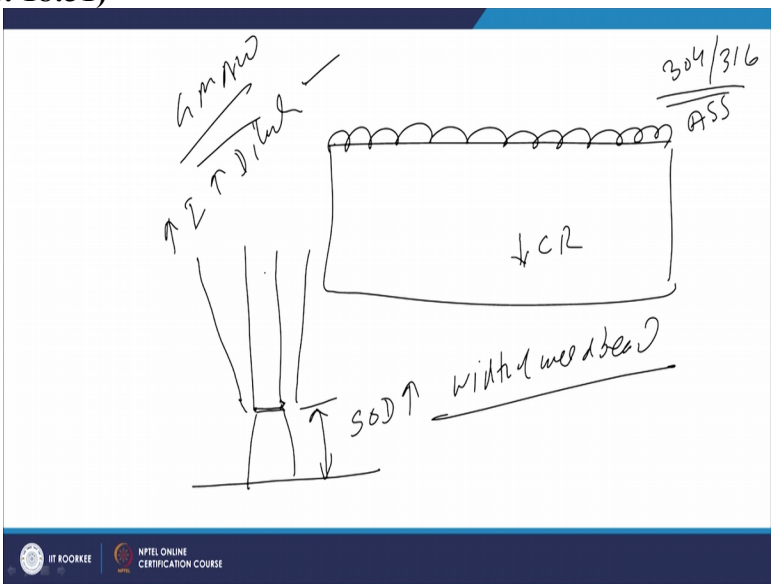

Austenitic stainless steel this is very commonly used like mild steel is offering the low corrosion resistance. So, if the corrosion resistance is to be improved then you would like to deposit a layer of the material which you can offer the really good corrosion resistance by depositing a ASIC 304 or 316 kind of the metals which are basically austenitic stainless and steel using the gas metal arc welding variant.

If we apply the weld surfacing using 3 austenitic stainless steel, on the mild steel what is observed that obviously other parameters are the same like increase in current increases the dilution and increase in there is one more parameter which is called standoff distance. That is the distance between the nozzle and the work piece and here we have the; this is the location of the nozzle and this is the electrode and the arc between electrode and the work piece.

So, the standoff distance SOD, if SOD is increased it increases the weight of the weld bead which is been deposited and increase in current simply increases the heat input because of the increased which in turn increases the dilution at the same time increase in current also helps to increase the deposition rate.

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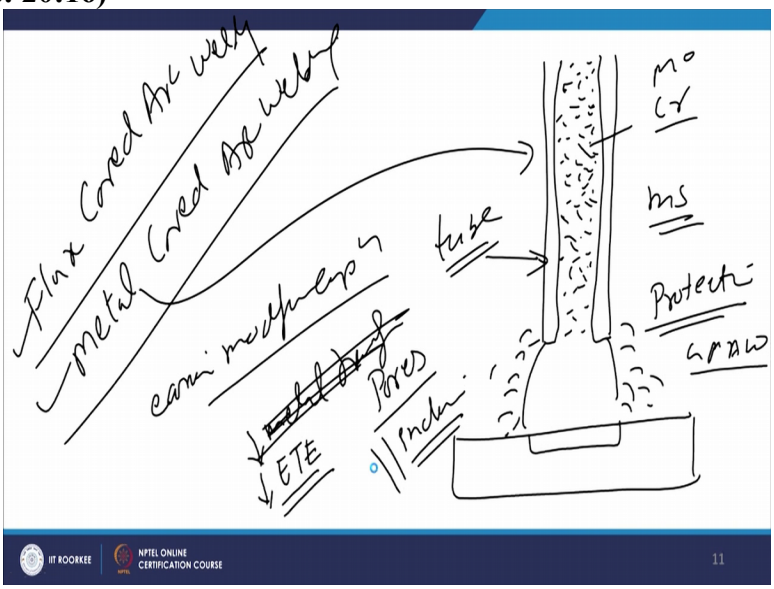

There is another variant of the gas metal arc welding process which is called flux cored arc welding or there is a one more variant which is called metal cored arc welding. So, idea behind this process is simple where we use one tubular electrode. So, there is a tube and inside that tube we feel in the flux. Flux may be with various types of the carbonate, Sodium, Potassium and line saw dust etcetera. These are basically this flux when the arc is established between the tube and the substrate.

This flux burnt's and provides the inactive gases to protect the molten metal. So, this is one variant which is called as the flux cored . In this case is, the metal to be deposited will be used for making the tube that is how it will be get transferred. But there is another variant where metal cored arc is used the tube is maybe mild steel. But if you want to add chromium or molybdenum in the weld surfacing and these constituents will be added with the flux.

And then it will be deposited using this process by establishing the arc between the electrode and the work and the work piece. In case of the metal arc, metal cored arc welding process it is easier to modify the composition and develop variety of the compositions and for developing the weld surfacing as per the requirement. So, but since in the flux cored and in the metal cored arc welding flux is burnt and develops the inactive gases for protection of the weld pool.

So, the protection in this approach is not as good as that of the gas metal arc welding where we were using the innert or inactive gases. So, since the production is not good there is a possibility for increased pores and inclusions in this kind of work in this process or which variant of the GMAW where in this approach means the flux cored arc welding or metal cored arc welding process may offer the lower elemental transfer efficiency because of the increased losses of the alloying elements in course of the transfer from one site to another.

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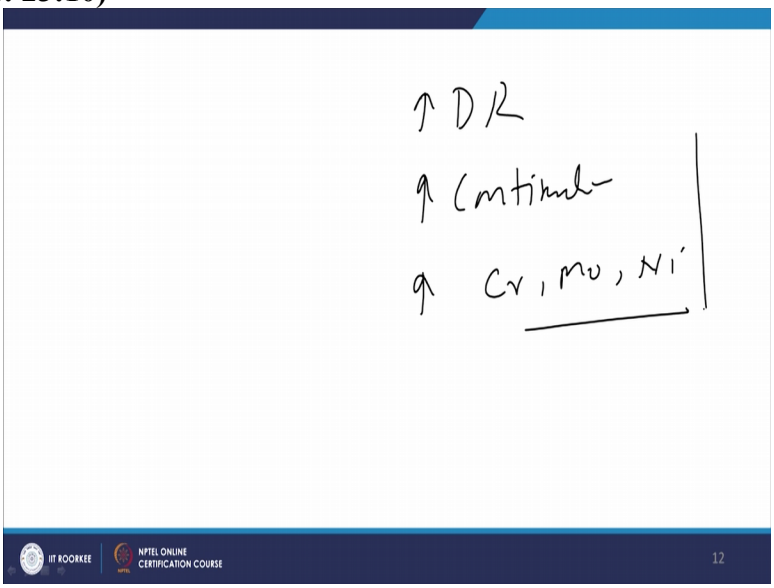

But like it offers the advantages of the advantage of high deposition rate like the GMAW process the processes continuous easy automation is possible, the processes continuous and it can be used to deposit the variety of the weld surfacing by regulating the composition of weld surfacing

by filling them into the by filling the required elements into the flux or into the tubular form so that during the word surfacing these can be applied on to the surface of the substrate for developing the weld surfacing.

Now I will summarise this a presentation, in this presentation basically I have talked about the two approaches of the weld surfacing one was the gas metal arc welding it offers very good quality weld surfacing and there is another variant of the gas metal arc welding which is called flux cored arc welding or metal cored arc welding. Metal cored welding process allows much more flexibility with regard to the developing the weld surfacing of the different compositions, thank you for your attention.