Fundamentals of Surface Engineering: Mechanisms, Processes and Characterizations

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Lecture-45
Surface Modification Techniques:
Weld Surfacing I

Hello I welcome you all in this presentation related with the subject fundamentals of surface engineering and you know we are talking about the third approach of the surface modification where in a layer of the desired quality of a material is applied over the surface of the substrate so, that the improvement in tribological life of the components can be achieved. Now basically now we are talking about the weld surfacing related techniques we have seen that the gas welding is one of the process which is used for depositing the layers of the required material which may be in form of Nickel or Iron based systems.

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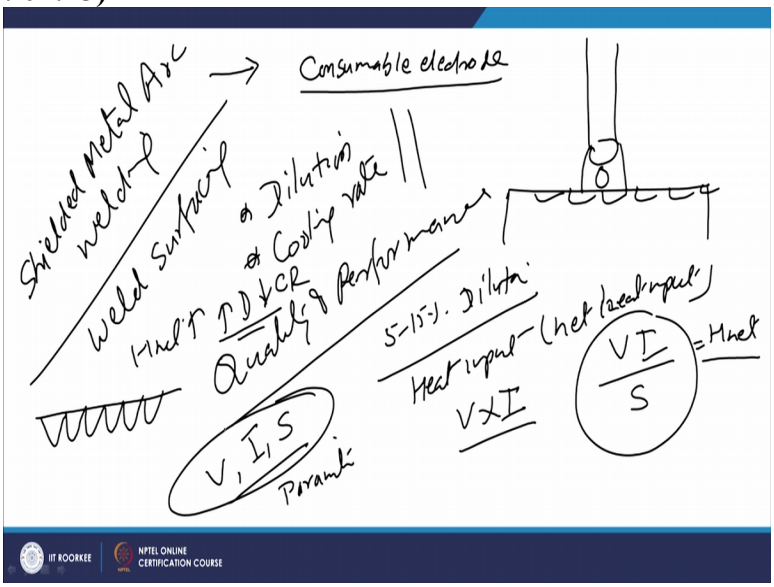

And now we have also talk little bit about the shielded metal arc welding processes. So, this group of the processes where the welding process are used to deposit the bead on plate these are called weld surfacing where bead on plate is deposited. In case of the shielded metal arc welding processes one consumable electrode is used and arc is strike between the electrode and work piece.

And so whatever the electrode melts that is deposited over the surface of the substrate. So, the melting of the electrode is; will be leading to the application of a layer of the material over the

surface of the substrate. We have also seen that the dilution which is about the change in composition of the metal which is being applied due to intermixing with the base metal and the cooling rate experienced by the molten metal during the solidification.

These are the two important technical aspects related with the world surfacing which affects the quality and performance of the weld surfacing. So, as far as the shielded metal arc welding process is concerned normally like the 5 to 15% the dilution is observed that the dilution is also affected by the kind of the heat input which is being given. Especially not just the heat input but it is the net heat input which is which is given.

So, there is a little difference heat input in during the arc welding is obtained from the product of the arc voltage and the current which is being used for depositing the bead on plate.While the net heat input is obtained by dividing this quantity VI with the welding speed because arc will be travelling continuously during the deposition of the metal whose speed is used. So, VI by S gives us the net heat input which is also expressed as H net.

So, primarely if we see the arc voltage welding current and the welding speed these are the three important welding parameters which will be governing the net heat input and this net heat input will be deciding the extent of the depth of to which melting of the substrate is taking place. In general increase in H net value increases the depth up to witch melting is taking place which in turn will be increasing the dilution.

So, increase in H net increases the dilution as well as it reduces the cooling rate so, both these are undesirable things. And this is the general principle which is applicable across the across all type of the arc base processes where the heat is applied for applying or developing a layer of the required quality of material over the substrate. So, what is important here that we VI and S are selected properly so that the dilution is as minimum as possible while melting sufficient death of the substrate?

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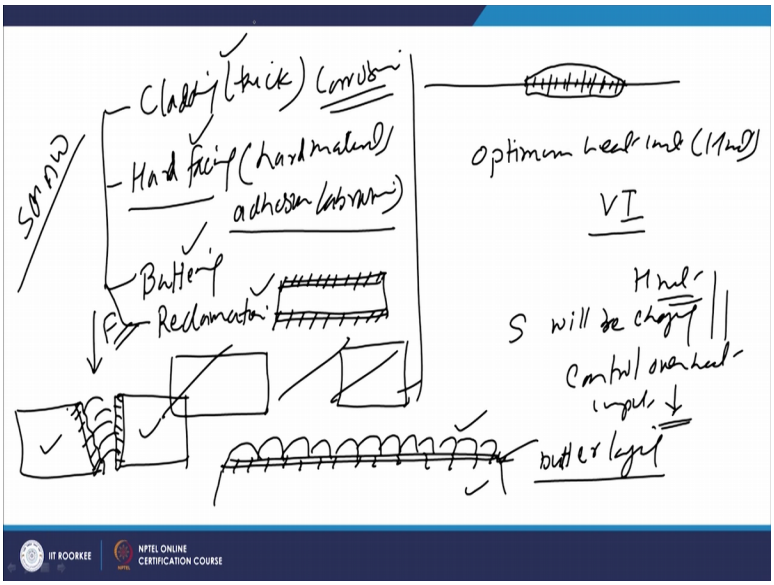

So that the good bond between the bead and the substrate can be created. Like if the heat input is very less than metal will simply be spreading over the subs over the surface of substrate and not very good metallurgical bond will be created. So, in this case poor bonding may lead to the denomination of removal of the bead. If the melting of the substrate is up to sufficient depth then it will be leading to the good metallurgical bonding.

So, not very less heat input will be sufficient but we need sufficient heat input so that enough melting of the substrate is also taking place apart from the melting of the metal which is to be applied. So, that is why there is a need of the optimum heat input precisely optimum net heat input. So, since the; for a given power of the arc which is obtained from VI when the arc is removed manually the speed will be changing.

And therefore H net will also be changing and that is why we say that control over the heat input control over the heat input is less in case of the shield metal arc welding processes. So, how does it affect the things as a whole? Now that is what we have to see. Now Celine SMAW process is very extensively used for applying layer of the material over the substance over the surface of the substrate for variety of the purposes.

According to the purpose the weld surfacing can be grouped as a cladding where very thick layer of the material is deposited and this is primarily used for corrosion resistance related applications where the tribological component can be expected to perform on the under corrosive wear conditions. Then it can be applied for, say the surfacing is applied for increasing surface hardness by depositing suitable material it is called hard facing.

In case of the hard facing here hard materials are deposited over the surface primarily for increasing the adhesive abrasive wear resistance. It can also be used to for the buttering purpose where in we want that the weld metal is isolated from the substrate to avoid the metallurgical incompatibility related issues like if they are the two components to be to be join or we will take another example something like this is a substrate.

And we find that substrate and the material to be applied do not have the compatibility metallurgical compatibility. Then will be depositing a layer of the material which is compatible with a substrate first. And then over this layer will be depositing another material which is to be applied at the surface for a required functionality. So, this layer which is present between the substrate and the world surfacing applied at the top.

This one will be termed as butter layer and this when the butter layer or additional layer is sandwiched between the hard facing layer of another surface material layer and the substrate then this is called the buttering it is also used in welding to isolate to them substrate from the; like a like these two components to be welded so one layer will be deposited on the surface of the base metal and the layer of the material also be applied on the surface of the base metal on the another side.

So, now we can use any electrode are there any suitable filler metal which is which can be used to join the two components together for achieving the required functionality. So, in that case if the filler is applied it will compatible to the both. So, this is primarily used when the filler and the base metals do not have a metrological compatibility than base metal is isolated from the filler by depositing this kind of the butter layers.

Are there is one more purpose of applying the weld surfacing is the reclamation is used to develop build up on the worn out components so that the dimensions can be regained after machine out like say this is the initial size of the component, initial new component and after the service it has been worn out. So, will be depositing a layer of the material over the worn out component and after the machining again the region will be the regaining the initial size original size and shape of the component which has been worn out.

So the reclamation is a kind of the repair refurbishing kind of things buttering is for the different purpose similarly for hard facing and the cladding feature in all the cases we apply the material

over the surface of the substrate for the different purposes and accordingly the different names are given. Now will see since the dilution and the cooling rates affect the things affect the performance of the weld surfacing significantly, so, now will see that affect.

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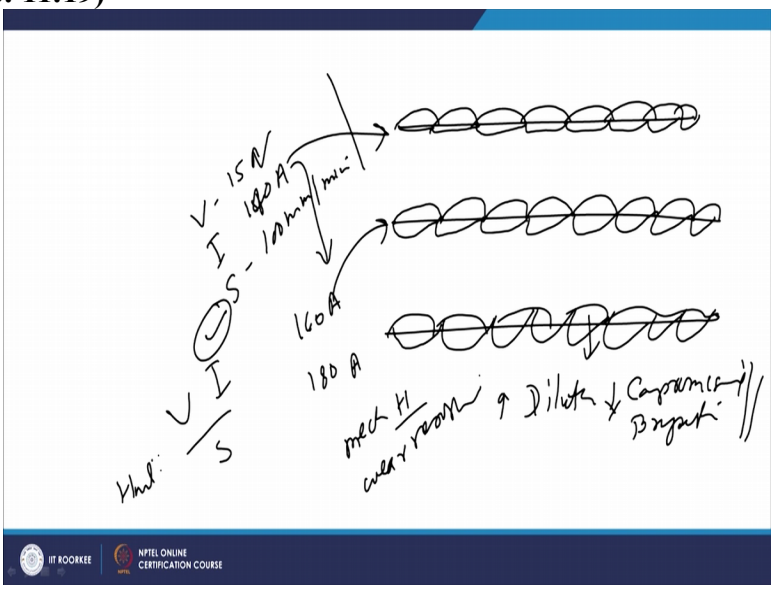

For example like this is a substrate and we are applying good quality material layer, so good quality material layer is applied like this using condition of the voltage say 15 volt and the current is 140 ampere and welding speed is say 100 mm per minute. So, these are the welding condition using which the weld bead has been applied. Now if we change the heat input conditions to 160 and to 180 ampere while maintaining the voltage and the welding is speed constant then what will be happening that increase in that heat input because VI by S this will be governing the H net.

And if you are increasing value of I, then it will be increasing H net value and increase in H net value if earlier the depth of the melting of the substrate was this much was then increase in H net value will be depositing the more amount of the metal over the substrate. While melting the substrate up to the greater depth and this increased depth of the melting will simply being; so, say this was for 140 amp as this is for 160 ampere and then for the deeper melting will be taking place in case of the 180 ampere current rating.

So, are increasing in depth of the melting will simply increasing the dilution level means the chemical composition of the surface layer will be modified to the greater extent. And this in turn will be compromising with the properties of the surface layers which are being developed so

there will be degradation. Degradation maybe in terms of the mechanical properties like hardness and accordingly the wear resistance is also compromised.

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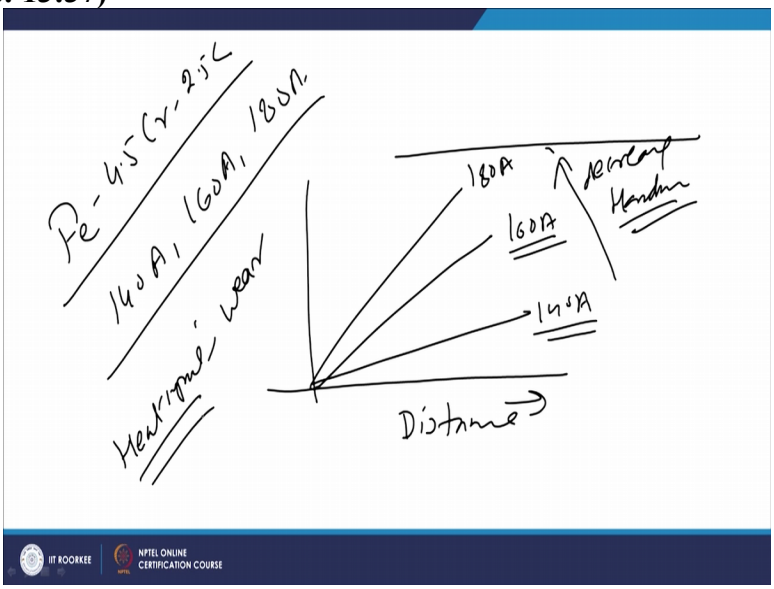

We will take up one example where in like iron 4.5% chromium and 2.5 % carbon was used for this is a typical iron chromium and carbon hard facing systems. So, in this case if say the hard facing over deposited using the three level of current like 140 ampere, 160 ampere and 180 ampere and then try to see how does the behaviour of the hard facing change as a function of the current and what we see that that like if such kind of the hard facings are tested by the abrasive to wear test.

Then as a function of the sliding distance wear of the material increases at different rates like this. So, what it is suggesting that 140 ampere current hard facing experience is the lower wear volume for a given sliding distance while 60 ampere hard facing will be leading to the higher wear and 180 ampere current will leading to the further higher wear and will see that this will be the order for decreasing hardness of the surfacing which will be produced.

This is one way of understanding how does the heat input is affecting the behaviour of the weld surfacing are the layers which are deposited and the way by which the composition is being quality of the weld surfacing is been compromised.

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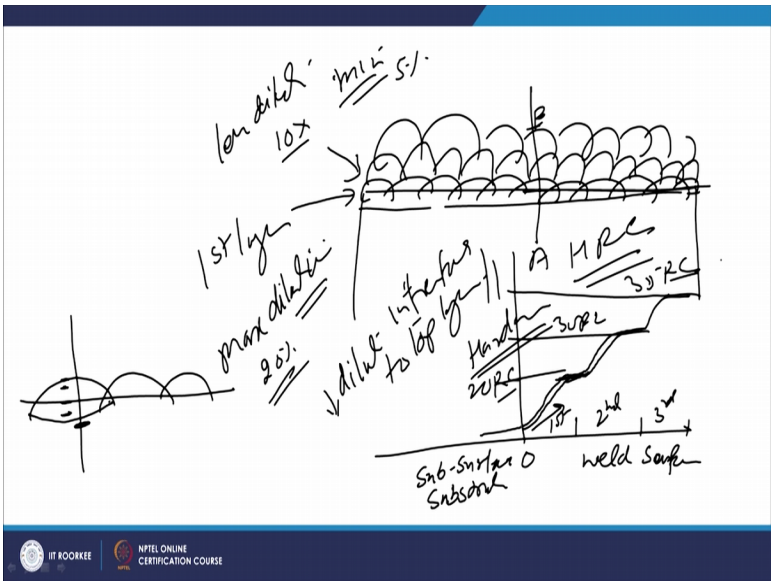

Now we will see another aspects related with the dilution like if the thick layers are to be deposited then initially deposit one pass. In one pass one layer is deposited and this layer first this we can see as a first layer experience is the maximum dilution. Because it comes in filler metal directly comes after melting in comes in contact with the substrate. And therefore it causes the maximum change in the composition of the material being applied and that is why will be having the maximum dilution.

Say it is 20% in case of the first layer then if the; if you are not able to realise the required thickness in one go then will be applying another layer of the hard facing like this. So, the second layer will be experiencing somewhat lesser dilution because already the surface layer which was deposited was of the same composition and in this case somewhat less dilution will be experienced which way we say like 10%.

And if the third layer is a deposited then again will see the dilution is for the reduced. So, minimum dilution in this case like say 5% is observed as we keep on depositing the number of layers one over other. We will notice that the dilution level or the kind of computational modification of the surface layers which are taking place that will be reducing. Now if we cut the section like this and try to measure the hardness from A to the B which is the surface.

So, from the substrate to the surface hardness is measured then what will notice, like this is the interface is here and then this is the subsurface zone means the base metal sub surface zone which is basically substrate. And this is the weld surfacing where in we have got one layer up to this and another layer up to this and third layer. So, obviously the hardness of the substrate will

be lower like this and then hardness of the as we go in the first layer which was deposited hardness will be increasing gradually.

Then it will be reaching maximum at the top of the first layer and then again there will be and gradual increase in the second layer and then again gradual will be increase with increase in third layer. So, this gradual increase is attributed to the reducing dilution from interface to the top layer of that; to the top of that particular layer which is been deposited. For example if this is the one layer which has been applied.

So, and so this is the interface will see that note will notice that dilution here is maximum than less and somewhat less and further less. Dilution will be reducing at in each layer on approaching towards the upper surface and that is why will notice that hardness is increasing because of the reducing dilution levels was the first layer. First layer is happening lower hardness then further hardness in the second layer this is your first layer second layer and his third layer.

So, as we keep on increasing with increase in the depositing the number of layers or dilution level keeps on decreasing and that is why will say that will notice that commotional modification of the layer being applied is reducing and that in turn in can say in case of the hard touching is increasing the hardness with the increase of number of layers. So, this is about the variation in hardness which movie seen in case of the hardness normally we measure the hardness in terms of the Rockwell hardness on the C scale.

Which may be say like here 20RC, 30RC, or say 35 RC value or HRC value, so, in on approaching from the substrate towards the surface increased will be in steps and that magnitude of the increase will be changing with the layer by layer.

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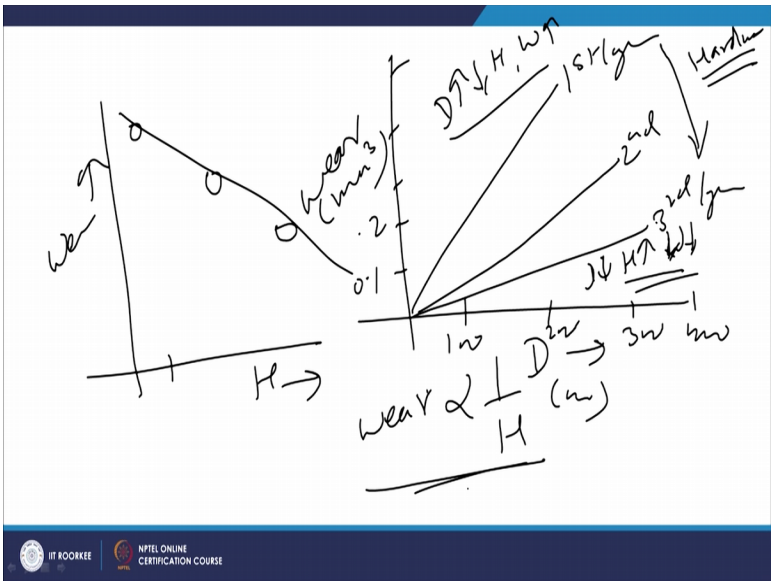

Now we will see how does layers will behave when subjected to the abrasive wear test. So, wear resistance in mm cube sorry wear loss in mm cube and sliding distance in metre. So, here we say 100, 200, 300, 400 like this and here we may have like .1, .2 like this and then I will see that the first layer which was the experience in the maximum dilution has lower hardness will be experiencing the maximum wear abrasive wear. Second layer will be experiencing somewhat lower abrasive wear and third layer will be experiencing this is second layer wear and this is third layer wear.

What it suggest that when the dilution is more hardness is less and this will be leading to the increase wear while the reverse will be true solution will be minimum for 3rd layer hardness will be high and this will be reducing the wear of the material. So, this will be inconsistencies, results will also be inconsistency or will be consistent with the hardness variation. This is direction for increasing hardness variation.

And accordingly if we plot hardness versus wear plot also, so minimum hardness for the first layer the wear will be here, somewhat higher hardness wear will be here and somewhat for the hardness so hardness in x axis and wear volume in the y-axis which will give us idea about that. As we increase the hardness value of; so increase the hardness value the weld surface in hard facing is specifically the wear volume will be decreasing.

And this is consistent with them established laws like a wear is found inversely proportional to the hardness. So, higher is the hardness lower will be the wear magnitude. Now we will notice a sum of the other factors associated with the weld surfacing what we have seen was about the

world surfacing when world surfacing is applied using the SMAW process but we will get the similar kind of trends when are the approaches are used

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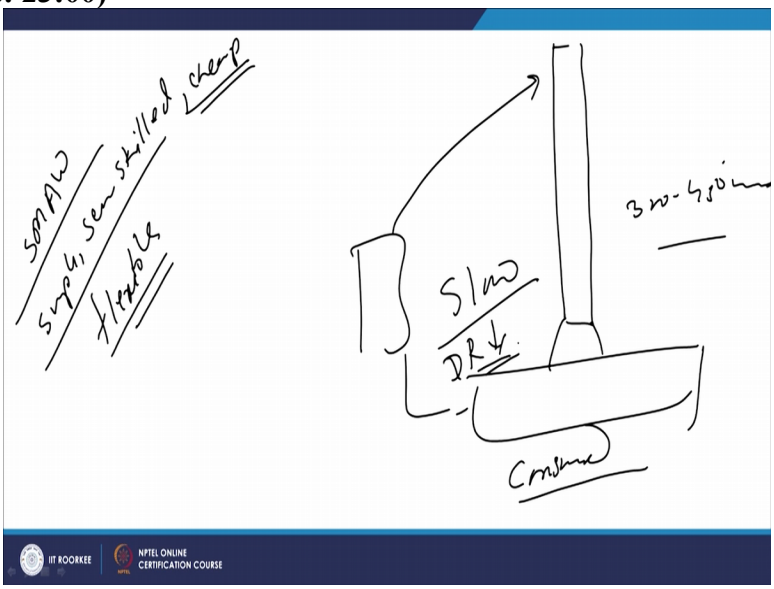

So, let us say when the SMAW process is used for Weld surfacing the process is very simple even semi skilled worker can apply this the process used is very simple equipments to the processes cost effective and cheap. It is very flexible it can be applied and you have not necessary to use and up use it in factory environment. But there are certain issues like a SMWA process uses one consumable electrode which is generally of likes in 300 to 400 mm length.

And this electrode will be connected to the power supply and work piece will be connected to the; will connect to the power supply and arc will be established electrode will be consumed. Since the electrode is consumed in this process. So, electro the process has to be stopped and electrode has to be changed and this makes the process slow. And that is why the deposition rates which are achieved by this processes is quite low.

And that is why for mass production where large areas are to be covered by for the weld surfacing. There this kind of the process may not be suitable

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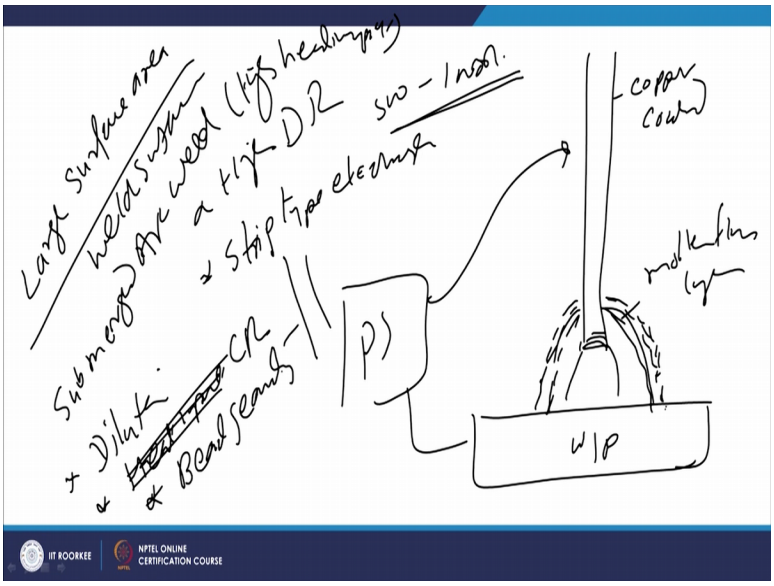

So, there are other alternatives as far as the under the conditions when large surface areas need to be modified by the weld surfacing. There are other options which are available like submerged arc welding. This is known as high heat input process and therefore allows us the very high deposition rate. All like current values maybe like 500, 1000 amperes so this is very good side and it permits the higher deposition rate.

At the same time it also allows us the use of the strip type of the electrode. In this process basically there is electrode which is bare electrode and usually copper coated to avoid oxidation and improve the conductivity. And this electrode is connected to the power supply and work piece is connect is also connected to the power supply. And arc is striked between work piece and substrate and electrode. And in this process electrode is consumed and protect the molten metal from the contamination.

By the atmosphere gases is it is covered under the granular flux, heap of the granular flux which melts and provides a protective layer of the molten flux layer that is welding process since the arc is submerged under the flux cover that is why it is called submerged arc welding and this process uses the high deposition rate and that is why permits us to cover the larger surface areas during the deposition.

Now if we want to understand the performance of such kind of the word surfacing deposited by the SAW process then we need to see the two aspects one is dilution second is cooling rate and third is the bead geometry which we can say that can help us to understand the dilution related aspects.

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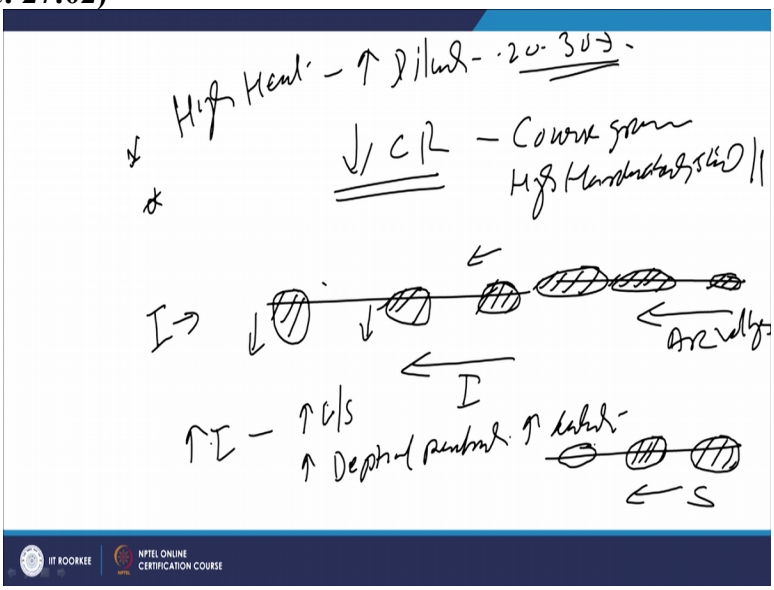

So, since the process high heat Input and their dilution levels are very high like 20, 30% so there will be lot of composition on modification of the world surfacing which will be developed by this process. But since high heat input allows the law coverage of the large surface areas and very fast pace because of the higher position rights which are possible. Further high heat input also reduces the cooling rate reduction in cooling rate will be leading to the course grain structure.

But this low cooling rate may be favourable especially in case of the high hardenability steels because it loses its cracking tendencies as well as enbrittlement due to the excess hardening to modes tic transformation. Now if you want to see how the bead are affected so far that we need to see certain effect of certain parameters like welding parameters. For example welding current like if this is surface of the substrate and when the bead is applied will notice that the cross section becomes like this.

And this is the direction for increasing in value of the welding current. So, as we increase the well as we increase the current for depositing the bead on plate the cross section keeps on increasing with the increase of current at the same time depth of penetration is also increasing. So, increase in current increases the cross section cross sectional area of the beat as well as increases the depth of penetration.

So, increase in depth of penetration leads to the increase dilution and then when we increase voltage and at the low voltage the weld width increases the width increases and weld with

increases with the voltage. Welding voltage or arc voltage increase of the arc voltage increases the width of the bead which is produced it does not affect the depth of penetration. So, bead width is certainly affected by the increase of the arc voltage.

Then third parameter is the speed, so when the speed is low we get much larger weld bead cross section because of the increased H net and cross section will be decreasing with the increase of the speed. This is the direction for increasing a speed when speed is less for given setting of the V and I the cross-sectional area is more depth penetration is also more and it will be decreasing with the increase of the welding speed.

Now see there is one more aspect to this that is about that if you want any compositional modifications modification of the weld surfacing is easier in case of the SAW because the constituents that we want to incorporate in the in the in the weld surfacing they are they are incorporated or they are got in with the so, like a the Silicon, manganese, chromium, molybdenum can be incorporated in the weld bead by putting them into in powder form with the flux itself.

So, they get transferred in course of the weld surfacing process compositional modification of the world surfacing is easier in case of the SAW process. So, now I summarise this presentation in this presentation talked about important technical aspects related with the SMAW and SAW process the way by which weld surfacing using these processes are carried out. Thank you for your attention.