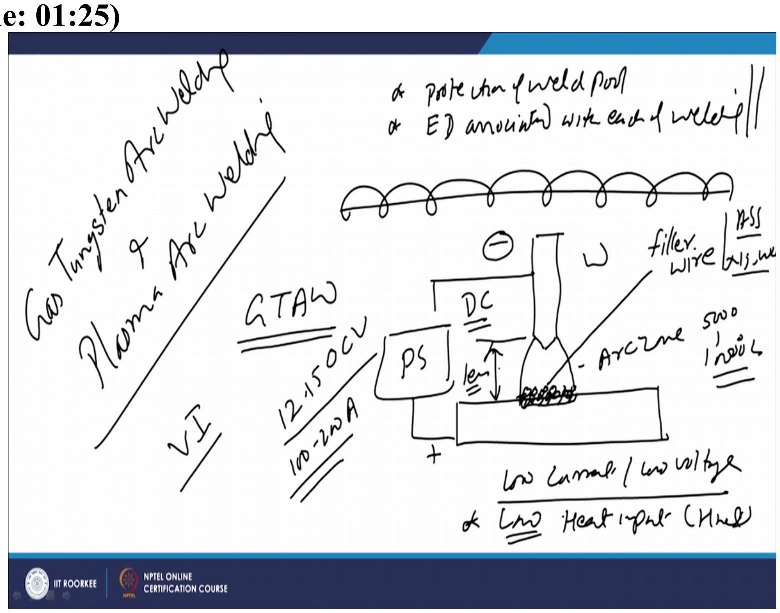
Fundamentals of Surface Engineering: Mechanisms, Processes and Characterizations
Prof. D.K. Dwivedi
Department of Mechanical and Industrial Engineering
Indian Institute of Technology-Roorkee

Lecture-47
Surface Modification Techniques: Weld Surfacing III

Hello I welcome you all in this presentation related with the subject fundamentals of surface engineering and you know we are talking about the techniques for the surface modification especially use of the development of layer of the suitable material so that the required improvement in surface properties can be achieved for longer tribological life of the component. So, under this approach we have talked about the various surface modification techniques especially related with the weld surfacing techniques like the weld surfacing using gas welding, shielded metal arc welding, submerged arc welding processes and the gas metal and the flux cored arc welding process also.

(Refer Slide Time: 01:25)



In this presentation is specifically will be talking about the two processes and it is these are like a gas tungsten arc welding and plasma arc welding. You know in all the welding related processes where a layer of the metal is deposited on this on to the surface of the substrate for surface modification bead on plate or bead on the substrate is deposited and the different processes work of the different approaches associated with the protection of weld pool which is formed while depositing the bead on plate weld.

And they also differ with regard to the energy density associated with each of the process associated with each of welding process. And these two factors intern depends internal affects the quality of the weld deposit features which is produced. So, as far as these two processes are concerned first of all will talk would the gas tungsten arc welding which in short is termed as GTAW process? In this process we use one non consumable tungsten electrode which is invariably connected to the negative terminal of the power source this is power source and invariably use the DC however while depositing in non ferrous metals we can use AC as well.

So, the positive terminal is connected to the work piece this is the normal configuration related with the power source connection is used and after striking the arc either using the high frequency unit the arc is established or by touch method Where are electrode is brought in contact with the substrate and then it is moved apart after use of the proper power setting like that 12 to 15 open circuit voltage is normally used.

And the current we can choose as per our requirement the kind of the heat that we want to generate. And once the arc is established the heat is used for fusion of the substrate thin layer of the substrate. Very thin layer of the substrate is brought to the molten state and since the electrode is non consumable and made of the tungsten so to deposit the material for surface modification we have to feed it from outside.

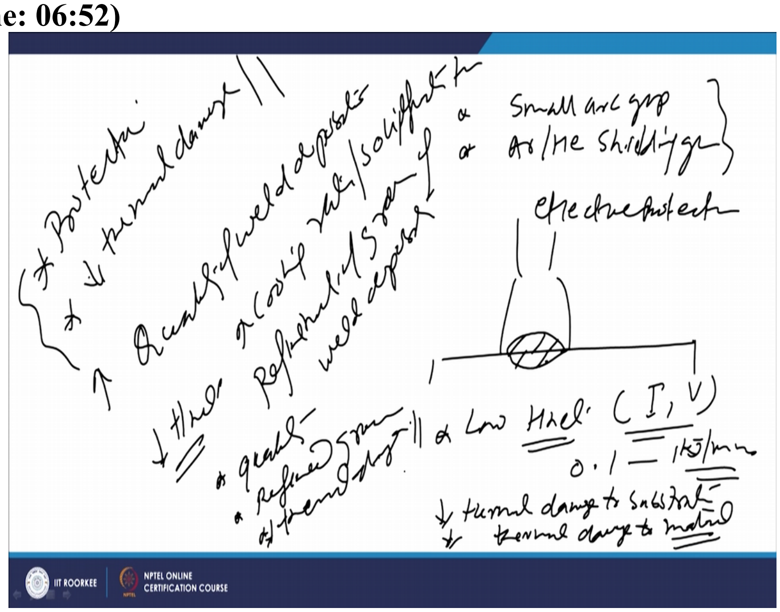
So, the electrode or filler wire is fed into the arc zones so that after melting it gets deposited over the surface of; it gets mixed with the molten substrate material and forms a layer of the modified composition in form of them bead on plate weld. Since the electrode is non consumable and other filler wire is fed in the arc zone which is at quite high temperature like a 5000 to 10000 degree centigrade the temperature is usually higher than what is normally observed in case of new like shielded metal arc welding gas metal arc welding process.

So, the high temperature and enough heat generation through the VI facilities the melting of the filler wire and the melting of the filler wire which is the material to be deposited in form of the bead on plate weld onto the substrate for surface modification and this material can be selected as per your requirement AS for corrosion resistance or it may be little tungsten kind of the material for surface modification as per our need.

So, idea is here is that filler metal is melted and mixed with the molten substrate state so that substrate layer so that required surface modification can be achieved. There few good points as far as this process is concerned since this process works with very low current and voltage levels and therefore the heat input associated with the process which is a specifically inert heat input is very low. So, this process is known as low heating input process.

And another aspect is that the distance between the electrode and the substrate is also very less this. So, arc gap is small the length of this kind of distance between the electrode and the work piece is very less. And that is why chances for entry of the atmospheric gases in the arc zone is less and through the use of the in inert gases we provide the required shielding.

(Refer Slide Time: 06:52)



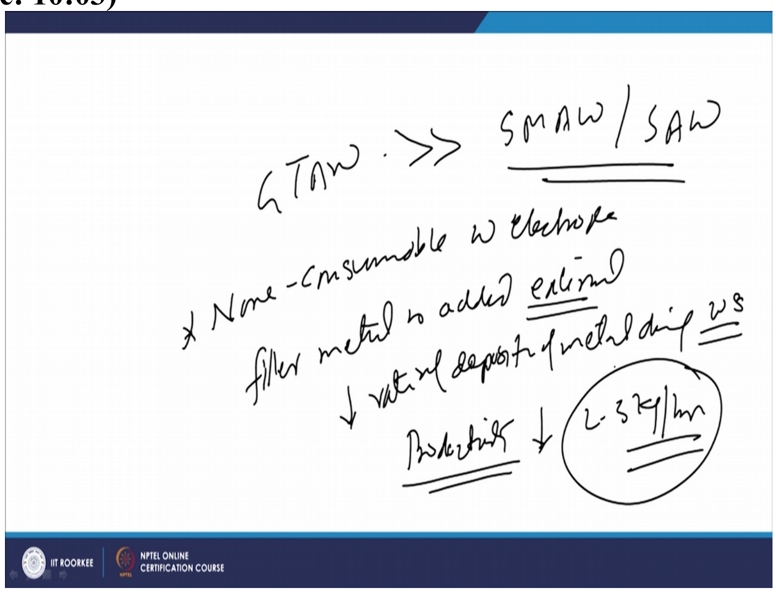
So, there are few good points that very small arc gap and the use of the Argon or Helium as shielding gas. These provide very effective protection to the molten metal which is being formed during the weld bead deposition by the GTAW processes. So, this one is protected very effectively and another aspect as I have set the process flow net heat input because of use of the very low current and the low voltage and this magnitude may be very likely .1 to 1 joule kilo joule per mm.

This is a kind of heat input to which is very less. So other low heat input associated with this process helps in reducing the thermal damage to the substrate due to the weld thermal cycle as well as it also reduces them the thermal damage to the surfacing material weld surfacing material which is being applied for the weld surface modifications. So, that two aspects very good protection helps to avoid the interaction of the molten metal with atmospheric gases which produces the possibility for inclusion and the less heat input associated with this process reduces the damage associated with the weld surfacing.

And factors helps in improving the quality of the weld deposits more specifically if you see reduced heat input reduced H net increases the cooling rate during solidification time is reduced and which in turn helps inrefinement of the grain structure of weld deposits which are made and this kind of the refinement. So, improve the quality in terms of the absence of the inclusions and it is very refined grain structure very less thermal damage.

Reduced thermal damage like on in terms of the adverse effect with regard to the residual stresses are cracking tendency or why the heat affected zone formation. So, all those adverse effects on to the substrate and the weld surface in materials are reduced when the heat input is reduced.

(Refer Slide Time: 10:03)

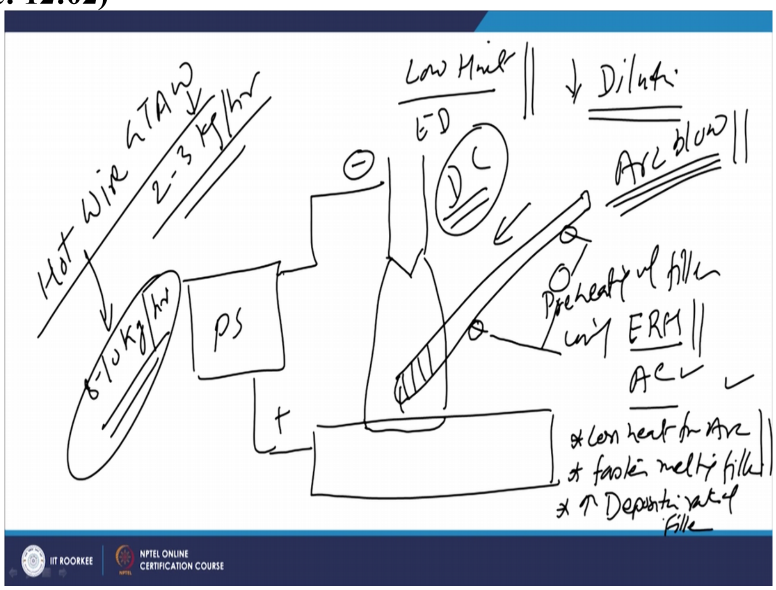


And that is why GTAW process offers the better quality of the weld deposits as compared to the SMAW and submerged welding processes. However there are some negative points associated with this process that is this process uses the non consumable tungsten electrode which is primarily used for the striking off the heat striking of the arc. So, that it can be generated and that heat is eventually used for surface modification by melting the layer of the substrate material as well as the filler material.

So the filler material filler metal is added externally means to be added from outside. So, one separate mechanism is needed to feed the electrode in the arc zone and this reduces the rate of deposition of the metal during the weld surfacing. So, the so the productivity associated with this process is very low because the amount of the metal which can be deposited for surface modification using this process is very less it will be like 2 to 3 kg per hour.

So, this is the negative effect the quality is there negative side or related with the GTWA process for the weld surfacing however the quality of the weld deposits are the weld surfacing of the GTAW process is very good and therefore to overcome this aspect another variant of the GTAW process has been developed

(Refer Slide Time: 12:02)



Which is called hot wire GTAW process, as I have said in the conventional GTAW process heat input is very low; energy density is higher than the SMAW and SAW process. These two factors in turn help in reducing the dilution level that is the quality of the metal which is been deposited is degraded to lesser extent due to the limited melting of the substrate and getting it mixed with them filler metal which is been deposited. So, the reduced dilution associated to the GTAW process is another positive side.

But we need to overcome the low melting due to low deposition rate issue related with the GTAW process; what we do basically use the conventional GTAW power source where negative terminal is connected to the electrode and positive terminal is connected to the substrate, arc is established. So, this will be facilitating the melting of the substrate up to some depth. Then we use water filler is being fed in the arc zone for developing the bead on plate weld surfacing.

And these filler is preheated, this is so preheating of filler wire using electrical resistance heating with the help of alternating current. So, the filler wire is fed with the AC current in between; before feeding it into the arc zone, so this will be helping to preheat the filler wire with use of AC for with use of AC. AC will be causing electrical resistance heating of the filler wire.

So once the heated filler wire is fed in the arc zone it requires less heat of fusion to take place and that intern facilities the faster melting of the filler wire when it is fed in the arc zone. So, the net advantages what it requires less heat from arc for fusion of the filler wire due to the preheating and reduce the need of the heat and facilitates the faster melting of them filler wire. So, faster melting of the filler these two factors in turn increases the deposition rate of the filler which is being applied on to the surface of the substrate.So, as I said like 2 to 3 kg per hour filler metal is deposited using the conventional GTAW process.

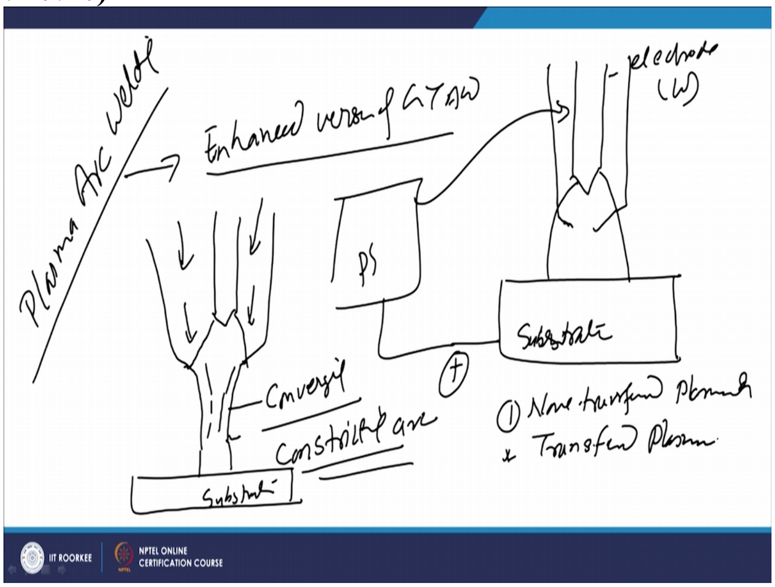
Then have hotwire GTAW process can increase this 8 to 10 kg filler metal deposition per hour. So, this significant increase in the deposition rate associated with hotwire GTAW process is facilitated primarily due to the preheating of the filler wire before feeding into the arc zone for fusion to take place and this happens due to the preheat facilitate electrical resistance heating approach due to the use of AC and DC current.

Normally we use DC current the GTAW process but for preheating of the electrode we use AC in order to avoid any the arc blow related issue during the weld surfacing. Because if we use the DC current for preheating of the filler wire then the electromagnetic fields associated with them DC current being fed in the filler wire and DC current dubbing used for developing the arc. These two electromagnetic fields can interact with each other and can cause the problem of the arc blow which will primarily be involving the deflection.

Deflection of the arc from its intended path or intended location and that will be leading to the deposition of the filler metal at the location elsewhere compared to the location where we want. So this will be leading to the primarily the misplacement of them molten metal or the weld bead which is being deposited. And if the weld bead is deposited at the location where we do not want then it will simply be leading to the wastage of the resources.

So, to avoid such kind of the tendency related to the arc blow the DC is used primarily for developing the arc and AC is used for preheating of the filler wire, now we will be a talking about will be talking about another process associate process of the weld surfacing.

(Refer Slide Time: 17:46)



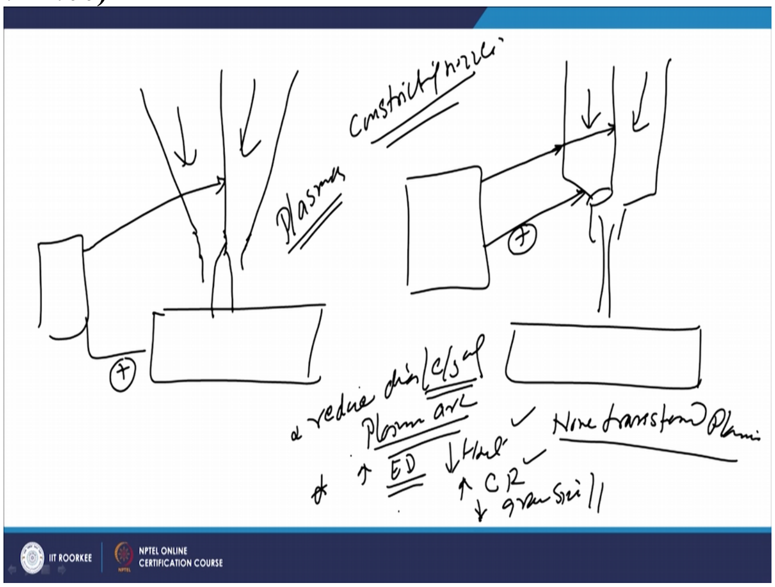
And that is called plasma arc welding, so the plasma arc welding is we can say as enhanced or advanced version of the GTAW process gas tungsten arc welding process. Because in plasma also we use one tungsten electrode and arc is established between the work piece, and between the electrode which is made of tungsten and the substrate. And the power supply negative terminal is connected to the electrode and positive terminal of the power source is connected to the substrate.

But in this process whatever arc is generated, arc is primarily used to generate the plasma and plasma is forced to pass through the nozzle. So, basically here we have one electrode there is one nozzle. So, initially arc is established between the nozzle and the electrode and the plasma forming gas is fed. So, the plasma forming gas will be passed through the arc and this plasma then will be passed through the nozzle. So this nozzle is basically will be converging or more technically it is termed as constructing the arc.

So, the arc is there initially between the electrode and the nozzle and the plasma forming gas is passed through the arc which will be leading to the formation of the plasma. Plasma is forced to pass through the nozzle of the smaller diameter that will be causing the constructing of the arc and then this plasma will be impacting with the surface of the substrate. So, this is how the plasma will be a leading to the transfer of the heat from the arc zone to the substrate.

Now as per the case there are two variants which are used in the plasma welding one is called non transferred plasma and another is transferred plasma.

(Refer Slide Time: 21:00)



in case when the work piece is independent of the power source like this electrode is connected to the negative terminal and positive terminal is connected to the nozzle arc is established and then plasma forming gas is passed and thereafter plasma is forced to pass through the nozzle that then plasma will be impinging with the surface of the substrate. This is the case when there is work piece is not in the part of the electric circuit. This one is called non transferred Plasma.

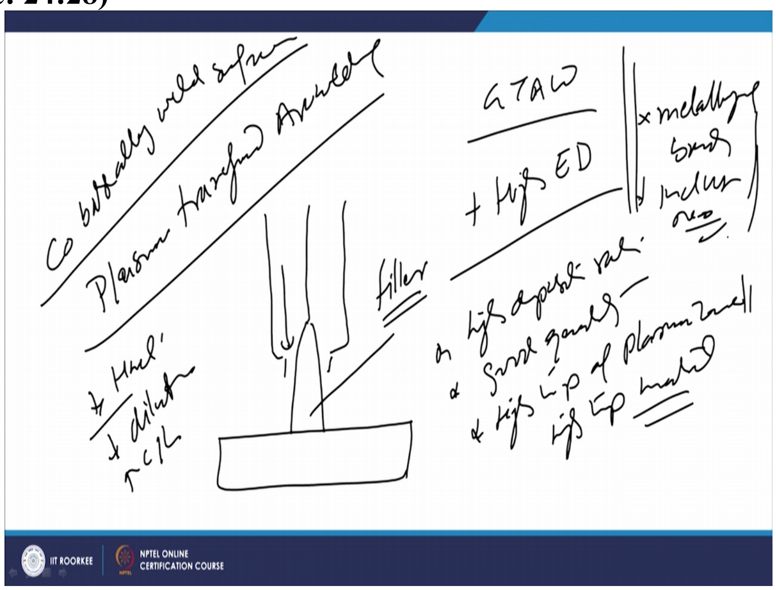
In this case the arc is independent of the work piece only the plasma whatever is coming out of the nozzle and will be impinging with the surface of the substrate. In another case electrode is the very much part of the work piece is very much work piece as a substrate is very much part of the electric circuit. In this case the arc is strike or between the electrode. And the work piece and the work piece is very much part of the electric circuit.

Here it is connected to the positive and negative terminal is connected to the electrode and the plasma farming gas is passed through and then what ever plasma is found that will you pass through the nozzle. So, in this case the plasma whatever is the; whatever plasma is formed that will be pass to the constricting nozzle. So, idea here is to use to reduce the diameter or you can say the cross section of the plasma arc, what, which is being formed.

This in turn will be increasing the energy density and increasing energy density will be reducing the heat input required for fusion of the substrate as well as filler metal. And then reduce input internal increasing the cooling rate during the solidification. Increase in cooling rate will be reducing the grain size. So, this is the kind of the technical chain reactions which is formed. So, due to the construction of the plasma in case of the plasma arc welding we get the higher energy density due to the reduced cross section of the plasma.

Higher energy density reduces the heat input required for surfacing reduced heat input helps in hair cooling rate and this will be refining the grain structure. Apart from the reduction in the heat input due to the increase in your energy density associated to the plasma arc. This will also be reducing the dilution level and this will also be reducing the thermal damages associated with the weld thermal cycle.

(Refer Slide Time: 24:28)



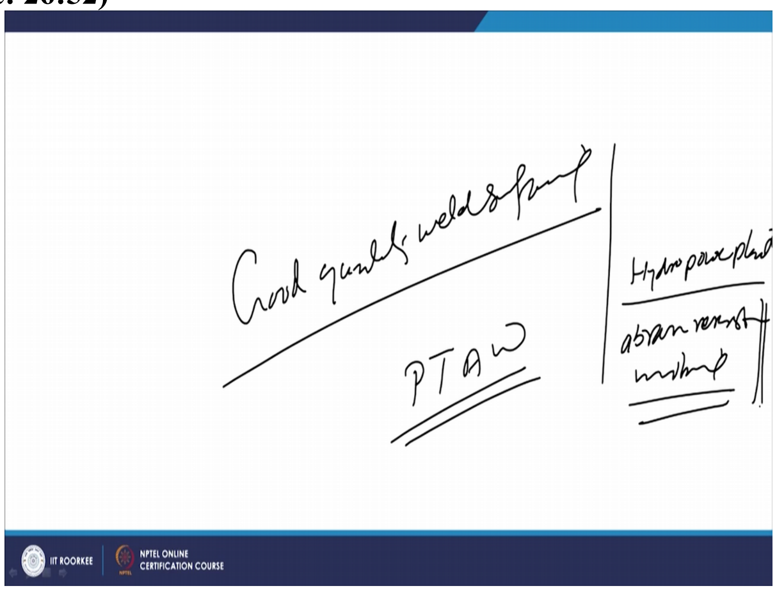
Since plasma arc has all the benefits of the GTAW additional it offers the advantage of the higher energy density and therefore we find the higher deposition rate and the good quality the weld surfacing and a much higher temperature of the plasma zone. And because of this we are able to the developed Weld surfacing of the high temperature materials also. And as a typical example is used for development of Cobalt base alloy weld surfacing.

Where in PTAW this is called plasma transferred arc welding, so in case of the plasma transferred arc welding you know the electrode and work piece, so arc is there between the electrode and work piece and the plasma forming gas will you pass through it will be passing through the nozzle and then it will be impinging with the surface of the substrate. So, filler wire has to be fed.

Like in GTAW process filler wire has to be fed in the plasma zone so that melting can be facilitated is the energy density is very high higher than the GTAW process, so it offers the advantage of the reduced heat input while facilitating the melting of the high temperature materials also. And this in turn reduces the dilution increases the cooling rate, reduces the thermal damage associated with the; thermal damage due to the best thermal cycle associated PTAW process.

Thermal damage due to the best thermal cycle associated with PTWA process and such kind of the claddings are found to be very sound good leading to the good metallurgical bonding and free from the defects like inclusions no inclusions.

(Refer Slide Time: 26:52)



And these in factors in turn help in developing the good quality weld surfacing. So, the plasma arc or PTAW process plasma transferred arc welding is very effectively used as mass process for developing the large scale weld surfacing for improving wear resistance of a number of the tribological components especially by developing the we are resistant materials like a cobalt based alloying steel etcetera and we notice that these are very effectively used for developing the weld surfacing in the field of a hydro power plants for increasing the cavitations resistance.

For increasing the abrasion resistance in the mining industry and in construction industry where good abrasion resistance is required so now I will summarise this presentation in this presentation which we have talked about the gas tungsten arc welding and the plasma arc welding processes. And we have seen that both these processes used and non consumable tungsten electrode for developing arc which and the heat of the arc is used for fusion of the filler metal. So, that the required surface modification of the substrate can be realised thank you for your attention.