Lecture 57: Weldability of Pre-coated Steel - I

Hello I welcome you all in this presentation and you know we have talked about the weldability of the different types of the steels like the plain carbon steels, high strength low alloy steels, heat treatable steels, heat resistant steels in form of weldability of chromium molybdenum Now, there is one more category of the steel which is frequently welded by both resistance welding processes as well as the arc welding processes. So, we need to see the kind of issues which are associated with the welding of the arc coated steel or pre-coated steels. So this is one big category of the steels which is extensively used. So first of all we will try to understand what these pre-coated steels are. Actually the steel which is an alloy of iron and carbon with the presence of other alloying elements. These steels are not very good with regard to the resistance to the environmental exposure in form of like say oxidation and corrosion.

So, to enhance the oxidation and corrosion resistance of the steels except the stainless steels these most of the steels having primarily iron, carbon and other alloying elements for strengthening purpose. They such kind of the steels do not offer very good resistance to the oxidation and corrosion. their resistance to the oxidation and corrosion the steels are frequently coated with the metals which can offer such kind of the resistance. aluminium or aluminium 8% silicon alloy.

When coating of either pure aluminium or aluminium 8% silicon alloy is made on the steel it is called aluminized. steel. On the other hand we can also do the coating of the zinc, when the zinc is coated on to the surface of the steel it is called galvanized steel. So, the aluminized steels offer very good resistance to the corrosion. while resistance to the oxidation is offered by the galvanized steel.

So, these are the two broad categories of the pre-coated. There are different methods of applying these coatings but the most commonly used method is hot dipping like the plate or sheet which is or the component which is to be coated with the either aluminium or the zinc. In the molten bath of the aluminium or the zinc the steel component is dipped and then it is taken out to develop the coating of the aluminium or the zinc. Another method is the electroplating. So, electroplating and dipping hot dipping both are used for developing the galvanized steel or for applying the coating of the zinc onto the surface of steel.

When these steels are welded You know like this is one component and this is another component say for example these are the coated steels. So, surface will have the coating of either aluminium or the zinc. So, for the welding barrage when the faying surfaces of such steel sheets are fused. The zinc and aluminium will also be heated and brought to the molten state. So, basically the aluminium and the zinc melting.

when it takes place this interferes with the welding. So heating and the melting combination of the zinc and aluminium leads to the interference welding in different ways.

So this interference of the aluminium and zinc due to the heating and subsequently in molten state leads to the reduction in the weldability of these steels. So in general if we compare. The carbon steel with coating and without coating then the coated steels will have the somewhat lower weldability than the uncoated or the bare carbon steel sheet.

So what are the ways by which these the aluminium or the zinc coating can interfere in welding and so as to reduce the weldability. Say these are the 3 different ways, one is like the melting of the aluminium or the zinc leads to the, it interacts with the iron to form the intermetallic compounds which are brittle low strength and the low ductility, so these promote cracking. On the other hand the evaporation low melting and boiling point metals like zinc when it evaporates it leads to the porosity and the interaction of the aluminium with the oxygen forms the alumina which appears in form of inclusions. So, these metals lead to the reduction in the mechanical properties. in mechanical properties primarily due to the formation of the intermetallic compounds which are brittle, low ductility, low strength as well as it promotes the discontinuities in form of these elements promote the discontinuities in form of pores and inclusions.

Now coming to the kind of processes which are used, so we will be talking about first the aluminized steels. As I have said these can be coated using the pure aluminium or these can be coated with the aluminium 8% silicon using the hot dipping method. So when pure aluminium is used it primarily helps in improving the corrosion resistance and when aluminium with 8% silicon alloy is coated it helps to increase the oxidation resistance at high temperature around 1200 degree Fahrenheit. So, the high temperature oxidation resistance is improved. But if we compare the weld joints of the weld joints or the steel sheets coated with the pure aluminium and the aluminium silicon alloy then the aluminium coated steels show better formability than the aluminium silicon alloy coated steel.

So this is one comparison as far as the pure aluminium and aluminium silicon alloy coated steel is concerned. Now these can be welded like aluminized steels can be welded using the resistance welding processes like it may be spot welding, it may be seam welding. But as far as the weldability of the coated steel is concerned by the resistance welding processes it is similar. to that of the bare low carbon steels. Whatever is the weldability of low carbon steel by the resistance welding processes the coated steels also offer similar kind of them.

weldability but there are some issues to understand those issues we need to understand little bit about the resistance welding process. In the resistance welding process the electrodes copper electrodes which are water cooled are brought in contact with the surface and then these electrodes are used to apply the pressure and once the sheets to be joined are in forming contact the current is allowed to flow from one side to another. So, this current generates the heat by I square RT principle. Since the contact resistance becomes the maximum in conventional resistance welding processes So, maximum at the interface, so maximum heat is generated at the interface and that leads to the softening and the partial melting of the sheets to be joined to develop the nugget and ensure the metallurgical

continuity between the sheets or the parts to be joined by the resistance welding process. Now, coming to the aluminized steel since in these cases the aluminium coating is there on both the sides.

So, say this is the sheet coated with the thin layer of the aluminium both the sides and likewise there is another sheet which is also coated with the aluminium. So, this thin layer of the aluminium will be there at the interface and both the sides will be having the electrodes which will be used to apply the electrode force. then the current will be allowed to flow from across the sheets to be joined and that will be generating the heat through I square RT principle. But in this case since the contact interface in both the sides the contact interface we have aluminium which is of the higher thermal conductivity and the higher electrical conductivity, high electrical conductivity. conductivity which means electrical resistance is low.

So, in order to generate so if we compare with the bare sheets where there is no coating of aluminium in the case of aluminized steels R value at the interface will be low and that is why the heat which will be generated under the identical conditions of the current and the time values the heat generated will be lower because of the lower resistance value. And therefore, in order to generate the sufficient amount of the heat at the interface, so that the softening and the required partial melting to form the nugget can take place we need to increase. To counter the reduction in the value of R we need to increase the current and the weld time, the time for which welding will be taking place. So, in general the kind of welding current which is used and the time for which current is allowed to flow and the electrode pressure which is used to hold the sheets together all are increased, so that the required amount of the heat for softening as well as the partial melting can be facilitated. So likewise in case of the seam welding of the aluminized steels also the current and the pressure and the time for which current is allowed to flow all are increased, so that the required amount of the heat can be generated in order to produce the sufficient nugget size as well as thermal softening of the metal.

Coming to the arc welding of the aluminized steels. Arc welding of the aluminized steels may be carried out using the shielded metal arc welding process. It can also be carried out using the gas metal arc welding process or the gas tungsten arc welding process at the same time it can also means things can also be joined using the soldering processes. So but the kind of issues which are related with these processes when the aluminized steel is welded they are different. So we will be talking about one by one each of these processes when they are used for welding of the aluminized steels.

So, say when the shielded metal arc welding process is used we know that since the protection associated with these welding processes of the weld pool from the atmospheric gases is very less. So, this is the protection of the molten pool. in case of the SMAW process from the atmospheric gases is poor. Because here the whatever inactive gases are produced they are produced through the thermal decomposition of the coatings available in the flux

and they will provide the loose shroud of the inactive protecting gases around the arc as well as the molten pool and therefore protection is poor. So, in order to provide the effective protection basically the basic coated electrodes are used for the welding of the aluminized steels by the SMAW process.

But since the protection or the effectiveness of the shielding. shielding of the weld metal from atmospheric gases like oxygen, nitrogen this is very poor. So, it frequently leads to the interaction of the aluminium with oxygen and nitrogen which in turn leads to the formation of the alumina. Since alumina is a refractory it does not melt under the arc environmental conditions and this reduces the formation of alumina reduces the wetting of the steel sheet with the molten. So molten weld metal and the steel sheet or the portion which has fused due to the reduction in the wettability of the molten metal due to the interference by the alumina the weld contour.

or weld bead geometry. This is badly compromised as at the same time the presence of Al2O3 in the weld metal acts as inclusion. So, weld bead geometry is not poor when it is present in form of inclusions these lower the ductility. of the weld joint. So, basically the formation of the Al2O3 is a major problem as far as the SMAW of the aluminized steel is concerned which in turn lowers the due to the formation of Al2O3 lowers the ductility and the formability of the joint if it is to be carried out. On the other hand when the GTAW process is used gas tungsten arc welding process is used.

Since the gas tungsten arc welding process is the process which offers the cleanest weld means the oxygen and nitrogen content and the hydrogen content in the weld metal is minimum. So, the chances for Al2O3 are very less because of the effective protection which is available with the GTAW process because the shielding is very effective. The argon is used as argon or helium is used as shielding gas, the arc gap is very close, the arc is very stable and that is why the entry of the atmospheric gases in the arc zone is very limited and that is why it produces very So, Al2O3 formation is significantly reduced and that is why even if the steel is of the rimmed or capped. type where oxygen is in the higher the concentration of the oxygen in the steel sheet itself. Steel sheet of the rimmed or cap type can also be welded effectively using the GTAW And the aluminium in those cases does not create much problem rather aluminium present acts as a deoxidizer in those cases.

So, in case of the GTAW aluminized steels do not create much problem. Now coming to the another dimension like. the aluminized steel sheets being welded by the GTAW say using the autogenous welding approach where just the faying surfaces are brought to the molten state without adding any filler. So, in that case whatever is the aluminium that will be retained by the weld metal. Now we need to see one very simple thing.

When the thickness of the sheet is more, the aluminium of particular thickness is being used. and when we melt its portion the aluminium will be going into the weld metal. But when we use thick sheet the percentage of aluminium in weld metal is low as compared to

the case when aluminium coated thin sheet is welded the proportion of the aluminium going into the weld metal is much more. So, the aluminized steels when thin sheets are welded in general the aluminium concentration in the weld metal is high. As compared to the case when the aluminized steel sheets of thick greater thicknesses are welded by autogenous welding process then the aluminium concentration in the weld metal is less.

Higher concentration of the aluminium greater than 1% in weld metal, since aluminium does not dissolve in the iron it forms the brittle iron-aluminium intermetallic compounds. So, the formation of the brittle aluminum-iron intermetallic compounds reduces the ductility. reduces the strength, reduces the formability of the welded sheets. So we need to look into this aspect also like how much the aluminium is getting into the weld metal especially in case of the autogenous welds. So greater is the thickness of the sheet Lesser will be the weight percentage of the aluminium in the weld metal that will be.

there. On the other hand if the coating thickness is very limited or coating thickness is more. So thin coated aluminium of greater thickness in form of coating will be leading to the greater percentage of the aluminium in the weld metal and that will be more troublesome as far as the reduction in ductility and reduction in the formability is concerned. On the other hand when we talk of the GMAW process. GMAW process is very different process as compared to that of the GTAW process where the filler in form of electrode will be developing the arc, it will be generating the heat. So, at the same time the electrode will also be melting and getting transferred into the weld metal.

Advantage of this is that whatever aluminium is coming from the base metal due to the fusion that will be diluted by the electrode material which is coming due to the consumption of the electrode during the welding process. So as a result of this the weld metal. composition is being modified by the electrode. At the same time whatever metal is coming from the electrode that will be diluting the aluminium percentage in the weld metal. So, the dilution of the aluminium due to the addition of the metal from the electrode will be reducing the concentration of the aluminium in the weld metal and therefore in case of the GMAW process.

So, the problems associated with the aluminium are reduced significantly, there is no problem of the reduction in the ductility, reduction in the formability of the aluminized steel weld joints prepared by the GMAW process. But since the effectiveness of the shielding associated with the GMAW process is not as good as that of the GTAW. So if we lose the protection of the weld metal from the atmospheric gases then it can lead to the formation of the shielding. Al_2O_3, it may reduce the wetting of the molten metal, it may reduce the ductility and the formability of the weld joint. So, effective protection of the weld metal from the atmospheric gases is needed in order to avoid the adverse effects.

Apart from this since in case of the GMAW process when we are using argon as a shielding gas frequently would like to add the oxygen and the carbon dioxide may be like 20 to 30% so

that the arc stability. is improved and that in turn will be helping in providing the effective protection to the weld metal. Now coming to the joining of the aluminized steels by shouldering. Here the presence of the alumina because wherever aluminium coating is there it will be forming the oxide in form of alumina. So, we need to do away with this alumina or aluminium coating.

And to take care of the alumina and aluminium coating basically the mechanical and chemical cleaning, thereafter dipping of the aluminized steel in 5% tri sodium phosphate solution, thereafter the rinsing in water. and drying of the sheet and after this the sheets to be joined by the shouldering very high speed heating methods are used like electric or ultrasonic shouldering irons. providing the required faster heating so that the aluminium does not get time to get oxidized during the heating. So, the main idea here is to apply the faster heating methods. So, that quickly the required soldering temperature can be realized and suitable shoulders can be used to develop the shoulder the joint at the interface.

So, cleaning is basically key in aluminized steel soldering thereafter faster heating and then application of the shoulders for developing the shoulder joints. I will summarize this presentation, in this presentation I have talked about the pre-coated steels and the weldability aspects of the aluminized steels. We know that aluminium creates some trouble in welding of the aluminized steels in both the cases in like the fusion welding processes as well as the resistance welding processes. Thank you for your attention.