Weldability of Metals
Prof. D K. Dwivedi
Department of Mechanical and Industrial Engineering
Indian Institute of Technology-Roorkee

Lecture-17
Weldability of Carbon Steels and Welding Processes-I

Hello I welcome you all in this presentation related with the subject weldability of metals and you know we are talking about the weldability of the carbon steels. So, there various types of the carbon steels like low carbon steel, mild steel, medium carbon and high carbon steels. And the weldability of the carbon steels to a great extent is affected by the composition because the composition of the steel affects the hardenability.

And which in turn determines the cracking tendency, higher the hardenability lower will be the weldability because of the increased cracking tendency. And to take care of those cracking tendencies especial precautions are needed and whenever the is requirement of the extra efforts to perform the same job that in turn reduces the ease of welding as far as the welding is concerned. We know that there are different types of the welding processes which are used for welding or joining of the metals.

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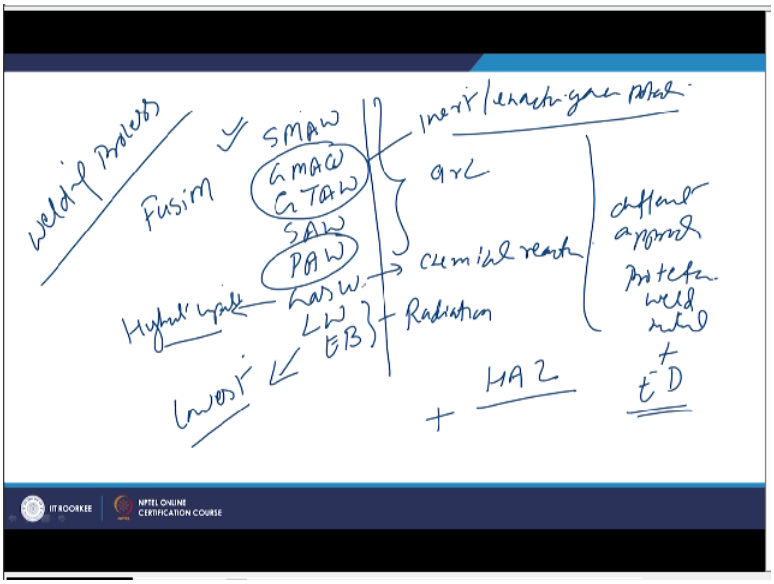

So, if we talk of the few welding processes the most common welding processes are based on the fusion based welding processes like shielded metal arc welding, gas metal arc welding, gas

tungsten arc welding, submerged arc welding, plasma arc welding, gas welding, laser welding, electron beam welding. In all these cases the fusion of the faying surfaces is facilitated in order to have the metallurgical continuity.

So, **so** in any case we have to supply heat using the suitable heat source either it is the like it is in form of the radiations or it is in form of like chemical reactions leading to the combustion of the fuel gas to produce the heat or it is in form of the welding arc . Each of these source results in the different approach as far as the protection of the weld metal is concerned as well as each one of these processes will be different with regard to the kind of energy density associated with that particular heat source.

Say gas welding offers the lowest energy density among these processes, so it requires the highest heat input to facilitate the fusion for a given set of the welding conditions. On the other hand the highest energy density is offered by this radiation based processes and therefore these result in the lowest heat input. On the other hand the processes which use inert shielding gases like the plasma arc, gas metal arc or gas tungsten arc.

Even in laser beam also sometimes inert or inactive gases are used for protection purpose. So, since the ease of welding to a great extent depends upon the extent of damage which will be taking place in the heat affected zone due to the heat application during the welding as well as the quality of the weld metal is affected by the kind of protection which is being provided during the welding.

And that is why depending upon the type of welding process which is being used will be coming across the different degree of the weldability or the weldability of the different metals will be different for the different welding process. So now will B is starting with the weldability of the carbon steels for the shielded metal arc welding processes.

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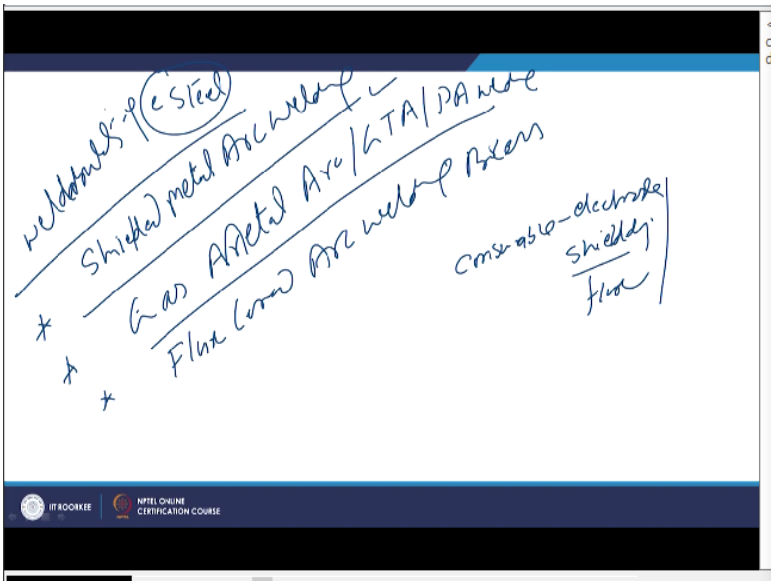

And what are the aspects that we are to look into, so the weldability of carbon steels with regard to the shielded metal arc welding process. So in this presentation I will try to talk about the weldability of carbon steels of these 3 processes. One is the shielded metal arc welding processes another will be the gas metal arc and gas tungsten arc and plasma arc welding processes.

So this is one category basically and then also will try to see the weldability with respect to the flux code arc welding process. So since the each of these processes will be having the different protection approach as well as the kind of the consumables which are used consumables in terms of the electrode, shielding gases the kind of fluxes which are use these are a different. And that is why we will see the issues which are encountered during the welding of the carbon steels are found to be different.

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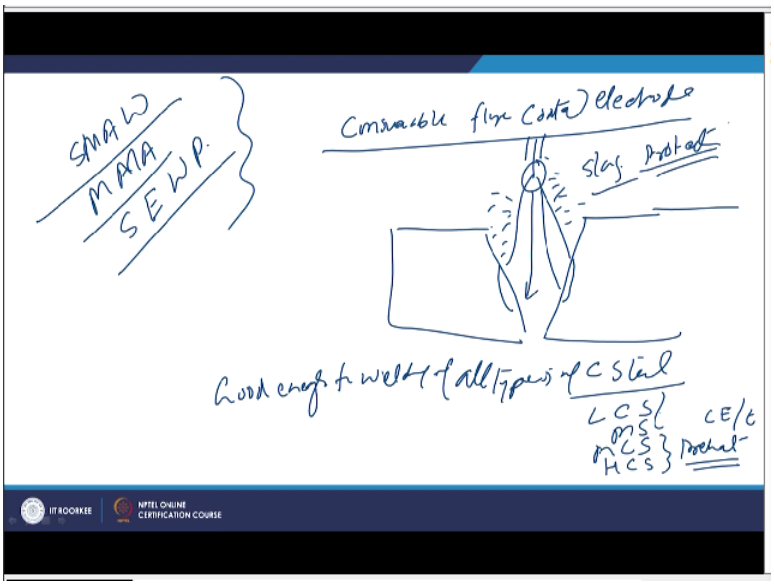

So, as far as the SMAW is concerned shielded metal arc welding process, so this is also known as manual metal arc welding process or strict electrode welding process . This is one of the most commonly used welding process because of it say easy to use and a flexibility to apply the molten metal at the required places. So, as for as the SMAW is concern it uses the consumable flux coated electrode which during the welding process itself is consumed.

And there by it has to deposit the metal at the required place in the process when in during the process of the welding when the arc is established. So, establishing the arc facilitates the fusion of the faying surfaces as well as the fusion of the electrode itself. And this metal gets deposited, at the same time the coating with the electrode is thermally decomposed which provides the inactive environment for protection of the molten metal from the atmospheric gases.

So, at the time whatever slag is formed due to the interaction of the slag interaction of the flux with the molten metal this slag also provides the protection to the molten metal from the atmospheric gases. So that the contamination of the weld pool from the atmospheric gases like of oxygen and nitrogen can be reduced. The kind of the energy density and the protection approach which is associated with the SMAW process that is good enough for welding of all types of carbon steels ranging from low carbon steel, mild steel, medium carbon steel and high carbon steel.

Accept the problem may be that when we are working with the thick sections of the high carbon and medium carbon steel we may require preheat. So the preheat requirement will be influenced by the carbon equivalent as well as the thickness of the plate which is being welded. Otherwise low carbon steel and mild steel can be easily welded using the shielded metal arc welding processes.

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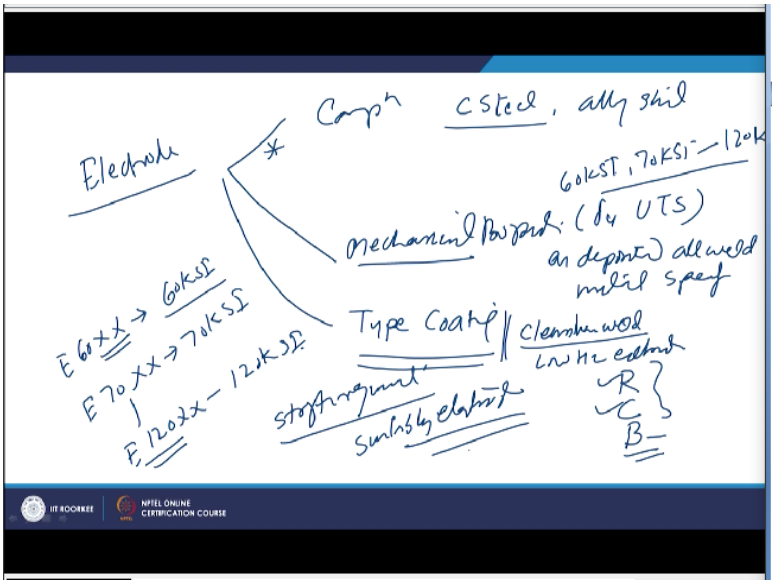

So, the kind of the electrodes which are used in during the shielded metal arc welding process these electrodes are classified on the basis of the 3 broad factors. One is the composition, so what we say it is either simple carbon steel electrode or the alloy steel electrode. The second is the mechanical properties the kind of the mechanical properties which are offered by the as deposited all weld metal specimen not the transfer section of the weld joint.

These are about the properties of the all weld metals samples and primarily these are characterize or specified in terms of the UTS the ultimate tensile strength of the weld metal. Another one is the type of the coatings or the flux which is being applied, so as for as the properties are concerned the properties maybe like 60 KSI, 70 KSI or up to 120 KSI. So, as per the strength requirement the electrode of the suitable matching mechanical properties are the tensile strength can be selected.

Then there is another aspect that is about the type of coating, this type of coating determines the kind of the cleanliness of the weld metal or the kind of the low hydrogen electrode characteristics. So there are various types of the coatings are available most commonly used are like rutile like coatings or the rutile electrodes, cellulose coatings on the cellulosic electrode, basic coatings for the basic electrode.

So, for low hydrogen electrodes physically basic coatings are used then they are there can be the combination of the rutile and the cellulosic are the acidic and the retail electrodes. So, acidic electrode is the another category or another type of the coating materials. So, for most of the non critical applications rutile and cellulosic electrodes are used but for the critical applications and for the low hydrogen situations where we want that process is performed under the control low hydrogen environment.

Then the basic electrode coatings are used, so this is how the electrodes are grouped or the classified for the SMAW. And then there is a typical way to understand the kind of the strength which will be offered by the typical weld joint which is being developed using the SMAW. Like if the electrode being used is 60 xx is kind of the designation which is used for the various constituents which are there in the weld metal.

And then 60 xx this indicates that the all weld metal properties will have the strength of the 60 KSI while the E 70 xx will show the 70 KSI the weld metal is strength and this can range up to 120 xx which means 120 KSI. So, this electrode designation itself will indicate the kind of the tensile strength and mechanical property combination which will be offered by a given electrode.

And accordingly, so according to the strength requirement we select the suitable type of the electrode for the welding purpose. So that the required combination of the strength and the strength and the properties can be realized.

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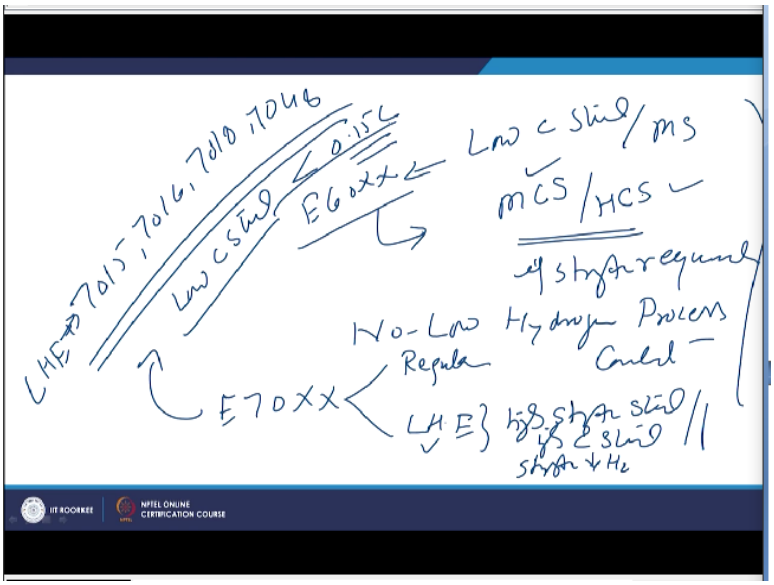

For most of the low carbon steel and mild steel joining E600 type of the electrode is used. Even this type of the electrode can be used for joining of the medium carbon steels and the high carbon Steels. If the strength requirements or requirements by or satisfied by the joint which are being made to connect the members of medium or high carbon steels members. Mostly this is used when the no low hydrogen conditions or the process conditions or to be realized.

For the low hydrogen conditions the another type of the electrode is used like E70xx this electrode is produced in both regular formats and the low hydrogen kind of the electrode. So, low hydrogen electrode means the coating will be of the basic type. While it can be cellulosic or the rutile type for the regular electrode purposes, so mostly for the conditions where high strength steels or high carbon steels are to be welded.

There we prefer to use the low hydrogen electrode, so that not just the matching strength is realized. But using the low hydrogen the cracking tendency using the low hydrogen electrodes the cracking tendency is reduced. And so therefore for all critical applications where SMAW welding is to be applied for welding of the medium carbon steel, high carbon steel or other high strength steels, low hydrogen electrodes are used.

So, the typical low hydrogen electrodes include like the LHE7015, 7016, then 7018 and 7048. So these are the common low hydrogen electrodes with for the different concentration or different

alloying elements produced in the low hydrogen format or low hydrogen variant. And most of these steels are designed to have the very low carbon content so not just the low hydrogen is facilitated.

But the carbon content is also less than normally it is less than 0.5%, so lower carbon content, lower hydrogen level associated with the weld metal. While some of the carbon will be coming from the base metal due to the dilution effect, so in order to neutralize the high carbon content coming from the base metal normally the very low carbon content. The electrodes are design using very low carbon content.

So that the associated hardening and the cracking tendency can be reduced, another one the now next process is the gas shielded arc welding process.

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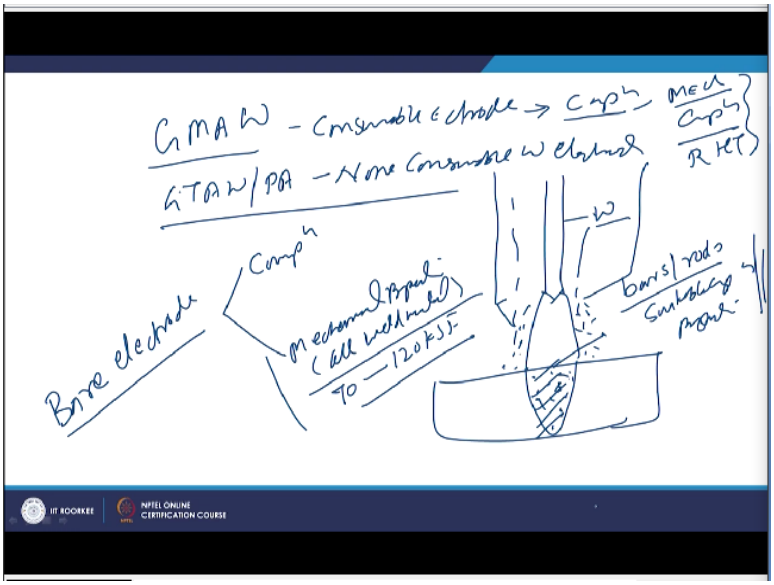

So, this is a category of those welding process where the shielding gas is used for protection of the weld metal like the heat source and the base metal is being brought to the molten state, so in the molten state this becomes very active if has high affinity to the environmental gases. Then the atmospheric gases like oxygen and nitrogen will interact and will produce their oxides nitrates these gases will have tendency to get dissolved.

So, will be leading to the inclusions as well as pores in order to reduce those tendencies effective protection of the weld metal from the atmospheric gases becomes important. And that is why we need to use the, so in certain processes the shielding gases are used for effective protection of the weld metal from the atmospheric gases. And this includes the gas metal arc, gas tungsten arc and the plasma arc welding processes. So, wherein all these processes differ from each other significantly like gas metal arc welding process.

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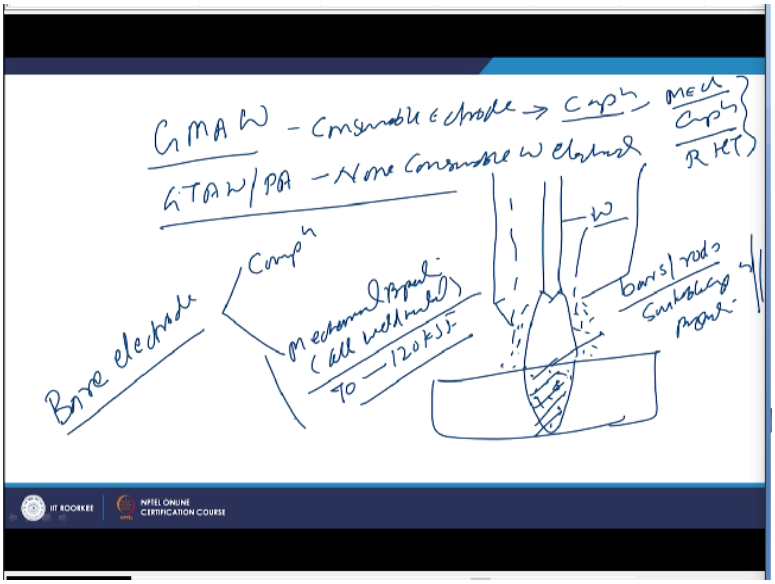

This process uses the consumable electrode while the gas tungsten arc and the plasma arc both these use non consumable tungsten electrode. So in this case the whatever electrode is there it is composition is to be identified in such a way that it helps to satisfy the requirement of the mechanical properties composition response to the heat treatment. So that we can get the properties as per the requirement of the weld joint while in case of the gas tungsten and the plasma arc welding process.

We use the tungsten electrode which does not melt in course of the welding, so in order to fill the gap and in order to deposit the metal from outside. In this case the bars and rods of the suitable composition and properties are used. So that the matching strength matching response to the heat treatment and composition can be realized, so this is the basic difference in this processes.

But in all these processes we use the external shielding gases it is called post production where eject of the shielding gas will be coming out of the nozzle. And will be covering the pool by pushing the atmospheric gases away from the molten metal. So, that the effective protection is provided by the welding processes, so when we use the bare electrode in case of the gas metal arc welding there is no coating over the electrode.

Electrode is bare, so the bare electrodes are classified based on the composition whether it is carbon manganese electrode simply carbon steel or alloy steel. Similarly they are also classified based on the mechanical properties like how much strength will be offered by the all weld metal properties. And because that will be used as a primary criteria for selection of the filler for developing the weld joint of the matching strengthen.

These are designed to have the strength from 70-120 KSI, so as per the requirement will be choosing the bare electrodes of the suitable mechanical properties. So, that in the joint of the required strength can be realized, rest of the like the factors associated with the selection of the bare electrode it is composition and properties. Those factors will be similar to that what we have talked for the SMAW process.

Now another important aspect related with these welding process the shielding gas, because shielding gas apart from the other bare electrode which is used in this processes. Another important aspect is the shielding gas, so the shielding gases which are commonly used in these welding processes like in GMAW gas metal arc welding process about which we have just talked like it can use the CO2 argon+CO2 or argon+oxygen mixture.

So, since CO2 acts as a becomes inactive to the ferrous systems. So, when the reasonable quality of the weld is needed at low cost CO2 is used as shielding gas. And for most of the low carbon steels and the mild steels the CO2 is very commonly used as a shielding gas in case of the gas metal arc welding process. There after we have the argon+CO2 and argon+oxygen and then sometimes we may also use the organ+helium gas mixture.

So, but when argon+CO2 or argon+oxygen gas mixture is used it helps in these are used for alloy steel and the high carbon and medium carbon steel welding. And the kind of the weld metal properties which are offered by the CO2 and the oxygen when the argon is mixed with the CO2 and oxygen the kind of the joint strength is a good in terms of the toughness.

As compared to the case when we do not use the oxygen or the CO2 as a mixtures with the oxygen. Because the presence of oxygen in the shielding gas promotes the delta ferrite formational secular ferrite formation in the weld metal. And which in turn helps to increase the toughness of the weld metal, so CO2+argon and oxygen+argon these gas mixture helps in improving the toughness of the weld metal when we use the GTAW process and PAW process.

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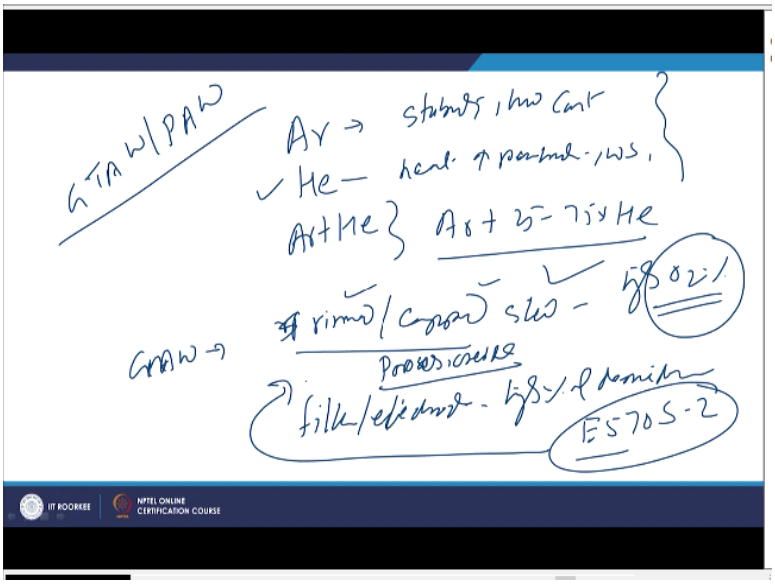

Invariably the argon is used as a shielding gas and helium for extremely high quality weld joints even helium is used. And when we want to take the advantage of both argon+helium then mixtures of the 2 is also used where argon+25-75% helium mixtures can be used. Helium results in very high heat input increases penetration it increases the welding speed, it increases the productivity.

On the other hand it offers very good arc stability, stability of arc it offers very low the good reasonable quality at low cost. It offers and if we want to take the advantage of and the mixtures of the 2 are used. Now will talk of the GMAW process when it is used for the welding of the

rimmed and capped steels, we know that the rimmed and capped steels are known to have the high oxygen percentage.

And when these are welded when the base metal of the rimmed and capped steel type is welded the higher oxygen content with the steel will be leading to the development of the pores and oxides. To take care of this normally the filler rod or the electrode which is used that must have the high percentage of the deoxidizers. So the most common electrode which is used for to satisfy these kind of requirement is E570S2.

This is one among the most commonly used the bare electrode which helps to take care of the issues related with the rimmed and capped steels.

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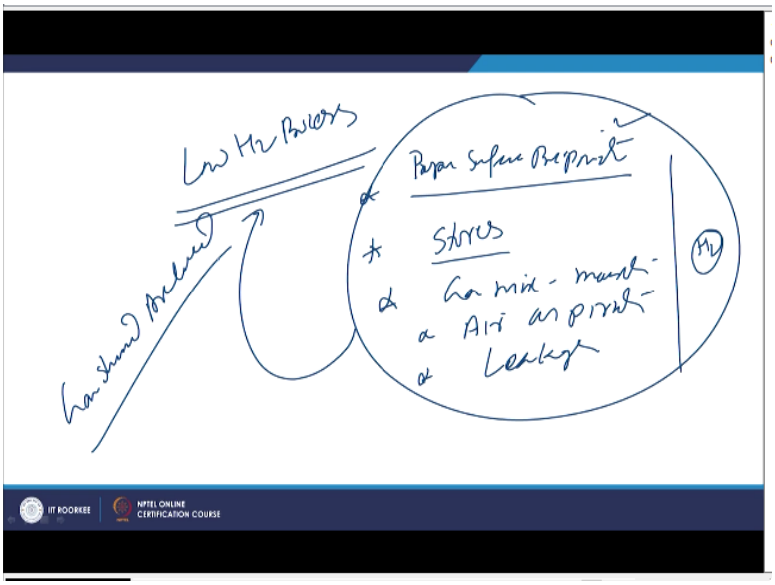

And when these are basically low hydrogen processes because there is nothing like the moisture which will be observed with the flux coating. And after decomposition it will offer the moisture H2O and which on decomposition further will be providing the hydrogen. In general these are the low hydrogen processes but if we do not take care for proper surface preparation.

Especially with regard to the cleaning of the paint, oil, rusted, dust extra from the base metal, from the filler metal or from the electrodes or the electrodes have not been properly stored or the gas mixture is having the moisture or there is air aspiration during the welding or the leakage of

the air into the shielding gas pipeline. So, all these can lead to the presence of hydrogen in the weld metal.

So, if we do not take proper care with regard to this points which can act as a source of the hydrogen then the low hydrogen characteristics of this processes like the gas shielded arc processes, gas metal arc, gas tungsten arc and the plasma arc welding processes. Then all those benefits are reduced means low hydrogen related benefits are reduced which is otherwise available with these gas shielded arc welding processes.

Now will summarize this presentation, in this presentation basically I have talked about the weldability of the carbon steels and how it is affected when the shielded metal arc welding process and the gas shielded arc welding processes are used, thank you for your attention.