Welding Processes

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Shielded Metal Arc Welding

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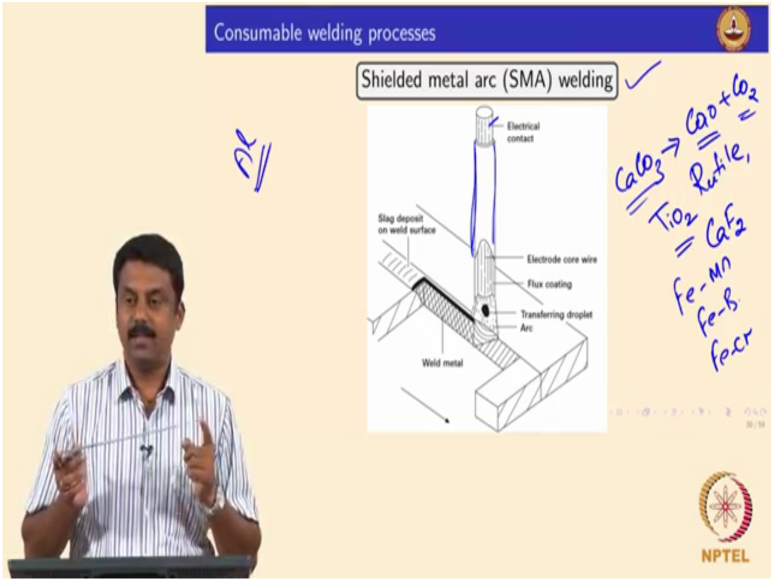

So what we looked at in GMAW fundamentals? We looked at the system, so we looked at the force balance, so the metal transfer forces and we looked at melting rate or we calculate the melting rate and then we looked at the transfer modes, the influence of current on the transfer mode, so what are the advantages and disadvantages transfers we see and then yeah so we are here.

Move on to the another variant of consumable welding process, which is the by volume the most widely used welding process which number of manner was spent in welding the SMAW or manual metal arc welding by for the largest most used welding process. So it is very easy to use very user friendly you do not need complex systems, you just need to burn the electrode, you do not need a shielding gas in most of the cases because most of them are self-shielded, so the electrode I showed you so this is a typical electrode where you have a metal core the metal rod and then a flux.

So the flux contains most of the cases the oxides, so we can also change the (())(1:55) of the system by either having titanium oxide or rutile based flux forming during welding or alumina based flux or calcium carbonate systems or you can also have a calcium fluoride systems CAF2 and based on the chemical composition we can also choose the flux used for the (())(2:26) coating.

So we will see in subsequent slides but what you need to identify understand here in this case is, in this case the electrode is self-shielded electrode where you have a metal core and flux on top of the metal core and this flux contains the elements which promote the shielding gas generation as well as they control the liquid surface tension and the viscosity of the molten droplet.

So we can have basic electrode or (())(3:15) based electrodes. In most of the cases the flux contains a calcium carbonate to generate carbon dimension oxide and then we add other fluxes like titanium oxide or calcium fluoride to change the surface tension and thermal physical property of the liquid metal so that droplet transfer can be promoted in like either globular or in spray mode.

The system is very simple so you just need a power source which can give a low voltage current, so once you have a simple power source which can generate the arcing waveform with low voltage and reasonably high current and you can use that power source to strike an arc between the electrode and the base material. In most of the cases arc is struck by short circuiting because power source for MMAW are very simple you may not see up a welding MMAW power source with high frequency ignition because high frequency ignition is you need to have an high frequency unit to strike an arc with non-contact ignition, where most of the cases the arc is struck by short circuiting and then you can retract and form a stable arc and then during this process the flux is also decomposes forming the shielding what is needed for the sustained discharge during welding.

And during this process you also form a slag and slag protects the weld pool because when you have an oxides or fluorides and they not only change the surface tension and they also form a slag and which protects the molten pool from the atmosphere oxidation and the vaporization. So this is an electric contract like if you look at the schematic a typical the electrode when you have a core, core is the metal wire and then you have a top, the flux coat and this fluxes burn and most of the cases they contain calcium carbonate, it burns into Cao and Co2 and this is the oxide slag.

And similarly the flux may also contain titanium, there is rutile or calcium fluoride and we can also add the alloying elements in the flux. Suppose if you want to increase the magnetics content of the droplet, so you can also add Ferromanganese in the flux and if you want to change the composition of the metal core, metal core can be simple, simple plane carbon (())

(6:23) carbon steel, but you can also change the droplet composition by adding the alloying elements in the flux.

So for example most commonly the ferrol (())(6:35) like Ferromanganese and Ferro boron and these are Ferro chromium these are also added because when you make the wire you can make it with very simple composition you do not need to go for suppose you did not add boron of say 50 ppm and if you want to increase the manganese concentration of the droplet subsequently weld pool to high manganese you do not need to go for high manganese wire. So you can add ferromanganese in the flux and that will (integrate) disintegrate and then it forms the allowing manganese with the droplet and you end up getting a droplet the composition of your requirement. So you can also play around the composition of the droplet by adding pyrolyse in the flux, is it clear? Process is very simple you ignite an arc by short circuiting and subsequently the yeah.

Student is questioning: What is the allowing element come out as a?

Professor: It will come out, for example aluminium it is very difficult to add aluminium in the flux.

Student is questioning: Then how will we decide that if we want this composition of is the (())(7:52) of aluminium in the (())(7:54), some part of it will come out.

Professor: Yeah, so then you need to have a proper calculation it is called burden calculations you need to do. In most of the cases the aluminium is very difficult to add or you need to very difficult to create aluminium containing droplet because aluminium always oxidize. So recovery of aluminium in the weld pool is nil. So that is why when you want to have an aluminium added to the pool you always add in the wire and then you have a proper shielding, so that aluminium does not oxidize.

For recovery of aluminium from the flux is very difficult you do not really because aluminium readily oxidizes. So if you add a (())(8:39) aluminium you will never get anything you will get in most of the cases not even more than 0.2 (())(8:47) percent aluminium. So in that case you need to play around the alloying element in the wire itself or in the base material so that you can have delusion from the base material coming to the work piece, is it clear? Good.

So again it is simple, so you melt the wire and then droplet is transferred and it is also protected by the shielding and then the flux also makes a slag layer on top of the molten pool and you can (())(9:19) the slag layer upon welding, is it clear? How it is done? Yes, which is?

Student is answering: (())(9:27).

Professor: Yeah, no flux does not melt. So the calcium carbonate disintegrate as much lower temperatures around 680 centigrade, so when you have short circuiting you also heat up the flux and you would start disintegrating the flux for example calcium carbonate so by 680 centigrade it will start disintegrating into carbon di oxide so then you already starts generating carbon di oxide, okay.

And then the arc ignition is same as we saw in ignition arc mechanism during short circuiting. So you have a Joule heating effect and during this process you also generate the carbon di oxide and then you pull it slowly, then you form a neck and then you have a Lorentz force against the nick forms heats up enormous amount temperature is heated up. So obviously so then once you have the wire is or the electrode is retracted you strike an arc by the (())(10:31) the same principle. The only trick is to generate sufficient gas carbon di oxide CO2 and that can happen on much lower temperature, is it clear?

Okay, the process is very simple you do not need a complex the power source as long as the power source can give you low voltage current then it should be alright you can strike an arc that is why this process is extremely simple and does not need any complicated setups and you do not need a shielding gas in most of the cases. So it is for a low end applications or high volume applications the manual metal arc welding or shielded metal arc welding is very widely used and most of the cases the electrode is like a stick that is why it is also known as stick welding, so the stick welding, okay good.

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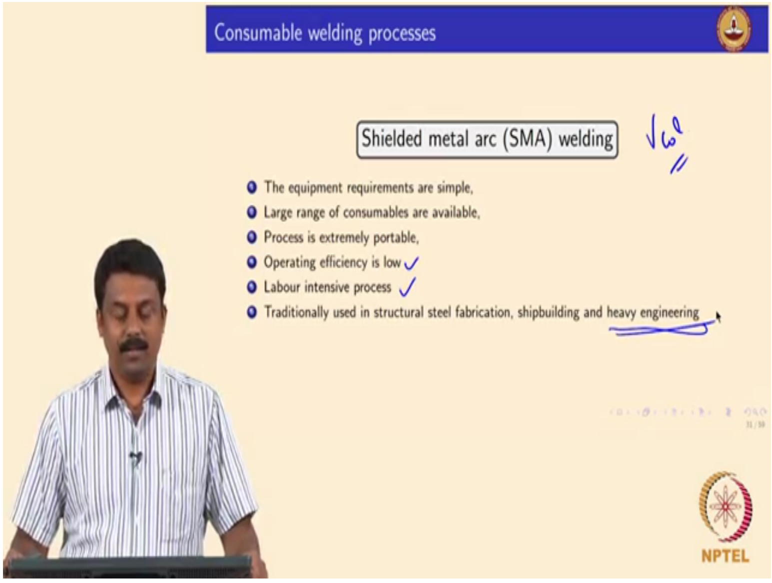

So what are the characteristics the equipment requirements are very simple, so if you want to repair or weld your the motor bike you take it to the garage and most of the cases we will be doing a stick welding SMAW welding and you can do it by yourself. So when you are for a first year B Tech students we have welding workshop and most of the cases we let the students to weld by SMAW so you get a feel of welding and it is very dirty process because the fumes you generate especially the manganese fumes it is (())(12:20) and also the oxides, the fluxes when they burn you inhale the welding fumes and it is not good for health.

So that is why the welders respiratory diseases are much higher than in any other jobs because of the welding fumes welding fumes are not really good for human body, so the prolonged exposure to the welding fumes by burning of fluxes also the vaporization of the metals it is not really good but yeah so that is life. So because of the low cost and high productive nature of this process it is very widely used and we can also play around with the consumables (())(13:11) by changing the either the core wire composition or by manipulating the flux composition, we can generate very wide range of consumables and it is very portable process, you can have a small rectifier invertor system which can give low current, low voltage currents and you can carry wherever you want and you can just take it as a suitcase and go around and then you start welding.

The efficiency is quite low because the radiation the heat transfer from the arc is extremely high and we also use the heat in the arc to burn the flux and the slags also carry the heat from the arc and it is not transferred back to the work piece. So the efficiency is low compare to GMAW because the arc the V column is also observed by the fluxes, so you have additional heat taken away by the flux when they burn and disintegrate the heat in the arc column is taken away by the burning and then melting of fluxes. So the efficiency comes down and also the process is open to the atmosphere so you also radiative and convective heat losses.

And it is most of the cases done manually that is why we say manual metal arc welding, so you need to have a (())(14:45) to carry out this process and when you have a stick electrode and manual metal arc electrode it is difficult to make it continuous or automated because the electrode is over then you need to change the electrode, so we cannot make it continuous electrode because when you make it continuous the flux gets broken.

So it is very widely used for structural fabrications for building bridges for example for fabricating a simple construction buildings so these kind of manual metal arc electrodes are very widely used and ship building as well. So as I said in a typical ship you have a kilometre of welds so these welds are made by manual metal arc welding and the heavy engineering applications (())(15:47) for example welding thicker sections these are done with manual metal arc welding, is it clear? Okay, good.

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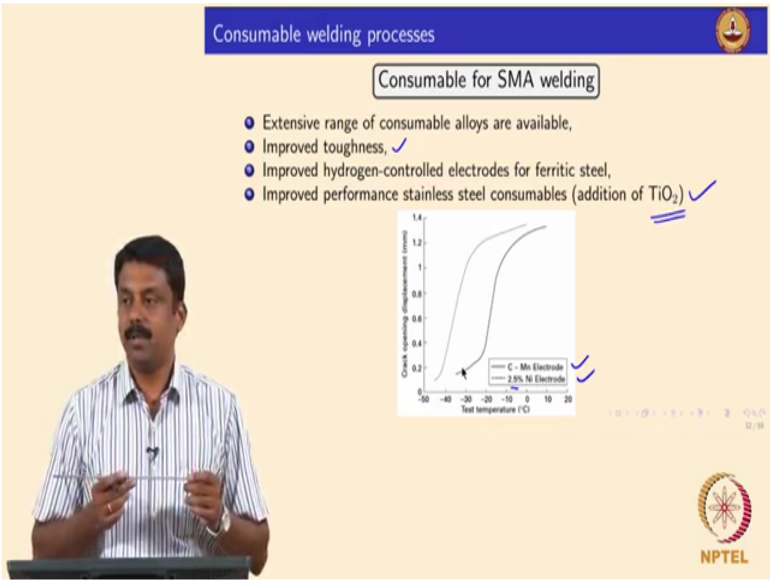

So the consumable prospective there is a very wide range of consumables are available and we can also play around the micro structures, okay so by controlling the micro structure we can also get the very good toughness. The main disadvantage of using MMAW is hydrogen absorption in the flux. So if you expose the electrode to atmosphere then you cannot weld as such, you need to heat the electrode above (1000) 100 or 150 degree centigrade to vaporize the entire volume of the moisture accumulation condensation.

Because the flux is very poor structure, so when you keep the electrode at room atmosphere it gathers moisture. So when you weld the electrode as such after keeping outside in room atmosphere and you also generate hydrogen by disintegration of the moisture so that would lead to the hydrogen diffusion in the weld pool subsequently the weld would undergo (()) (17:20), okay.

So when the stick electrode is used when you receive from the company which makes the electrode you always receive the electrodes in a very nicely packed humidity controlled envelope, where the packing ensures no humidity condensation of the electrode. So once you moment you open the envelope you need to keep the electrode in a very controlled atmosphere chamber, otherwise before welding you always need to pre heat the electrode to temperature 100 to 125 not more than 150 to make sure that the condensed moisture is operated and then you can start welding. If you do not do that the most likely you will have a hydrogen (())(18:16) issues, okay.

So we can also play around with the fluxes to improve the transfer characteristic as well as the weld pool dynamics. So we looked at inactivated (())(18:31) so we add oxide fluxes or fluoride fluxes. So these fluxes favourably change the surface tension of the weld pool, so if you add those fluxes and you also improve the weld pool dynamics so you can achieve the metal penetration may change in the composition of the fluxes.

So for example you can also change the composition much easily so I have given two graphs say comparing 2.5 percent nickel electrode and carbon manganese electrode and by changing the nickel composition we can achieve a very good (())(19:16) displacement toughness can increase can be increased significantly. So this kind of alloying strategy we can think about to improve the metallurgy of the weld pool, in a GMAW it is not possible what you give the filler that is what is going to happen except you may lose some elements, it is very difficult to control the alloying strategy in GMAW because that is fixed by the filler composition and here you can play around with the fluxes so you can generate your own composition of the weld pool.

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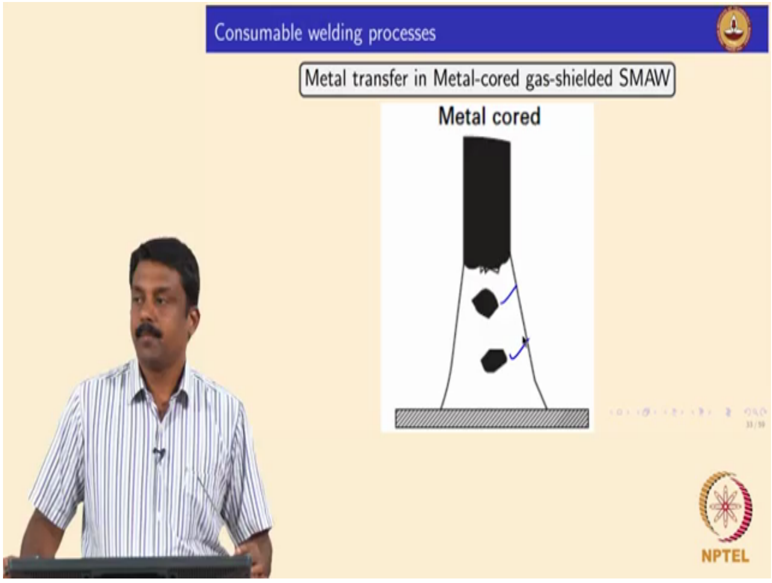

So the metal transfer in most of the cases in SMAW it is globular assisted by the fluxes, the droplet diameter is much smaller because surface tension decreases by the addition of the fluxes especially in (rutile containing) titanium oxide containing electrodes, it can influence surface tension in such a way that the droplet can be detached with much smaller diameter, good.