Welding Processes

Professor Murugaiyan Amirthalingan
Department of Metallurgical and Materials Engineering
Indian Institute of Technology, Madras

Electrode fluxes and process characteristics of flux cored arc welding

In the last class we have looking at the two things metal transfer characteristics of a consumable welding process, ok and then we move on to the another variant of consumable welding process which is shielded metal arc welding SMAW. So in metal transfer is very important because that determines the stability of the process and the productivity and the static and mechanical properties and so on and so forth, ok.

So we have looked at the metal transfer characteristics as a function of varying current, right so at low current it is starting from globular if you increase the current and then globular becomes rippled and globular and then there is a spare transition in which the globular and ripple globular becomes as free transfer, ok. So the sphere transition current is extremely critical to get the stable metal transfer characteristics within acceptable productivity, right.

So from the sphere transition if you keep on increasing current the drop spray becomes an a jetting spray, alright and then continuously if you increase the current and jetting spray becomes rotating jetting un subsequently in explosive transfer, So in GMAW the transfer characteristics very important.

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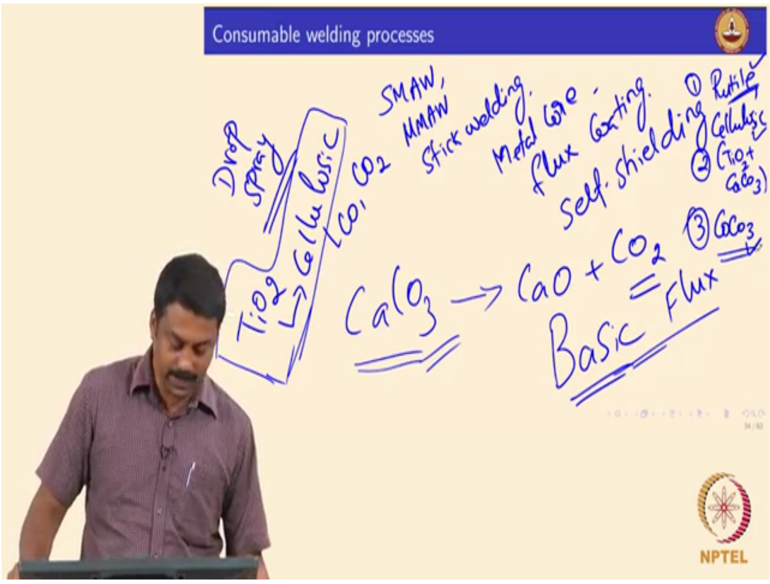

So we always (())(01:33) getting an a drop spray transfer and that is what it looked it right and you also looked at the video, so which is the most ideal transfer we always get and this happens just above the spray transition current so they are the they droplet diameter would be similar to the filler diameter and individual droplet with the filler diameter would transfer to the weld pole and this drop spray can easily achieve it by pulsing, current pulsing.

So we will see the effect of pulsing in detail in this class, right and then if the current is increased further then it becomes the jetting spray and jetting spray and some extends can be used for some application where you need to have an a higher melting rate of the consumables for example spraying and cleaning cladding applications you can use a jetting spray and further increasing current lead to unstable jetting leading to a rotation of the droplets spray and the for some cladding applications we can still use an a jetting or a rotating jetting spray, right but for ideal GMAW case the drop spray just above spray transition is very widely used, right it is clear.

And then we move on to the other variant of the consumable welding process which is SMAW, ok it is also known as MMAW the shied metal arc welding and manual metal arc welding or even a stick welding, so where the welding electrode the consumable welding electrode it is discontinuous and it has an metal core and with flux coating, right. And most of the cases the SMAW process is self-shielding process, ok so we do not use an external shielding (glass) shielding gas, so most of the cases the process which self-shielding, right ok.

And what is call self-shielding? The self-shielding because the shielding gas is generated by the decomposition of the flux, right so generally the flux contents the elements they either dissociate or decomposed to generate the gasses, so one of the examples I showed you in the last class the flux content calcium carbonate based fluxes, so these carbonate the calcium carbonate when you heat it up it burns and decomposes into calcium oxide plus carbon dioxide and these carbon dioxide generates the shielding and arcing gas required for striking an arc and protecting the weld pole, ok.

So if the flux concept the composition needs majority is made of calcium carbonate and these kinds of fluxes are known as basic fluxes, basically because of the basicity, right. So it is the same use it in a as a still making process, so basic slags (())(04:58) slags, ok. So if the flux contents primarily calcium carbonate based the decomposition and this is basics slag, right and you can also have the flux made out of rutile and some cellulosic material what is cellulosic material? It is made of wood, wood and wood particle so the natural fibers and these cellulosic material can also be added either to basic flag basic flux or rutile based fluxes and most commonly cellulosic material are added with rutile fluxes titanium oxide fluxes because when cellulosic material burns how would generate?

Student is answering: Carbon dioxide.

Professor: Carbon dioxide again, right carbon dioxide so you will also get carbon monoxide and then carbon dioxide then the cellulosic material burn, right so that provides enough carbon dioxide and carbon monoxide gasses require for arcing as well as shielding. See in most of the cases so when you are welding steels with are thicker sections so we need to make sure that high region is not diffuse to be weld pole, right.

So for example if you using an a low carbon steel for structure applications to build a bridge the thickness would be 25 mm thick in that case you need to make sure that the hydrogen is not diffuse to the pole and whatever the moisture is there in a condensed in the system should not leak too diffusion of hydrogen by disintegration of water H2O into higher region, right so for welding thicker sections 25 mm thick plates or even higher.

So we prefer using an a basic electrodes which is calcium carbonate because when you use calcium carbonate we make sure that it is shielding gasses only carbon dioxide, right so the basic flux coated electrodes most commonly used for low hydrogen environment that mean is that when you do not want the higher region to diffuse and you want to avoid the moisture condensation and then the effect of mass moisture integration so we need to make sure that the shielding gas is only carbon dioxide, right.

So (un) in contrary to the basic fluxes if you use rutile based fluxes for example titanium oxide, titanium oxide is known to disintegrate water so for photocatalytic like applications what is photocatalytic applications? For generation of hydrogen from water, ok so in those applications titanium oxide is very commonly used as a catalyst, so photocatalystic applications.

So if use a rutile based fluxes, ok you can also disintegrate the moisture by titanium oxide because that is an a catalyst very effective catalyst and then you can also generate hydrogen, is not it so because if hot water is disintegrated by the titanium oxide and then you will also have cellulosic material to generate carbon dioxide, so by binding titanium oxide with cellulosic material you can generate the mixture of carbon dioxide and hydrogen, right.

So for welding thinner sections for welding is austenitic stainless steel or for welding super alloys or for weld for a cladding of hot phasing sterlite Cobol chrome super alloys, so the rutile based electrodes are commonly used, ok so these rutile based electrodes they bring the versatility because you do not need to bake the electrodes, is not it even moisture is there titanium oxide would take care of the moisture by disintegrating the moisture into hydrogen and hydrogen can be used for shielding, hydrogen gas can be used for shielding suppose if you want to have an arc facing or welding of a stainless steel arc where the hydrogen coal cracking is not that savior, ok.

The other advantage of titanium oxide is we already seen the road of titanium oxide in a cause to cause variation activate fluxes is known to change the surface extension of the martial so the droplet transfer can be enhanced still the behavior can be enhanced by adding titanium oxide because it can reduce the surface extension for example so then the droplet transfer can be promoted and also titanium oxide is at is in a very active flux for the weld material, so the weld fold dynamics can also be improved significantly.

And other one of the major advantage of using a titanium oxide is ionisation because when we looked at in a GTAW electrode tungsten electrode they are all thoriated or the oxides doped why because the ionization potential is much lower for oxides, so when you have titanium oxide in the system, so obviously you will also promote ionisation, is not it. So the arc stability increases tremendously if a flux contents a titanium oxide.

So these are the advantages of using the rutile based electrodes then the basic flux coated electrodes, so you can have a very good arc stability because of the promoted ionisation by the titanium oxide and you can also enhance the droplet transfer frequencies because these titanium oxide also affects the surface extension of the droplets, so you can also increase the droplet transfer frequencies and titanium oxide also disintegrates moisture in the system into hydrogen, so you also have extra shielding from the hydrogen gas, ok.

So you can also now use the electrode without baking, so generally this cellulosic and titanium rutile based electrodes you do not bake it because when you are baking it itself (()) (11:36) and disintegrating sometimes if you are baking at say 200 degree centigrade, so cellulosic and rutile containing electrodes, so it me also disintegrate during baking, ok. Whereas in the basic flux coat electrodes calcium carbonate containing electrodes you need to bake because there is no other way otherwise you can fix the hydrogen, ok.

So once you have the high (())(12:03) condensed electrode basic electrode and you need to bake and release the hydrogen and then you can use the electrode immediately for welding applications whereas if you have rutile based electrodes or cellulosic material you can straightaway you start using it, ok with the enhanced the basic baking is not necessary because the hydrogen heating it is going to disintegrate from the main of water is going to integrate into hydrogen and hydrogen can be used for shielding mix of Co 2 and hydrogen, alright.

So what are major three types of electrode fluxes we use rutile based, ok cellulosic material and cellulosic we also have some amount of titanium oxide as well, ok so the majority component determines the type, ok titanium oxide plus Ca Co 3 and then predominantly Co Ca 3 based systems,so 1, 2, 3 and apart from the titanium oxide, cellulose and calcium carbonate we can also add the align element for example if you want to increase the manganese concentration, so we can also add for a manganese and if you want to add chromium you can also add chromium for a chromium and those are all added in the flux (com) the composition and we also need some (blind) binders, ok to keep to the powder syntact and they are went when you bake it so binder have operates.

So you also have some binders added to that there any those are silicates, ok and silicates binders are commonly used for make sure the to making a to make the flux coating on to the electrode, right. So these are three major types rutile based, cellulose based and calcium carbonate based.

Student is questioning: What is the difference between rutile based in cellulosic based in terms of the applications?

Professor: So cellulosic based electrodes are very cheap, ok so in terms of applications cellulose (bate) based electrodes are used for a very low and production applications, ok the electrodes we do not need to add titanium oxide or calcium carbonate so these are very simple wood materials cellulose base (ma) electrodes material with these are very cheap, ok for a very common applications like you know repair applications or large volume or low end applications cellulose base electrodes can be used, ok.

For a higher engineering applications generally rutile based electrodes are used, ok so anyway so rutile based electrodes also contents some amount of cellulose to generate because when you have only rutile with the you can get maximum about 40 percent of hydrogen in the shielding, so the if you have 100 percent shielding if you have rutile so the maximum contribution from the rutile is only 40 percent so remaining 60 percent should come from burning of cellulose, right it is clear.

So cellulose burns and then gives carbon monoxide and carbon dioxide, rutile gives hydrogen, right it is clear. So in cellulosic (bed) material it is (may) the majority of the shielding gas is generated by burning cellulose which would be carbon monoxide and carbon dioxide, right. So when you burn and I do not how many of you had in your younger days mother cooking in a woods tow, so the smoke you generate sometimes suffocating, is not it because of increase constant carbon monoxide, so when you burn wood, ok so there is a similar reaction also takes place when the cellulose base material is burn in the electrode you generate carbon monoxide and carbon dioxide, ok so that is the shielding gas.

So an if you use a carbon dioxide cylinder obviously carbon dioxide will disintegrate first dissociate first into carbon monoxide and oxygen item, right in the same shielding gas can be generated by burning cellulose base material, right it is clear. So and then for low end hydrogen applications so where you do not need to generate hydrogen you need to avoid hydrogen diffusion the basic flux coated electrodes are commonly used and these electrodes are calcium carbonate containing, so these calcium carbonate burns and produce calcium oxide and carbon dioxide, yes it is clear.

So what are fluxes reuse and apart from the shielding gas generation these fluxes also have a varying other roles, right for example these fluxes also do the deoxidizer him of the weld metal same steel making, so when you want to do the deoxidization, ok so what you do?

Student is answering: Few aluminium silicate.

Professor: Yeah, so you add a aluminium, so aluminium killeding they call it, so killed aluminium killed, so that you can take the oxygen concentration out from the liquid fold, so these fluxes would also content deoxidizers, so typically aluminium, ok so aluminium when you add aluminium burns with the oxygen and forms aluminium oxide, right so these fluxes would also content amount of aluminium for deoxidization and you can also desulphurization, ok and also denitrition denitriding, denitrifying, so what they call it.

So varying a low amount of these elements can also be added to achieve a required weld metal property, right it is clear. And some amount of following elements you can any may add by adding say ferroalloys or ferro even elemental alloys can also be added if the recovery is very high but it is depending on the nature of element for example you cannot add an elemental aluminium because aluminium oxidize, so the recovery of aluminium in the based and in the weld pole it is almost very low, so he cannot alloy the weld metal with aluminium from the flux or from the electrode you will always lose aluminium, ok.

So you can try adding boron Ferroboron can be added so boron would recover in the weld pole, so similarly align elements we can add manganese, chromium, silicon, ferrosilicon you can add ferrotitanium, ferroniobium and these elements commonly added in the weld pole to improve the weld metal properties because when you add titanium, niobium, vanadium and they are all micro align additions they can cause specific types to increase the weld metal toughness.

So you can play around the flux compositions to achieve the required weld metal properties as well, yes it is clear. So these are the roles of the fluxes, so we will see in this class, so how the these things or you know the role of fluxes in detail in both SMAW and FCAW and we will also look at the videos when these fluxes burn, how the metal transfer takes place, right the process, ok good so this clear, right.

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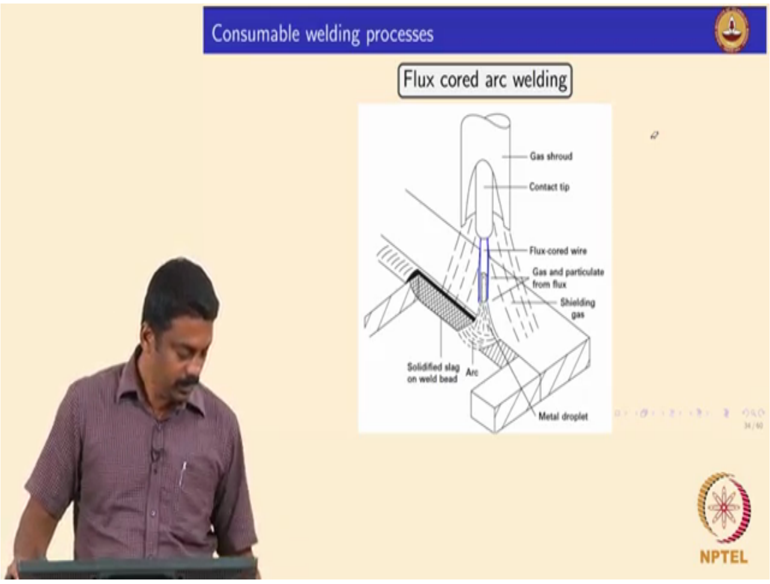

So what we use in the electrode in SMAW? So we have the metal core and then flux coating on the top and this is the electrode what I have in my hand it is a basic flux electrode, so what is basic flux electrode needs? Calcium carbonate based and if I used this electrode right away after this class to welding, so I would definitely get an coal cracking, ok so it is already in very humid environment unless I bake it to remove the hydrogen or remove the moisture and if you weld it straightaway and then I may end up getting coal cracks.

So the basic flux cored electrode suit always be baked to avoid the hydrogen embattlement, ok so if I have an rutile based electrode, right so now I do not need to bake extensively, simple baking because you need to reduce the moisture otherwise your hydrogen gas generation will be higher than the power the shielding gas natural be different that means all characteristics is also different.

So say small baking say 100 degrees sometimes so that I can start welding because titanium oxide will take care of the moisture because titanium oxide would (dis) dissociate water into hydrogen and then hydrogen can be used for shielding, ok same goes for cellulosic electrode as well, so cellulosic electrode, ok you do not need to bake because cellulosic electrode can also content some amount of titanium oxide and even it burns it generates carbon monoxide and carbon dioxide, ok and then titanium oxide can generate some hydrogen, right it is clear, ok.

So the we also looked at in last class the major disadvantage of this process is the electrode is not continuous it does not define length, is not it so the automation is difficult or if you want to deposit continuously so you need to make the electrode sort of an the long lengthy electrode like you make in GMAW, like an a role, ok right. So in order do that it also in order to efficiently produce the electrode so we can also it convert the geometry of the electrode and we just reverse the role reverse the position of the flux and the electrode and then we also make the electrode by keeping the flux inside and the metal outside, ok.

So that is what known as the flux code electrode electrodes, so which are something like this, ok. So this can be made into flexible, so now the flux goes inside, ok so metal shield is outside, so now we can make such electrodes and we can make it large as long as possible and we can roll it and then we can fill continuously again the chemistry of the flux and the shielding gas generation from the flux is a same as SMAW, you also have a 3 types of electrodes, ok basic, rutile and cellulosic electrodes alright but the difference is here the flux is inside, metal shield is outside so it is can be made into flexible, if I bend that it will break and the all the flux would go away because flux is very brittle.

In this case the flux very loosely packed and even if it is yeah you bend it yeah the flux remains inside, right now we can make this process continuous, right so the process is the same so you have an a flux cored electrode coming in, ok and then (ref) the flux insides again though disintegrates based on the nature of the chemical composition of the fluxes, you may either have Co 2 generation or Co 2 carbon monoxide generation or carbon dioxide, carbon monoxide, hydrogen generation, right it is clear ok.

So then this flux again burns it forms slag and the deposit on it is top and then you can take quite off so when you need, the other process characteristics are similar to GMAW, right so the only thing is here the melting rate can be different melting rate will be different than the GMAW because some amount of heat is also lost by the flux, flux take away some heat, right so the flux also takes some heat so the melting rate compare to GMAW in this case is slightly lower but then most of the cases will be using (())(24:00) the diameter filler, ok so you also generate more volume, so right it is clear, good.