Fundamental of Welding Science and Technology

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Lecture – 19
Oxy-Fuel Gas Welding

So, in the last lecture, I was discussing about Oxy-Fuel Gas Welding techniques. There, I was discussed about categories of different oxy-fuel gases, their properties in details and also at the end of last lecture I was discussing about oxyacetylene gas flame. There what we observed? There, we observed that by changing the ratio of oxygen and acetylene gas we can get different types of oxyacetylene flame and the about the different types of oxyacetylene flame I have already discuss in detail.

Today, I will discuss about oxyacetylene fuel welding rest of the part. First of all I will discuss about other fuel gases combustion in details. Then I will goes for categories of different oxy-fuel welding techniques, then I will also discuss it is advantage drawbacks and application in details. And if time permits then I will start to discuss about electric arc welding technique that is the first electric arc welding techniques we saw we will start that will be the what it is called SMAW welding that is Shielded Metal Arc Welding techniques.

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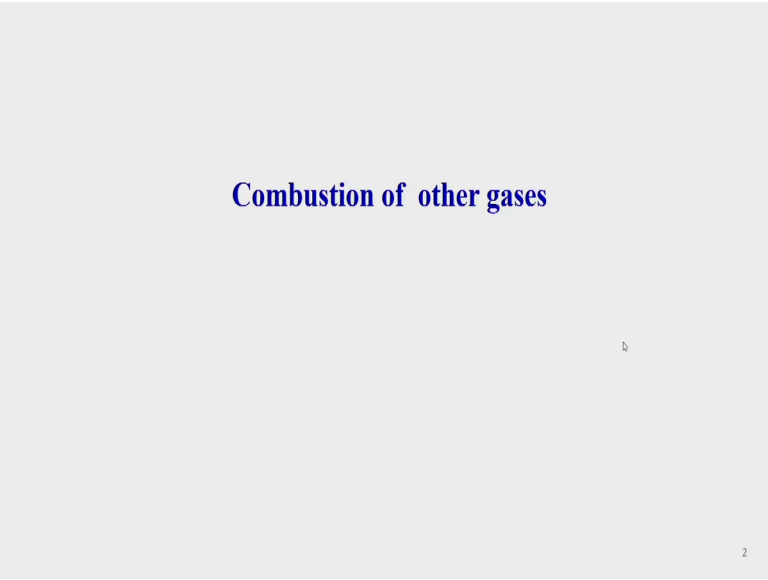

So, first of all I will discuss the combustion of other fuel gases So, first last class I have already discuss about combustion of oxygen and acetylene gases.

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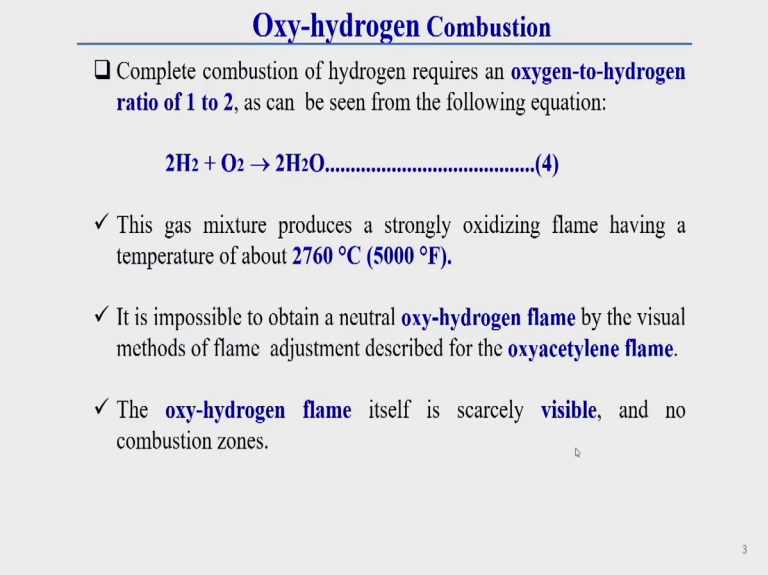

Today, I will discuss about other fuel gas with oxygen how the combustion is taken place. First of all oxy-hydrogen combustion. Here generally complete combustion of hydrogen require an oxygen to hydrogen ratio of 1 to 2, that we can observe from this chemical equation. That means, here generate two molecules of hydrogen with one molecule of oxygen generally complete combustion taken place here generally output is heat a heat is generally generated. This gas mixture produce a extra strongly oxidizing flame having a temperature of about 2760 degree centigrade. This much of temperature it can rise that maximum temperature is rising by the combustion is around 2760 degree centigrade.

But, here you see this flame is oxidizing in nature because, here the presence of oxygen is there. That is why it is impossible to obtain an oxy hydrogen flame by the visual method of flame adjustment which generally describe for the oxyacetylene flame. In oxyacetylene flame what we observe by visual inspection itself we can generate our required types of flame characteristics, but here this flame combustion zone is not well visible; that means, the combustion zone cannot be distinguish in case of oxy hydrogen types of combustion flame. That is why by visual inspection we can distinguish the whether it is neutral flame or oxidizing flame in natures.

So, whatever the things we can observe in oxyacetylene flame; that means, there we can easily see depending upon the size of inner cone then acetylene feather we can say what types of flame is generally generated over there, but here it is very difficult because it is not visible. That is why generally the oxy hydrogen flame itself is generally scarcely visible whatever I have already written and there is no combustion zone what we observe like in oxyacetylene that types of combustion generally zone generally have it is not available.

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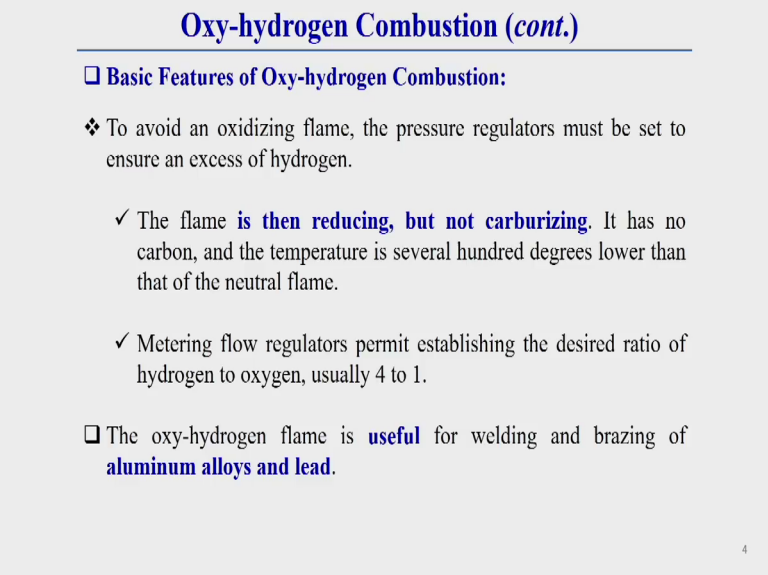

The basic feature of oxy hydrogen combustion here one things you should keep it in mind to avoid an oxidizing flame the pressure regulator must be set to ensure an excess of hydrogen because here oxygen is already there, but if we increase the hydrogen supplied rate more, then we can reduce that oxidizing flame condition. Here then if the supply of hydrogen will be more by controlling the pressure regulator then the flame will be reducing, that flame will not be carburizing type. Because what happens here there is no carbon is available, that is why here the flame will be reducing in nature, but that flame will not be carburizing types of flame.

And if we increase the supply of hydrogen during this combustion this temperature decrease drastically and this temperature is several hundred lower than neutral oxyacetylene flame. And that is why always here we should keep in mind that metering flow regulator here permit establishing the desire ratio of hydrogen to oxygen usually 4

to 1. The oxy-hydrogen flame is useful in welding and brazing of aluminum alloy and lead. This usually used for low melting point material that is aluminium alloy and lead.

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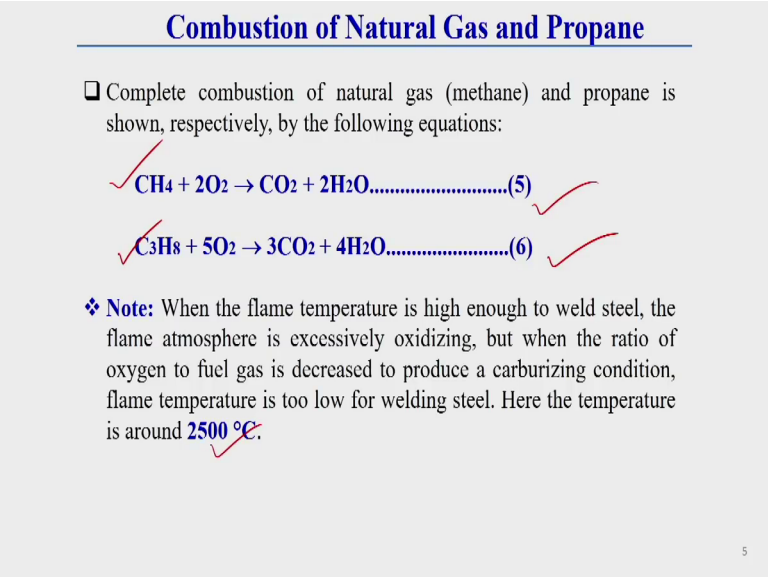

Now, we will discuss about the other fuel gases combustion that is the combustion of natural gas and propane. This equations 5 and 6 generally represent the detailed combustion chemical equation of a first equation represent the methane combustion details and second equation represent the propane combustion chemical equation or chemical reaction.

Here one things we should keep it in mind this flame also cannot produce high temperature too to the steel welding because, this combustion due to this combustion or from this flame if we go for developing higher temperature then this flame become highly oxide. These oxides or these highly oxides flame is not applicable for steel welding because this create defects in welding.

Then the for that reason if we go for reducing the oxygen to fuel gas ratio; that means, if we go for reducing the oxygen supply in this combustion zone, then this flame though it is here the oxygen to fuel gas ratio is decreased but what happens once it go for reducing the ratio then its temperature drastically reduce. So, whatever the temperature required for doing steel welding that much of temperature then it is not this types of mixture cannot be able to supply if we go for reducing the oxygen to fuel gas ratio to generally less oxygen; that means to avoid oxidizing flame.

So, when the ratio of oxygen to fuel gas is decreased to produce a carburizing condition; that means, if we go for reducing that what it is called oxygen supply during combustion then what happens flame temperature is too low for welding steel. So, that is why here this types of flame is rarely used in steel welding purpose because if we go for steel welding the whatever the temperature here it is required to get that temperature this flame become highly oxide which is not good for welding steel. That is why it is not applicable in case of steel welding. Here in this types of combustion maximum temperature rises around 2500 degree centigrade.

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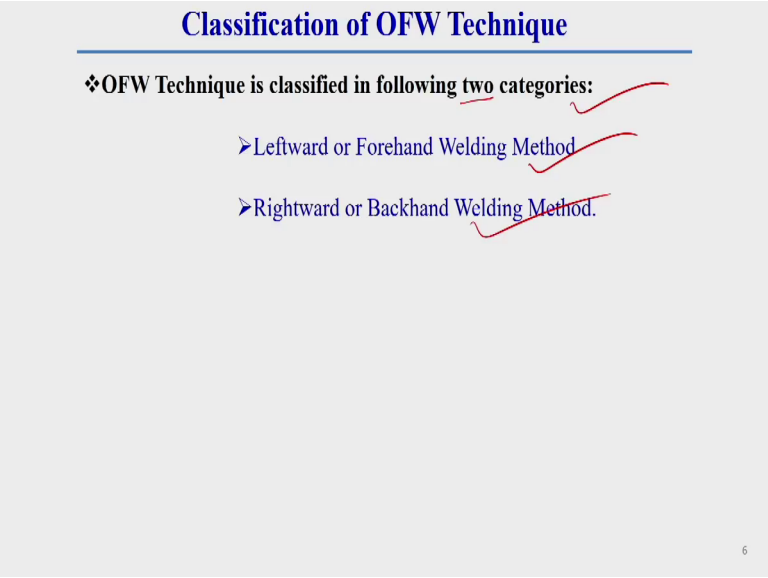

Now, we got the idea about different combustion of different oxy-fuel gases and there we have observed that how much temperature what is the range of temperature generally developed for different combustion of a different fuel gases. And we have observed that where is the application of what types of fuel gases that we already observed. Now, we will discuss about classification of oxy-fuel welding technique.

Oxy-fuel welding technique generally classified into two different categories. This two different categories are there one is called leftward technique or forehand welding method, another one is called rightward or backhand welding method; that means, rightward technique or a backhand welding method. About this welding method I will discuss in details in subsequent slides.

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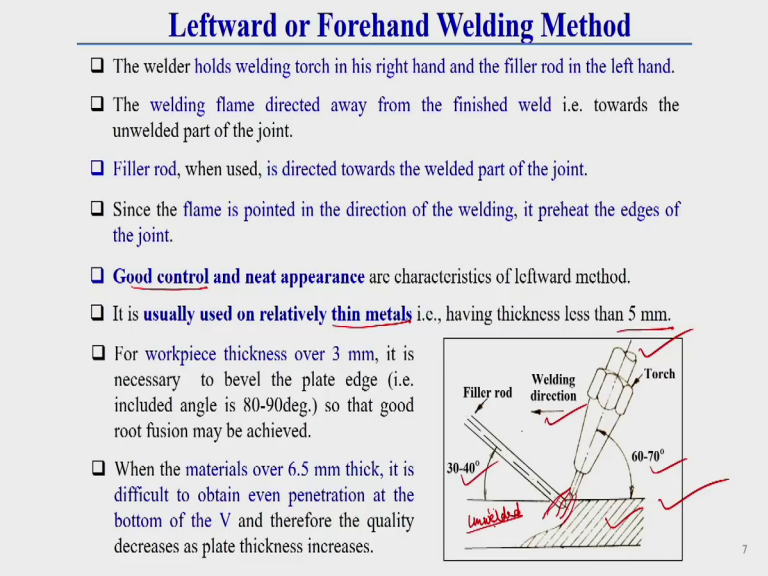

So, first of all I will discuss about leftward or forehand welding method. This is the symmetric diagram which shows the leftward or forehand welding techniques. Here the welder holds the welding torch in right hand and if the filler rod is required filler rod hold in left hand. And here the welding starts from right side and its go towards left direction; that is why this welding technique known as what it is called leftward welding techniques. Why it is called leftward welding technique? Because, it starts from right hand side and its go towards left direction. So, it is direction is left that is why it is called leftward welding technique.

Here the welding flame is directed; here we will see whatever the welding flame is coming out from this torch this welding flame generally directed away from the finish weld. You see this is hashes represent the weld wed zone and this is non welding zone. So, here this is the direction of weld. So, whatever the flame it is coming out it is directed away from the finish weld you see from here itself you can see that is it is directed towards the unwelded part of the joint. Here there is no weld this is unwelded part, here this flame is directed towards unwelded part of the joint.

Here this filler rod; so, here filler rod when used directed toward the welded part of the joint. Here you see this is towards the welded part direction this filler rod direction is toward the well weld rod, right. So, since the flame is pointed in the direction of welding and it is preheat the edge of the joint. So, you this flame to heat the edge of the joint

because flame is pointed in the direction of welding, that is why it is generally heat the edge of the joint. For that reason here good control and neat appearance are characteristics of leftward welding method. Here appearance of welding and good control of welding are there. So, this is the characteristics of this welding techniques.

These types of welding technique used relatively in case of thin metal who having a thickness less than 5 millimeter generally this leftward or forehand welding method generally use. Here you see what should be the angle of position of torch and what should be the angle of position of filler rod is also given. This is within a range of 60 to 70 for torch and for filler rod it is around 30 to 40 degree.

Here one things you keep it in mind for welding a workpiece thickness, if this workpiece thickness is over 3 mm then for this types of welding operation there is required edge preparation; that means, beveling is required in to do the welding operation. And this bevel angle or you can say included angle here is little bit higher side that is this beveling angle here it is little bit higher side this bevel or included angle has varying from 80 to 90 degree itself if the plate thickness just exceed 3 mm thickness.

So, that this beveling edge preparation is required because for this types of welding to get good root fusion or good root fusion this types of beveling is required. Here one things you should keep it in mind when the material plate over 6.5 millimeter thick for this case it is difficult to obtain even penetration at the bottom of the V; that means, at the root side of this V even penetration is difficult if the plate thickness goes beyond 6.5 millimeter thick.

That is why the quality decrease for this types of welding techniques that is why for this types of welding technique the quality decrease if the plate thickness increases. So, this types of welding general techniques is preferable for low thickness types of welding operation.

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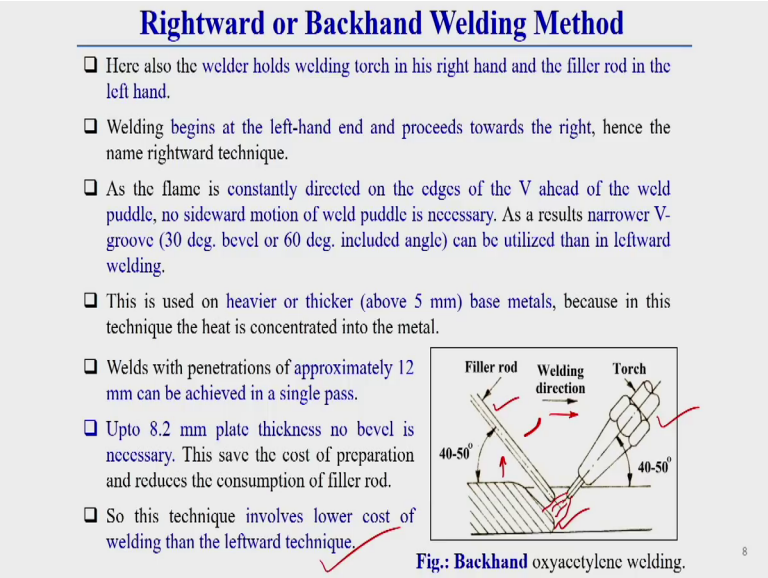

Then we will go for rightward or backhand welding method. Rightward or backhand welding method here you see here also the torch is hold in right hand and this filler rod hold in left hand. Why it is called rightward welding method or rightward technique because here the welding start from left side and it is moved toward right direction; that means, right direction. That is why this welding techniques is called rightward welding techniques then you can thinks what is why it is called backward welding method and why previous one is called forehand welding method depending upon the position of what it is called filler rod then this types of name generally is given.

Like what happens in case of here you see this filler rod position over the welded portion backside you see. Whereas, in other side so, the there is as it positioned back of the welding position of this filler rod that is why this you can called as backhand welding method and other cases you see this position of the generally filler rod is in front of the flame and which is unwelded portion of that thing. So, that is that way you can say that is generally called forehand types of welding technique.

Here as the flame is constantly directed on the edge of the V ahead of the well puddle. So, here generally one things you keep it in mind no sideward motion of the weld puddle is necessary. Here weld puddle sideward motion is not necessary because here this arc directly position toward the weld puddle direction. So, as a result here you can make narrow types of V groove. And whatever the V groove you made for left order forehand

welding method that is the whatever the bevel angle we made here this bevel angle we can reduce drastically. Like there the bevel angle or included angle was around what is called 80 to 90 degree here that bevel angle can be 30 degree or included angle can be within a range 60 degree only.

So, here as a result of narrow V groove can be utilized than in leftward welding technique. So, whatever the group used in leftward welding techniques in rightward welding techniques that bevel angle can be reduced drastically because here the arc is position towards the puddle direction. So, this forceful arc create you can say more penetration in soft material zone than other welding method. This is used on heavier or you can say thicker base plate. Especially we have seen this leftward welding technique use thin section, but where the plate thickness less than 5 mm that is preferable, but here this is used above the 5 mm base plate because in this technique the heat is concentrated into the molten metal zones.

It has seen approximately 12 millimeter thick plate can be weld by this welding techniques by single run only. So, by single run here we can do the welding tills 12 millimeter thick plate and up to 8.2 millimeter thick plate no bevel is required. Without bevel itself we can do the welding up to 8.2 millimeter thickness; whereas, in previous case we have seen that if the plate thickness exceed 6.5 mm then even bevel angle or bevel edge preparation is also not sufficient for even root fusion.

But, here it has observed that without edge preparation till 8.2 millimeter thick plate we can do welding. Here we can eliminate this edge preparation part. So, for edge preparation part there is time as well as cost is cost will be more that is why so, this techniques involve lower cost of welding than leftward welding technique.

So, from this discussion we got a very fuel very good idea about rightward and leftward welding techniques. We have observed that what is leftward welding techniques, what is rightward welding technique, what is the difference between two; that means, leftward welding technique used for thin section, there is a costlier than what it is call rightward welding techniques why because there is required this edge preparation which requires a time as well as more cost. This rightward welding technique also we observe this is preferable for thicker section why it is preferable that also we will discuss. So, this is also the difference between these two. We got a fairly good idea about this.

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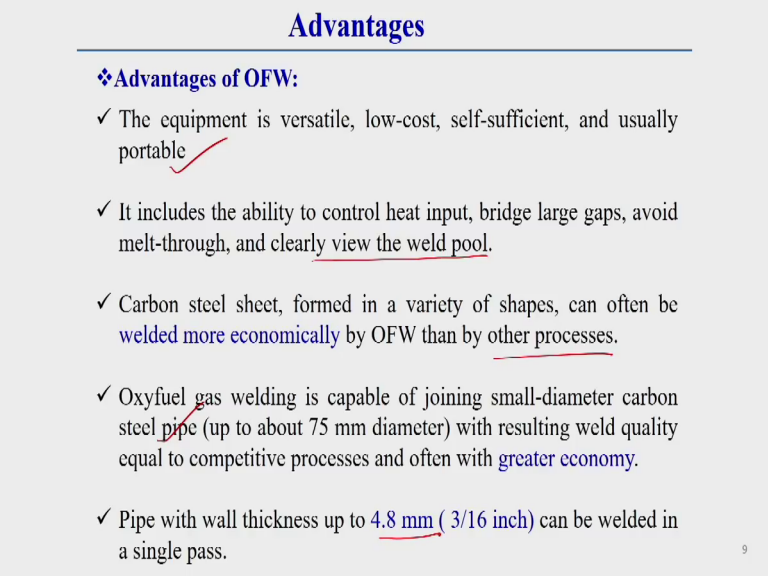

Now, we will go what is the advantage drawback of these types of welding techniques that also we should know. Here you see this oxy-fuel welding techniques have huge advantage why there is huge advantage of this welding techniques.

First of all this equipment is versatile, this equipment cost is low; that means, compared to other welding technique so, low cost, self-sufficient and usually this welding techniques is portable type. This welding equipment is portable type; that means, you can shift from one position to another position very easily.

It includes the ability to control heat input bridge large gaps avoid melt through and clearly view the weld pool in this techniques we get this types of inventory it is also clearly visible. So, we can control the weld deposition by visual inspection during welding itself. That mean monitoring of weld bead itself is possible because as this during welding this arc is well visible. Carbon steel sheet formed in variety of shape can often be welded more economically by oxy-fuel welding technique than other welding. So, here this is more economical for doing welding of steel than other welding process.

Oxy-fuel gas welding is capable of joining a small diameter carbon steel pipe small diameter; that means, this by this [welding techniques we can do a pipe welding whose diameter is only 75 millimeter diameter is only; that means, 75 millimeter diameter pipe we can do welding very preciously by this welding techniques. Whatever the quality of

welding we can get for this a small diameter pipe itself that quality is comparable with some very high quality types of welding techniques.

Pipe with wall thickness up to 4.8 mm can be welded in a single pass by this welding technique. So, pipe whose thickness is 4.5 millimeter itself can be welded by single pass by this welding techniques also. This is the different advantage of this welding techniques.

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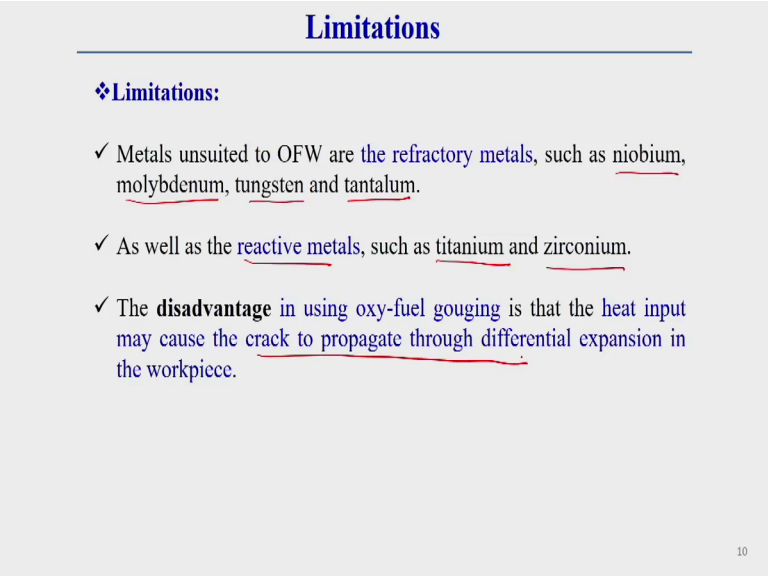

Now, we will go for limitation of this welding techniques. These welding techniques is unsuited for refractory and reactive metal generally the metal are unsuited to oxy-fuel welding or refractory metal such as niobium, molybdenum, tungsten and tantalum as generally oxy-fuel welding technique is unsuited. As well as in reactive material also or reactive metal also this oxy-fuel welding technique is not suitable; that means, reactive metal example is titanium, zirconium by this oxy-fuel welding technique difficult to weld.

Here one important things you should keep it in mind the disadvantage in using oxy-fuel gouging. Gouging means removing of welded material from some portion; that means, gouging operation is a operation by which defect we can repair, for that gouging operation is required to do. Gouging operation means first of all by oxy-fuel flame or by some arc generally, here we are discussing about oxy-fuel flame that is why here we will tell discuss about oxy-fuel; by oxy-fuel flame there is creates defective weld zone that

defective weld zone melted and by some forceful pressure of gases that molten pool generally removed.

So, what happens the disadvantage using gouging of oxy-fuel gas is that the heat input may cause crack to propagate through differential expansion in the workpiece. That means, so, what happens during this gouging operation of oxy-fuel gas what happens there is a chunk of crack propagation. If there is a small micro gap that can propagate once you go for doing gouging by this types of oxy-fuel gas. So, this is these are the limitations generally or we can say drawback of this oxy-fuel welding techniques.

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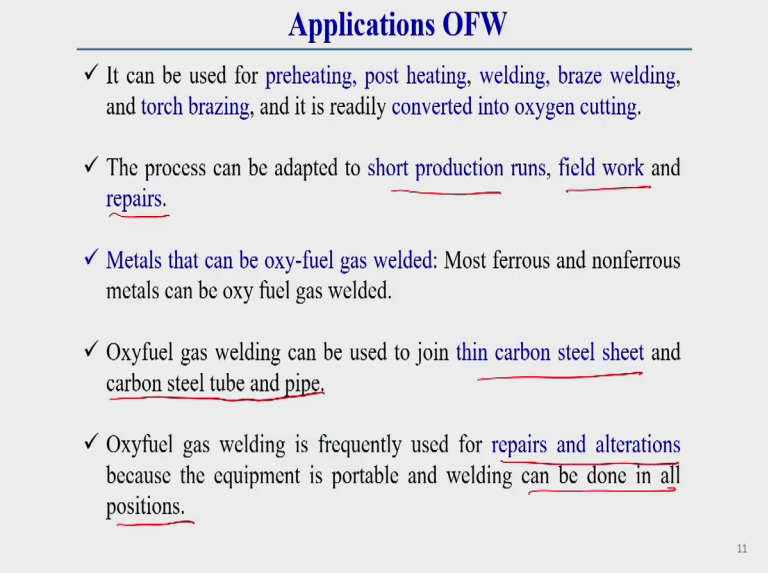

Now, where is the application? It has huge application. Like it can be used for preheating, post heating, then welding as well as braze welding then it can be used in brazing purpose also and it is readily converted to cutting operation also. That for that different types of torch is there. Cutting operation there will be some different torch is used; cutting torch is different than welding torch.

The process can be adapted to short production run, field work and repair. What I have told you it has huge applications; so, it can be produce short production run, field work repair purpose also. Then metal that can be oxy-fuel gas welding here most of the ferrous and nonferrous material or metal can be weld by gas oxy-fuel gas welding technique. Oxy-fuel gas welding generally can be used to join thin carbon sheet and carbon steel tube and pipe.

So, it is generally carbon sheet, then carbon steel tube and pipe, it has lot of application. Oxy-fuel gas welding also frequently used in repair and alteration purpose because, the equipment is portable and welding can be done in all position also; that means, here by this welding techniques we can do positional welding also. So, these are the generally application of this types of welding techniques.

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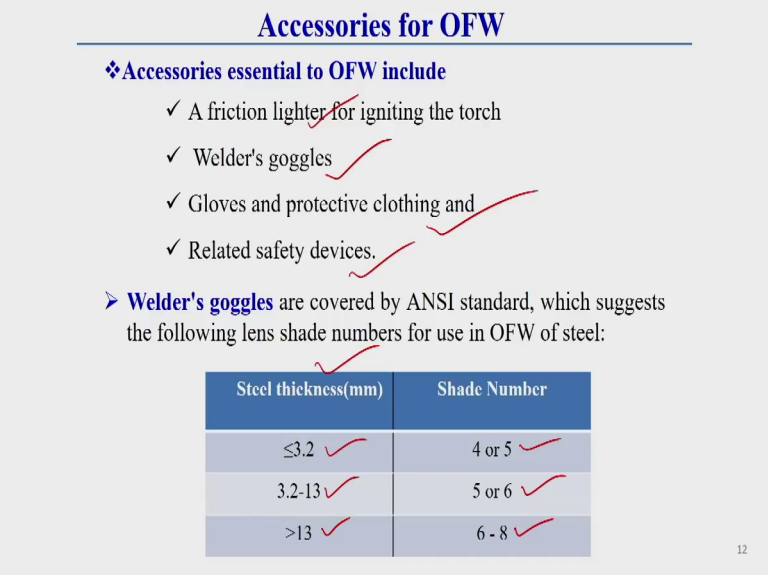

Now, what are the accessories for this oxy-fuel welding technique that also you should know. Here the measure accessories of oxy-fuel welding techniques are for starting the arc, there is required a friction lighter for igniting the torch. Then there is required some welding goggles because whatever the arc is generated this arc can be harmful to eye. That is why they are used for some goggles. So, that goggles also is a accessories of oxy-fuel welding.

There is required gloves and protective clothing also there is required. Then generally related us other safety device also is there for oxy-fuel welding techniques. Here one things you should keep it in mind because this what are the different shaded of goggles used during oxy-fuel welding technique that you should know. Little bit I am giving you some idea about these thing.

Here you see here ANSI standard goggles lens shade is giving. For different different thickness different different shade of goggles the lens shade are used. For higher the thickness higher shade number is generally used for this ANSI standard. Here this table

represent the shade number for different thickness plate like, if it is less than 3.2 mm then 4 to 5 shade number of lens of lens goggle used; if it is varying from 3.2 to 13 millimeter thick plate then 5 to 6 or 5 or 6 number shade goggle preferable; if it is greater than 13 mm thick plate then goggle size is varying from 6 to 8 higher the thickness higher the shade long shade number of lens of goggles are generally used.

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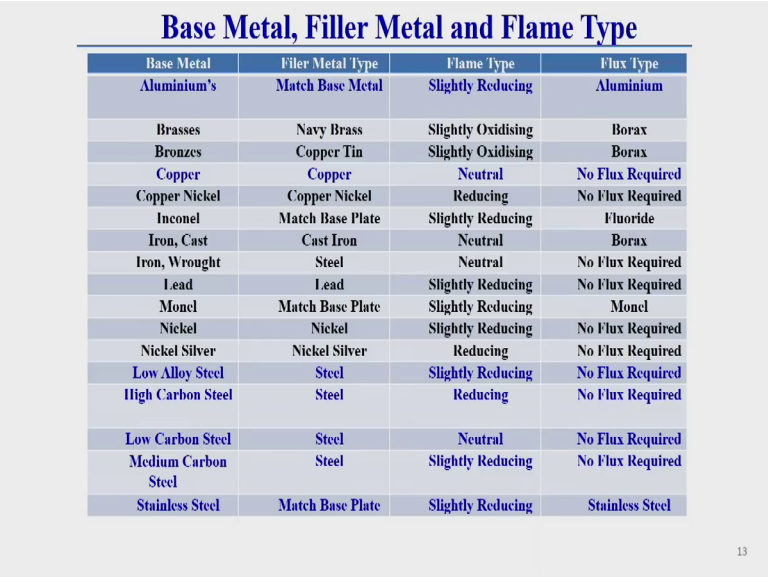

Now, this table represent for different-different types of metal, what should be the filler material type? What should be the flame type? What should be the what it is called and flux type? Whether flux is required or not that represent? From here, generally, were different different materials which is widely used in industrial application that I am showing. Here you see here just two – three I will discuss rest of the thing you can see from this table itself as per your requirement.

Like for aluminium welding generally here filler rod if it is require generally this filler rod should be match with base metal and generally for aluminium welding slightly reducing types of flame is preferable. And if the flux is required then flux is also aluminium is used. If it is brass then this types of filler what is the filler material, what is the means type of flame and what types of flux generally preferable is given borax types of flux if required that is borax is preferable. You see lot of places there is not require no flux here. You see a lot of metal there is not require flux, flux not require flux, but sometimes somewhere it is require flux then what types of flux it is required everything

is giving all types of flame required for different different metal from this you can get the idea.

This is all about this oxy-fuel welding techniques. Now, we will start different types of arc welding process. In first lecture of arc welding techniques I will discuss about SMAW; that means, SMAW or you can say this is called Shielded Metal Arc Welding techniques.

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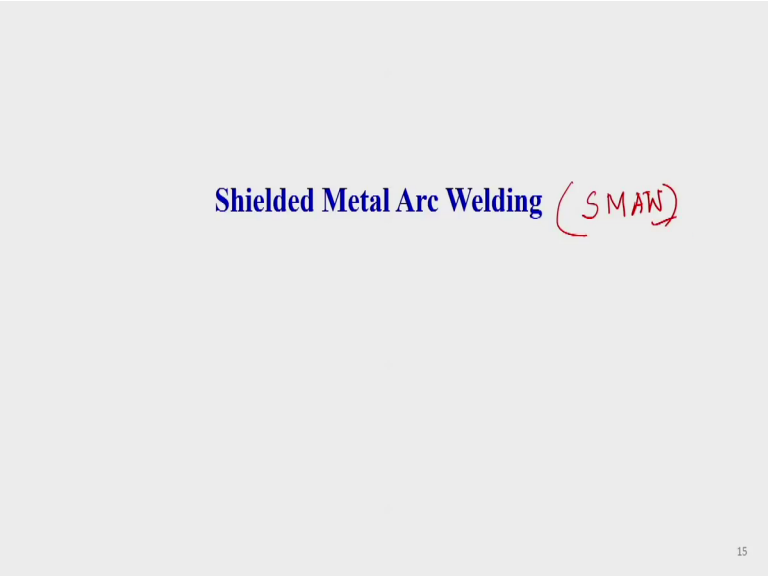

So, the last one is a gas welding techniques I discussed, now I will discuss about different types of arc welding that is first one of this arc welding techniques is Shielded Metal Arc Welding. The short form of this thing generally SMAW; S stand for Shielded, M stand for Metal and A stand for Arc and W stand for Welding. So, you see this is the short form or that what I have already discussed in nomenclature of the different categories of welding technique. There I have already discussed about this thing. So, you are aware about this about the name of this welding technique.

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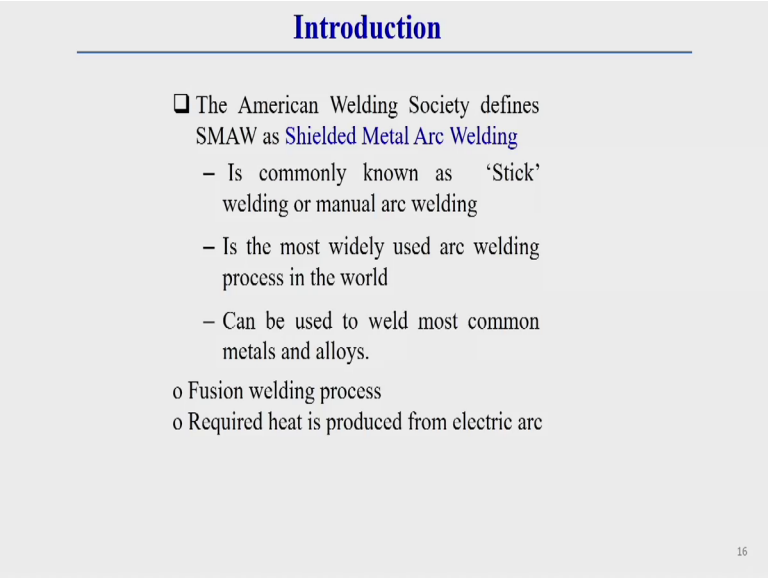

The American society define this welding technique as shielded metal arc welding is commonly known as the whatever the welding techniques you seen then this welding technique has wide application. You can say this welding techniques is widely used all over the world that is that this is the most applicable welding techniques. This is the most widely used what it is called welding techniques. It is commonly known as a stick welding or manual arc welding whatever the welding techniques you have seen there is a stick of or electrode stick electrode is there that I will discuss in subsequent, then it will be very clear to you. So, this is commonly known as stick welding or manual arc welding.

This can be used in most of the common metal and alloy. This SMAW what I have told you this is a arc welding techniques and this is another thing it is a fusion welding techniques. What is fusion I already you already know about this thing; that means, here the temperature goes of the current metal or work piece beyond it is melting point. So, that is why this is called a fusion welding technique.

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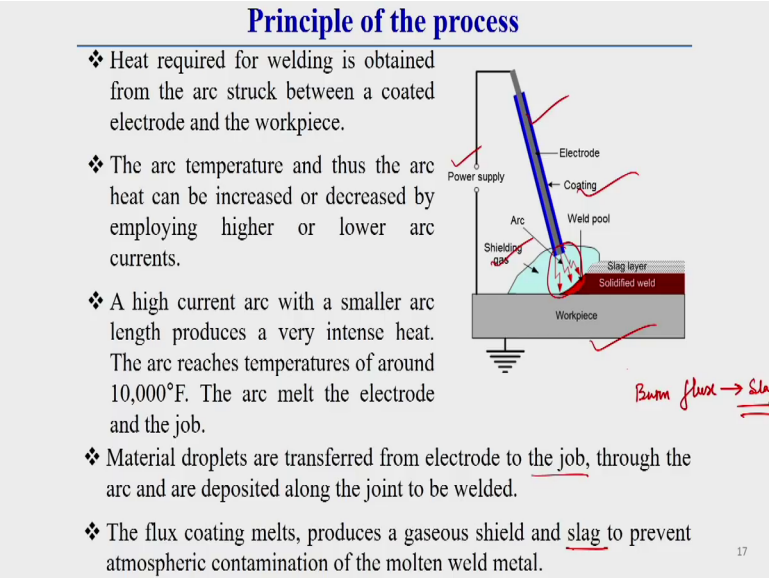

Now, one by one I will discuss in details about this welding technique. First of all I will discuss what is the principle of this welding process, then I will discuss what are the different what is the setup or different equipment of this welding process, then we will discuss what are the different constituents, then its variables, then what are the advantage, drawback different-different thing whatever the things is there in this welding category that I will discuss subsequently.

So, first of all we should know principle of the process; that means, how it is operate, that we should know. Here this symmetric diagram represent the SMAW process. Here you see this is electrode; this electrode terminal is connected to power supply, another terminal connected to work piece. This is generally the work piece. Here you see in front of this electrode there is arc. So, here heat required for welding is obtained from the arc struck between a coated electrode and the workpiece. So, whatever the heat here is required that supplied from a arc which is generated between this electrode and workpiece.

The arc temperature and thus the arc heat can be increased or decreased here this arc temperature or the arc heat we can increase or decrease by employing higher or lower arc current. So, higher the arc current arc temperature we can increase or heat input we can increase in arc. Say here a high a current arc with a small arc length produces a very intense heat. So, high current and smaller arc it produce a very intense heat here. The arc

can reaches a temperature around 10000 degree Fahrenheit the arc melt the electrode here this arc melt both electrode and workpiece.

So, here this material droplet transfer from electrode to job through the arc and are deposited along the joint to be welded. So, here generally materials droplet transfer from this electrode and it transfer through the arc itself and it is deposited in weld joint. Here flux coating melt whatever the electrode flux coating is there you see this coating melts, and produce a gaseous shield and slag when this coating burn produce both slag as well as a gaseous medium. This gaseous medium and slag prevent the atmospheric contamination of molten weld pool metal. So, this slag and what it is call shielding gas which is generated from the flux cover protect the molten weld pool from atmospheric contamination.

So, here you should know what is the slag? Slag means when this flux cover burn then this burn flux is called slag. So, what we can say? So, burn flux called slag, so, after burning flux converted to slag ok. So, inside slag generally there can be impurity also of the base material. So, this is the principle of this SMAW welding process.

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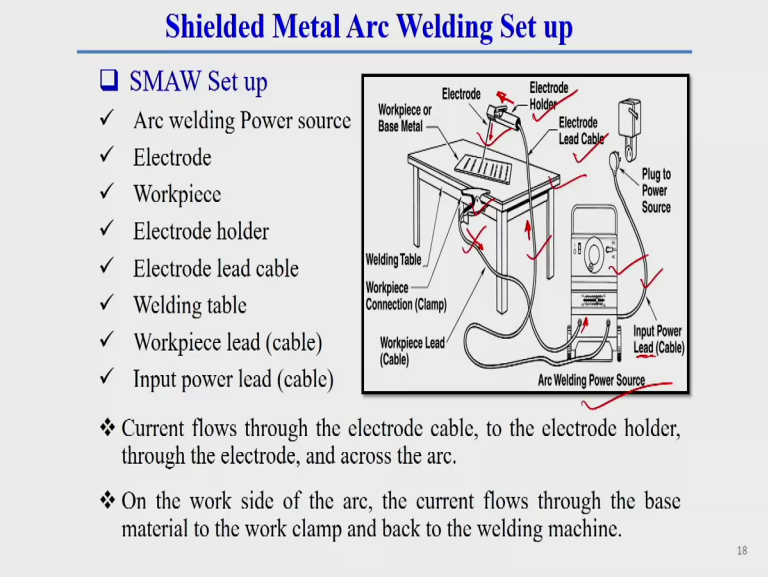

This represent the setup of shielded metal arc welding, this figure represents. Here you see here this is called power source, so, there is a power source. There is you see input power cable or using this power cable also sometimes call input power lead ok; cable is also sometimes called lead. There is a electrode lead cable is there, this is electrode lead

cable, this is called workpiece lead cable and there is a working table, there is a clamp; you see this is generally clamp is there is a electrode is there and electrode holder is there. These are the major component of this welding process.

So, here the major component is 3 different cables are there; one is called input power lead cable, electrode holder cable holding cable, then workpiece lead cable, there is a clamp, there is a electrode holder and a electrode and apart from this thing there is a welding table. This welding table should be metallic because what happens this current should conduct through this welding table also. Here how the current is conducting?

So, here current conduct from this electrode lead cable to electrode holder; to electrode holder, then it comes to what it is calls electrode and then workpiece. And from workpiece it is come to this clamp then it is come to this what it is call workpiece lead or workpiece cable and it is return brick return back to power source. This way a circuit is completed.

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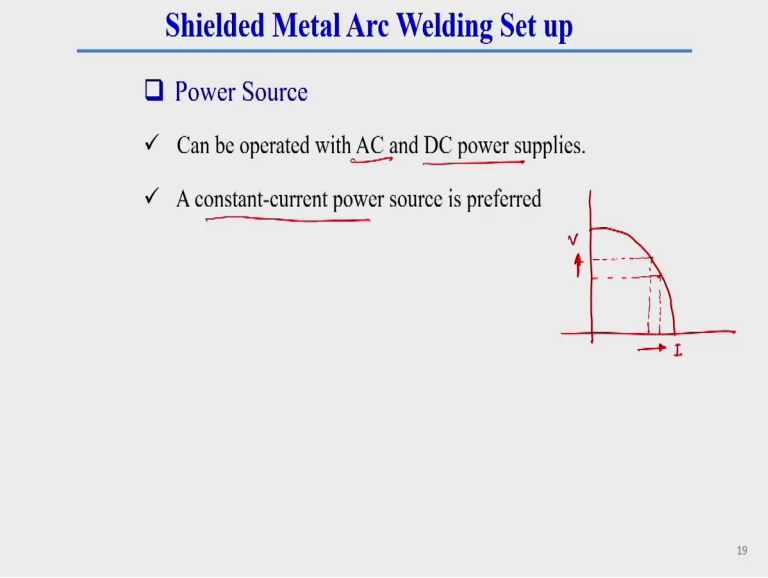

Now, this is the generally shielded metal arc welding set up. Now, we will see what types of power source used in case of SMAW. We already know as it is a manual types of welding process. Why it is manual types of welding process that also I will tell, whatever the electrode here is used this electrodes provided a coating, this coating brittle in nature. So, what happens supplying of this electrode by some automatic feeding mechanism or by some phase roller is difficult and winding of this types of coated electrode is very

difficult in a roller. So, that is why what happens here contain means continuous feeding of that types is things is not possible.

So, that is why this types of welding technique done by manual operation; that means, manual operation I have already discuss where this welding is speed and feeding of this electrode is done manually. Then this is call manual types of welding operation. Here this welding power source is AC is can be AC or DC power source, but here characteristics of this power source is constant current types of power source characteristics is preferred. Why constant current types of power source is preferred that I have already discuss little bit I am just telling here also for recalling purpose.

Constant current power source characteristics we know. Voltage current constant current power source characteristics look like this. This is also called drooping characteristic. Here what we observed there is a small change of current or a small change of voltage in a small change of current will be there. So, we during manual operation of the if there will be due to shaking of hand and other things, if there will be any arc length variation; due to this arc length variation if there will be any change of arc voltage then what happens this current rise or current drop will not be very high.

Then what happens there is a chance of high charge of current is less. So, that is why this is used here constant current power source characteristics is used. Now, these are the detailed constituents of SMAW process. Here from this diagram itself you can see.

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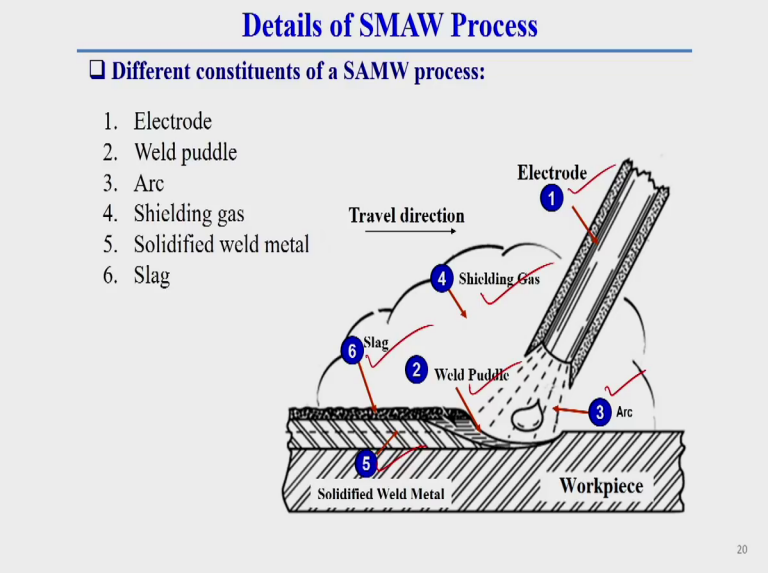

Here the in case of SMAW process there is used a electrode, then you here is a weld puddle, second one is weld puddle, there is a arc, there is shielding gas which is generated due to burning of this coating electrode coated electrode flux. Then, there is slag; slag means after burning of this flux generally it is float over the solidified weld metal and it is solidify, then this is generally called slag and this is generally called solidified weld metal also.

So, these are the different constituents of this SMAW process. About this constituent I will discuss in details in subsequent slide.

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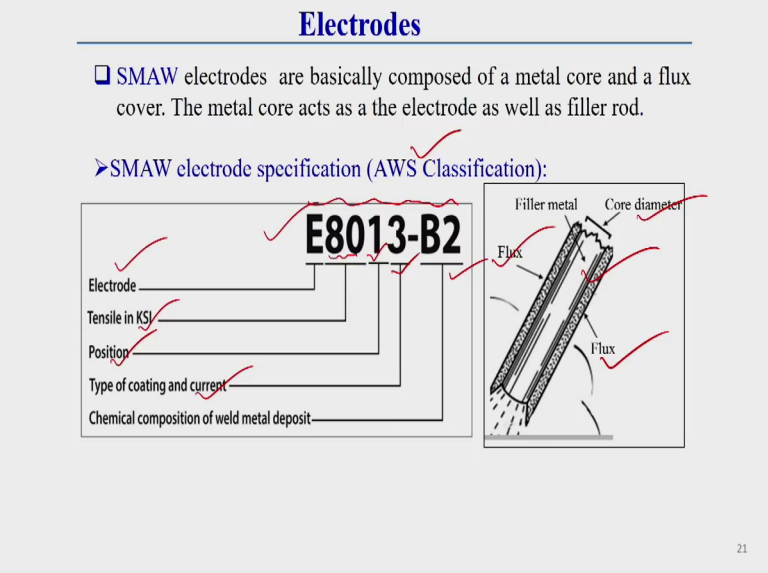

So, the first of all I will discuss about electrode. So, you see generally SMAW process the electrode what I have already told you there is a core metal wire, over this core metal wire there is flux cover. So, you see this is symmetric diagram represent here you see there is a core wire, metal wire through which current is flowing and over this core metal wire there is flux cover; you see the there is flux cover there.

This electrode is used as a consumable as well as this electrode supply consumable material, as well as what happened it act as a electrode. Mentions through this current is passing for generating the arc as well as it generally melt and supply melt material to workpiece. So, this is a consumable types of electrode, so, this is SMAW this electrode is consumable type . Here I am showing a simple electrode specification here know the

characteristics or we can say how to know the type of electrode used in SMAW process for that I am just giving a single example of this electrode specification.

There is different different types of specification is there. Here just showing a American welding society classifications one example I am showing. Here to see this different part of this nomenclature you can get the idea about the type of electrode, where we should use this electrode, what type of flux cover is using; to see this different symbol or we can say to see this different number or letter we can get the idea about details of these electrode types.

This is a example of electrode specification of SMAW process. Here you see this E represent for electrode, this second two word or three word here this if it is second two word or three word is there this is represent tensile strength that is in KSI then this word represent the position; that means, 1 for all position, 2 for a flat or horizontal position. This types of details is given in classification book from where you can get the idea. Then this last number represent type of coating and what types of current generally used and at the end this B2 represent the chemical composition of the electrode or we can say that weld metal deposit.

So, to see this different number or different word itself or if you check 18 classification rulebook there you can get the idea what does it means. So, for a particular types of welding operation, if you just choose the type of different thing then based on this characteristics of your welding process you can decide your electrode. So, if you just provide this number to supplier or any company they can easily supply you the what happens electrode as per your requirement. So, this is electrode.

So, here what I have told you the primary function of a electrode I have a flux cover and a core metal wire. So, this flux cover have a significant generally significant function during welding operation. This flux cover when it is burned generally it is produced some shielding gas as well as slag cover. So, what happens this shielding gas and this slag provide the shielding medium of molten pool from atmospheric contamination. It has seen that so, this flux has significant function in welding which determine the quality of welding we can say because it prevent the atmospheric contamination.

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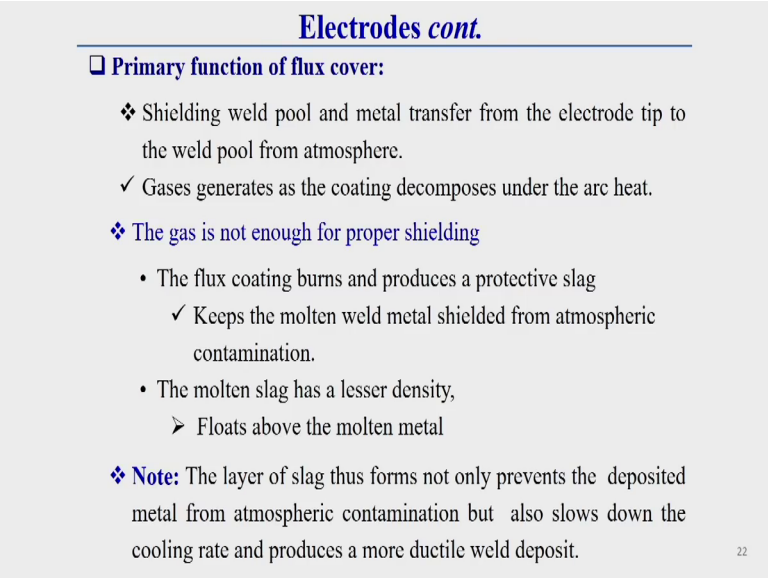

So, these gases generated as the coating decompose under the arc heat. So, these gas sometimes is not sufficient for proper shielding. That is why whatever the slag it is forming that slag due to burning of flux that slag have lower density than molten metal weld molten metal. So, due to this lower density of that slag, it flow towards the surface of the weld pool. So, due to this what happens if float the surface of the weld pool and it is also act as a protecting medium of molten pool from at atmospheric contamination.

So, this slag protect from atmospheric contamination as well as it has a very excellent function on welding process that excellent function also it reduce the cooling rate of the molten metal. So, as the cooling rate reduces here due to the slag this weld zone will be more ductile. So, it is also produce a more ductile weld deposit. This is the primary function of flux cover.

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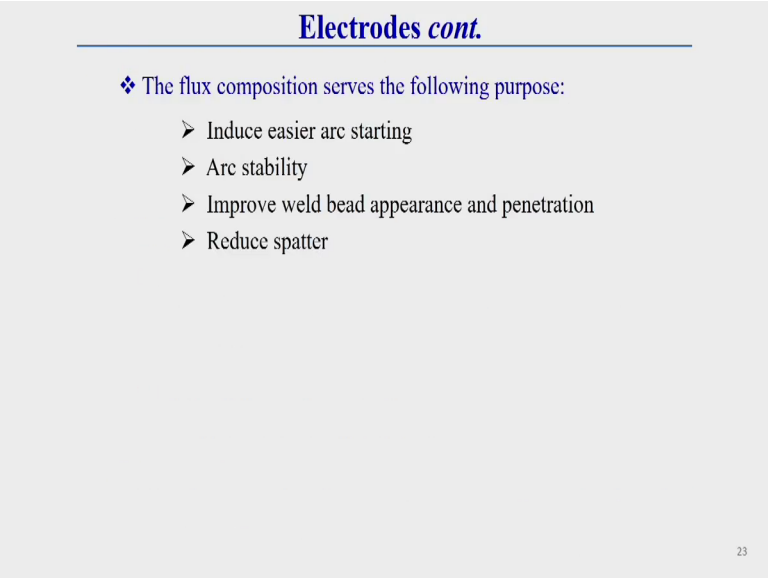

Now, the flux composition serves the following purpose; that means, this flux composition also induce easier arc starting, this flux composition provide arc stability. It is also improve weld bead appearance and penetration and it also reduce the spatter during welding operation of welding operation.

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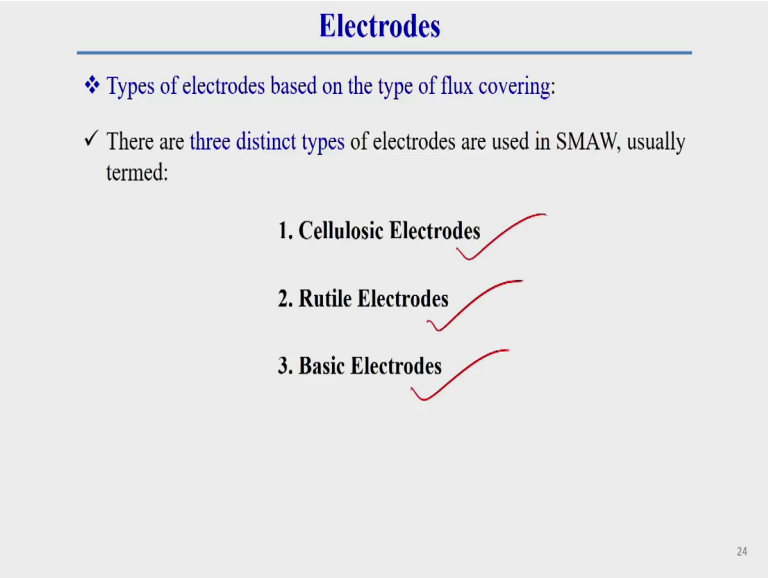

Now, we will discuss about different type of electrode which used in case of shielded metal arc welding process. In case of shielded metal arc welding process there are depending upon the composition of this flux cover, this can be categorized into 3

different category, this 3 different categories widely used in shielded metal arc welding process. These are one is called cellulosic electrode, second one is called rutile electrode and third one is called basic electrode.

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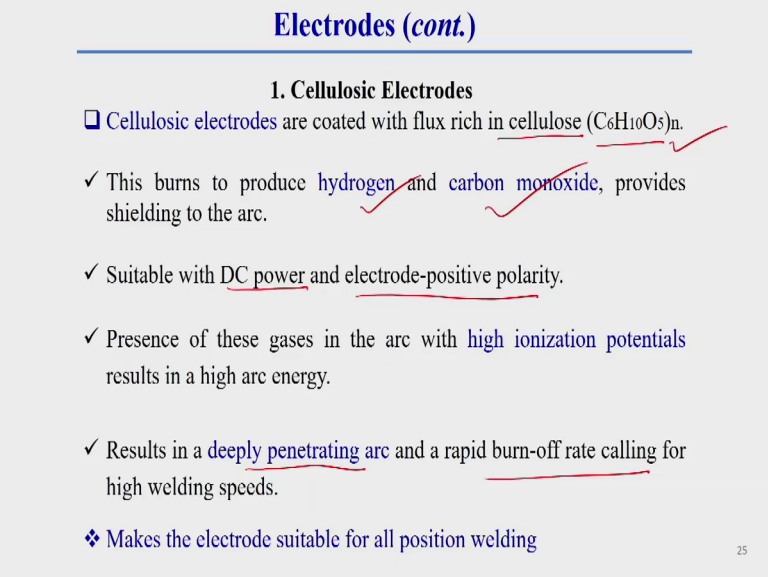

Now, one by one I will discuss in subsequent slide. First of all I will discuss about cellulosic electrode. You see cellulosic electrodes are coated with flux rich in cellulose. So, whatever the flux cover we are using they are generally rich of cellulose is there cellulose is a chain of C6 H10 O5. So, this rich of these composition is there in this electrode. So, when this electrode or a flux burn then this produce hydrogen and carbon monoxide.

This types of cellulosic electrode generally suitable for DC power source and it is also suitable for electrode positive flux is that means, DC with DC EP, Electrode Positive polarity generally these types of electrode is preferable. Now, here one things you can keep it in mind this hydrogen and carbon monoxide this types of gas have high ionization potential. Due to this high ionization potential has result in a high arc energy.

Why this high arc energy is there that I have already discussed in case of helium types of gases, there also I discussed. Due to this high arc energy because where due to this high ionization potential here voltage also is in higher side due to this high arc energy is there. So, due to this high arc energy by this electrode you can get deep penetration and due to

this high arc energy are there. So, it will provide more heat. So, here the burn-off rate also will be increased.

So, if burn-off rate as well as penetration will increase by this electrode so, we can increase the speed of the welding also. So, that is why it generally calling for high welding speed. Here another things we should know that makes the due this high penetration and you see this high power arc, these electrodes suitable for all positional welding means it can be used vertical horizontal. These are the generally vertical horizontal down hand these are the different types of positional welding technique that you already know about this thing. These types of electrode you can use almost all types of positional welding process.

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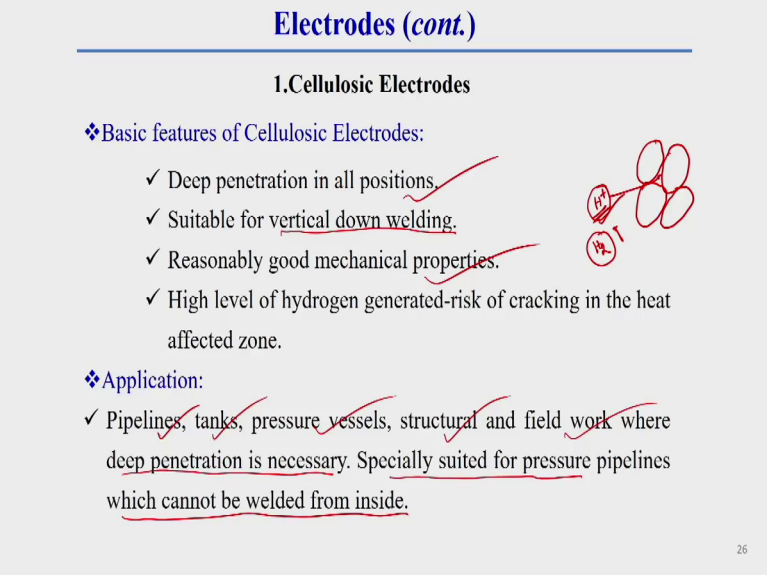

But, here you say you such see this is basic feature of cellulosic electrode. What are the basic feature? By using the cellulosic electrode you can get deep penetration in all position. This types of electrode is more suitable for vertical down hand welding; vertical down hand means like this; that means, vertically down hand direction and horizontal means like this. So, vertical means like this; this is overhead second is the gravity overhead. So, if this is generally you can do successfully a very critical types of welding processes is vertical down hand welding process that also you can do successfully by the using this cellulosic electrode.

Here you can get a reasonably good mechanical proper welding. Here though this has different advantage, but what happens this welding have a drawback also. This drawback of this welding it can generate hydrogen induced crack in heat affected zone. So, hydrogen induced cracking they can generate due to the generation of hydrogen due to this cellulosic burn. This hydrogen whatever the hydrogen is generating this hydrogen can generate some hydrogen crack in heat affected zone. This hydrogen cracking, how it is generated? Little bit I am giving the idea.

Generally hydrogen molecules or you can say hydrogen molecules at high temperature converted to hydrogen atom. So, hydrogen atom these hydrogen atom, it is enter inside the gap of grain boundary. So, you see here this hydrogen atom entered at high temperature. So, what happens; once the welding temperature is reduced, this hydrogen atom converted to hydrogen gases. Once it converted to hydrogen gases, then it is volume are generally drastically increase.

So, during high temperature they are generally stored this hydrogen atom during cooling this hydrogen atom combined together and form hydrogen gas. Due to this hydrogen gun formation generally there is double of high volume of hydrogen gas. They which hydrogen gas volume is higher than this hydrogen ion or you can say hydrogen ion volume. So, due to this high volume; due to this high volume of hydrogen gas in this is space it create huge pressure. Due to this huge pressure there can be slip of a two grain boundary can be there.

So, due to the slip of two boundary there can be what it is call, there can be cracking. So, what happened this thing generally also call hydrogen embrittlement. Due to this hydrogen embrittlement means due to this hydrogen gas formation and what happens due to this hardness of this zone, generally there is a chances of slippage of grain boundary has there. Due to that what happens there can generate a crack. So, this is called hydrogen induced cracking. This thing generally occurs near the heat affected zone. So, for by using this types of electrode there is a chances of hydrogen induced cracking.

So, now what is the application of this types of electrode? This application is there is lot of application of these types of electrode like it is used in pipelines, tank, pressure vessel, structural and field work where generally deep penetration is necessary. Especially these types of; these types of electrode is suitable for pressure pipeline which cannot be

welded from inside. That means, the pressure pipelines which cannot be weld from inside there this types of electrode is fitted.

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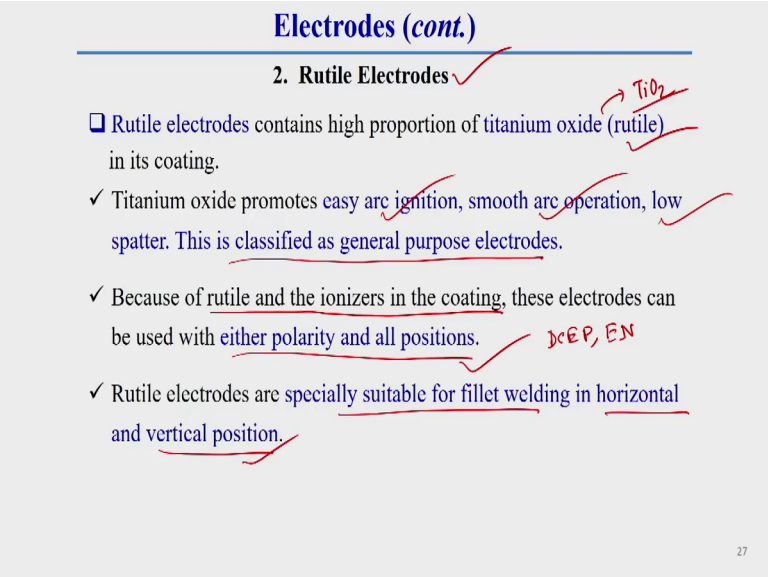

Now, another electrode I will tell and then next class I will discuss in details about rest of the thing. So, this is called rutile electrode. This is the next category of electrode is rutile electrode. Here why it is called rutile electrode because here the high proportion of rutile are there rutile is titanium oxide rutile called titanium oxide. So, once in the flux cover there is high proportion of titanium oxide are there, then that types of coating is called rutile types the rutile coating or that types of electrode is called rutile electrode.

This titanium oxide promote easy arc ignition, smooth arc operation, low spatter. This is classified as general purpose types of electrode and because of rutile and ionizer of the coating this rutile and ionizer coating this electrode can be used in either polarity and in all position welding. You see this cellulosic electrode preferable in DCEP, but these types of rutile electrode you can use both the polarity; that means, here this you can use both DCEP as well as EN – Electrode Negative polarity also you can use because due to this rutile and ionizer in the coating.

Rutile electrode especially generally suitable for fillet welding in horizontal and vertical position. Though it is suitable for wall position, but that was is more suitable for horizontal as well as vertical position of fillet welding also.

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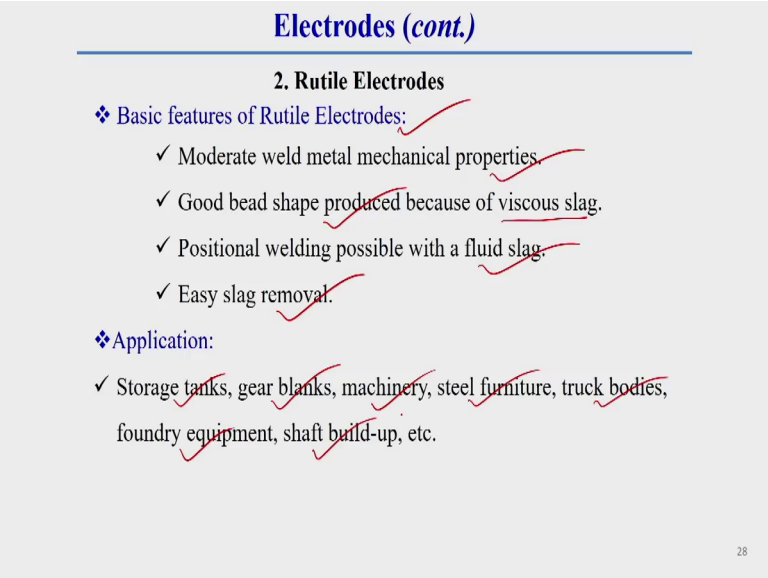

This is the basic feature of this rutile electrode. Here moderate weld metal mechanical property we can get by using this electrode. Good bead shape produce because of viscous slag, due to this rutile material the slag whatever it and this slag become viscous type. That is why here the due to this viscous or viscous types of slag the bead shape can be good quality. And positional welding possible with these fluid slag.

And here one things you should remember here generally slag removal also comparably easier. This application of this rutile electrode have application in storage tank, gear blank, this is the generally practical application of this types of electrode, machinery, steel furniture, tank bodies, foundry equipment, shaft build-up. So, there is lot of application of this rutile electrodes are there ok.

So, in next lecture I will discuss about the rest of the types of electrodes in detail and what are the different of application, then different advantage, drawback of this welding process I will discuss in details in next lecture.