Fundamental of Welding Science and Technology

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Lecture - 21
Gas Tungsten Arc Welding (GTAW)

In last lecture, I was discussing about SMAW process and I have completed the SMAW process there we discussed detail about SMAW process that was a arc welding process actually. Today also I will discuss about a another arc welding process SMAW process generally a consumable types of electrodes generally used today whatever the welding process I will discuss that is a generally non consumable types of electrode here used to generate the arc here, a non consumable electrode tungsten is used this welding techniques name is GTAW process or that full form of GTAW process is Gas Tungsten Arc Welding process. This is also simply it is known as TIG welding process that is Tungsten Inert Gas welding process.

Why it is called tungsten inert gas arc welding process? because here a tungsten electrode is used and a inert gas is used to shielding the molten pool as well as electrode a from atmospheric contamination that is why it is called that in a other shielding gas is generally is a inert gas that is why it is called tungsten inert gas arc welding process also. I will now, I will discuss in details about this welding process generally will generally whatever the flow of a lecture a where they are in previous lecture like in SMAW here will be also the similar flow there will be introduction of this welding process.

Then principle of this welding process, then this setup of this process and if there will be any categories or welding parameters or important parameters of this welding process then that I will discuss and at the end I will discuss the advantages, disadvantages and application. So, this is the generally flow of the lecture about whatever the welding techniques I will discuss in this course this will be the flow of our lecture.

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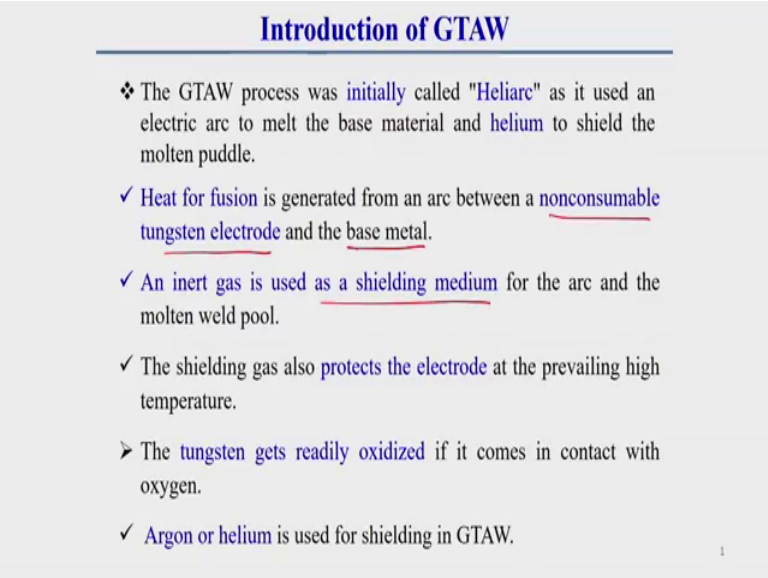

So, first of all I will discuss about introduction of GTAW process, Gas Tungsten Arc Welding process was initially called as Heliarc why it was called is Heliarc because here use a shielding gas that was helium gas and here to generate the heat here was use a electric arc. So, combination of this helium gas as a shielding medium and the electric arc. So, from helium's heli was taken and from arc from electric arc; arc was taking and we combining this combinly this was called as generally Heliarc, it was invented generally in 1939 it is long back actually.

Here generally what happens here heat for fusion is generated from an arc between a non consumable electrode and base metal, this non consumable electrode is tungsten electrode it is not consumed during welding operation. It remain as it generally it is not consuming or melting of that electrode is taken place that is why it is called non consumable electrode, through this generally only current is flowing and it is responsible for generating the arc.

So, here generally it is not act as a filler ware generally here an inert gas is used as a shielding medium for the arc and the molten weld pool, there one thing you should keep it in mind this inert gas or the shielding medium not only protect this molten pool from the atmospheric contamination at high temperature it is also protect the electrode; that means, this tungsten electrode from atmospheric contamination.

Generally at higher temperature tungsten is very reactive with oxygen, that is why what happens the tungsten gets readily oxide if it come in contact with oxygen especially if the temperature is little bit higher side. Then here generally another things you keep it in mind here either argon gas as a inert gas is used or helium as inert gas generally used or combination of this can be used as a inert gas in this welding process.

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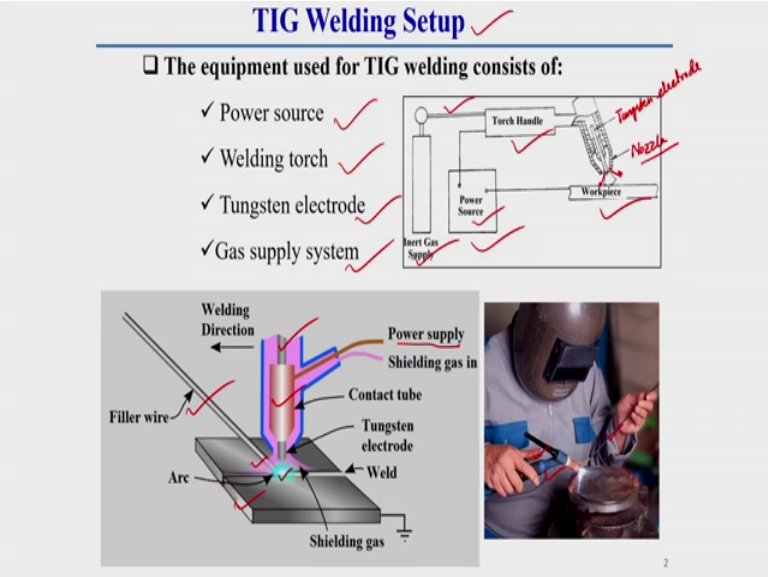

Now, this is the TIG welding setup or we can say GTAW welding set up here the equipment used for TIG welding here it is showing, here use a inert gas supply cylinder, it can be argon gas, it can be helium gas or it can be a mixture of argon helium gas. Here is used a power source this is the power source with this inert gas holes is connected to this torch and it is go to this nozzle here you see this is called nozzle and this is called tungsten electrode tungsten electrode.

So, through this generally this inert gas pass through this torch handle to this nozzle and it cover this it is flow around the arc. So, it generally cover this molten pool arc as well as electrode also, what I have already discussed previously. So, here you see this is generally power source this power source can be AC power source or DC power source this power source one terminal connected to the workpiece another terminal connected to the torch.

Generally torch actually what happens, torch there is a contact tube is there this contact tube here this is here it is more clearly shown here you see this is generally called contact

tube with this contact tube this power supply cable is connected. So, another terminal is connected to this workpiece here you can easily see this is shielding gas this is generally call tungsten electrode and you see this is here over arc is generated.

Here some time generally if filler material is required this filler material is supplied separately this is called filler wire or filler rod which is generally used during welding operation with this is act as a consumable material this filler wire it does not carry the current, but it is act as a consumable material, it generally melt by the arc and what happens is melted and it is melted and it is deposited towards the weld pool.

So, this is generally detail setup of this welding process it has generally a power source a welding torch, a tungsten electrode and a gas supply system are there. This is the actually practical view of this gas tungsten arc welding set up here you see this is left hand, this is filler wire and in right hand this is a torch here, you see there is a control there is a control switch at the thumb.

So, generally by pushing these things there we can control the flow of gas flow rate and other things we can control by pushing or pulling this knob we can control the gas flow rate ok. Now, you see now we will discuss more details about this TIG welding set ups.

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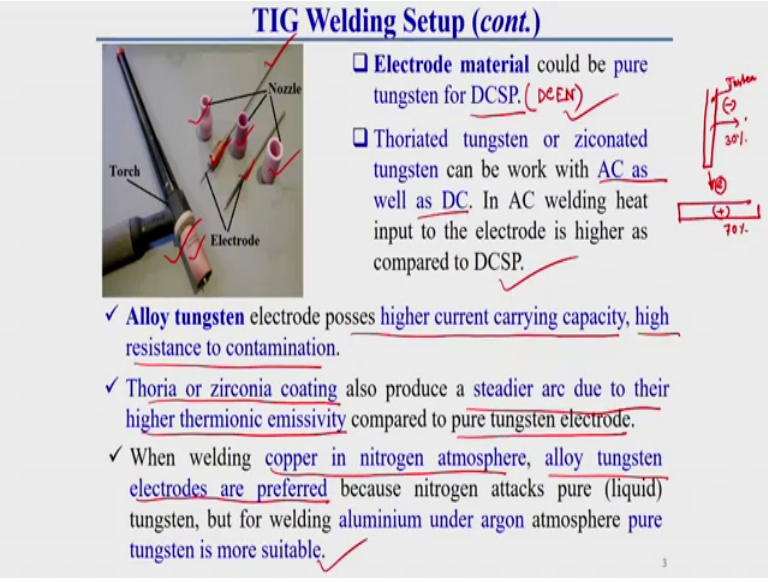

Here it is the original or a actual setup of this TIG welding process this is called a torch and this torch there is a nozzle you see, this is nozzle where this here I am showing this

is that this nozzle size also depending upon the gas pool rate this nozzle, nozzle size generally varied that I am showing. Here you see this is generally tungsten electrode this is tungsten electrode how it is look like, this tungsten electrode size also varying it is generally varying it varying from depending upon the requirement generally it is varying it is size it is maximum size within a range of around 4.5 millimeter diameter.

And you see this is generally called contact tube ah; that means, through this generally this tungsten electrode is pass and from this contact tube connected to the power source through connecting cable. So, through this generally this current pass through this contact tube to electrode here one thing is you should keep it in mind these electrodes can be your tungsten or it can be generally some alloy tungsten; that means, here this pure tungsten here you should know what is the difference between pure tungsten alloy tungsten.

Pure tungsten generally temperature resistance or comparatively lesser than alloy tungsten, alloy tungsten can carry more temperature than pure tungsten. Apart from this thing it has high resistance to contamination also in alloy tungsten, but what happens in some cases what it is called? Alloy tungsten is preferable in some cases pure tungsten also preferable, where it is that I will discuss in details in here. Electrode material could be pure tungsten especially this can be pure tungsten if the DCSP is used.

DCSP means direct current electrode negative if the electrode negative terminal is used because, if the electrode negative terminal is used then what happens you can see from here itself, if the electrode is negative terminal if it is negative terminal and if it is positive terminal, then what happens? Bombardment of electron will be taken place to workpiece.

So, what happens here? Less heat will be generated in case of tungsten electrode in case of this tungsten electrode, tungsten electrode generally less heating put around 30 percent that I have what I have already discussed and here generally 75 percent heat will be there. So, here as here less heat will be generated that is why pure generally pure tungsten we can use in case of DCSP they because what happened there are no need to alloy the alloyed the what it is called tungsten material.

That is why pure tungsten it is easily be used if the a straight polarity is there because less heat is generated. So, what happened less chance of contamination of electrode are

there or less chance of molt melting of the electrode will be there that is why DC en generally for DCEN we can use pure tungsten. But generally alloyed or we can say generally alloyed or coating electrode like generally thoriated tungsten or zirconated tungsten is used in AC or DC as well as AC current this thoriated alloy tungsten or zirconated alloy tungsten we can use both AC and DC why?

Because generally if we used a DC EP also we can use these things they DCEN DCEN is possible apart from DCEN, here we can DCEP also because this alloyed tungsten electrode generally height thermal resistance power, that is why what happens due to the thermal resistance we can use this alloy tungsten electrode. And in AC why it can be used? In AC generally C is a combination of direct polarity; that means, DCEP as well as DCEN.

So, what happens here generally compare to a straight polarity or DCEN in case of AC generally due to this combination of DCEP and DCEN in case of AC generally more heat is generated. So, what happen else here more heat is generated it is better to use alloyed a alloy tungsten electrode here, that is why generally in case of AC as well as DC there the DC we can used this what it is called this alloyed tungsten electrode.

Alloy tungsten electrode what I have already told alloy tungsten electrode causes high current carrying capacity, high resistance to contamination, it is generally high resistance to contamination also. Thoria or zirconia coating or this thoria or zirconia, coating also produce a steadier arc due to their higher thermoionic emissivity compare to pure tungsten electrode. So, whatever the arc we get from pure tungsten generally if we use alloyed tungsten electrode there we can get better or a more a steadier types of arc.

Apart from this thing here one thing you should keeps in mind generally this thoriated or pure generally tungsten pure tungsten or this alloy tungsten have some a specific application also. When welding of copper like in nitrogen atmosphere once we do welding copper in nitrogen atmosphere then this alloy tungsten electrode are proffered this you should keep it in mind, alloy tungsten electrode are prefer.

Because nitrogen generally attacks pure tungsten very easily; that means, once it is higher temperature or at molten state and to molten state generally nitrogen attack the pure tungsten that is why, if we use alloy tungsten over there then what happens chances of this attacked will be less; that means, reaction will be less.

So, what happens that is why for copper welding especially this is some specific a special case once we go for doing welding of copper material by using nitrogen gas, then we should use this alloyed what it is called alloyed tungsten electrode. Whereas, for aluminum it is preferable to use pure tungsten compared to alloyed tungsten electrode that that also you should keep it in mind.

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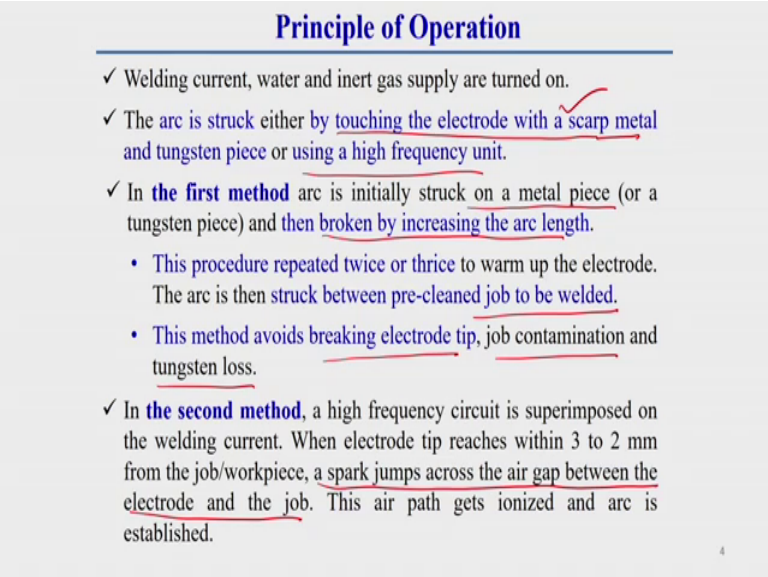

Now, we will discuss what is the principle of this operation ? Principle of this operation here generally; that means, for the ; that means, detail of the principle of operation is first of all first of all we have to switch on the power source; that means, welding current then water and inert gas supply or turned one first of all we have to do. Then the arc is a struck between work piece and electrode either two different process either by touching the electrode with scrap material or is scrap material or using a high frequency unit.

So, these two method generally used to generate the arc between electrode and work piece, that is by touching electrode with scrap metal or using some high frequency unit. So, in the first method generally; that means, touching the electrode with scrap material what it is do generally in the first method arc is initially a stuck on a metal piece or a tungsten piece that is a scrap metal and then broken by increasing the arc length, then this arc is extinguish by generally increasing the arc length between the work piece and electrode then generally there is a arc extinguish.

So, this arc extensionally should repeat two to three times to warm up the electrode, then the arc is a struck between pre cleaned job to be welded ; that means, so after of warm up of the electrode; that means, two to three times in a scrap material then we have to do the actual welding operation. So, that then we have to struck our arc after two to three times in scrap material we have to start our arc stop the welding arc to pre cleaned actually, this should be clean pre cleaned job to be welded there we have to start the arc.

Then if we do in this way; that means, before starting the actual welding if you warm up the electrode to two to three times in a scrap material then what happen this method avoid breaking of electrode tip, job contamination and tungsten loss. So, these are the things if we do it like this, then we can eliminate this things; that means, job contamination breaking of electrode tip and tungsten loss.

In the second method, that what I have already discuss in details when I was discussing starting of arc that is a high frequencies unit high frequency unit consists of what I have already discuss, it is consist of a high voltage and low current equipment these high voltage and low current which is passes through very high frequency. That is why a high frequency circuit is generally superimposed on the welding current here. So, when the electrode tip recess within 3 to 2 millimeter from the job or work piece, generally a spark jump across the air gap between the electrode and the job what I have discussed already.

Then due to this a spark jump across the air gap between electrode and job generally the arc air per get ionized and arc is established this is another way or this is another way generally to struck the arc, this is the principle of this TIG welding operation.

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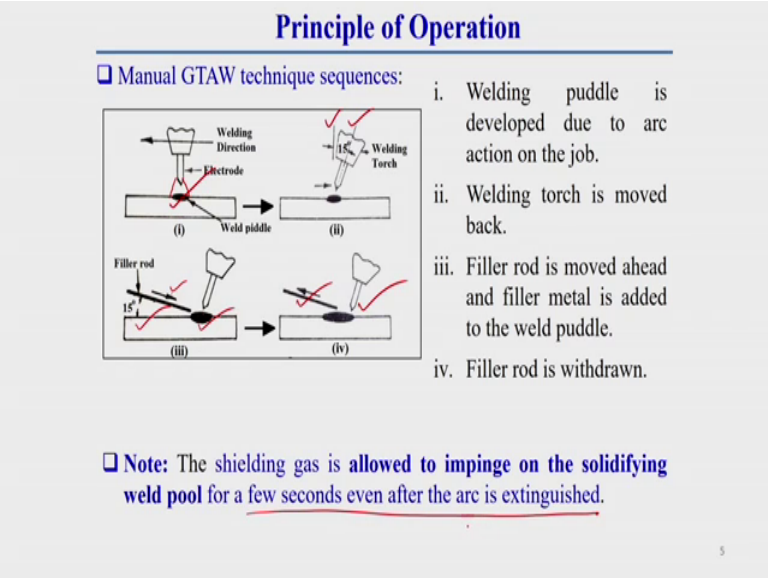

Now, will go for what are the different sequence of this welding process that also we should know because how the welding is start and how it should finish and what should be the sequences of this process that is also you should know that I am showing here.

In case of manual GTAW process generally these are the sequence we should follow, is a first of all this weld puddle is developed due to arc action to the work piece and the electrode the; that means, whatever due to arc action generally here a weld weld piddle is developed. So, once the well puddle is developed then what happens this welding thoughts is move back. So, in second sequence generally next system we should move the welding thoughts back this should makes a angle a angle around 15 degree with this vertical axis.

Then if filler material is required we have to supply filler material this filler material also a position should be like this also should make say angle around 15 degree with horizontal surface and this should put in front of this thoughts and this filler rod is moved ahead and filler material is generally added to the weld puddle this filler metal generally continuously here you see supply to the weld puddle.

So, so in this way it is move with this torchs is in front of this was and it continuously melt and supply filler material to the weld puddle. At the end when the welding is completed then what we have to do? Then we have to first remove this filler wire from there so first remove the filler wire from there then we have to extinguish the arc.

So, here one things you should keep it in mind the shielding gas is allowed to impinge on the solidifying weld pool for a few second even after the extinguishing of work, this thing we should keep it in mind; that means, the shielding gas supply should be there even after extinguishing of arc for few second then your welding will be a weld puddle will be fully eliminated from oxidation or whatever the generally contamination from atmospheric contamination.

So, the that is why is here the shielding gas is allowed to impinge on the solidifying weld pool for a few second even after extinguishing of the arc, that you should keep in keep it in mind.

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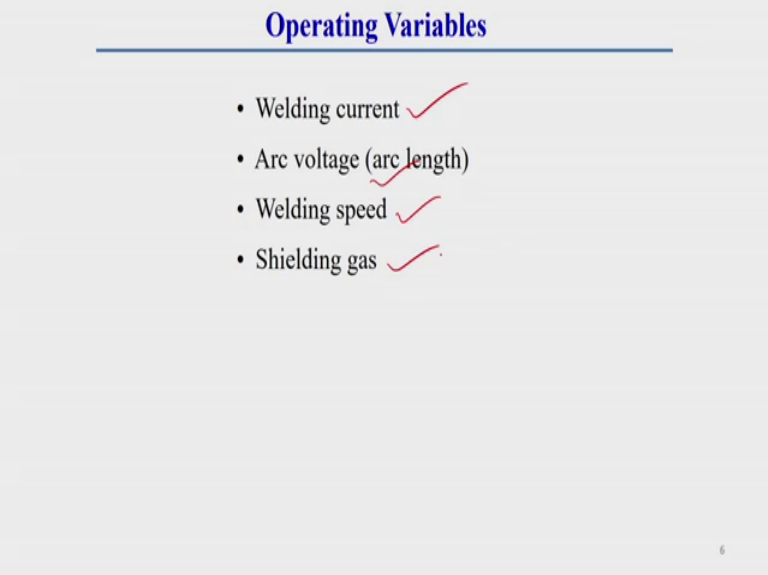

Now, here these are the main operating variable is welding current, welding voltage [noise,] welding speed and shielding gas. I have already discuss about this thing at the end of the physics of welding topics they again have their some a specific or a special generally purpose, some especial types of polarity and other things is used that is why I will discuss about this welding currents here, but rest of the things generally arc voltage welding a speed shielding gas that what I have already discuss in details in that topics itself.

So, I will not discuss that things here because whatever the function of that thing over there that is the general function of that things here also; here also this current also same

function, but here generally some a specific purpose it is used here that is why I will discuss here about welding currents in detailed here.

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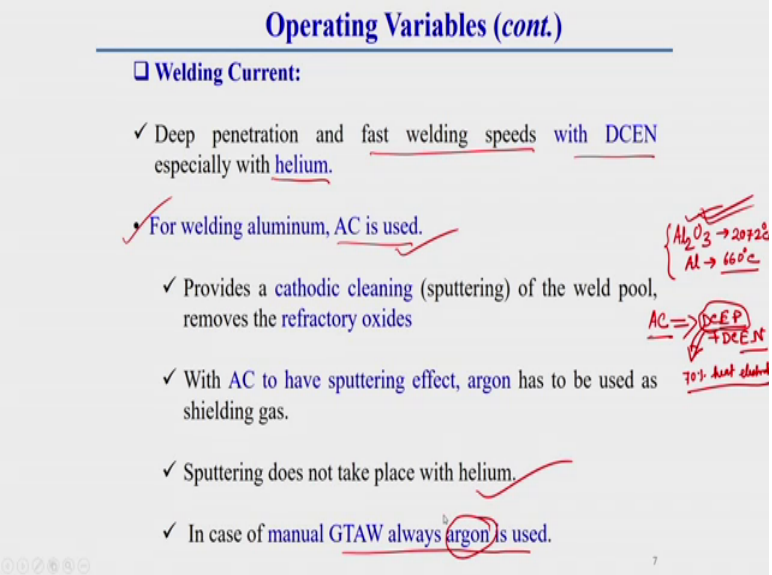

So, generally here one things you keep it in mind here either AC current or DC current is used what I have already told that; that means, direct current or alternating current or such can be used here ; here one things you should keep it in mind as it is a non consumable types of electrode that is why always keep it in mind here DCEN is preferable because a state polarity is preferable because if it is astate polarity that you know then less it will be generated in electrode because as it is non consumable so less it should generate over there. So, what happens here? Less chance of melting of that electrode also will be there and heat loss also will be less that is why DCEN is preferable

Now if we want for a steel metal especially for steel material if we want the high penetration then helium gas is generally used, that is why here one things I have written deep penetration and fast welding speed with DCEN especially with helium gas. Now here another things we should keep it in mind; that means, for welding aluminum once we go for welding aluminum there is generally use alternating current why alternating current is used? The that I will discuss in details in subsequent slide.

Here generally one things you keep it n mind, due to this AC current generally why alternating current is required? Generally this aluminum is a reactive types of material,

generally once you just keep it in open way the atmosphere you can see immediately you are the surface of this aluminum they are generate some oxide layer that you can see.

So, what happens immediately it is oxidized; that means, aluminum is such a material. So, what happened this oxide is a refractal types of oxide in this excide the whatever it is form in case of aluminum with oxygen, that is generally Al 2 O 3 it has a melting point around 20 2072 degree centigrade whereas, pure aluminum generally has a temperature only 660 degree centigrade 660 0.3 centigrade actually.

So, you see from here itself you can see this oxide on it is form then it is temperature raise around three four times more than it is original aluminum. So, generally during welding operation if this is included inside the weld metal then it is create some inclusion in the weld that is a defect actually it is create defect.

So, generally we should avoid this alumina or refractory oxide this is a very tenacious oxide that we should avoid this, we can avoid or this we can remove once you use AC current; AC current in case of aluminum welding aluminum or magnesium types of material generally they are this types of oxide formation chances of this oxide formation is high.

So, that is why generally here AC current is used why AC current is used generally? If we use AC current in AC current AC generally is a combination of DCEP plus DCEN; that means, it is a combination one half is electrode positive another half half is generally electrode negative is there. This electrode positive polarity generally here is very helpful to clean this alumina or you can say this refractory oxide aluminum oxide, that is why generally this DCEP, but if we continuously use this DCEP ; that means, DCEP if you continuously used then what happens your electrode will be warm up or heated more.

So, what happen because it in case of DCEP generally 70 percent heat is generated heat is generated in electrode and so what happens if the continuously if it is connected to DCEP then what happens there is a chance of what it is call warm up these electrode and melting of that electrode is there. That is why I generally what happened, but DCEP have a effect of on this oxidized cleaning, that is why if you continuously use this DCEP for there, then there is a chance of tungsten electrode melting and it deposited towards the what it is called welding material.

Then there is a chance of what it is called inclusion tungsten exclusion inclusion inside the weld material. To avoid this thing if we use AC, then in one portion of the cycle will be DCEP that time generally this cleaning action will be taken place in other portion generally it will be DCEN that time generally this tungsten electrode will be cool down.

So, what happens so here generally continuously warming up of this electrode will not be there. So, chances of that thing what it is called melting of electrode inflation will be less over there. So, that is why generally if we use AC current then in one cycle we will get cleaning action which generally eliminate this aluminum oxide in other polarity case generally we can get (Refer Time: 25:21) the temperature in electrode as well as deep penetration because more heat will be generated generally in DCEN more heat is generated in work piece and bombardment is of electron also is taken place in work piece say the, that is why general there is a chance of more penetration also.

So, once we use AC our aluminum welding then generally we can get this cleaning action as well as high penetration here one things you should keep in mind for aluminum welding generally argon shielding as is preferable why argon shielding gas is preferable? Generally argon, generally in argon atmospheric atmosphere, generally this cleaning action is occurred, generally that cleaning action or this is sometimes called sputtering effect.

Generally this sputtering effect generally occurs in case of argon atmosphere it is not occur generally or generally in case of helium atmosphere it is not good; that means, helium atmosphere is not good, this sputtering effect or cleaning action, that is why argon gas should use during aluminum welding and you should use alternating current.

So, sputtering does not generally take place with helium here it is written already in case of manual GTAW generally we should keep it mind argon as a helium guys generally is more preferable or generally use.

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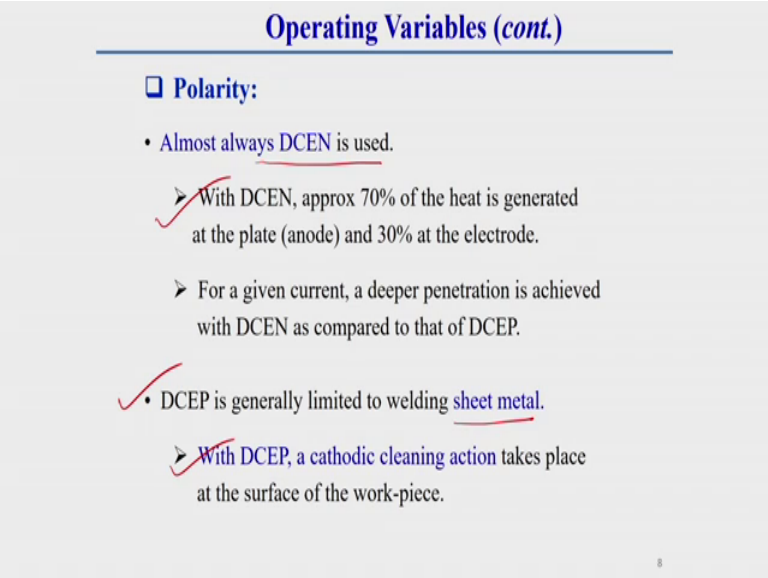

Now, what I have already told you generally polarity in this currents almost every time it is DCEN is why it is used? That I have already told you generally if you use DCEN then generally less chance of warm up of the electrode and molten melt melting of the electrode is there because less heat it will be generated in the electrode and more heat will be generated will to the work piece.

So, generally for differ penetration is acid with DCEN then DCEP but DCEP generally have limited application for a steel material also, generally if the steel material whose thickness is less or for generally for generally some sheet metal types of material generally this DCEP is also preferable because why it is preferable because in case of thinner material we want less heat to generate in work piece.

Because if more heat will be generate there is a chance of melts through this work piece to avoid this melt through generally DCEP is also used in case of sheet metal for TIG welding process. But DCEP what I have told you DCEP is preferable for cathodic cleaning especially for magnesium and aluminum alloy this what I have told you.

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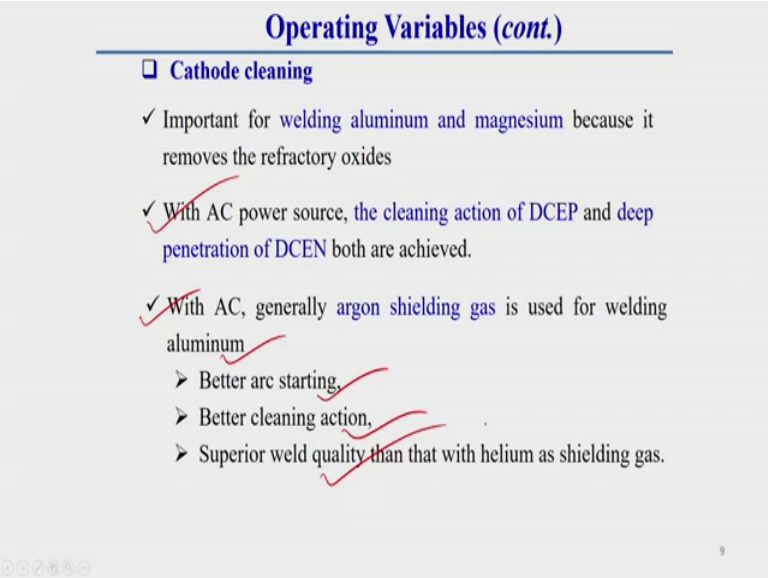

Now, here cathodic cleaning action I will discuss here in details, generally here a cathodic cleaning action is taken place with alternating power source and here one thing you keep it in mind with AC argon shielding gas is used for welding aluminum or magnesium; because once we use AC current towards there, then and argon gas is there then there will be better arc starting, better cleaning action and superior weld quality.

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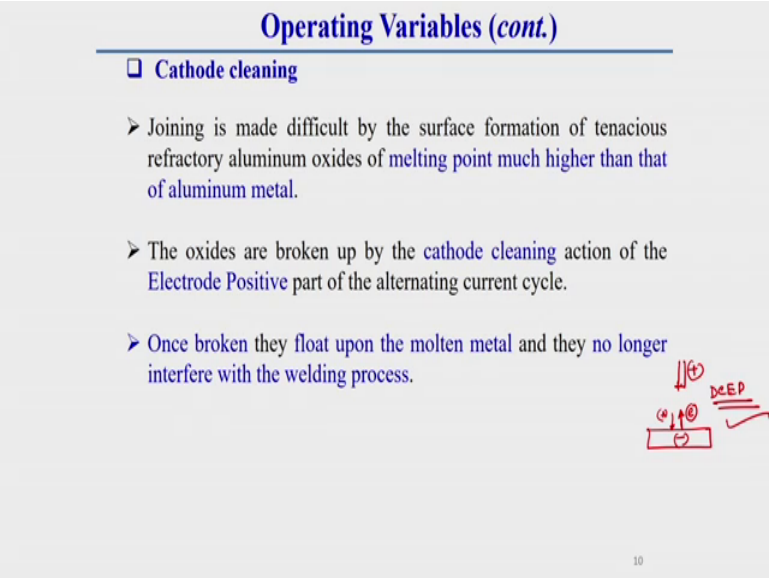

Now what happens during cleaning action that also you should know once what I have already told you once this aluminum or magnesium expose to atmosphere, then this

immediately some oxide layer is form over the surface of the aluminum. Then this oxide generally once we include inside the weld material then it is create some defect, this oxide can be broken by using DCEP polarity what happens due to this DCEP? DCEP means here you see DCEP means this is negative this is positive, this means electrode.

So, if it is DCEP then what happens electron will flow from electrode to work piece direction. So, due to this electron flow or you can say ion coming to work piece, so here generally positive ion is will be attracted here and generally electron will flow upward direction. Due to this flow of electron and ion generally what happens once it is DCEP or it is also called generally reverse polarity if it is reverse polarity then what happens? This aluminum that means, that refractory oxide broken up.

So, the so this refractory oxide broken up and once it broken up then it is generally float over the surface of the molten pool. So, generally then due to this DCEP polarity this thing happen once it is broken up and generally they float upon the molten metal. So, then this thing; that means, this broken of alumina or you can say this broken of refractory oxide no longer interfere with the welding process. So, then it will not be able to create any defect inside the weld metal. So, this thing generally happened once we use thisDCEP as a what it is called DCEP as a polarity.

So, that is why you should keep it in mind for aluminum magnesium types of material generally alternating current is used, here you can use DCEP continuously, but if you use DCEP continuously then there is a chances of that thing what I have already discuss warm up of the electrode and melting of the electrode apart from this thing you can get less penetration. So, to get this high penetration and less warm up of the electrode here generally it is preferable AC current. So, that is why you keep it in mind for aluminum magnesium alternating current is very much preferable over here.

Ah So, and other things here you should keep it in mind once you go for aluminum welding with AC current there you should use argon has a shielding gas why because argon has suitable for spattering effect, then aluminum then helium inert gas.

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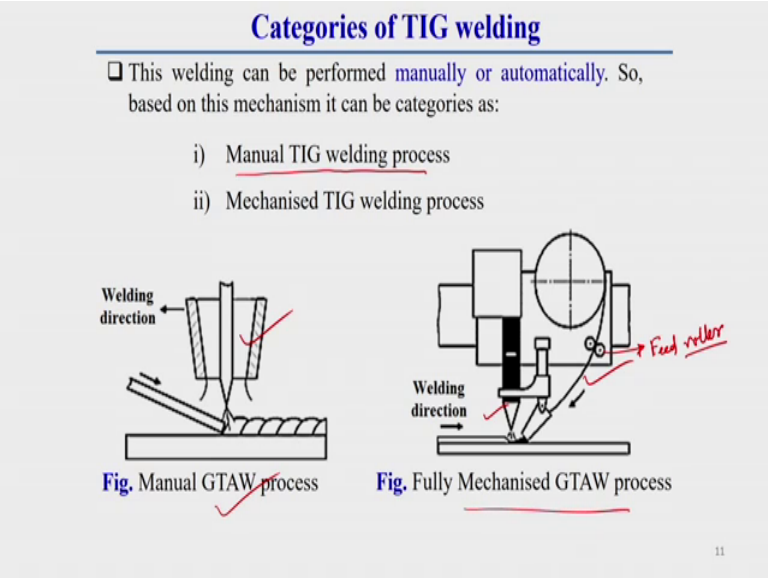

Now, this is the categories of TIG welding process, now we will discuss what are the different categories of TIG welding process. Generally this TIG welding can be done manually or it can be mechanised also, that is why depending upon this mechanism it can be categorize in two different categories one is call manual TIG welding process manual TIG welding what I have already discussed during categories of different welding process.

Manual means here both speed of the welding as well as filler wire deposition is control manually. So, generally here generally no mechanize system is there. So, that is why generally it is called manual TIG welding process; manual TIG welding process means torch is operated by one hand and filler wire is also operated by another hand. So, here both the things is control manually then this is called manual TIG welding process.

And in case of mechanized TIG welding process here generally this torch movement; that means, a welding is speed is control by some mechanize system as well as this filler wire this filler wire is also is controlled by some mechanized system. This mechanized system means from some roller it is generally continuously feet to the molten pool through some feeder feed roller actually this is generally called feed roller, this feed roller generally control by some mechanized system.

So, what happens by this generally we can we can control both what it is called control both filler wire deposition as well as speed of the welding torch by some mechanized system then it is called mechanized GTAW process.

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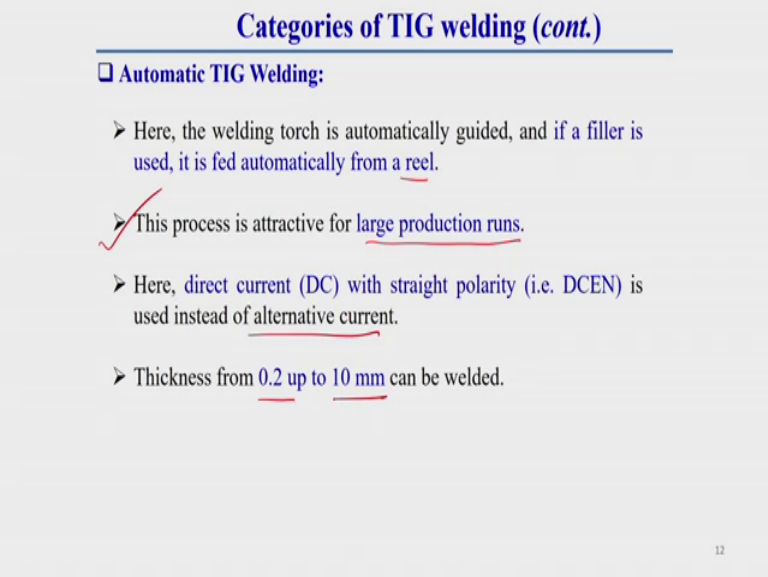

Here you see so this automatic TIG welding or this mechanized TIG welding here the welding torch is automatically guided and this filler material if there is use it is also fed automatically from some a reel. This process is attractive for large production run as it is automatic process that is why attractive for large production run, here instead of AC current here DC current is preferable and DC current with DCEN is used instead of AC current. Here we can do the welding from a thickness varying from 0.2 millimeter to 10 millimeter.

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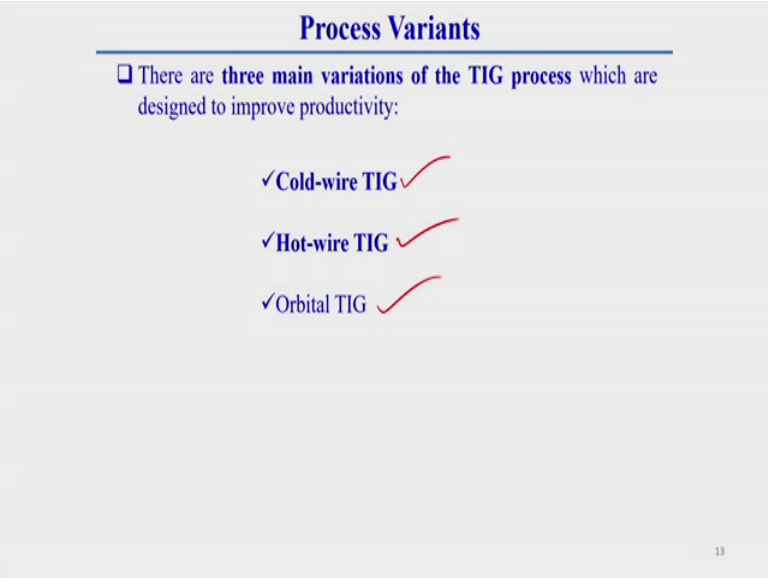

Now, these are the different other process variants, generally what happens to increase the productivity of TIG welding process there are some other variation of this welding process are there what is this variation, what are these variation? This variation can be cold filler wire TIG welding that is called cold wire TIG welding and to increase the productivity you can use hot wire TIG welding apart from this hot wire TIG welding here you can supply hot wire as well as some oscillation of the wire by some oscillation system, you can supply the wire by this also we can increase the productivity and another process variant it is what we tell TIG welding.

So, now, I will discuss in details about this welding process in subsequent slide. First of all I will discuss about cold wire TIG, here cold wire TIG it is a conventional GTAW process.

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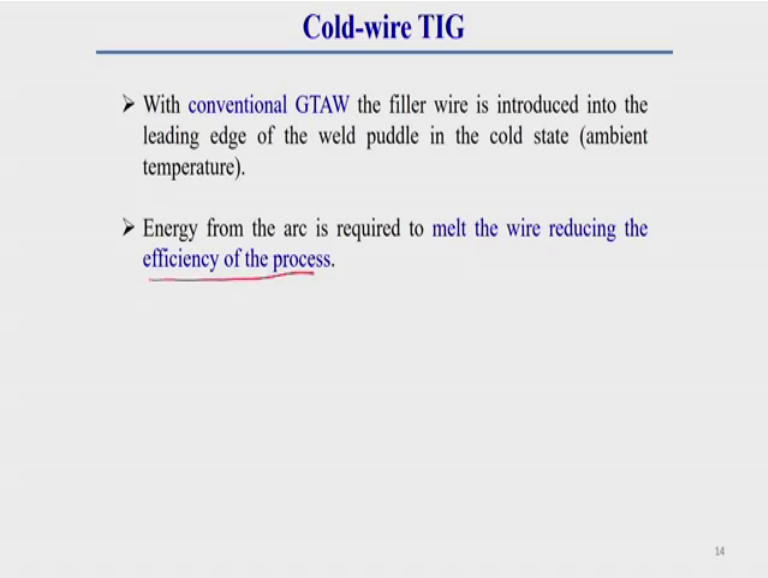

Here whatever the filler wire is supplied or introduced into the leading edge of the weld puddle is supplied at atmospheric temperature ; that means, the temperature of the filler wire is before supplying to the leading edge of the electrode or arc, generally this temperature is within the temperature is atmospheric temperature that is at; that means, here pool condition.

So, whatever the energy required for melting of the filler wire generally whatever the energy required to melt this filler wire that is generally taken from this arc. So, as this filler wires melting temperature is or energy is taking from arc that is why here generally heat losses we can say some sort of heat energy reduces. So, due to the so due to this generally here efficiency of the process decreases because heat is taken away by this filler wire to melt it and deposit it.

So, that is why generally less heat is supplied to the edge of the weld pool. So, what happens less forceful arc will be there so less penetration and other things will be there, so here generally efficiency is less. So, here generally it is reducing the efficiency of the process.

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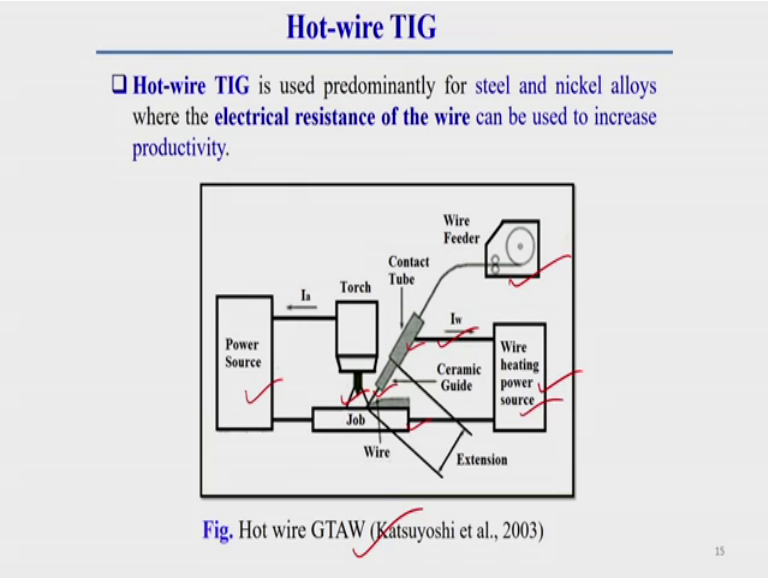

Now, in case of hot wire what happens this instead of supplying this filler wire at room temperature, here this filler wire supply at a temperature which is closure to it is melting point temperature by some heating mechanism. Here this mechanism is showing here then it will be very clear to you, this is the hot wire GTAW process or set up, here you see this is the arc, which is generated by this power source and you see this is generally wire feeding mechanism from wire generally this wire is continuously feed to this job.

Here with this contact tube there here you see, with this contact tube and this work piece in between a power source is used that is called wire heating power source. This power source generally use heat of this filler wire to heat of this filler wire by electrical resistance heating because what happens by this heating power source is generally due to the resistance of this what it is calls filler wire, it is warm up by this wire heating power source.

So, what happens this heating generally here you see how it is heating this power source generally connected with this what it is called a contactive and what it is call work piece. So, in between whatever the filler wire are there, that filler wire heat by electrical resistance heating. So, what happens this resistance heating generally raise the temperature of that filler wire and once it closer to melting point temperature of this filler wire then what happened? It supply to the to the weld puddle or we can save wire pool.

So, so what happens here generally less heat will be required from the or less heat will be taken from the arc to melt this filler wire.

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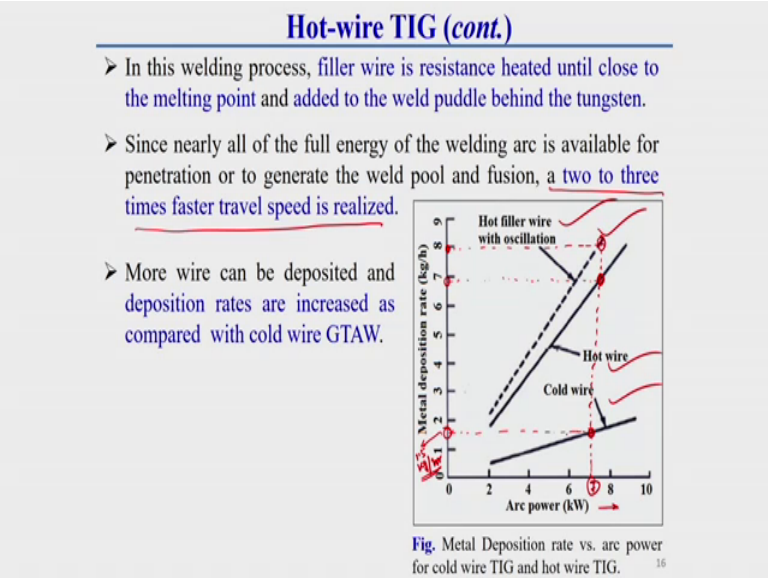

So, what happens here you can say that whatever the arc force or arc energy is that that generally directly supply to the molten pool. So, here generally more forceful arc and more forceful arc we can get. So, what happens due to these things, by this welding process generally we can increase deposition rate as well as penetration. So, what happens for this reason this welding process or this techniques can be two to three times faster than the cold wire TIG welding process.

Because what happens here we can increase both penetration as well as what it is call deposition rate. So, that is why a sentence is written here a two to three times faster travel speed is realized by this welding process. Here generally a graph is show now you can say from this figure itself we can see how the means deposition rate bearing with cold wire TIG welding process, and hot wire TIG welding process here hot wire TIG welding process. Here you see with variation of arc this is generally represent with variation of arc how the filler wire deposition rate; that means, kg per hour how it is varying.

With variation arc are it has observed that let us let us I am just considering for a particular for a particular then it will be very clear to you. That is for a particular power; for a particular power; for a particular power generally for a particular power lets for a

particular power at around 7 lets 7 kilowatt power, for 7 kilowatt power if we use a cold wire then we can get a filler material deposition rate that is around 1 point around 0.5 kg per hour.

Whereas for the same power if we use a whatever TIG welding techniques there we can get a there we can get a what it is called deposition rate is around 7 around 7 kg per hour. Further if we want to increase the deposition rate if we just oscillate this filler wire by some oscillation technique, then oscillation mechanism, then further we can increase the filler wire deposition rate which is around which is around 8 kg per hour; that means, further also we can increased by increasing the hot wire filler wire oscillation by providing the hot wire oscillation by some oscillation mechanism.

So, the in this way one things you can observe we can get around four to five time more deposition rate compared to cold wire in case of hot wire techniques and if even further increase of deposition rate we can oscillate that hot air by some oscillation system ok, this is the field of how the means deposition rates. So, due to this high deposition rate we can increase the speed of the welding also, that speed of the we can increase the speed of the welding two to three times more than the cold wire welding techniques.

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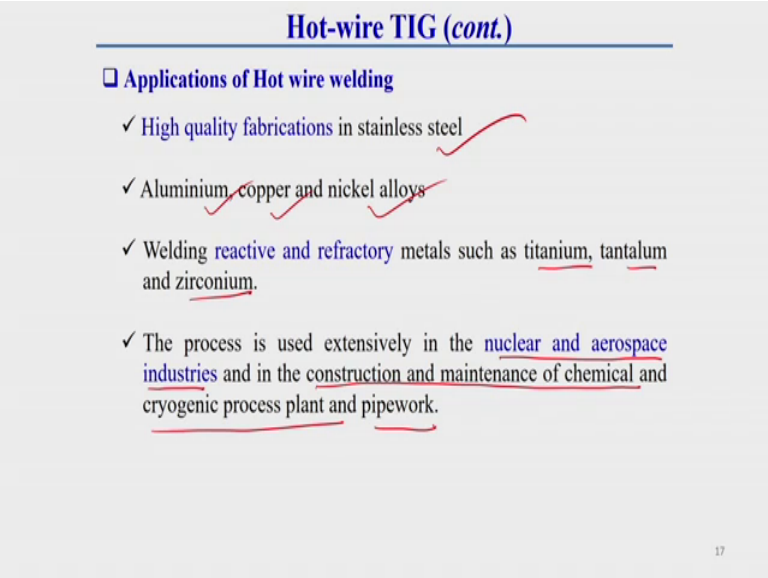

Now, this hot wire TIG welding techniques have huge application is has in early application it is its apply in high quality fabrication lie in stainless steel it is used in

aluminum, copper and nickel alloy. Then only welding in reactive and refractory metals such as titanium tantalum zirconium it has wide application.

This process generally this hot wire process is extensively used in nuclear and aerospace industries and in the construction and maintenance of chemical and cryogenic process plant and pipework this hot wire techniques is wide layer.

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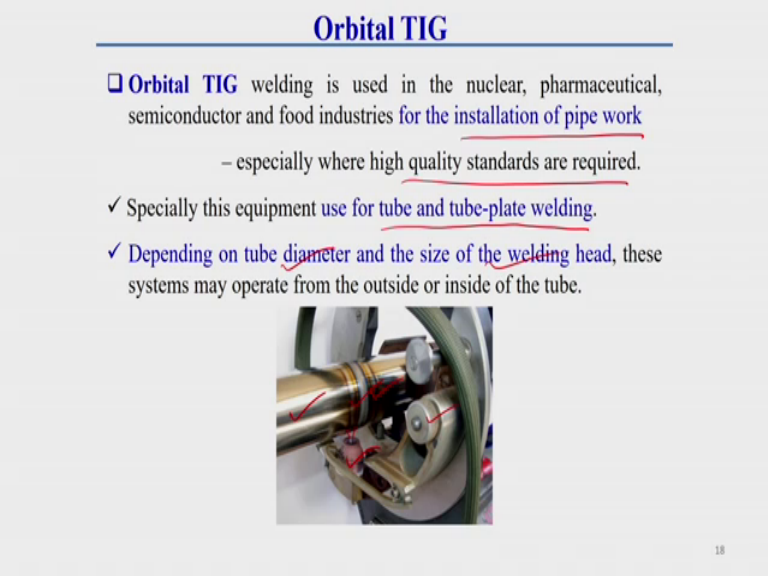

Now, we will go for orbital types of TIG welding techniques, orbital TIG means it is generally used for circular section; generally it is used in nuclear, pharmaceutical, semiconductor and food industry for installation of pipework. So, where generally circular section is there generally it has wide application. It has a specially used where high quality standard are required this TIG welding because TIG welding is a itself is a very high quality welding techniques it is generally give very high quality weld, that is why most of the time I am telling this high quality purpose generally wire is there generally this types of technique is used.

Especially this equipment is used for tube and tube plate welding; that means, where there is circular section is there. Now depending upon this size of the tube or this means size of the tube and size of the welding head generally what happens? This welding techniques we can do from inside tube or from outside the, of the tube also. So, that is also written here depending of the tube diameter and size of the welding head this system

maybe operate from inside or outside of the tube. So, this is generally here you can see let this is a pipe which is welded by this orbital TIG welding process.

Here generally you see this orbital TIG welding head is setup generally outside generally this what it is called this pipe generally rotate by some rotating mechanism here you see by some rotating mechanism and here generally arc is generated between this work piece and electrode, then what happens we can do the we can join this two pipe separately. So, we can do this is rotation of these pipe and the supply of arc heat generally we can join this pipe here it is showing like this.

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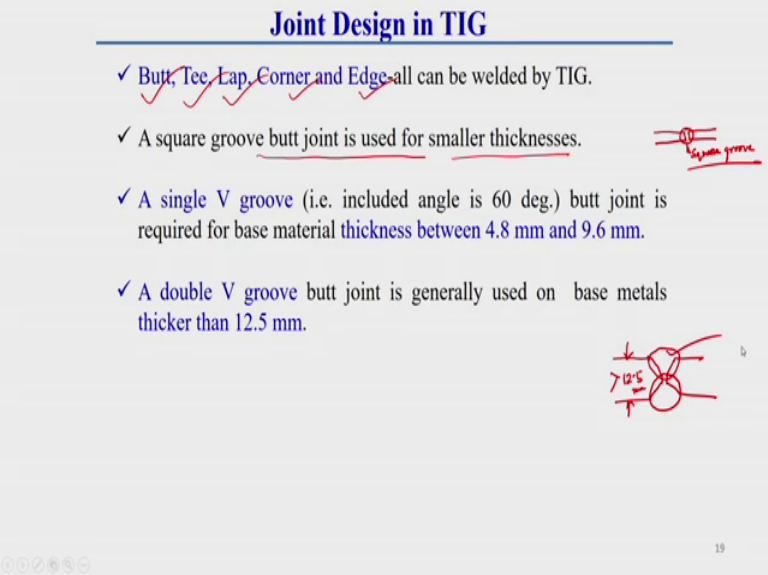

Now, joint design in case of TIG welding also we should know what are the different joint we can do by this welding process that also we should know. Here generally most of the joint we can made by the TIG welding process, like it can be used in butt, tee, lab, corner as well as well as edge all can be edge joint also here. Now all can be welded by this TIG welding process. A square group generally butt joint is used for a smaller thickness plate. So, generally for a plate thickness lower than around 4.5 millimeter there cannot be require any s preparation.

For or lower thickness plate s preparation means a square butt; that means, here no v angle is required. So, without s preparation that is called a square a square group a square group that you know already I have already discuss about this thing this is call s square group for lower thickness where material know Vivel angle or V angle is required, but a

single V angle is required one of the plate thickness varying from 4.8 to 9.6 millimeter ; that means, within a range of around 10 millimeter thickness plate there is required a single vivel angle. This single vivel angles or included angle ranges ranges is around 60 degree.

Generally a double V groove generally is required for this TIG welding process if the plate thickness exceed 12.5 millimeter thickness then double v s preparation or double sided s preparation is more preferable, that means at both side you have to make the s preparation you have to make the s preparation. So, from this side we have to the double weldings similarly from other side also you have to do the welding. So, once this plate thickness is exceed greater than 12.5 millimeter thick generally this types of s preparation is required over there.

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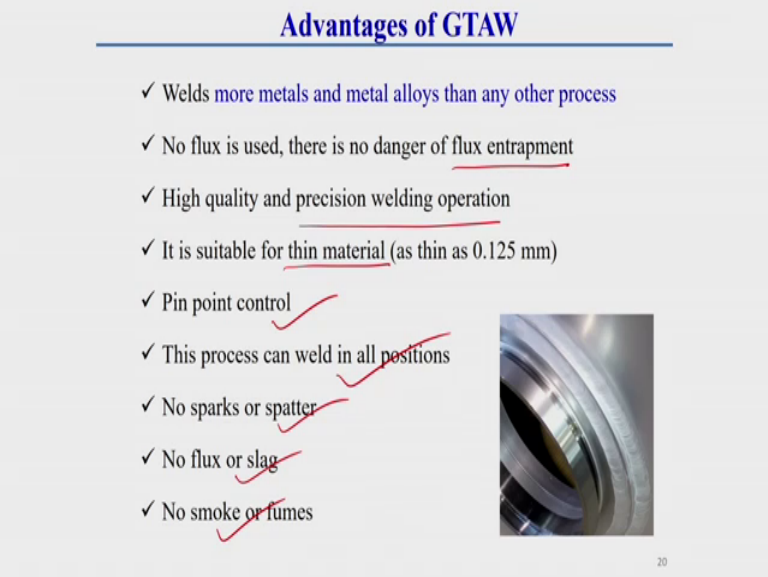

Now, we will discuss what is the advantage of this welding processes, drawback of this welding process and application. This welding techniques has huge advantage the because this more metal and metal alloy can be welded by using this welding process then any other processes. Here what I have already discussed here generally a shielding gas medium generally used to protect the weld pool as well as electrode. So, that is why as here no flux is used. So, there is no chance of flux entrapment inside the weld puddle.

Here generally high quality and precision welding operation this is a very high quality and precision welding operation technique, it is suitable for thin material as thin as 0.125

millimeter thick section also we can weld by this welding process. It is a here generally pinpoint control are there this process can weld in all position this can be weld, this positional welding; that means, all position welding you can do by using this welding process.

Here this SMAW whatever this spark and other thing are there here generally that types of a spark or a spatter is marginally less we can say here no smoke fume; that means, whatever the smoke fume you observe in case of what it is called SMAW process here that thing is not there and no flux or slag also is not there because flux or slag is not used here. So, these are the advantage of this welding process.

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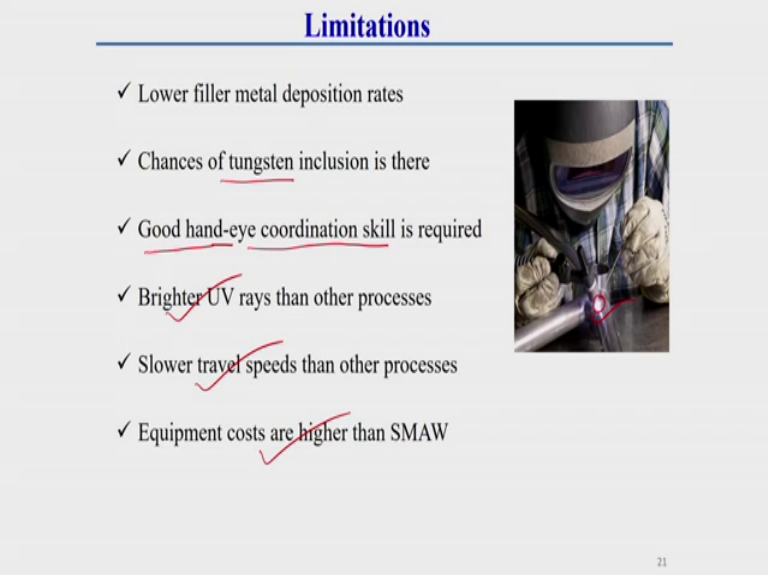

Now what is the drawback of this limitation of this welding process ? Here one things you keep it in mind here generally lower filler material deposition rate comparatively lower than mig welding process. Generally here metal deposition is less and just here is used tungsten electrode so there is a chance of this tungsten melt and deposited towards the molten metal.

So, there is a chance of tungsten inclusion is there, here on things you keep it in mind here generally very good hand and eye coordination skill is required here you can see this types of pin point skill is required generally pin point concentration is required to do this welding operation here you see um.

So, that good hand eye coordination skill is very much essential in this welding operation. Here generally there can be brighter uv ray than other process, in this process whatever the uv ray here in arc are there that can be brighter than other process here slower travel speed than other process like mig welding process here generally equipment cost are higher than SMAW and now SMAW process whatever the equipment cost are there has generally more than that cost.

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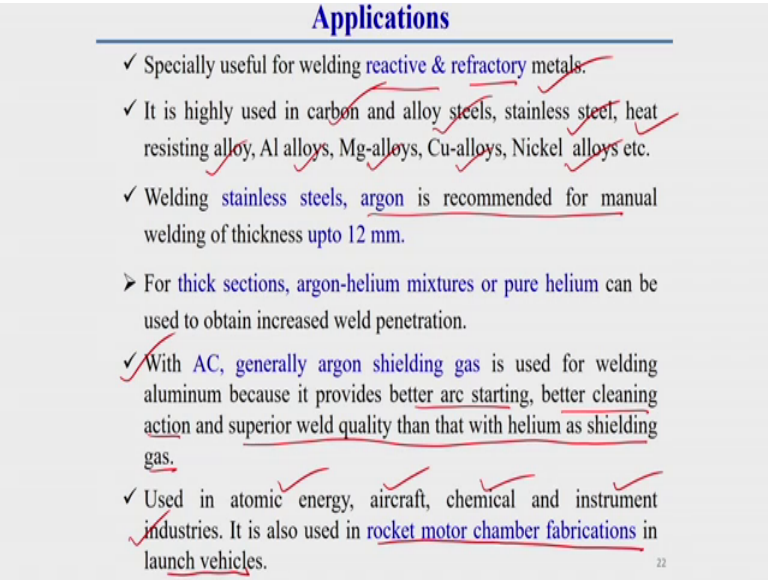

Now, application of this welding process what I have already told you this is generally very much suitable for reactive and refractory metal what I have already tell told you what is reactive material and refractory material. If reactive material titanium zirconium then refractory material generally tantalum molybdenum these are the refractory material metal, this is very difficult to weld which can be weld by this welding process it has wide application in this reactive and refractory material.

It is highly used in carbon alloy steel carbon and alloy steel stainless steel, heat resistance alloy, aluminum alloy, magnesium alloy, copper alloy and nickel alloy also. Welding stainless steel here one things you keep it in mind welding stainless steel, argon is recommended for manual welding of a thickness of 12 mm; that means, if the plate thickness within a range have 12 mm, then argon gas is sufficient for what it is called stainless steel welding.

But if it is exceed this 12.5 millimeter thickness of a stainless steel plate then what happens it is more preferable to use organ helium mixture gas or simple simply helium gas is better. So, over 12 millimeter thickness it is better to use helium as a shielding gas for stainless steel. Another things also you should keep it in mind if we use aluminum or magnesita types of welding their alternating current is preferable what I have already told and what happens and there should use argon as a shielding gas.

Because generally if we use AC with argon gas for aluminum welding it provide better arc starting, better cleaning action, superior well quality, than helium as shielding gas. It has wide application in atomic energy aircraft chemical instrument industry it is also used in a rocket motor chamber fabrication in launch vehicles. So, it has wide application in here; that means, rocket motor chamber fabrication purpose. So, you see it has very high advantage process and it has very high application also.

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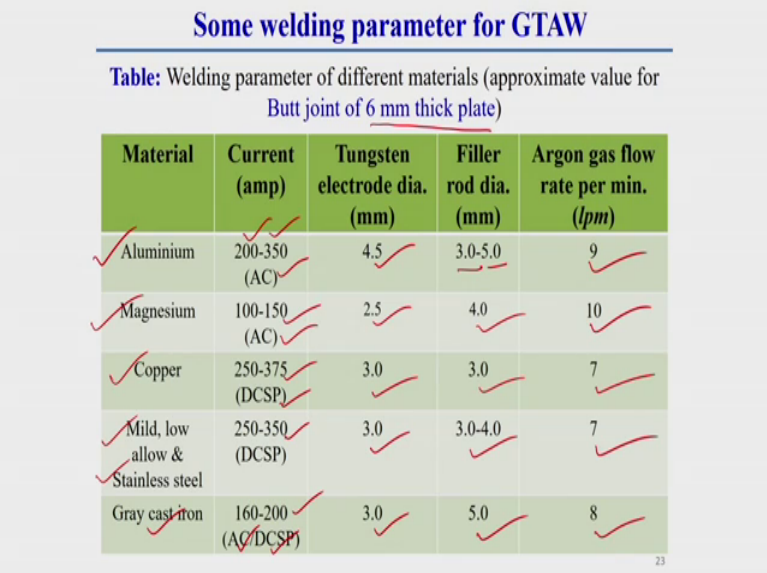

Now, here just I am showing some welding parameter for GTAW process then you can get some idea that what should be the range of welding current required for doing steel welding aluminium welding or it is called copper welding, what should be the tungsten size, what should be the filler wire rod size and what should be the range of flow rate of shielding gas is required ? That respond for the purpose of some knowledge, here I am showing some parameter for different types of material for a.

Tthat means, for 6 millimeter thick plates for different types of metal what are the process parameter is required? Here one things you can see if we use aluminium for 6 millimeter thick plate, here the current range varying from 200 to 350 and here generally current type is AC and here the tungsten diameter is within range of 4.5 millimeter and filler rod if you use this filler rod size is varying from 3 to 5 millimeter depending upon this variation of current it is a filler rod diameter and here argon gas flow rate is 9 liter per minute; that means, per minute 9 liter of gas should flow then what happens you can get a very good quality welding.

That means there will not be atmospheric contamination and it will be almost defect free types of welding process welded joint. Then for magnesium have you see current is varying from this for 6 millimeter thick plate here tungsten diameter is 2.5 millimeter filler rod diameter is 4 millimeter and argon gas flow rate is 10 liter per minute. If you go for here also AC current is preferable not I have already told you, then for copper here you see 250 to 735 current range is required here direct current is state polarity why a state polarity? Because DC DCEN is used because DCEN is a state polarity.

Then electrode will be less heated, that side generally DTA state polarity is preferable or DC you can say DCEN is preferable then DCEN is used and here tungsten diameter is 3 millimeter, filler rod diameter 3 and gas flow rate is this 7 liter per minute. If it is mild steel, low alloy steel or a stainless steel for 6 millimeter here current is varying from 250 to 350 and here also DCSP because definitely in case of this welding positive welding process generally DCSP is preferable what I have already is told and as it is what it is called 6 millimeter thick plate, and a steel plate that is why here tungsten electrode diameter is 3 millimeter here filler wire diameter can be 3 to 4 millimeter and gas flow rate that is argon gas flow rate is 7 liter per minute.

If it is cast iron then also it is give given in case of cast iron both AC or DC a state polarity we can use, here generally 3 millimeter diameter tungsten 5 millimeter filler wire and 8 liter per minute generally what it is called argon gas flow rate is required to get good weld. So, this all about TIG welding process or GTAW welding process generally in next lecture I will discuss you about another arc welding process that is called GMA GMAW process or that is simply it is also called MIG welding process that is called Metal Inert Gas welding technique that I will discuss in details in next lecture.