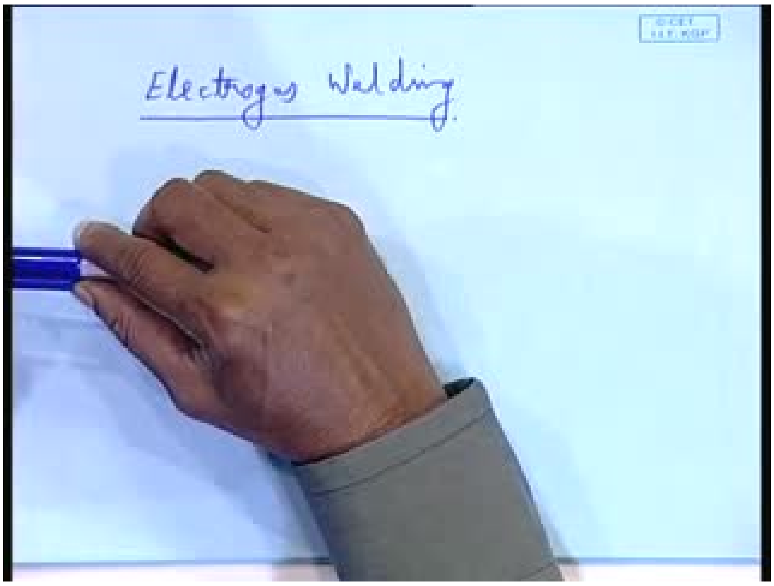
Marine Construction and Welding

Prof. Dr. N. R. Mandal
Department of Ocean Engineering and Naval Architecture
Indian Institute of Technology, Kharagpur

Lecture No. # 34

Electrogas Welding

(Refer Slide Time: 00:24)

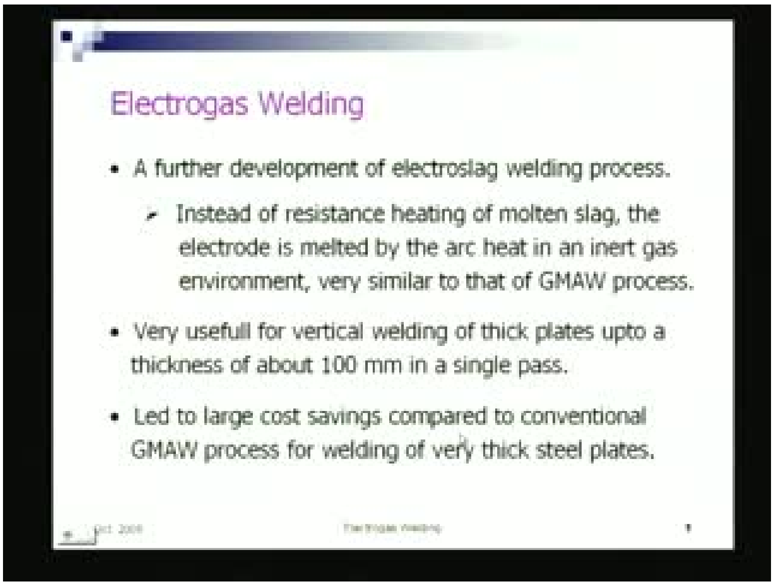


Today, we will start with another welding process which is referred to as electrogas welding. As we have seen, the electro slag welding, there the heat of the molten slag was used, that means the joule heating of the molten slag was used to generate the necessary heat for melting of the electrode as well as the parent metal.

Here, in the electrogas welding, this is a kind of a, one can say a one-step, well, a kind of a development further from electro slag welding, but at the same time, somewhat similar to that of gas metal arc welding. In gas metal arc welding, we have seen the welding arc and the molten pool are shielded by an inert gas media. Here also, in electrogas welding, it is shielded by inert gas medium. So, this is also an arc welding essentially, it is not like, unlike, electro slag welding where there is no arc; it is the joule heating - the resistance heating - of the molten slag, that is what it is used, but in electrogas welding, it is again an arc welding; it is a fusion welding process, the heat source bearing the electric arc.

And it is shielded by the gas, inert gas. So, the difference, what is the difference then between gas metal arc welding and this? The difference is in gas metal arc welding, the gas continuously keeps flowing, and that is used in all positional welding, but this is again a vertical welding process as that of as like electro slag welding, and here, the gas is fed; the gas remains in that position which is covered by that similar kind of shoes, what you have seen in case of electro slag welding.

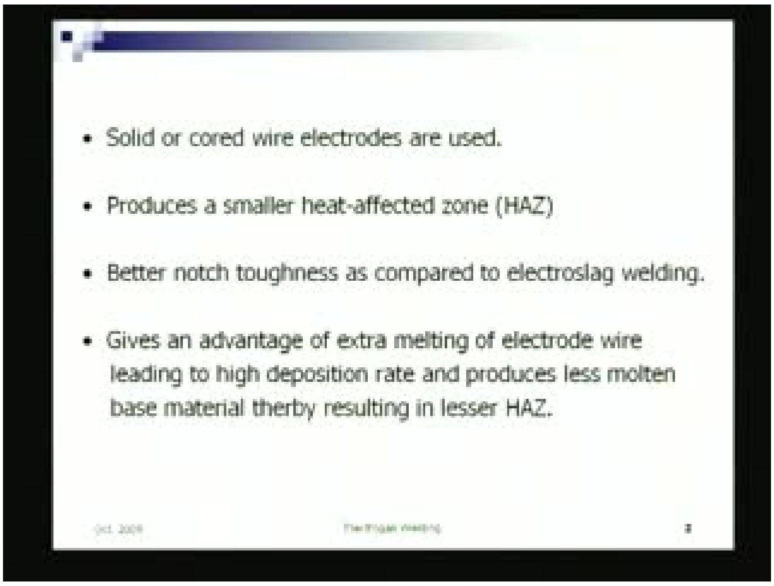
(Refer Slide Time: 03:11)



That means a molten pool is formed, and the sliding shoes, they slide up the plate surfaces, vertical plate surfaces and the shielding medium is the inert gas which is put there, right. So, that is how we see that it is a very useful welding method, in which, one can weld very thick plates like in a electro slag welding, here also one can go up to thicknesses of around 100 millimeter thick and the welding can be done at one run at a single run. So, obviously then compared to a conventional gas metal arc welding. It leads to a very substantial savings cost savings.

Because, if you have to weld a plate of say 100 millimeter thick and that you will have to, if you have to do with a conventional gas metal arc welding, you will have to do several runs, because the deposition rate is much less. Whereas, if I use electrogas welding, then one can go that welding deposition rate can be made much higher and welding can be done at one run.

(Refer Slide Time: 03:50)

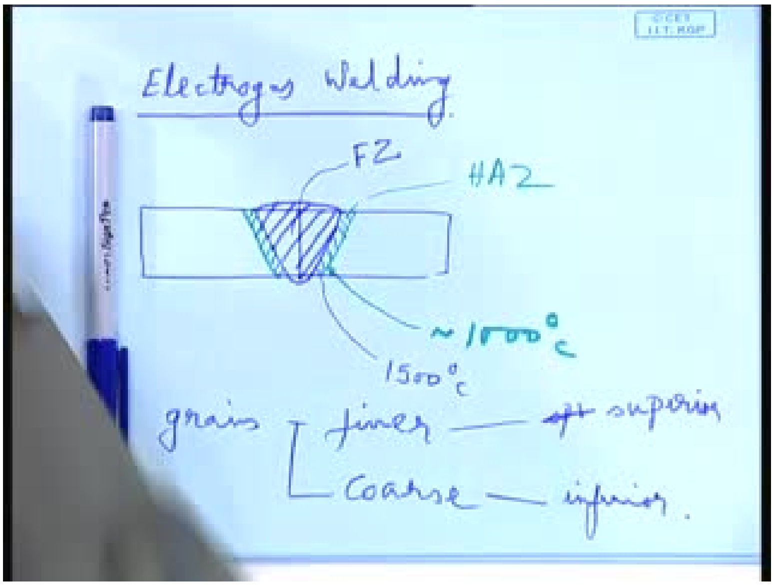


In this process, these are the some of the features; it uses solid or cored wire. Cored wire means, in the core at times flux is used that is called flux cored wire, like, just the opposite of the electrode, welding electrode for manual welding. In manual welding, you have the flux coating outside, outside the metal electrode. Imagine that is just the reverse of it; you have the electrode with a flux inside.

That means -it is an electrode having a fine hole at the center which is filled up with a flux. So, that is what is referred to as flux cored wire; it produces smaller heat affected zone; it produces a weld joints with better notch toughness. Notch toughness means impact strength compared to electro slag welding. That means, here, so or in other words, if you want, I mean, a superior mechanical properties can be achieved with electrogas welding as compared to that of electro slag welding because these are the two welding methods, where in you can do welding of very thick plates in a single run.

So, in a single run, so that, that is how both these methods are very useful for welding of vertical joints, and especially in ship building or offshore industry, you may have such long vertical joints of very thick plates. So, these two methods are very much suitable for this purpose of these two electrogas is a superior method one can say because it gives me a better mechanical property; it gives me a better notch toughness that means the impact strength of the joint achieved is better.

(Refer Slide Time: 05:53)



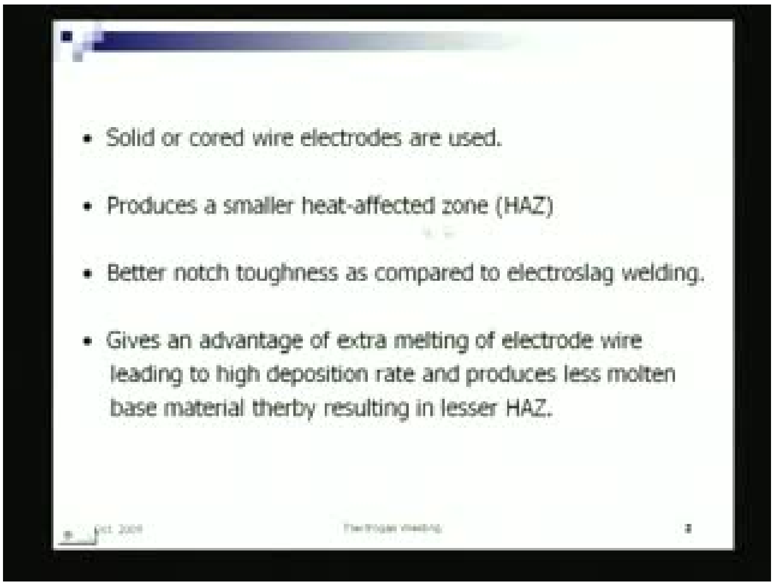
It gives an advantage of extra melting of electrode wire leading to high deposition rate and produces less molten base material; there by resulting lesser heat affected zone. What does it mean means? It with electrogas, we can achieve a higher deposition rate. It is a high deposition rate welding, but at the same time, it produces lesser heat affected zone. The heat affected zone in electro slag welding is more; heat affected zone means, if you recall once again, say a conventional butt welding, if it is done, suppose they are the two plates butt welding has been done, and the fusion zone looks like this; this is my fusion zone.

So, the heat affected zone would be the zone just adjacent to this. This is what it is referred to as heat affected zone that means it is between the fusion boundary and about 1000 degree isotherm because, this particular, this particular line, which refers to the fusion boundary; that refers to what? It is the melting temperature isotherm essentially is not it that means melting temperature of steel is around 1500 degree centigrade.

Because this shaded zone is the fusion zone; this is my fusion zone, (Refer Slide Time: 7:36) that means there the total fusion took place; fusion took place means, what that means, this boundary line refers to the solid liquid interface line, or in other words, this is the isotherm of 1500 degree centigrade, means along this line maximum temperature attended was 1500. So, similarly, if I can locate a line where 1000 degree was attend, so that zone in between is the, is the zone which is called heat affected zone, this part is called the heat affected zone; what happens here, your microstructure re-crystallization takes place.

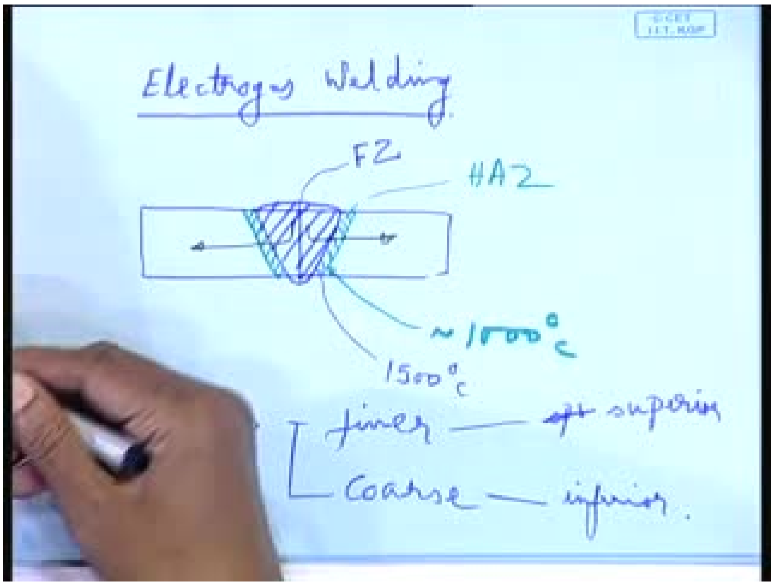
So, either the grains becomes finer or become coarse; either it turns fine or coarse or both essentially what happens, immediately closer to the boundary of the fusion zone. You have a fine grain structure; little away from that, we have a coarse grain structure. Anyway, in other words, the heat affected zone is the, one can say location in within the welded joint, which has a different material property compared to the parent material property. Why? Because the microstructure has changed, and within that zone, a smaller part would be of fine grain structure - fine means finer than the parent metal - and rest would be coarse grain structure. So, it will be coarser than the parent metal, and as you know, fine grain structure gives you a superior mechanical property.

(Refer Slide Time: 10:19)



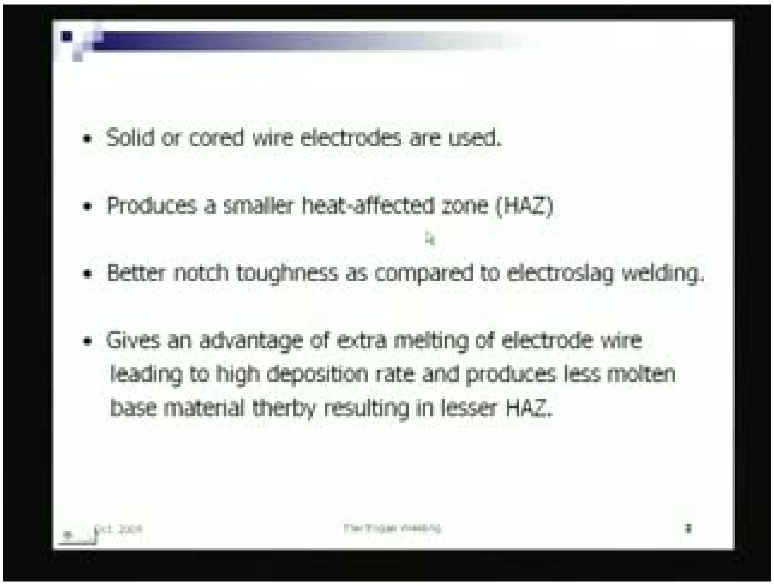
And coarse grain structure gives inferior mechanical properties, or in other words, a good welding procedure would be one which produces minimum width of heat affected zone. So, that is why it says here that electrode gas welding produces smaller heat affected zone, whereas, smaller means what? Smaller as compared to that of electro slag welding. In electro slag welding, a larger heat affected zone occurs, why? Because the heat resident time of the heat at a given location is much higher, because there the molten slag is floating there on top of the molten metal which is at a much higher temperature, what temperature? More than 1500 degree centigrade, so, the quantum of heat at one place is much more, so it gets enough time for the heat to get conducted along the plate.

(Refer Slide Time: 11:04)



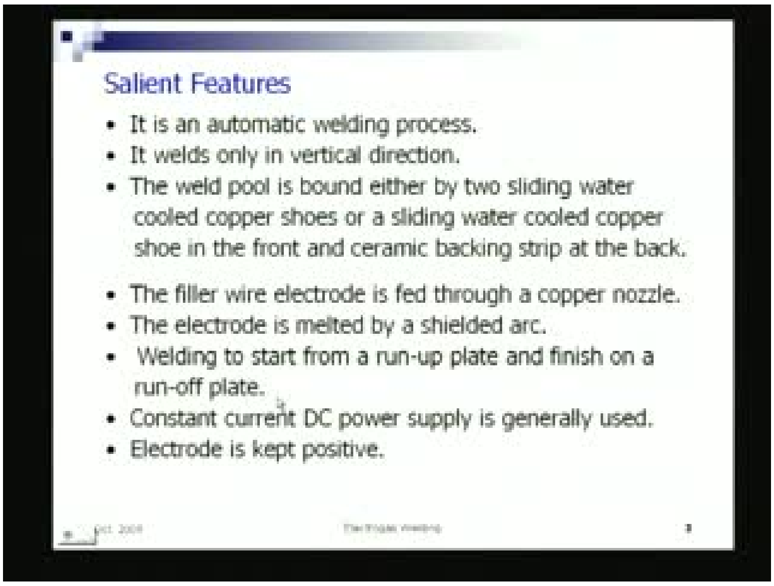
Because more the heat get getting conducted, you have this isotherms shifted away, is not it? If I hold the heat for a longer time, then this isotherm of 1500 also will shift to some extend and the isotherm of thousand also will shift further, means what? That means more heat is getting conducted; more zone is getting a temperature rise to above 1000 degree centigrade.

(Refer Slide Time: 11:43)



So, you have a wider heat affected zone. So, that is what in electrogas that does not happen means, here you have a lesser heat affected zone, so, it is a better welding process. That is why it gives a better notch toughness compared to electro slag welding.

(Refer Slide Time: 11:54)

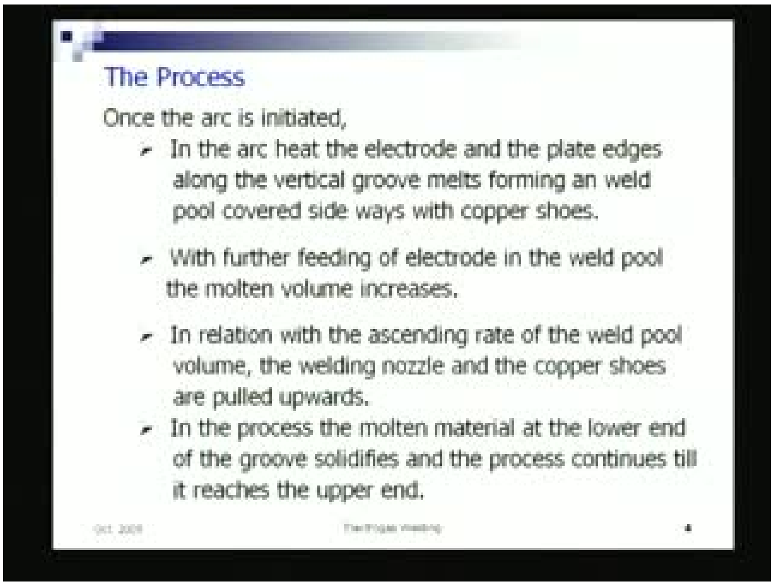


Well, if we summarize the salient features - this electrode gas welding is a automatic welding process like electro slag welding and you can tell I am in the class (( )) It is an automatic process; it welds only in the vertical direction. The weld pool is bound either by two sliding copper cooled water cooled copper shoes or it has a water cooled copper shoe in the front and a ceramic backing strip at the back.

Because say two vertical plates are there, it is being welded. So, it has to be covered from both the sides. If I say this side is the fore front portion, this is the back portion; so, either there are two copper shoes which slides up or a copper shoe as well as a ceramic shoe.

The filler wire electrode is fed through a copper nozzle; electrode is melted by a shielded arc, that means, melted by a shielded arc means what? It is nothing but the entire mountain zone as well as the arc is shielded by a, I mean a gas shielding is only provided. It starts on a run up plate and finishes on a run off plate.

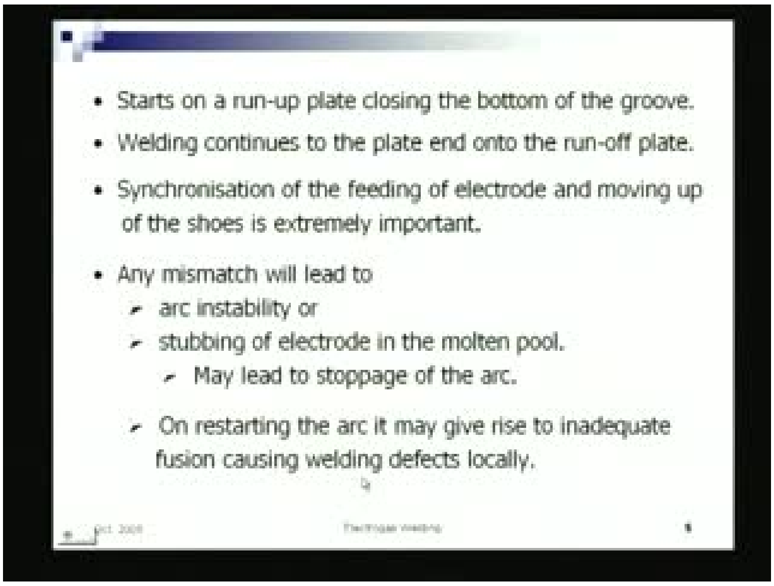
(Refer Slide Time: 14:02)



Constant current DC power supply is generally used and electrode is generally kept positive, that means DC e p power supply is used. Electrode is kept positive because of the simple reason I want to melt more of electrode at a time that means higher melting rate is desirable. So, the electrode is kept positive. What is the process? Once the arc is initiated, in the arc heat electrode and plate edges along the vertical groove melts forming a weld pool covered sideways with the covered copper shoes.

That means a weld pool is formed and that weld pool is continuously maintained. With further feeding of electrode in the weld pool the molten volume increases. In relation with the ascending rate of the weld pool volume, the welding nozzle and the copper shoes are pulled upwards. Like same, in that case of the electro slag welding, here also you will have to synchronize; the lifting up of the shoes as well as lifting up of the welding nozzles which is feeding the electrode.

(Refer Slide Time: 15:04)

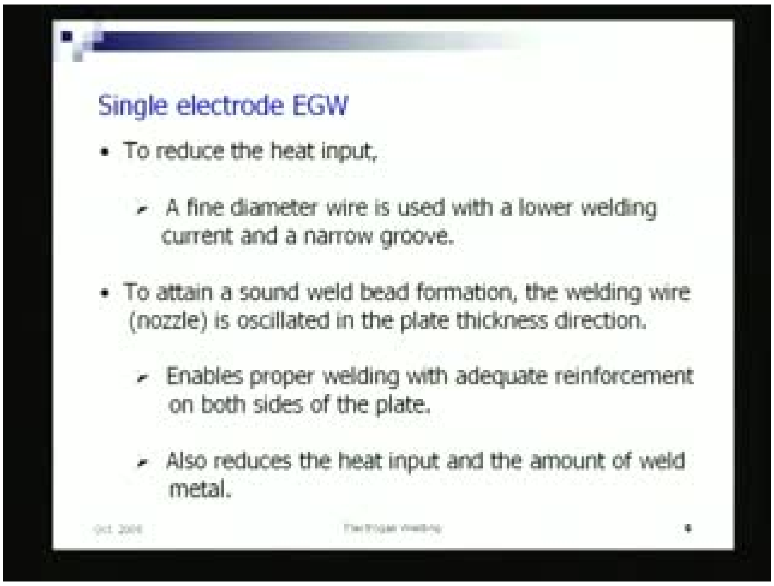


In the process, the molten material at the lower end of the groove solidifies and the process continues till it reaches the upper end. Starts on a run up plate, run up plate means essentially it is starting on a best plate and which finally makes the bottom part of the weld zone of the weld pool which holds the molten metal. Continuous to a run of plate that means it goes out because the welding should continue beyond the plate edge; if it does not continue, then the plate edge will remain un-welded, then again you will have to weld there.

So, it will continue beyond that, and that extra, that is what is called run off plate; then run off plate will be cutout. Synchronization of the feeding of electrode and moving up of the shoes is, obviously, extremely important. Any mismatch in this synchronization may lead to arc instability or stubbing of electrode, both ways. If it is going up faster, electrode is not moving at the right speed, then it will stub means, it will actually touch the molten metal pool and touching the molten metal pool means that arc will get extinguished instantaneously, there will be certain drop in the current. So, the process will stop.

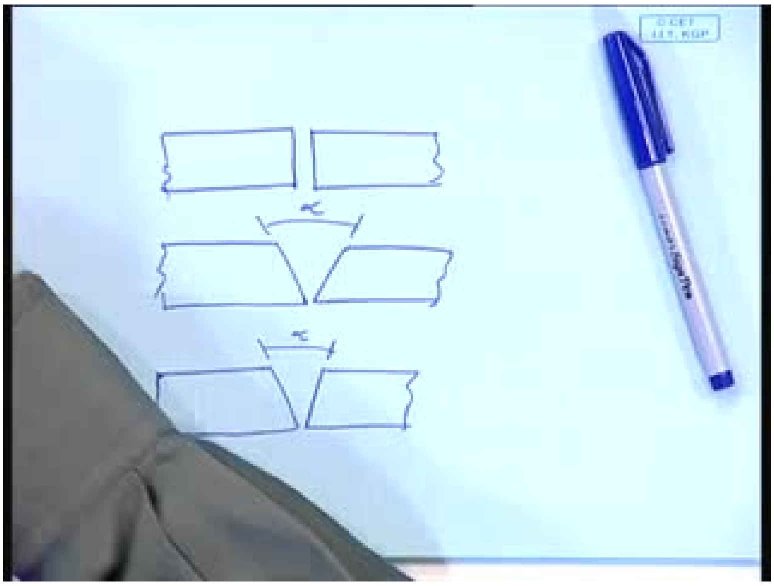
So, if that happens, then you will have to restart the arc and that may give rise to inadequate fusion causing welding defects locally. That means these processes like same in the electro slag welding also that you cannot afford to as such, you cannot afford to have a stoppage in between the process, because the moment it stops, to restart it becomes difficult; not only difficult, it leads to local defects and those defects will be difficult to rectify, because, here, we are talking about welding of very thick plates.

(Refer Slide Time: 17:00)



Well, this electrode gas welding it is being termed as single electrode that means there is a possibility of multi electrode welding also; it only signifies that. If I say single electrode electrogas welding, that means there can be a multi electrode also. The whole idea is single electrode and double or multi electrode is, if I need, if I have to weld a much thicker material, thicker plate, then I need higher still higher deposition.

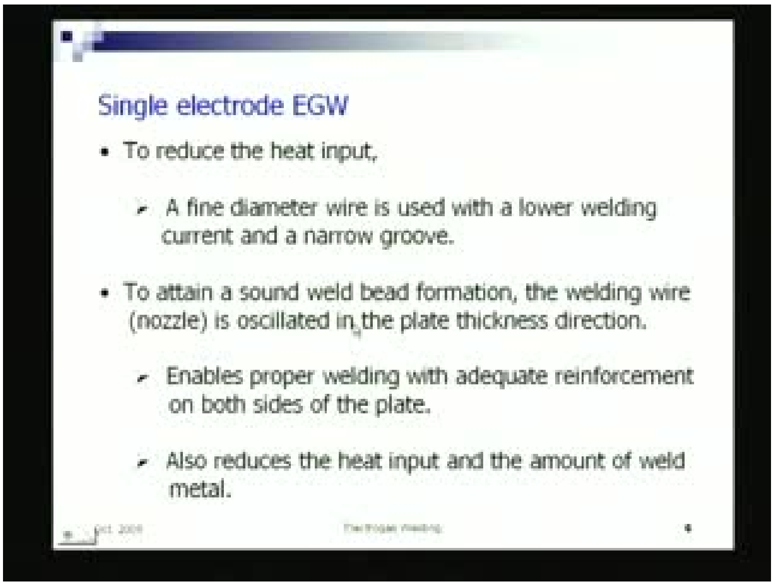
(Refer Slide Time: 18:04)



So, for that one may have to use multiple electrodes. So, we will see what this single electrode is. This is to reduce the heat input a fine diameter wire is used with lower welding current and narrow groove. Narrow groove means you make the weld, the joint geometry; the weld joint geometry having a like one is this. This is what is referred to as we have said square butt.

This is a v group. Now, this angle, if I make it much smaller, this is what is referred to as narrow groove, that means, this groove make it narrow. There is aspect that means, one of the extreme cases of this is the square butt, and the edges become parallel. Other extreme is the very wide groove. So, narrow groove welding means you have to deposit less amount of material again. So, obviously, it is better best would be square butt.

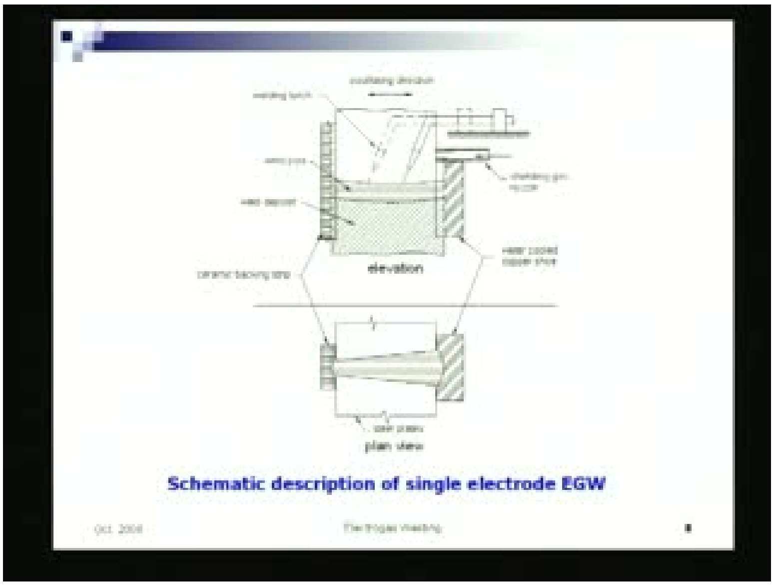
(Refer Slide Time: 19:35)



Butt, but in square butt, you may have difficulty in getting fusion over the entire zone. That is why this v grooving is done, and now, if I make it wider, then there is a chance of much higher heat input, because much higher volume of molten metal will be there. So, that is how it says that it for reducing heat input, one goes for a narrow groove welding.

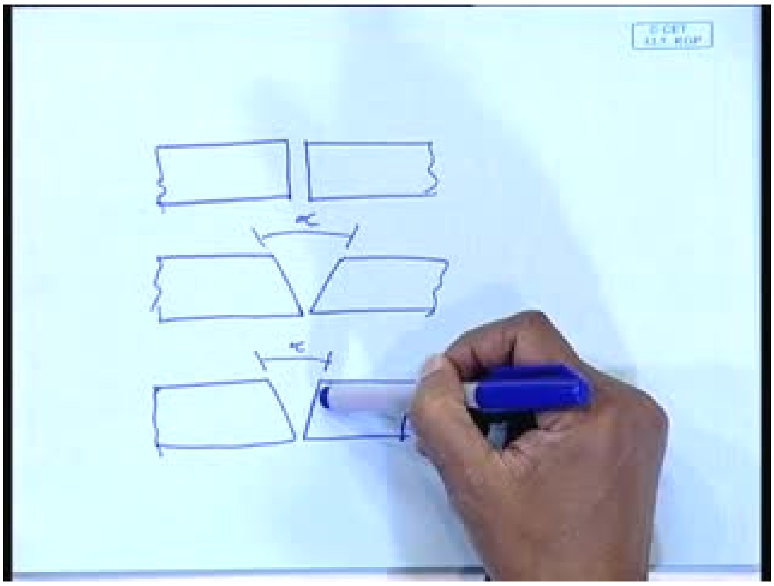
So, there is another corollary from this, that means to have a, where distortion is of very important issue, that means the dimensional deformation because as you know, when you do welding, it generates stresses and leads to some dimensional deformation, structural deformations, which are referred to as distortions. So, if distortion of is of great important, then one should go for a welding process which leads to lesser distortion, one of that is in narrow groove welding.

(Refer Slide Time: 20:47)

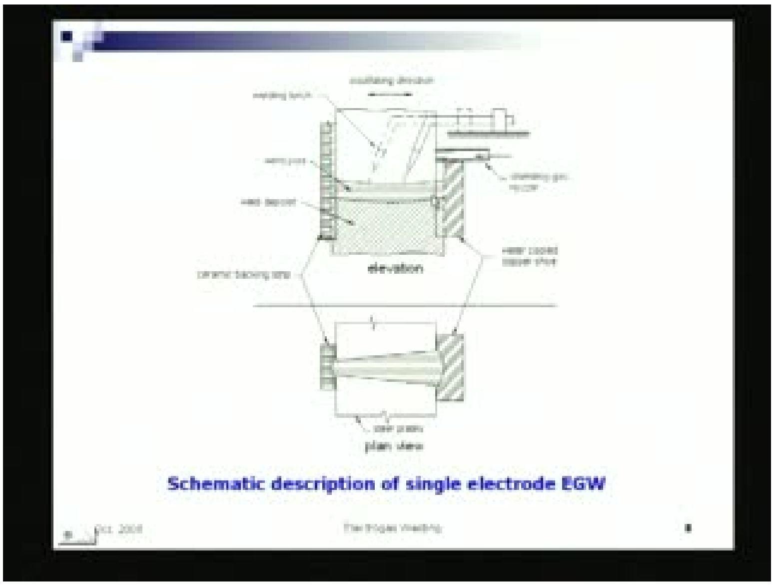


Why? Because, here, the heat input required is less, and once the heat input required is less, your resulting distortion will be less. So, in narrow groove welding, results in lesser distortion also. To attain a sound weld bead formation, the welding wire is oscillated in the plate thickness direction. So, this is another aspect you can see, here the electrode is oscillated, somewhat schematically it is shown like this.

(Refer Slide Time: 21:21)

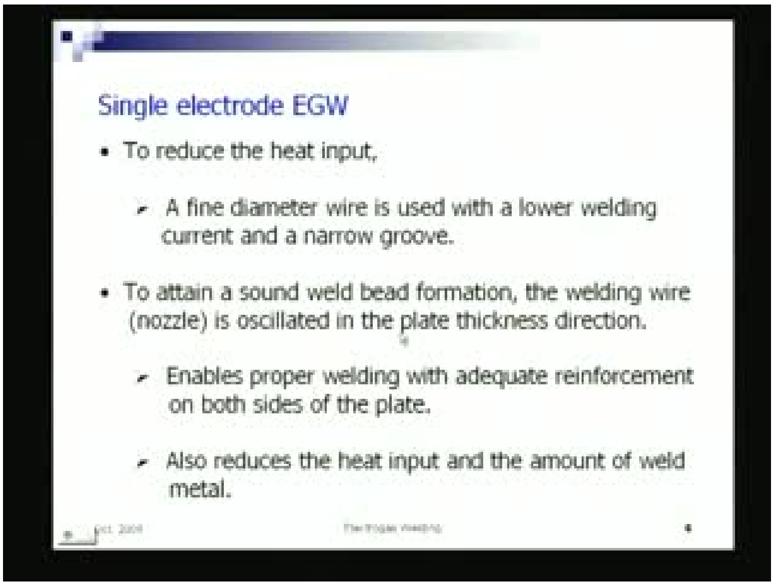


(Refer Slide Time: 21:25)



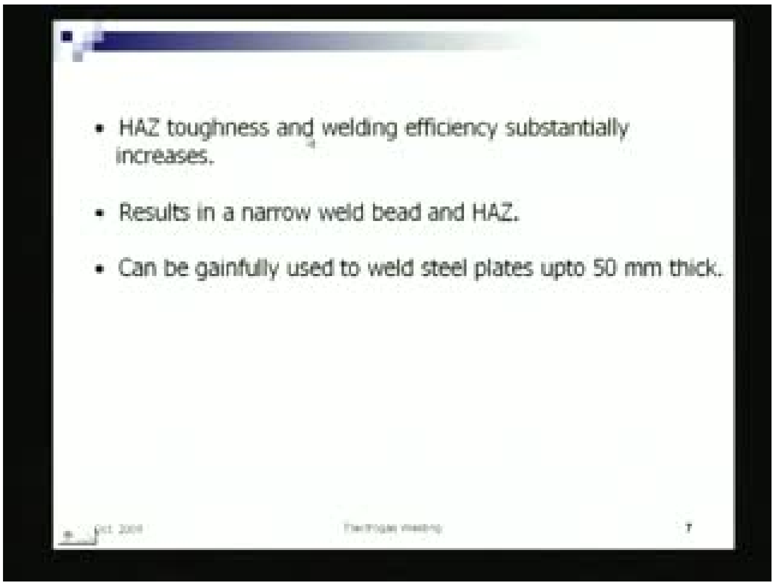
This is the view I mean, in the elevation view, this is the plan view; this is what is the, these are the two plates, this white part. These are the two plates being welded. Here, you have the ceramic backing strip, here is the water cooled copper shoe and this is that narrow groove, what has been formed, narrow groove. - What I was talking about here? The narrow groove - so, this is what is the narrow groove and the electrode is fed like this and the electrode is oscillated along the thickness, as if you are depositing the material over the thickness.

(Refer Slide Time: 21:44)



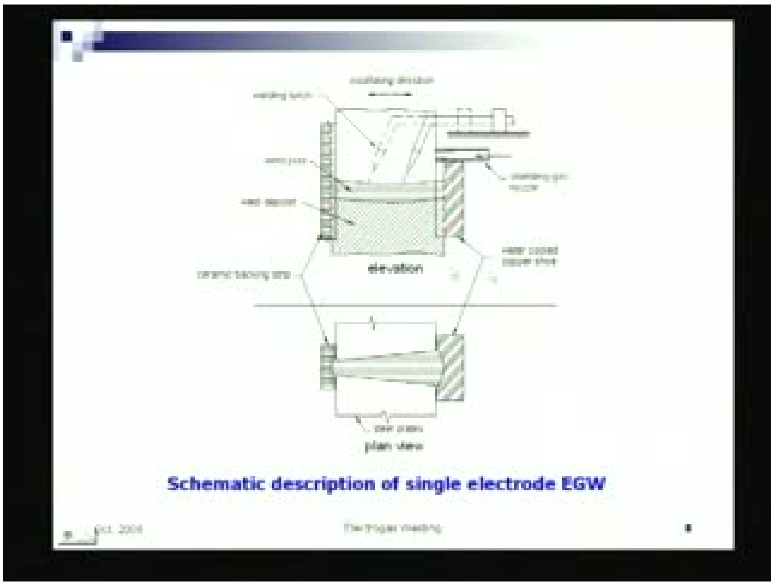
So, that is what it is oscillated or the entire plate thickness. This enables, this oscillation process enables proper welding with adequate reinforcement on both sides because you need to have the reinforcement on both the sides.

(Refer Slide Time: 22:09)



Also reduces the heat input and the amount of weld material. How much weld material is going that that reduces as well as the heat input. Heat affected zones toughness and the welding efficiency substantially increases by which by oscillating the nozzle. The oscillating the electrode, if we oscillate the electrode, it leads to a higher welding efficiency. Results in a narrow weld bead and narrow heat affected zone. It can be gainfully used to weld steel plates up to even 50 millimeter thick.

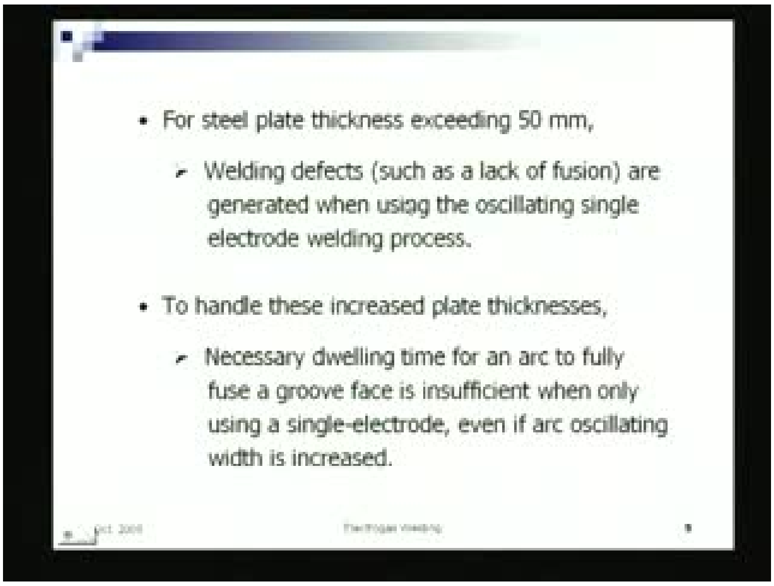
(Refer Slide Time: 22:43)



This is what schematic description of the thing is, that means, even of the order of 50 millimeter thick plates can be welded. So, here you can see this is a wider zone where you have the, well, this, the fused metal, the fused metal here is supported by the backing strips one at the back and one at the front. Those strips has a profiled surface to accommodate further reinforcement, such that, you get that weld bead you get that reinforcement on the front surface as well as on the back surface.

And the electrode is oscillated to and fro along the thickness directions such that one can have a proper inform deposition all along the thickness. Through this nozzle, the inert gas is fed in, this is schematic representation

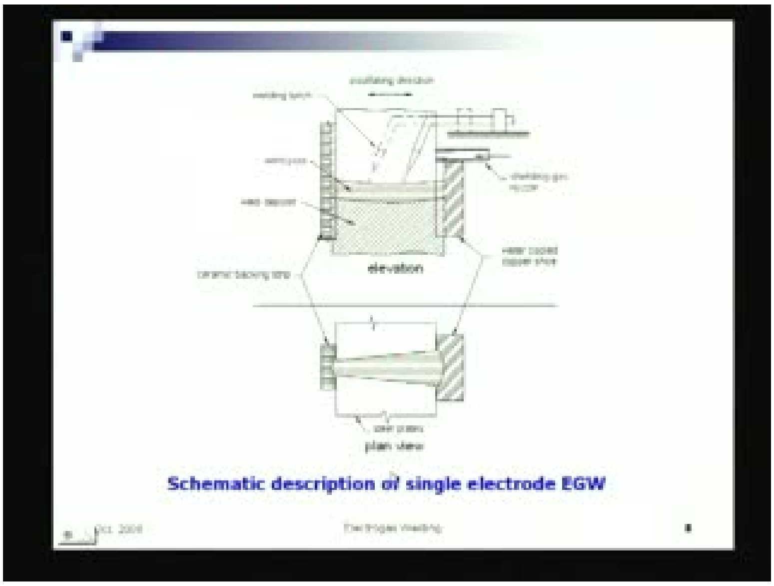
(Refer Slide Time: 23:51)



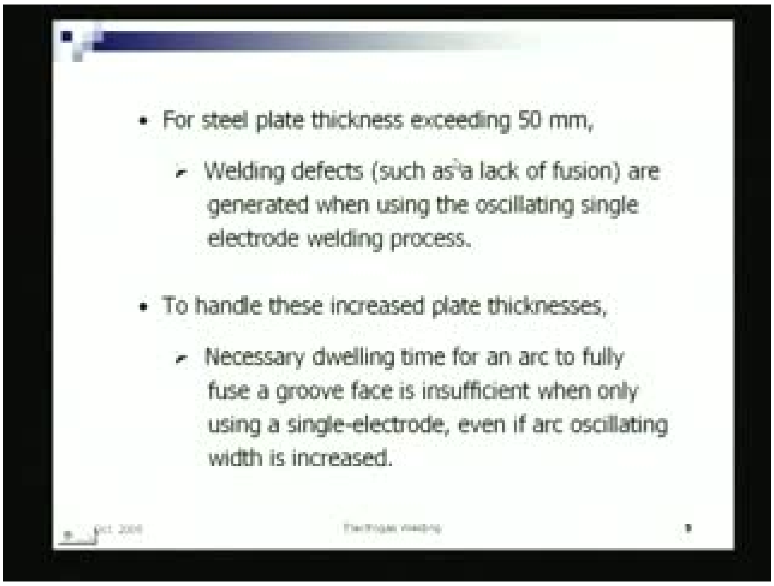
Well, for steel plates exceeding 50 millimeter welding defects, I mean with single electrode welding if we do, we have said that up to 50 millimeter it can do suitable welding. If the plate thickness exceeds 50 millimeter, then welding defects are generated when using the oscillating single electrode process; essentially, lack of fusion takes place.

These are actually, well, these are actually, there is, I mean one can these are the upper limit of the process. That means - if I want to do implement so called electrogas welding for plates of, say 70 millimeter thickness, it will not do a good job. That means, there will be a possibility of defects coming in, or in other words, electrogas welding using single electrode, it has a limitation; it can weld up to a plate of thickness of maximum 50 millimeter, beyond that you will have to look for some other method that is what it says.

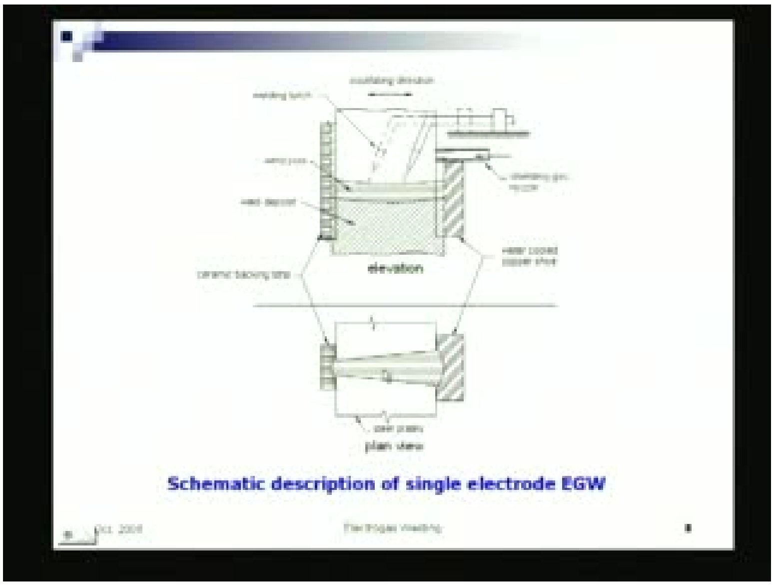
(Refer Slide Time: 25:21)



(Refer Slide Time: 25:37)



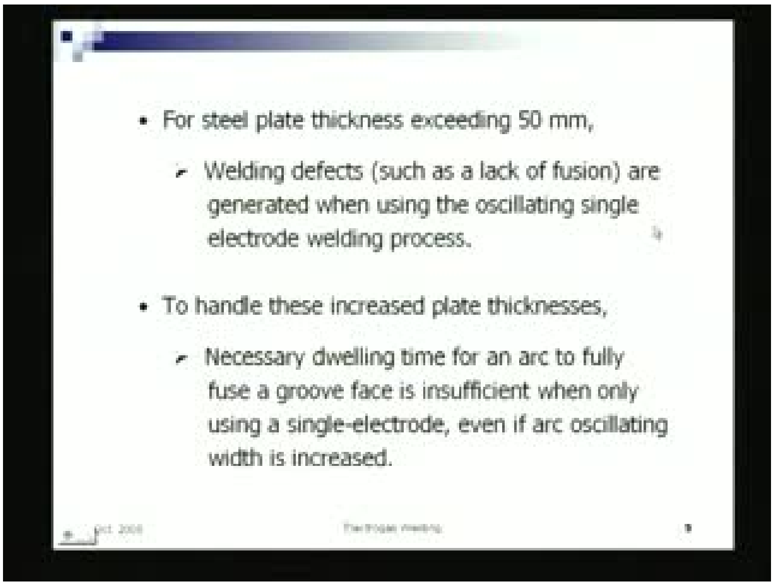
(Refer Slide Time: 25:44)



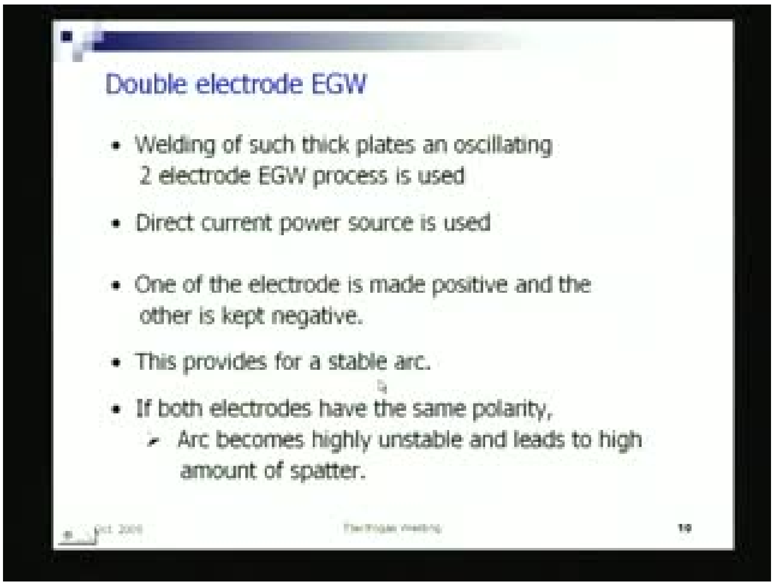
To handle these increased plate thicknesses, necessary dwelling time for an arc to fully fuse a groove face is insufficient when only using a single electrode, even if arc oscillation width is increased. What does that mean? That means, if I have a thicker plate, even a thicker plate, then one can try this oscillating width to increase the oscillating width, such that, I deposit sufficient metal, but the trouble is what happens, the heat available, the arc heat available becomes insufficient. The dwelling time of the arc head, that means - the arc at this level should be present for the sufficient time, such that it fuses the parent metal both sides, I mean both sides, here, both sides the parent metals are fused along the entire thickness as well as necessary electrode is also melted and gets deposited.

But if it is too wide, it is moving up and down the arc, right, you will have to do it at a certain speed. If you do it very slow, then the metal at the front will get solidified or by the time it travels there metal at the back get solidified. If you do it too fast, then enough heat is not going.

(Refer Slide Time: 26:32)

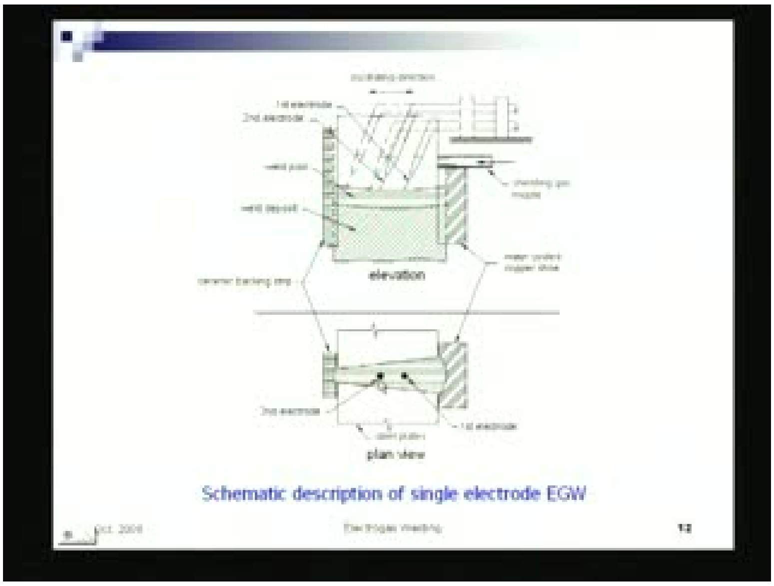


(Refer Slide Time: 26:44)



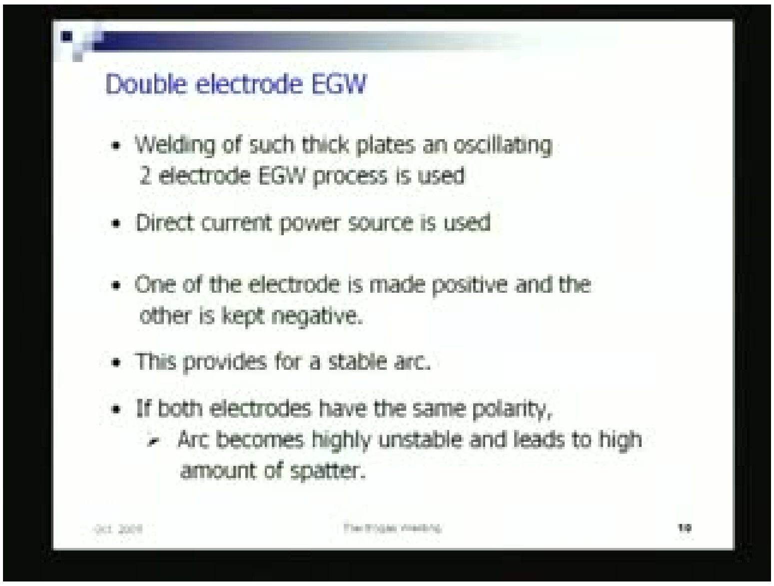
So, there is a limitation up to 50 millimeter, it can be done with desirable qualities; beyond that a single electrode is not a feasible solution. So, comes to the necessity of double electrode, electrogas welding. So, what is done here? Welding of such thick plates and oscillating 2 electrode system is used.

(Refer Slide Time: 27:12)



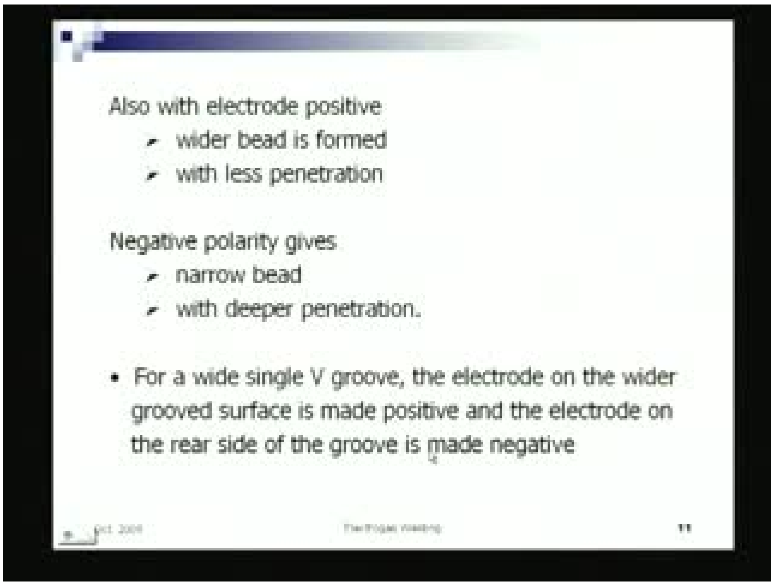
Here also direct current power sources are used. One of the electrodes is made positive and the other is kept negative, because there is again other difficulty. This provides a stable arc because when you are doing a double electrodes, say, I mean the schematic is similar, only thing in case of only difference is, instead of a single nozzle, you have two nozzles and both of them oscillating simultaneously. Now the gap between the two nozzles means the gap between the two electrodes that again plays a role.

(Refer Slide Time: 27:40)



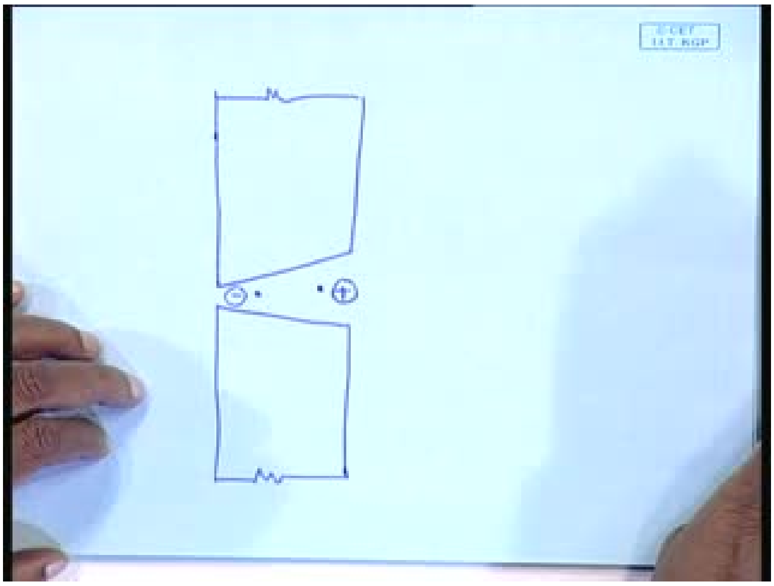
Because if both are positive, then there will be repulsion in the arc column. So, what has been found is that they are kept one is kept positive another negative; that gives us a stable arc. If both are of same polarity, then arc becomes unstable and leads to high amount of spatter possibly because of continuous repulsion between the arcs, there will be a high amount of spatter as well as the arc tends to be become unstable.

(Refer Slide Time: 28:06)



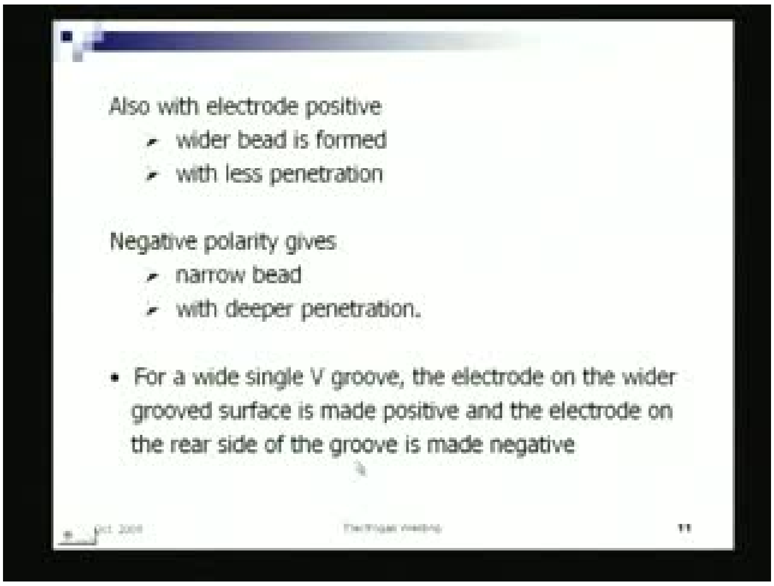
And also with electrode positive, we get a wider bead formation and less penetration. Because, this again is, as you know as the electrode is positive, more heat is generated electrode. So, it causes a less penetration, but a wider bead formation means more melting of the electrode leading to wider bead. A narrow polarity, a negative polarity will give a narrow bead and deeper penetration.

(Refer Slide Time: 29:08)

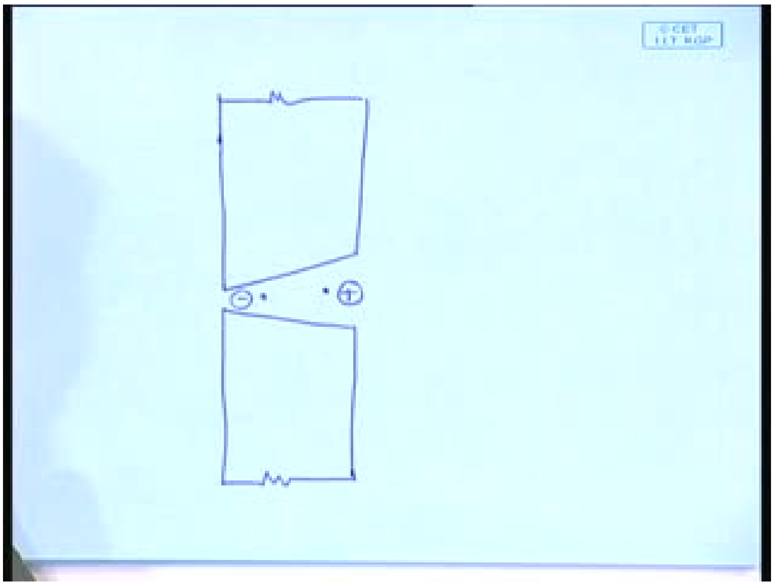


So, you get the advantage of both because you need a wider bead also you need, because this is thicker material, and you need proper penetration. For a wide single v groove, the electrode on the wider grooved surface is made positive and the electrode on the rear is made negative, that is another aspect. That means, here, suppose, well, say schematically it is something like this; so along the wider groove, you have the electrode is kept positive and the electrode closer to the narrower end is kept negative.

(Refer Slide Time: 29:44)



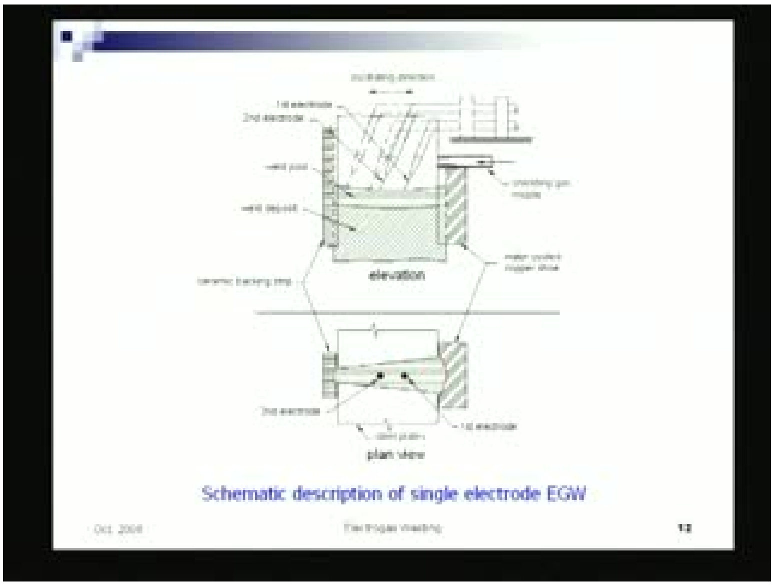
(Refer Slide Time: 29:57)



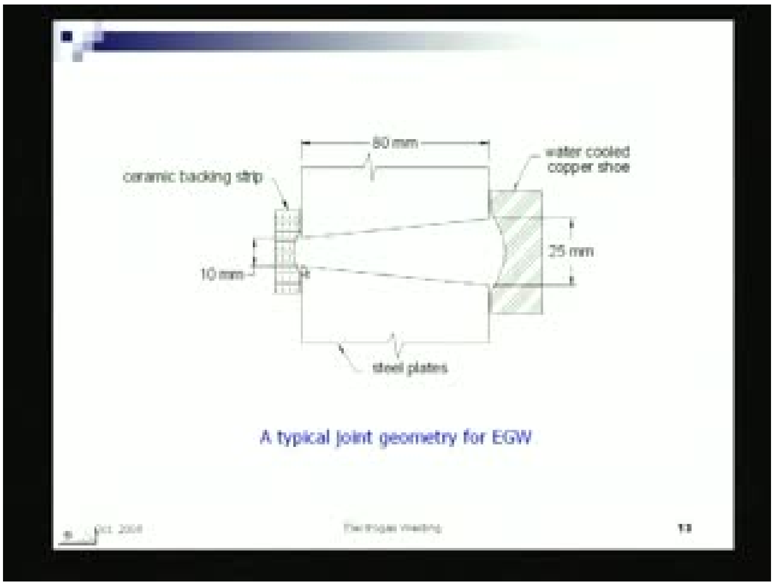
The electrode on the wider side is positive; on the narrower side is negative, because you see, on the, here it is kept positive means what? It is a wider side, you need more deposition of the metal more electrode melting is required. So, you kept the electrode positive. So, firstly we have say, we have seen that we will not keep both of them of same polarity.

We will have to keep one of them positive; another negative. So then automatic question comes which one positive, which one negative. So, this is the logic of keeping the front, keeping the one which is on the wider side of the opening positive. The logic is that you need more melting of electrode. So, that is how that becomes positive; the other automatically becomes then negative.

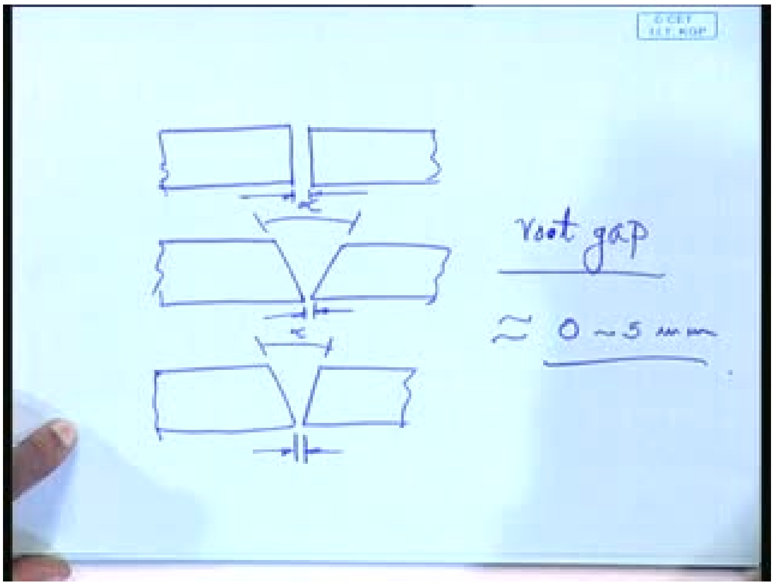
(Refer Slide Time: 30:42)



(Refer Slide Time: 30:56)



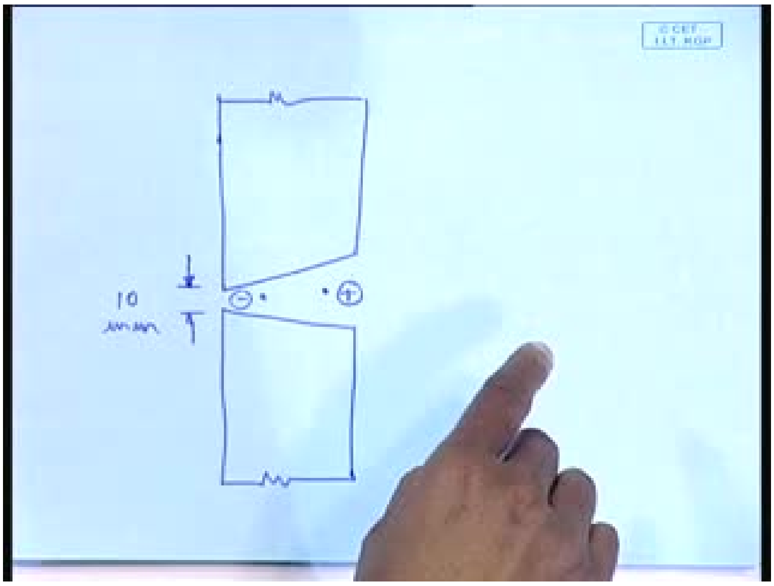
(Refer Slide Time: 31:24)



So this is what is schematically it is represented. You have two electrodes in tandem which are oscillated together; rest other aspects are same. So, this is a typical geometry of that, suppose you have a 80 millimeter wide plate, then the group as you can see is quite narrow because where 80 millimeter deep. The phase opening is only 25 millimeter, and the root gap at the narrower end is 10 millimeter. So, the difference you can see all the other butt welding processes as I was telling you, the minimum root gap, the root gap is this particular distance.

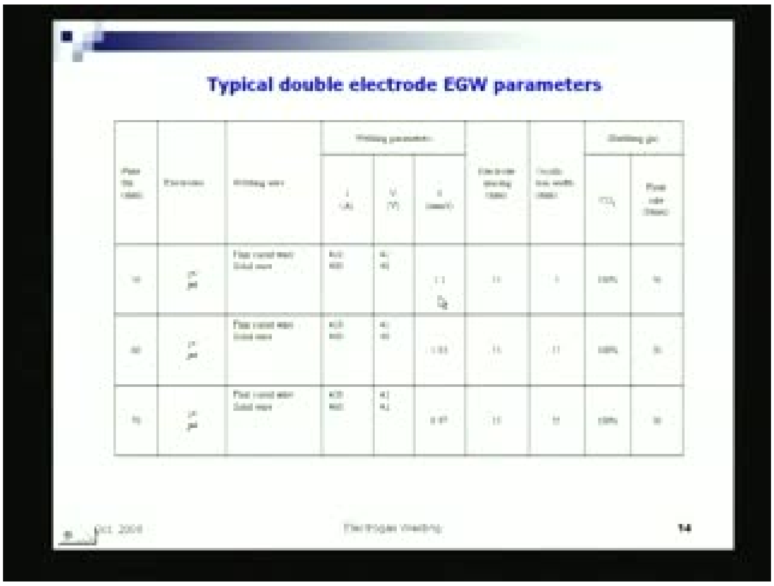
The distance between the 2 plates are at the narrower end. In case of a square butt, of course, the root gap both at the bottom and at the top are same, because it is a square butt; there is no edge preparation, but if it is a v groove, then the gap at the bottom, or the minimum gap between the 2 plates are referred to as root gap. So, in all butt welding cases, the root gaps are of the order of it varies from 0 to, well, around say 5 millimeter maximum.

(Refer Slide Time: 32:13)

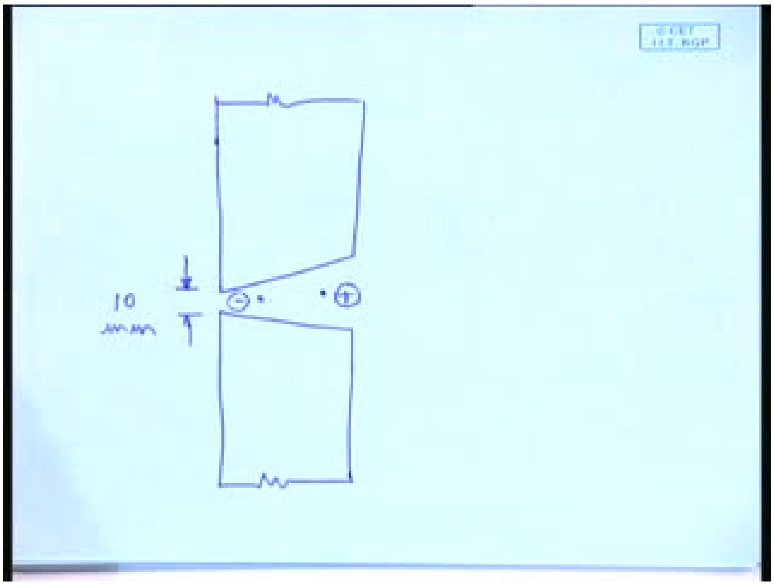


But here, you see the so called root gap is equivalent in this case, here, it is about 10 millimeter in electrogas welding. So, that is what is the difference, that means, because here the aspect is somewhat different not in case, as we do, in case of butt welding.

(Refer Slide Time: 32: 40)

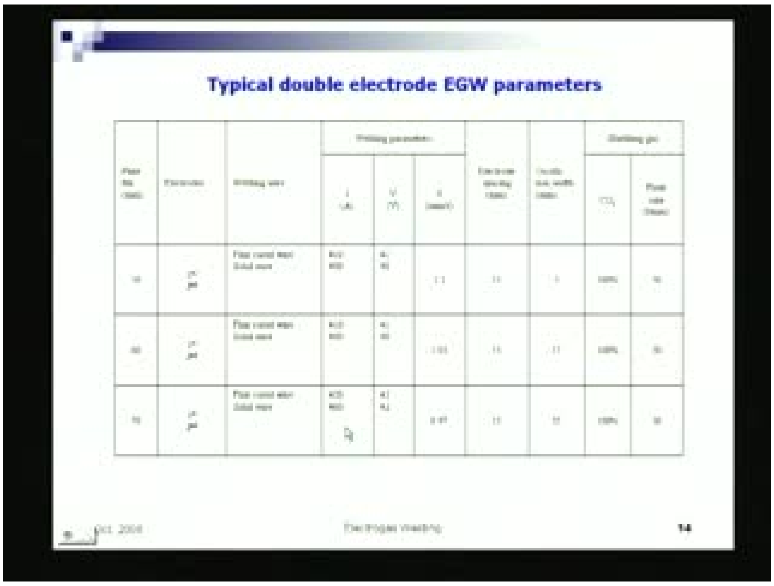


(Refer Slide Time: 33:11)



Well, these are some of the typical welding parameters, as you can see; say a welding of a 70 millimeter thick plate. The first electrode is fed with 420 amperes, whereas, the second electrode is with 460 ampere, that means there is a little bit of difference in the front and I mean the ampere is in the two electrodes.

(Refer Slide Time: 33:15)



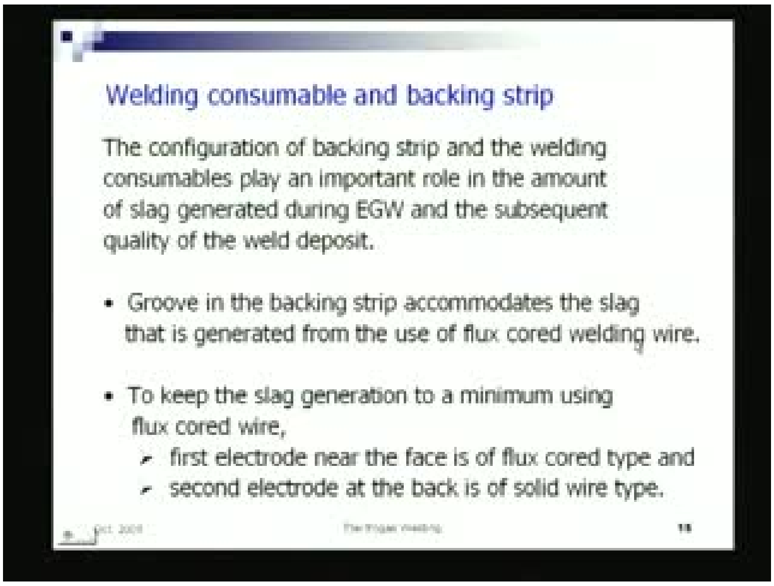
So, these are some of the sample weld parameters. The welding voltage one interesting thing, one can see in electrogas welding is the welding voltage is generally very high is of the order of 40 volts. Whereas, in gas metal arc welding, if we look into the welding voltage, would be of the order of 20 to 30 volts maximum.

And the welding current, if it is a manual gas metal arc welding, well, the welding current also will be less; it can be of the order of 200 250 ampere. Here, the welding current, you see, if I, in case of submerged arc welding, one can go up to welding current of 1000 ampere, if not even 1500 ampere depending on plate thicknesses and at what, how many runs you are doing, it will be like that. Like, for example, if you weld a plate of say 12 millimeter thick at a single run, then one can go up to a current of the order of 700 ampere.

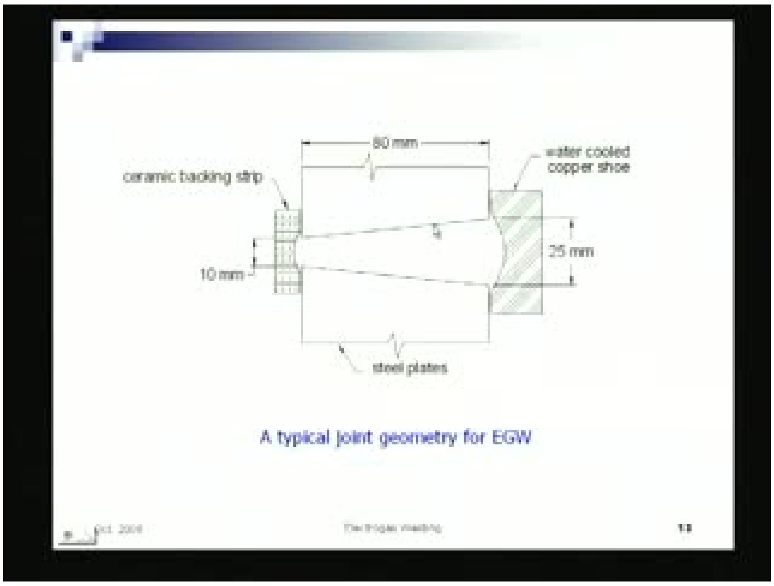
But here, you see a 70 millimeter thick plate is being welded, the current is only 400 in one electrode again another around 400 in another electrode. So, that way one can say total current is only 800 ampere approximately total current, but the plate being welded is 70 millimeter thick and that too at one run. So, that is how these processes are very effective, very efficient process, but of course, the voltage level is much higher here.

The shielding gas use is generally carbon dioxide in electrogas welding; the 100 percent carbon dioxide shielding is done. Obviously, carbon dioxide will be used when we do welding of steel; here, we are talking about welding of carbon manganese steels not stainless steels or any other non-ferrous material. If you weld non-ferrous material, obviously carbon dioxide, you cannot use you; go for argon or argon helium combination.

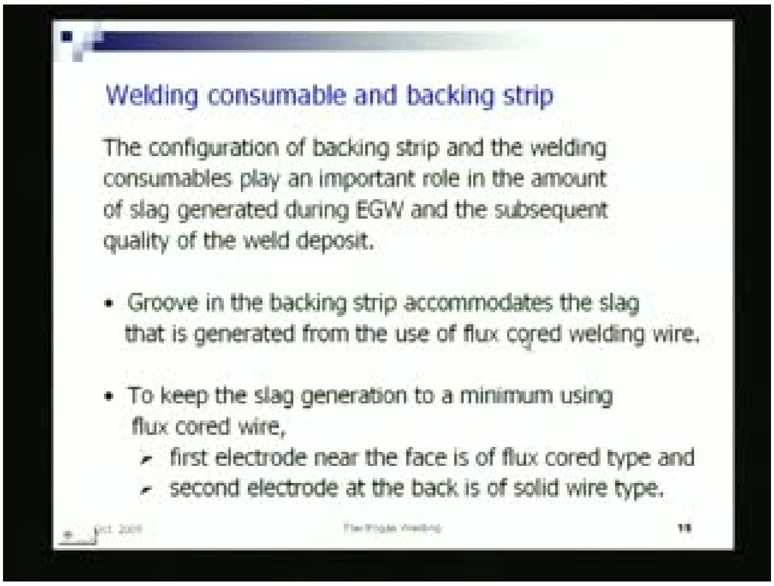
(Refer Slide Time: 35:35)



(Refer Slide Time: 35:43)



(Refer Slide Time: 35:57)



So, welding consumable and backing strip. So, these are the important aspect that backing strip means this backing strip, which is supporting the molten metal both sides, these at the back; these at the forward. So, design of those strips also determines the weld quality. The configuration of the backing strip and the welding consumables play an important role in the amount of slag generated during electrogas welding and the subsequent quality of the weld deposit.

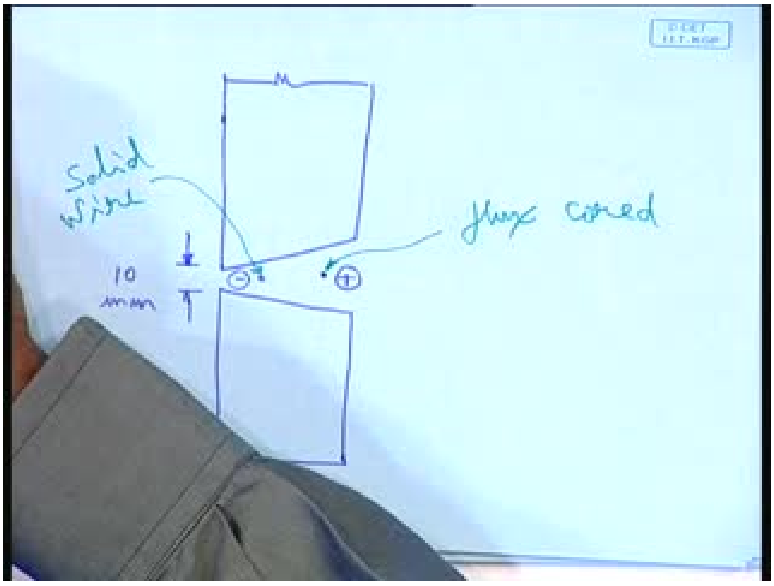
So, groove in the backing strip accommodates the slag that is generated from the use of the flux core welding wire, where from the slag is coming for the flux cored, in the core, there is a flux. So, that is forming the slag, why it is used? Because, well, it improves the, improves the fluidity of the material; improves the arc characteristics; helps in initiating the electric arc; helps in stabilizing the electric arc, so, and so forth.

So, having a flux core wire is good, but if you have that, you will have to have a mechanism of getting the flux out of the molten metal. So, where it gets out? It gets out at the backing strips. Obviously, it should float out. So, whatever, so, you will have to have a proper groove which can accommodate apart from the reinforcement, the amount of flux which may get generated if I use a flux core welding wire.

To keep the slag generation to a minimum using flux core wire, the first electrode near the face is of flux cored type, and the second electrode is a solid wire, because ideal would have been if we use solid wire electrode, because shielding here is being done by the gas, the inert gas or CO2, whatever is being used, but to take advantage of or to get the additional benefits of flux, one can go for a flux cored wire welding.

So, now, then it brings in a problem that means the slag forms. So, you will have to accommodate the slag. To minimize that difficulty of handling the slag as well as get the benefit of the flux core. So, what is done? Again a compromise is done, that means the one of the electrode is used with a flux core type; another one used as a solid one, like in submerged arc welding. We do not go for flux cored wire; there is no necessity, because you are using solid flux, the whole shielding is being done by flux.

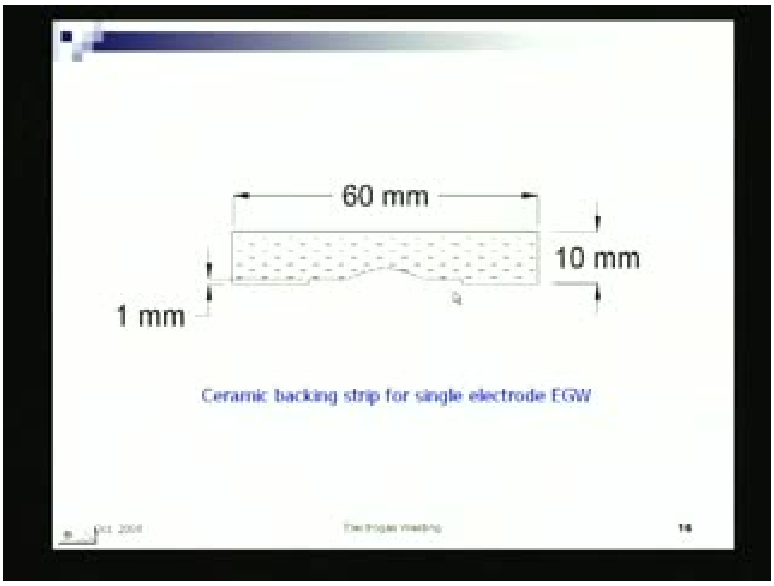
(Refer Slide Time: 38:55)



So, having a flux core does not make any sense. So, there a solid wire is used, solid wire electrode. Similarly, here, we are saying that the first electrode near the face means on the wider side, the first electrode used is a flux core type and the second one that means this is a flux cored type, and the one which is at the rear, is a solid one, is a solid wire electrode.

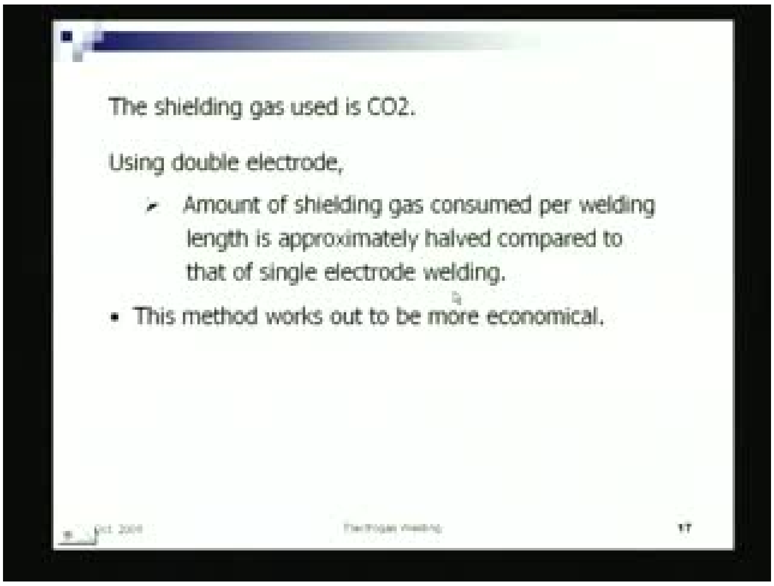
So, thereby, one so called make a compromise on the usage of flux cored wire reduces the slag generation. At the same time gets the benefit whatever is there from a flux cored wire.

(Refer Slide Time: 39:34)



So, this is the typical geometry of the ceramic backing strip for a cycle electrode, single electrode electrogas welding. So, here you can see that a typical groove is made for accommodating the flux, the slag and as well as the molten metal such that it forms the reinforcement.

(Refer Slide Time: 40:05)

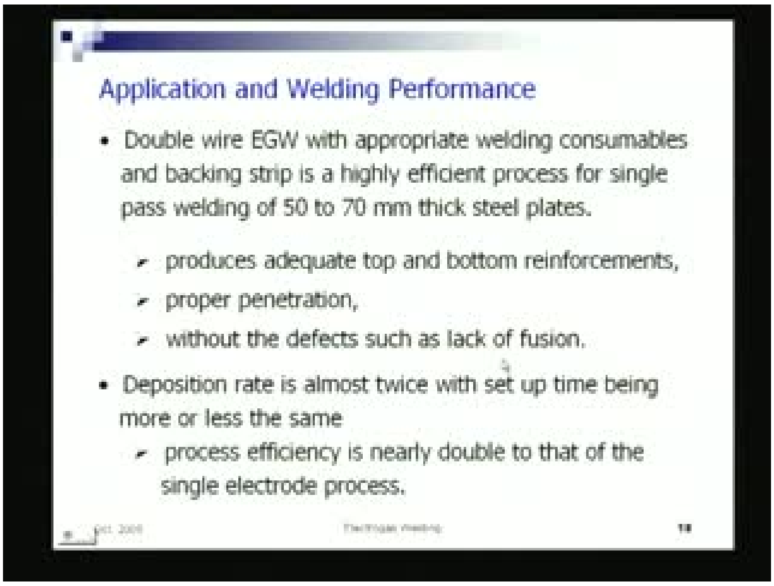


The shielding gas used is generally CO2 carbon dioxide is used. Using double electrode, the amount of shielding gas consumed per welding length is approximately halved compared to that of the single electrode welding.

So, what you see is that when you go for a double electrode welding, then, in fact, the consumption of shielding gas becomes half becomes less as compared to the amount of metal getting deposited. Because, to deposit metal from a single electrode, the amount of shielding needed remains more or less the same if I use 2 electrodes, but by using 2 electrodes, I increase, I double the deposition rate, but the shielding requirement remains the same. This is the, suppose for a plate thickness, say a plate thickness of 40 millimeter plate is being welded and I go for a double electrode welding, I will have less, I mean the cost of production will become less because I will be using the more or less the same amount of welding, the shielding gas, but my deposition will become double; deposition becoming double means what? Deposition rate becoming double means I finish the weld much faster. So, if I finish the weld faster means I consume less shielding gas. So, that is how over all costing becomes less. So, that is what it says that the amount of shielding gas consumed per welding length is approximately halved compared to that of the single electrode welding.

So, per welding length whatever is the cost involved, in case of a single electrode welding, the cost involved will be more compared to that of a double electrode welding. The method works out to be more economical.

(Refer Slide Time: 42:17)



What are the applications of these and how are the welding performances double wired electrogas welding with appropriate welding consumables and backing strips is a highly efficient process for single pass welding of 50 to 70 millimeter thick plates.

Double wire electrode is a good metal for such kind of plates produces adequate top and bottom reinforcement, by top and bottom means both the sides. Because this term top and bottom reinforce they are rather relative, they relates to a horizontal plate where the top surface and the bottom surface, but here the plates are vertical. So, in any case, the top means the wider surface; the wider opening is the top; the narrower opening is the bottom or the back surface.

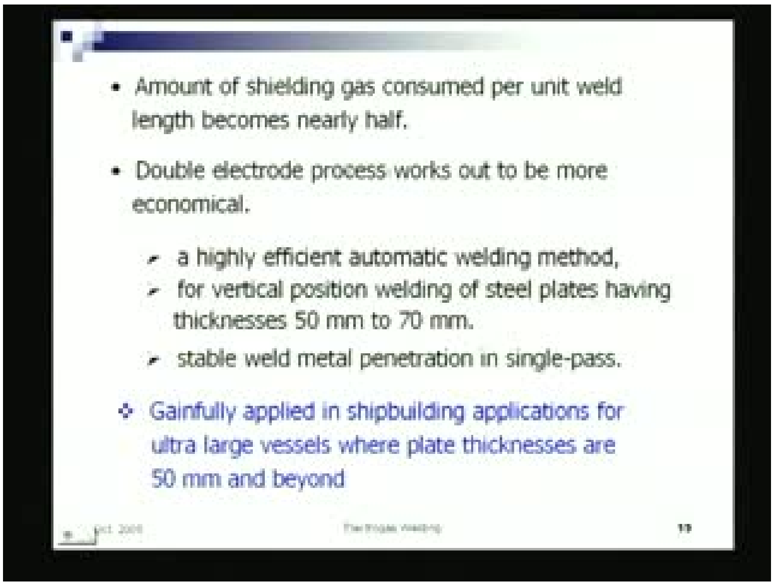
So, produces adequate reinforcements, it gives proper penetration. Proper penetration means total fusion of the entire thickness and it produces weld joints without defects such as lack of fusion. Why it is talked about because if such thickness plates are being welded using a single electrode, there can be a defect of lack of fusion. Lack of fusion is a defect means not proper penetration of the in the metal thickness. Deposition rate is almost twice with set up time being more or less the same this is another aspect. If we go for a double electrode welding, obviously, the deposition rate becomes roughly doubled, but the entire setting up time for the welding, because you see, the welding is such a process that actual welding operation takes very less time.

What time it takes, it depends on the what is the welding speed. Sa,y the welding speed is half a meter per minute, what does that mean? That means a 10 meter long plate to weld, it will take 20 minutes, just 20 minutes, a 10 meter long plate, but in reality, if you weld a 10 meter plate, you will find you have you have spent about 2 hours. So, where the time has gone? It is a setting up time.

First you have to align the plates; set the welding instrument; set the electrode; check the alignment; all those things and then switch on the power and it start welding; Say a automatic submerged arc welding. That means, once every alignment is done, you provide the power, then electrode will be automatically fed and will deposit the required metal along the weld length, and you will find from that point, twenty minutes job is done, but before that you have spent probably one and half hours setting up the thing aligning the plate, etcetera.

So, that is what it says that the setting up time being more or less the same. So, whether we are setting up for a single electrode or for a double electrode, the setting up time is more or less the same. So, thereby, process efficiency is nearly double to that of single electrode process. Here, we are talking about double electrode process; the application and the performance of double electrode process.

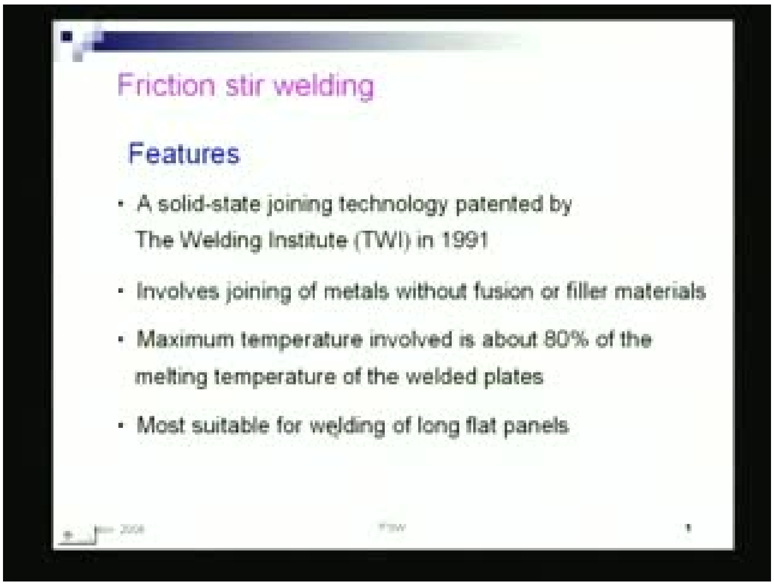
(Refer Slide Time: 46:11)



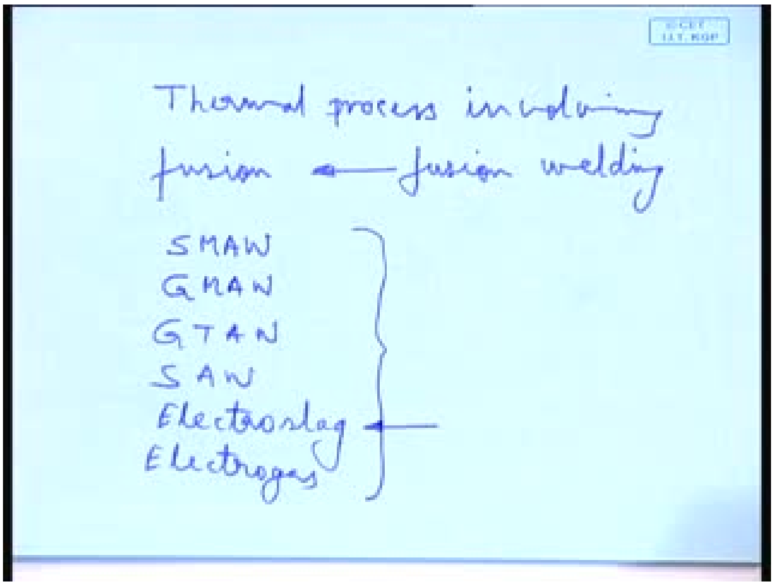
So, we see that the process efficiency is nearly double to that of the single electrode process. Amount of, at the same time amount of shielding gas consumed per unit weld length becomes nearly half, as I was saying, because the weld pool volume is not changing, neither the weld joint geometry is changing. So, the requirement of your shielding gas is remaining, is totally remaining the same. So, that is how the remaining same. So, if I compare that with that of the length of the weld, then one can say that it has become nearly half because the deposition rate has become doubled, so, my unit weld length has increased; gas consumption has remained the same. So, thereby, effective gas consumption becomes half. Double electrode process works out to be more economical, that is one of the conclusions, that means, wherever if one will have to do a electrogas welding, then one should try to look into whether a double electrode process can be implemented. If that is so, then we have a more economical process operation.

It is a highly efficient automatic welding method for vertical position welding of steel plates having thickness of 50 to 70 mm stable weld metal penetration in single pass. So, it can be gainfully applied in shipbuilding applications for ultra large vessels where plate thicknesses are 50 millimeter beyond. That means very those big vessels, essentially as I was telling that application of electro slag welding, same way for connecting the blocks, the vertical side shell plates, those welding arc done using this electrogas or electro slag welding.

(Refer Slide Time: 48:39)



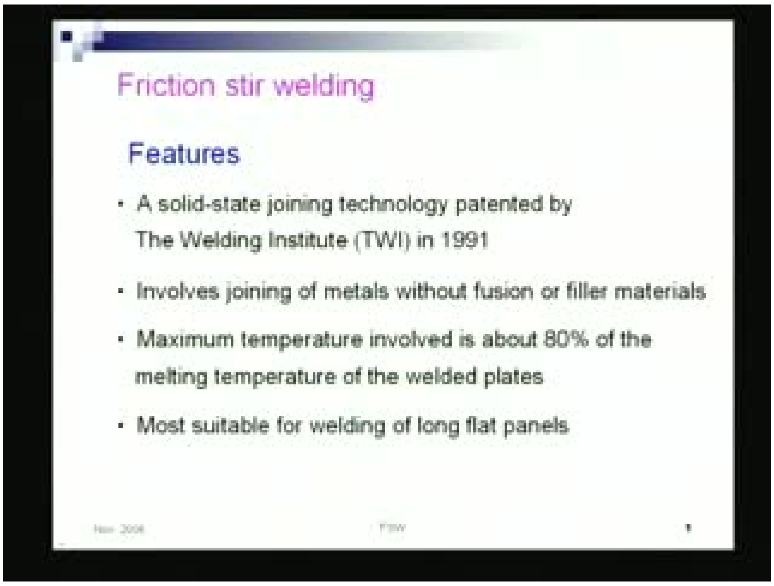
(Refer Slide Time: 48:43)



Well, next, so, this is all about the some of the welding processes which are widely used in shipbuilding. So, what we have talked about are all essentially thermal processes involving fusion, or can be referred to as fusion welding whether it is a shielded metal arc welding.

So, once again just to summarize shielded metal arc welding. Then we had gas metal arc welding, gas tungsten arc welding, submerged arc, then electro slag, and then electrogas, so, what happens? All of them are fusion welding process. Only in case of electro slag, welding the heat generated is from not from the electric arc but from the resistance heating rest all where from electric arc.

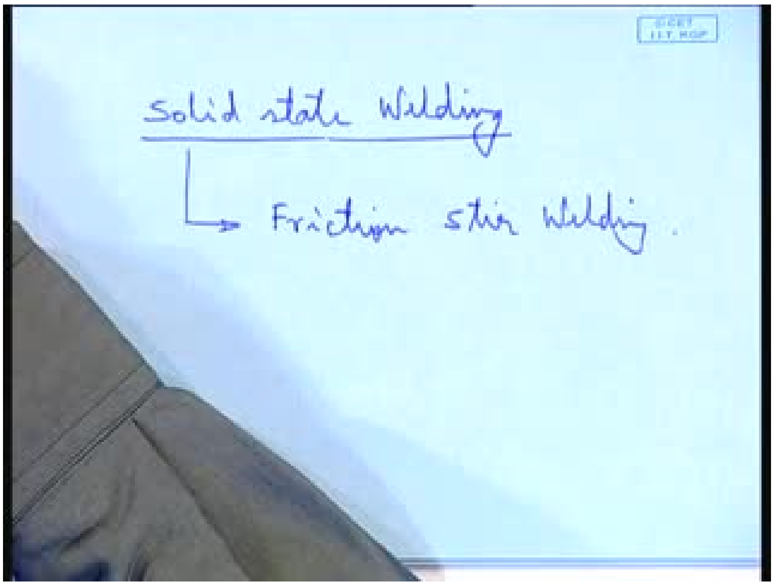
(Refer Slide Time: 50:06)



So, all are essentially electric welding process as well as a fusion welding process. Now the moment a welding process becomes a fusion welding process, then you have along with it, some of the advantages and disadvantages built in the system. One of the primary disadvantage is the moment metal is fusing; there is a chance of gas entrapment; there is a chance of slag entrap entrapment; solidified the molten metal is getting solidified, so, a very high thermal stresses work; so, chance of solidification cracking; so, all this defects are probable or possible.

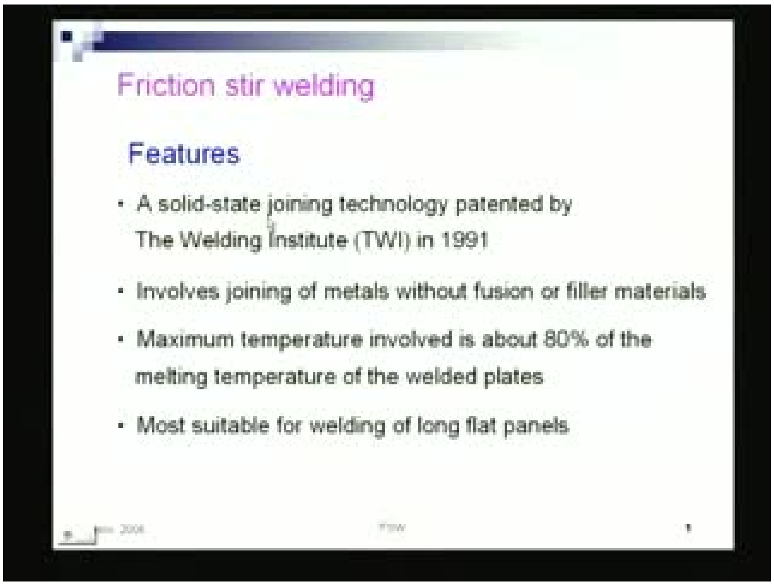
I do not say that you do fusion welding process so you will have all those defects, no, but they are more likely to take place. So, if I avoid that entire process of fusion, then all those defects are or difficulties are avoided, that means, if I can develop a welding method where in I do not melt the material, so it becomes a process where in I do not have all those difficulties related to fusion.

(Refer Slide Time: 51:24)

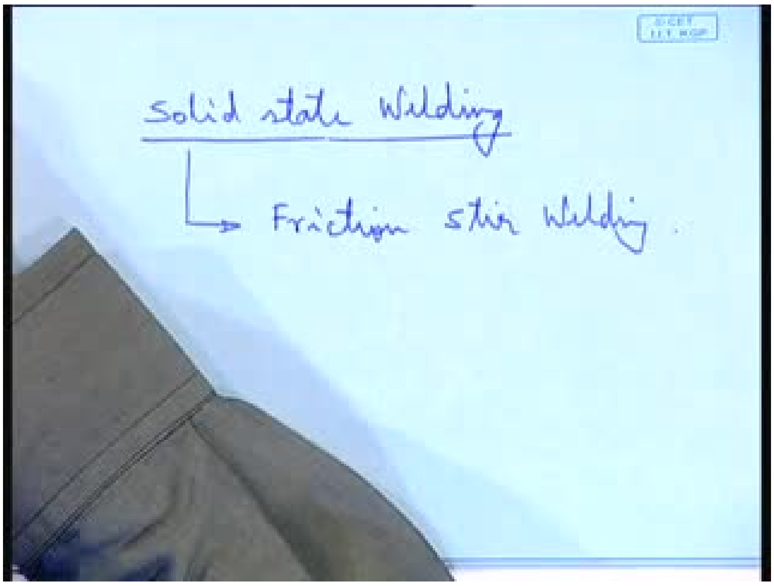


So, one such method, so where we do not melt the material is referred to as solid state welding, because in the fusion welding, the material was going in the liquid state, in the liquid phase - here we are not going in the liquid phase, so it can be referred to as a solid state welding. One of the methods is referred to as friction stir welding friction stir welding.

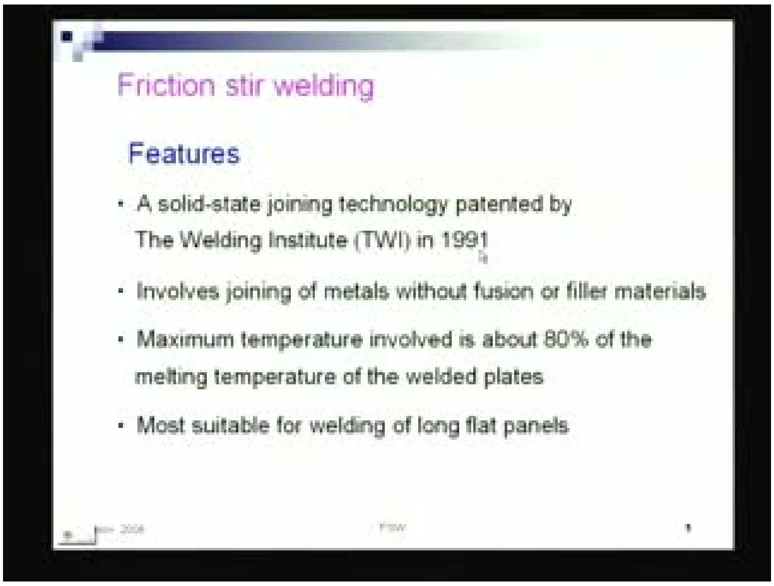
(Refer Slide Time: 52:10)



(Refer Slide Time: 52:25)



(Refer Slide Time: 52:27)

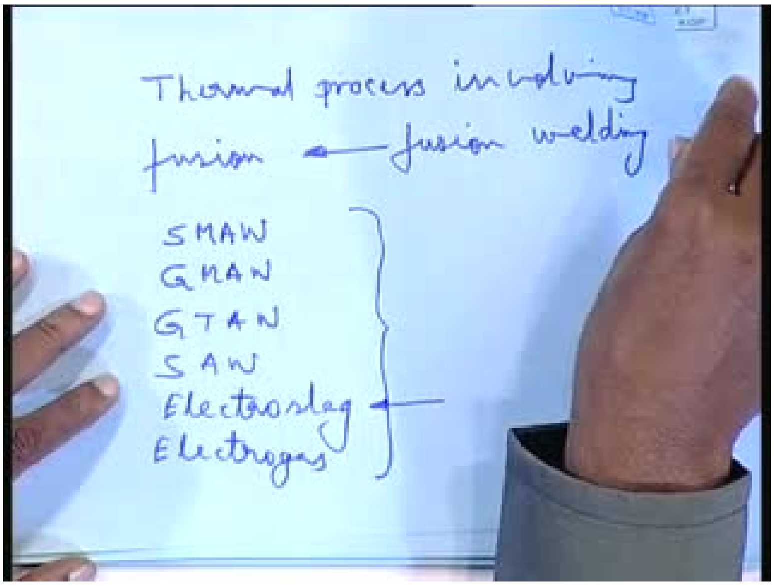


So, we will see what does this method. Here, the primarily, as you can see it is a solid state joining technology, the joining method, and as you can see, it is not a very old technique; it is patented as sort of late as 1991 only sort of came into being very new technique, whereas all the electric arc welding methods, they are all (( )) I mean many of those methods were in full operation and use in the time of, I mean at the time of second world war.

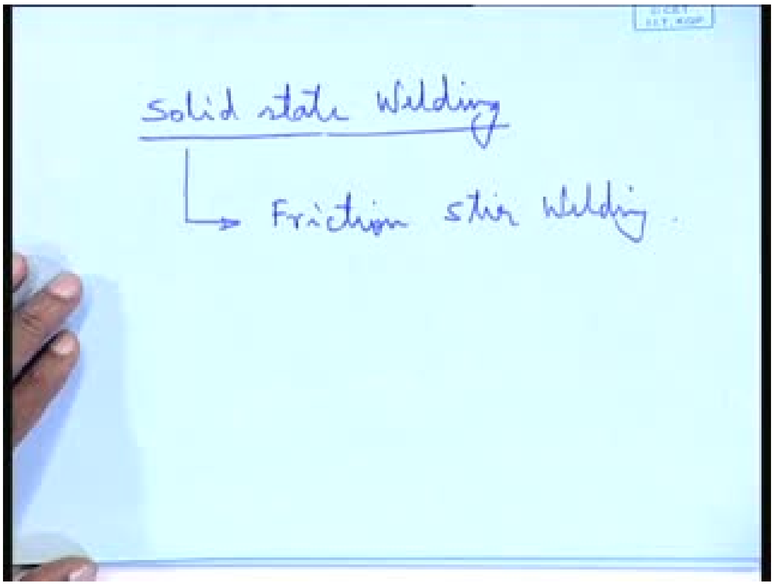
Well, so, that is what it is fairly a new technique. It involves joining of metals without fusion or filler material as I was saying there is no fusion taking place and once no fusion taking place means there is no need of filler metal also; in all the other fusion welding processes we have seen there is a filler metal generally always there is a filler metal.

The filler metal can be a can be a separate filler metal or can be the electrode itself acting as the filler metal that means it gets melted and gets deposited, but here the question of filler metal is not there that means in this process, the question of any square butt, v groove, wide groove, narrow groove nothing occurs, so, it has to be that root phase, root gap should be 0, because there is no, since there is no filler metal means, you cannot afford to have any gap between the plates or gap between the edges which are being joined, welded.

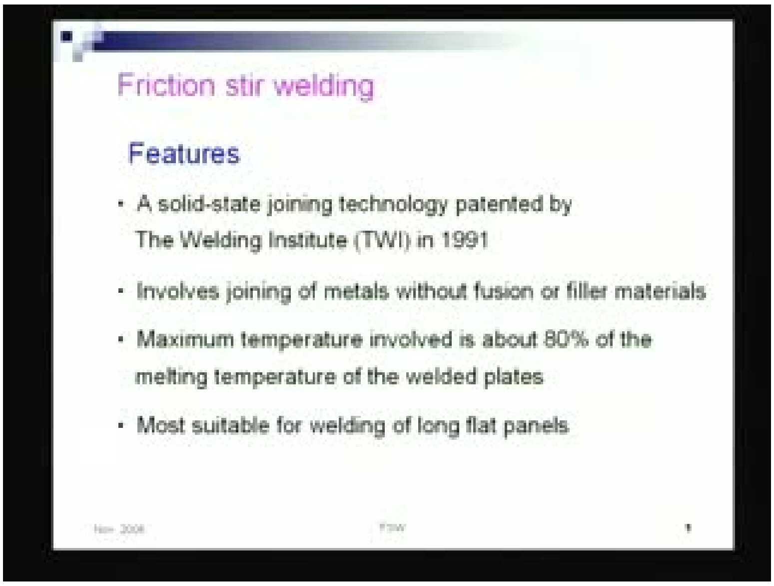
(Refer Slide Time: 54:10)



(Refer Slide Time: 54:22)



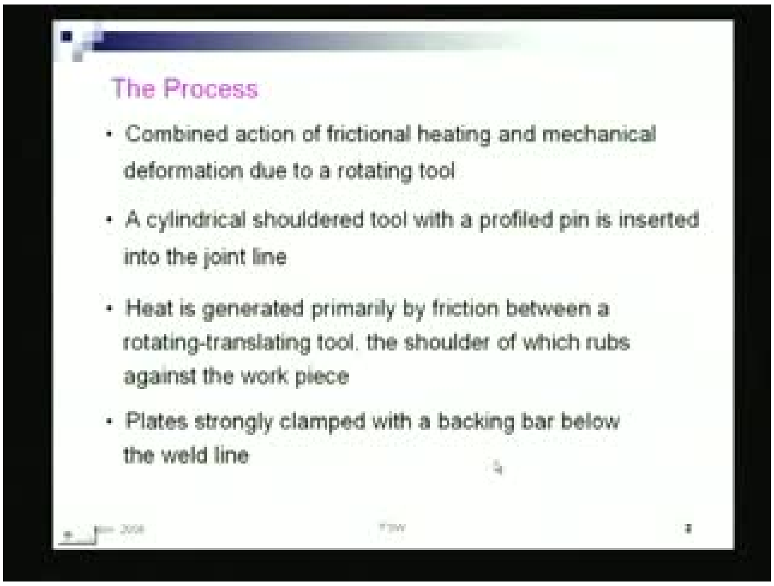
(Refer Slide Time: 54:29)



Well, how about this is also a thermal process, like, we said: the welding we talked about are the thermal processes involving fusion, it was there all the previous welding techniques. In this solid state process, it is also a kind of a thermal process that means some amount of heat is obviously generated, but it is not enough or we do not heat that much heat that it leads to fusion.

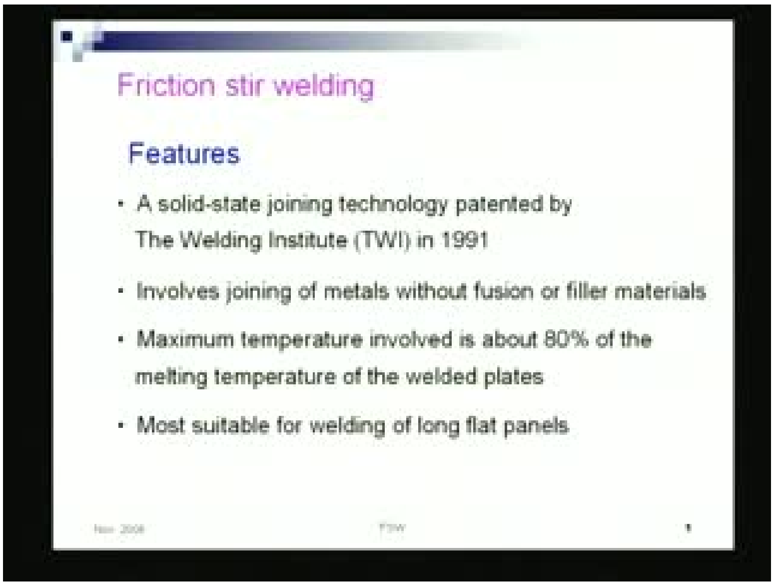
So, here what do we see is that about 80 percent of the melting temperature is attained that means, in this process, friction stir process, the whatever heat is generated that is about 80 percent of the melting temperature.

(Refer Slide Time: 55:00)

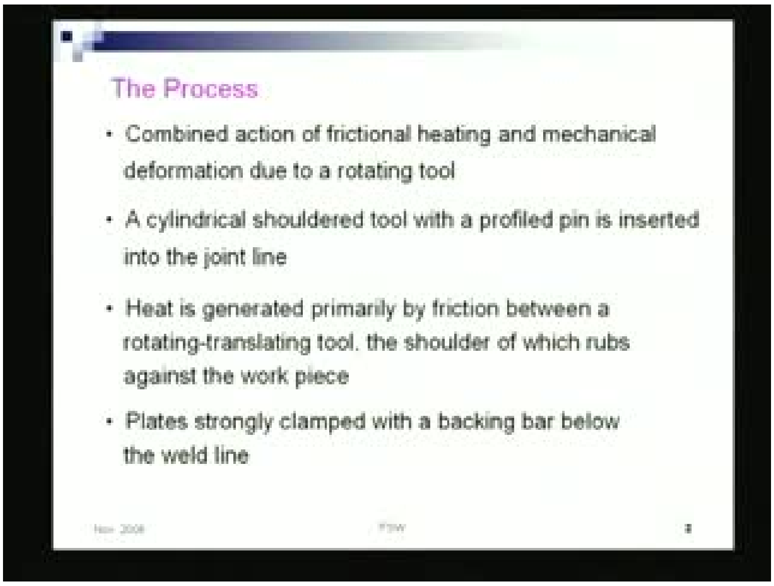


So, it is most, this technique is most suitable for welding of long flat panels for long longer welding, it is good. Obviously, this is not be a convenient process for very small and short welding. For long panels, like, say a deck panel will be fabricating or the bulkhead panels will be fabricating, wherein, you have to do though do the butt welding of 10 meter 15 meter length. So, this solid, this friction stir welding is a good method for that.

(Refer Slide Time: 55:34)

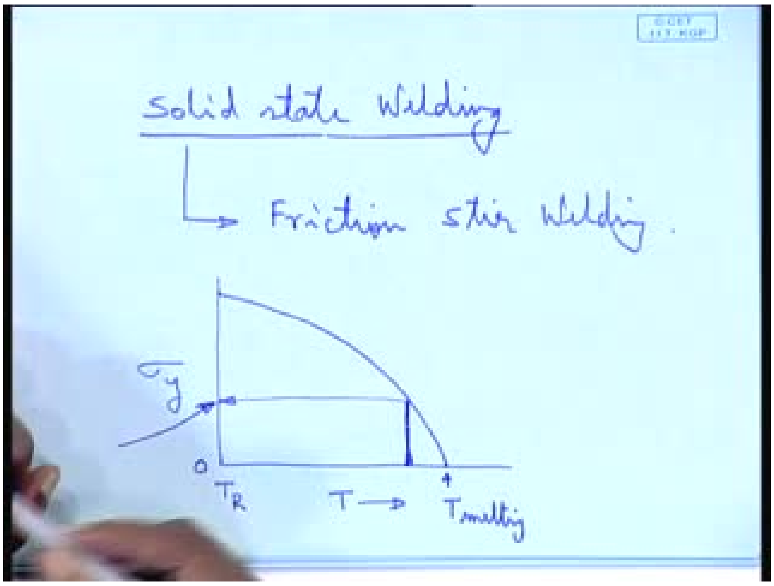


(Refer Slide Time: 55:40)



Well, so, this is the so called the basic features of the process, and now, let us see what the process is. Here, it works under the combined action of the frictional heating and mechanical deformation. What happens is the whatever heat is generated that is generated by the frictional forces acting between the welding tool, here instead of a welding electrode or a welding torch, you have a welding tool which rotates at a given r p m. So, that tools when it comes in touch in contact with the plate material to be welded, that friction generates the heat, and the tool, we will see some of the typical tools which has a small nib kind of a thing which penetrates along the joint, penetrates along the thickness and keeps rotating.

(Refer Slide Time: 56:56)



So, in the process what happens, that rotation, it generates enough friction and that friction generates sufficient heat to plastify the material because as we know, the if you look into the material properties of say steel, if we draw the temperature verses yield stress variation of the yield stress with temperature we would find a variation somewhat like this, what this temperature would be? This is say room temperature. What this temperature here should be? Tell me, what do you think at this point?

The yield stress is 0. This is the melting temperature. Melting temperature means all also it is referred to as refer to as liquidious temperature; at this point that metal is liquid, so, it does not sustain any stress. Anyway, so, what we said? Sometime back that it attains a around 0.8 the melting temperature, 80 percent of melting temperature. So, say it is here that means my I attain a temperature level of this.

So, there the stress is so much or in other words much less than what is there at the room temperature, or in other words, the metal is at a straight that means, the stress level needed is much less to take it to the yield point stress, because you will have to attain only this much. Well, so, in the next class, we will see further how this works, this solid state welding process.