Joining Technologies of Commercial Importance
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Lecture-19
Resistance welding processes: spot and seam welding

Hello, I welcome you all in the second lecture on the Resistance Welding processes. In the last lecture I talked about the basic principles by which heat by which weld joints are developed.

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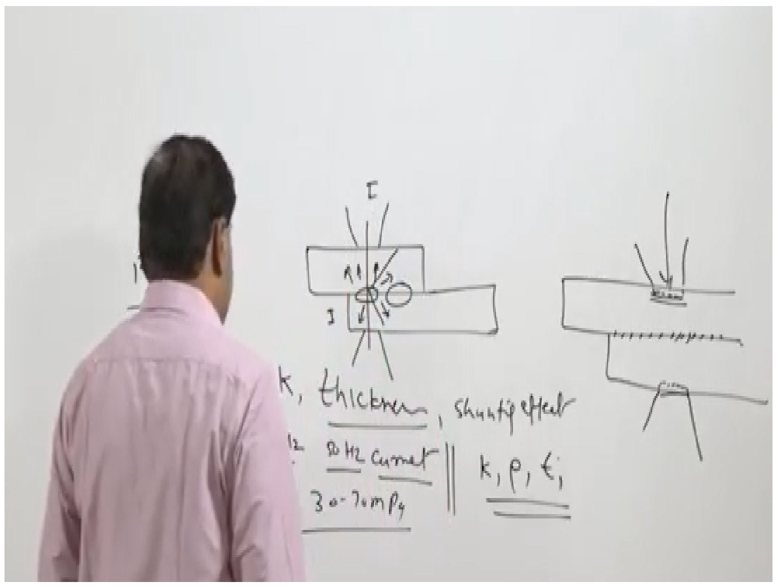

And we know that in the distance welding processes the heat used for the development of joint comes from the I square RD heating principle so the selection of the welding current the time, for which the welding current is supplied and the pressure which is applied under which the joint is made these three factors become extremely crucial because the size of the nugget or size of the nugget which is formed under the resistance of spot welding process like projection, seam, spot etc.

We will see that the size of the nugget is governed by primarily by the amount of heat being generated. So, the factors that govern the heat generation are these. And here we will see the welding current I is determined by the certain factors like the electrical resistivity of the material. When there is a flow of current I across the sheets to be joined then the resistance offered by the material for the flow of current significantly affects the heat being generated.

So electrical resistivity high electrical resistivity materials offer the more heat compared to low resistivity materials. So, if the material resistivity is low like for the electrical resistivity of the material is low like copper or aluminum systems then we need to set the higher welding current. Similarly, thermal conductivity, thermal conductivity K of the material also plays a big role in identifying the suitable value of the welding current.

Because whatever heat is generated at the contact interfaces that will be dissipated at faster rate according to the conductivity of the material. High conductivity, high thermal conductivity materials transfers the heat very rapidly as compared to the low thermal conductivity materials, that is why they require more heat generation for formation of the nugget of the desired size and so the welding current requirement increases.

And there after we have the thickness of the seat being welded. Thickness of the seat like thin seat will be occupying the greater resistance of the flow of current as compared to the thick sheets. So thin sheets will require lower welding current when compared to the thick sheets. Apart from the thickness we have also to consider how many wells have been made earlier to take care of the how many spots or the joints have been made earlier, like say, if one joint has been made.

The low current may be good enough but as soon as we start developing another joint by the shunting of current will be flowing through the earlier made nugget and this will reduce the actual flow of the current required location and this will reduce the heat generation and in turn it also reduces the size of the nugget. So, the shunting effect also need to be considered of in identifying or when selecting the suitable value of the welding current.

There after we have the time. Time which is normally measured in terms of say the Hertz like it may be 2 hertz to the 100 hertz for the 50 hertz current. So, time basically, if we see this equation, time directly effects or directly effects heat being generated during the spot welding process or the resistance welding process. So, what we have to see the current the welding current is allowed to flow through the plates for sufficient period.

So that the heat generated forms the well nugget of the sufficient size and therefore the parameters, the middle parameters the like K thermal conductivity, electrical resistivity and thickness of the material. All these plays a significant role in selection of the suitable the time for which current should be allowed to flow from the, current should be allowed to flow during the welding. Then the pressure ensures the kind of intimacy between the plates being joined

So, if the pressure is less then it may lead to the arcing between the plates and as well as between the electrode and the surfaces of the work piece. So there has to be sufficient pressure but pressure should not be too high otherwise it will cause the indentation on the surface of the work piece. So, this will act as a stress concentration because it will be changing the geometry of the plates or the damages of the plates in a very localized manner.

And another thing, so the factors that govern the optimum pressure which is normally kept like 32 to 70 MPA. 70mpa is enough for the mild steel plates and how the pressure is calculated like the load is applied divided by the contact area through which the load is transferred through the electrodes onto the surface of the plate. So, this one is also governed by the number of material related factors and which are mainly mechanical factors which will be governing the deformation of the material.

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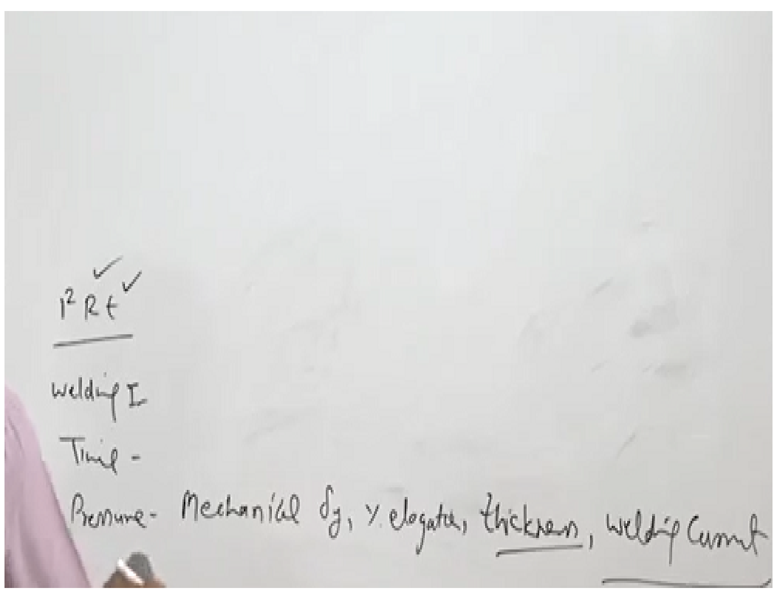

So, these factors are like in mechanical properties we have yield is strength of the material highly strength materials require greater application of the load in order to achieve the kind of metallic intimacy which is needed, and the percentage elongation the high ductility materials will require lesser load or pressure as compared to the low ductility materials and similarly the thickness of the sheets being welded.

So thicker sheets will require the more load heavier pressure as compared to the thin sheets in order to ensure the desired contact between the work piece at the end surfaces or the interface. Apart from this the kind of the welding current which is to be used that will also affect the time as well as the pressure to be used. So, these are the factors which are to be considered for selection of the pressure as well as the welding time and welding current.

During the process, the current is regulated in a specific manner especially in case of the hard enable steels.

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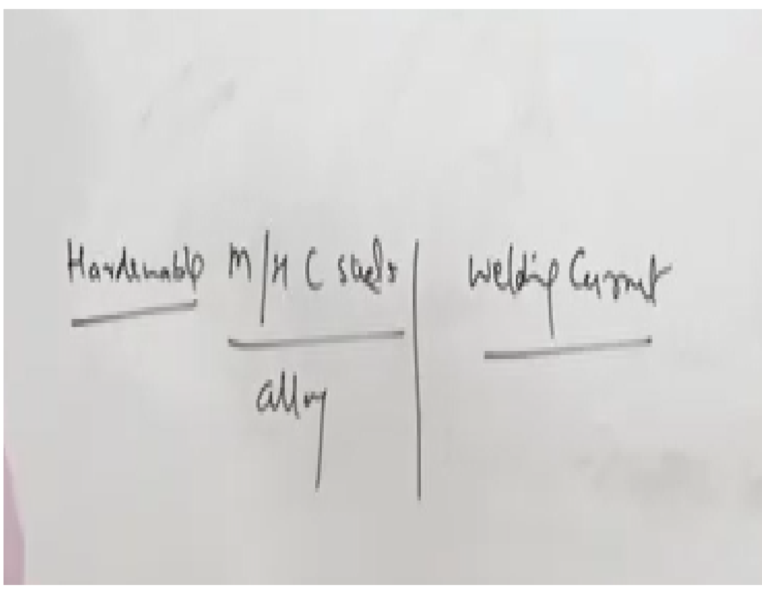

For example, hard enable metals, like medium or high carbon steels or other alloy steels which under the high rate of the heating and cooling conditions respond to the heat as well as the structural transformation which in turn affects the mechanical properties of the joint as well as t of the seat. So, these must so in these cases, in such cases, the welding current must be regulated properly or must be changed properly for the welding purpose.

And what is that the welding current value is increased gracefully, and it is also reduced gracefully after the welding time.

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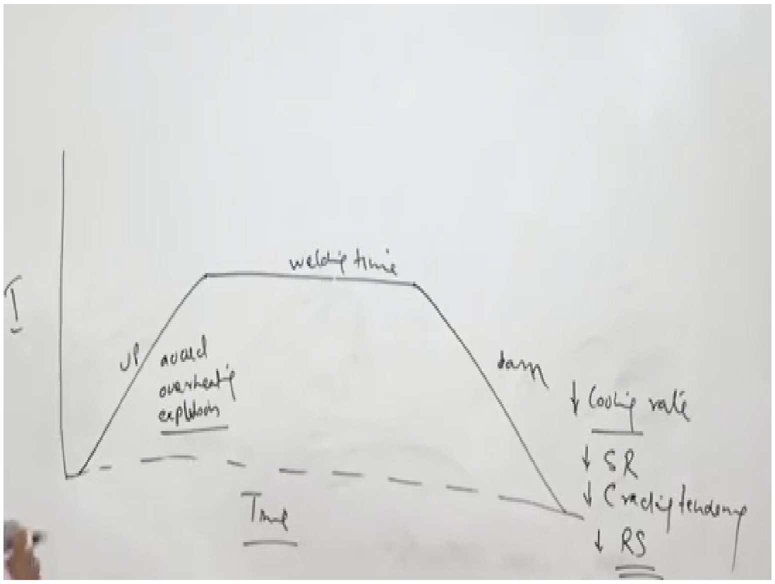

So, this is called slope up the rate at which the welding current value is increased from the 0 to the desired set value and then here it is kept constant for the welding period and there after gracefully it is allowed to fall, reduced. So as the function of the time how the value of the current changes that is what will be shown the up and the down and here what we will see is the welding time period.

In this case, up period will be deciding the rate at the heating rate to high heating rate may also be a problematic as well as the too high cooling rate can also be problematic. So, to Like say, in case of the up current value should be adjusted appropriately in order to avoid overheating of the surfaces of the plates as well as in order to avoid the possibility of the expulsion. Expulsion of the metal from the interface.

So, if the current is increased rapidly then excessive head generation can lead to the formation of the molten metal. Molten metal can start coming out of the interface. So, this is expulsion tendency is reduced. Similarly, in the case of the downtime temperature the welding current value is reduced gradually. So things will be heat generation will be reduced gradually and this will help to reduce the cooling rate experienced by the portion.

Which was heated during the welding and a reduced cooling rate actually reduce the solidification rate and also reduces the cracking tendency of the heat affected zone as we well as nugget and also reduces the residual stresses if at all they are being formed in course of due to the differential heating and cooling during the welding. So, it is important that the up and the down current values are adjusted suitably in order to avoid the issues and the problems related with the resistance welding processes.

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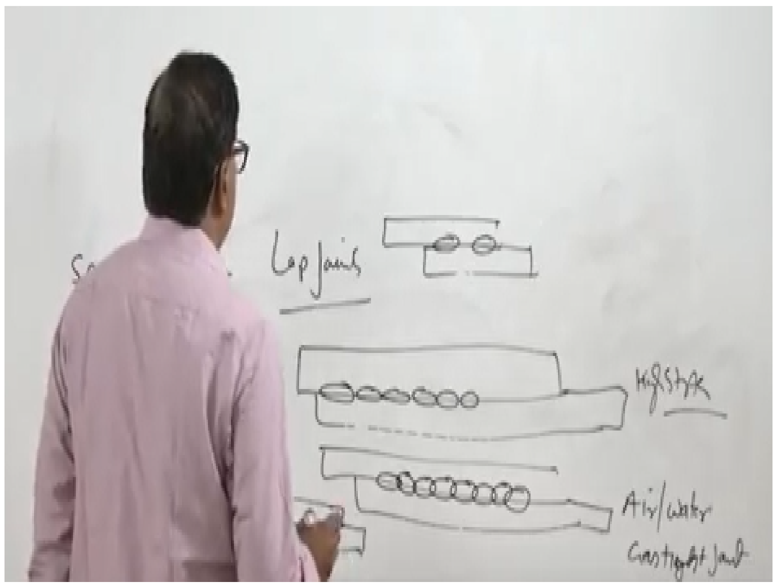

So now we will see the details of the three specific processes like spot welding, seam welding and the high frequency welding. So, we will be starting with the spot welding, and there after we will be going for seam welding and then high frequency welding processes. So, spot welding is mainly used for the developing the lap joints and mainly the nuggets are formed randomly here. And there in order to achieve the desired like one nugget is formed.

And another nugget is formed, at required sos, so that the required strength can be achieved. In case, of the seam welding, the arrangement is slightly different where in the spots or the nuggets they are either very close to each other like this or they start overlapping each other, this overlap may be 10 to 40 per cent or it may be continuous when the overlap is more than 50 per cent then it is kind of continuous seam weld is made.

So, this kind of arrangement is used for the air and water tight joint and this is for the high strength joints and when the continuous is made that is for the gas tight joints. In case of the gas tight joints what we will see that between the, there is a continuous nugget formation without so when overlap is more than 50% and the nugget is formed continuously. And for this purpose, Mainly the rollers are used which will be fed with the desired current which will be continuous or may be fed intermittently.

The resistance high-frequency resistance welding process is another newer development somewhat newer development, which is mainly used for the high-volume production of for developing the joints between the plates as well as the pipes. So, we will talk about all these three processes using this.

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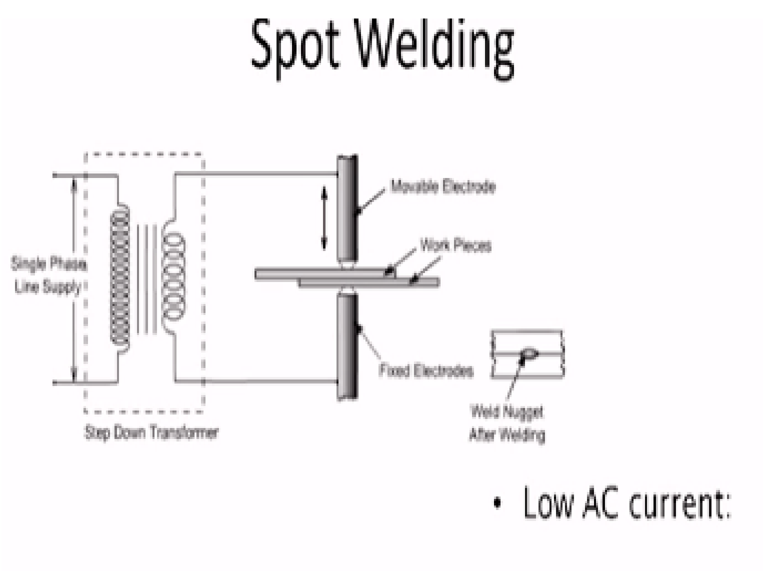

This presentation is here, what we will see here is one power supply and two sheets to be joined are kept in overlapping configuration through the electrode, the pressure and the welding current is supplied once the sufficient current is supplied the nugget if formed of the welding like this. The size of the nugget directly determines the strength of the load carrying capacity of the joint. It may use the low AC current or the high DC current.

But the frequency of the current which is used in this case is normally low which varies from say 350 to 350 hertz and for this welding processes normally the value of current is very high which is in thousands of the ampere.

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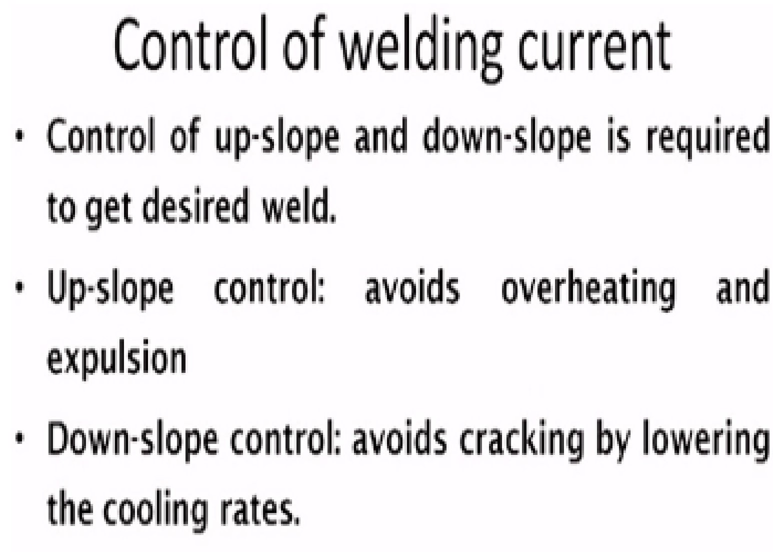

So, this is what I have explained the control of the up slope and the down slope is important. Up slope avoids overheating and expulsion, down slope avoids the cracking by lowering the cooling rate tendency.

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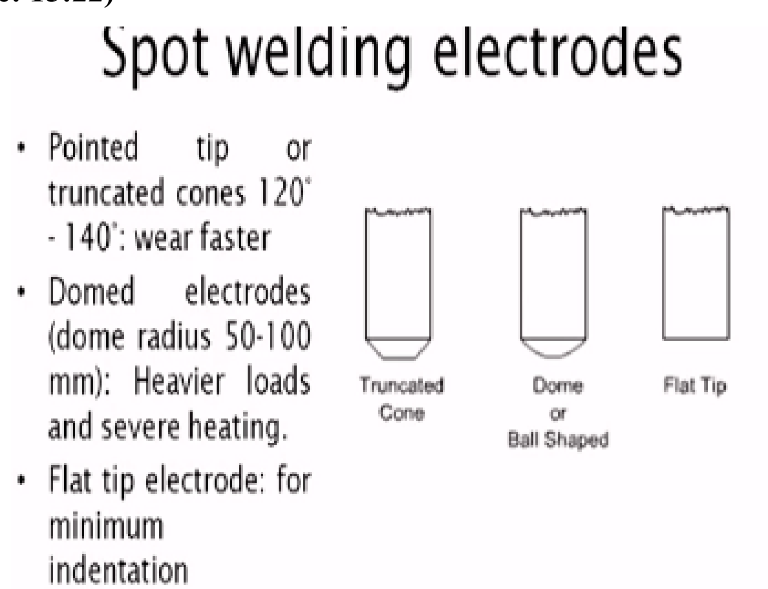

And there are three types of electrodes used for the spot welding processes one is like flat like this and another one is like truncated cone type which is like this and another one is dome type. In this dome type here, hemispherical shape. Dome is there in the case of the truncated, the angle between the conical surfaces is 120, 240. But this kind of system V as far at a faster rate. So, you know the change in the diameter.

Say initially this is the diameter is this much VR will simply result in the increase in the diameter of the electrode tip which will be coming in contact with the work piece. Which intern will lower the current density being fed, now current will be fed over this area instead of this smaller area. So, reduction in current density basically will be reducing the size of the nugget which will be formed due to the in case of rear of the electrode.

So, the dome shaped electrodes are used for heavy load and for whenever severe heating conditions exists and the flat tip type of electrode the entire surface comes in contact of the surface of the work piece. This type of electrode causes the minimum indentation of the work piece surface.

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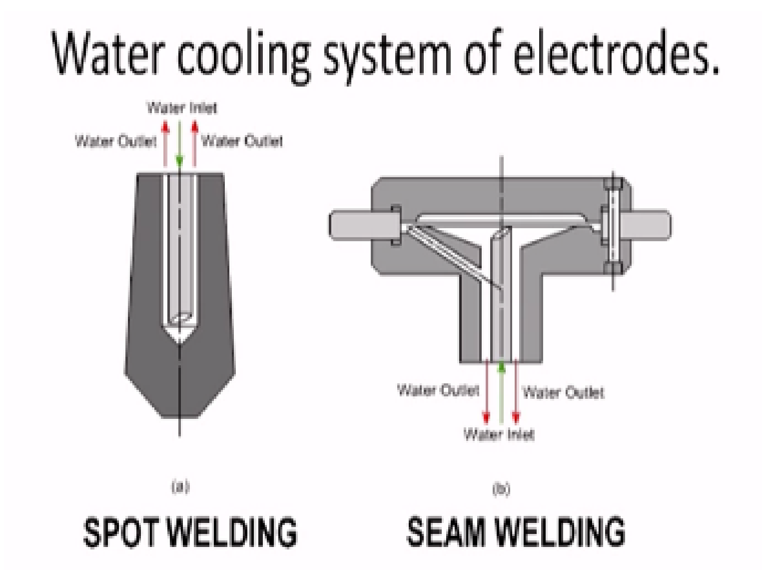

Heavy current is handled by the electrodes, so these are mostly made by copper and copper based alloys in order to have regionally high temperature strength and in order to resist the wire. Normally alloys of the different systems like copper chromium, copper cobalt, copper tungsten and other mixtures and other alloying elements like copper used in order to increase its capability to withstand the higher temperature.

And capability with high temperature but still it is required the temperatures of the electrodes is made with in safe temperature limits. That is why mostly electrodes despite being made of copper which has very good thermal conductivity these need to be water cooled. So that the life of the electrode tip means the life of the electrode can be improved and unnecessary damage to the electrode can be avoided.

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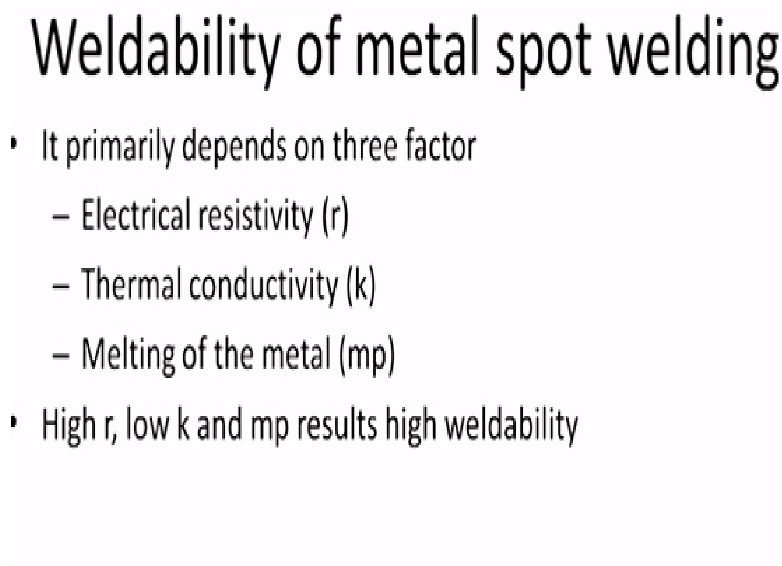

It is very important to say that how the ease of the welding. the spot wielding can be assessed and checked for this purpose. Normal there are three parameters the electrical resistivity, thermal conductivity and melting point of the metal. These three parameters will significantly affect the ease of the welding. Here if you see that high electrical resistivity, low thermal conductivity and low melting point is always desirable.

So, given amount of the heat will be melting the metal at the interface at a faster rate. Heat generation with high AR means high electrical resistivity will ensure the much means of the higher heat generation for a given current supply. Low heat conductivity will reduce heat transfer dissipation to the base metal. And the melting point, low melting point will ensure that the melting takes place at a faster rate.

And these all combination of all these three factors in turn will be resulting in higher weldability. And reverse will happen when value of K is high, the value of resistivity is low, and the melting point is high. So, if we consider the aluminum and copper which are known to be of the higher thermal conductivity and lower electrical resistivity. That is why they are found to be difficult.

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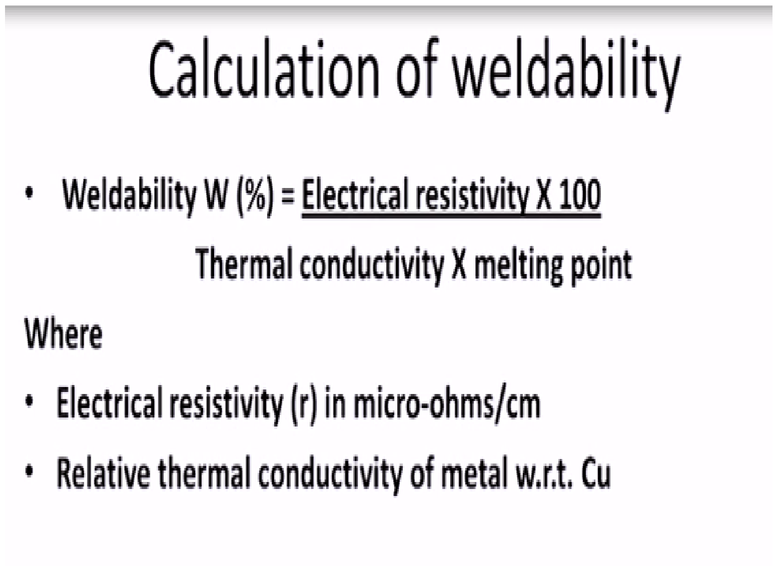

That is what we can see it from this equation the re-weldability for the spot welding can be checked using the simple formula where in electrical resistivity divided by thermal conductivity into the melting point multiplied by 100 this will give us the weldability W in terms of the percentage. So where electrical resistivity micro ohms per centimeter under the and the thermal conductivity it is a relative conductivity of the metal with respect to the copper and melting point in degree centigrade.

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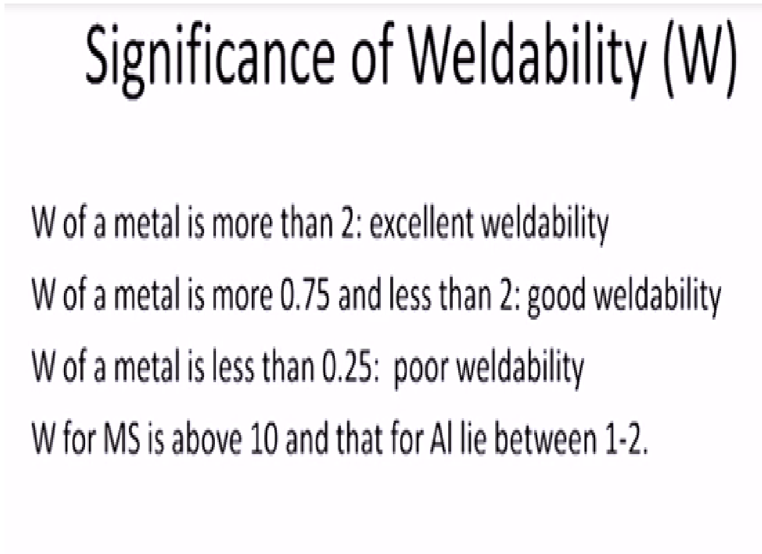

So, when these thermal and physical property of the material are used to calculating the ease of welding by this part. welding then we will be able to part to know the value of W, we are getting that is weldability we are getting. If the weldability of W is more than 2, then the weldability is considered to be excellent. If the weldability is between the 0.75. Then the weldability of W.

The metal is more than 0.75 and less than 2 then it is considered to be a good weldability. If the weldability is less than 0.25 then it is considered to be a poor weldability. So here if you will see mild steel W comes out to be of 10 which is considered to be very good weldability by the spot welding. Provide W for the weldability. For the aluminum comes out to between 1 or 2.

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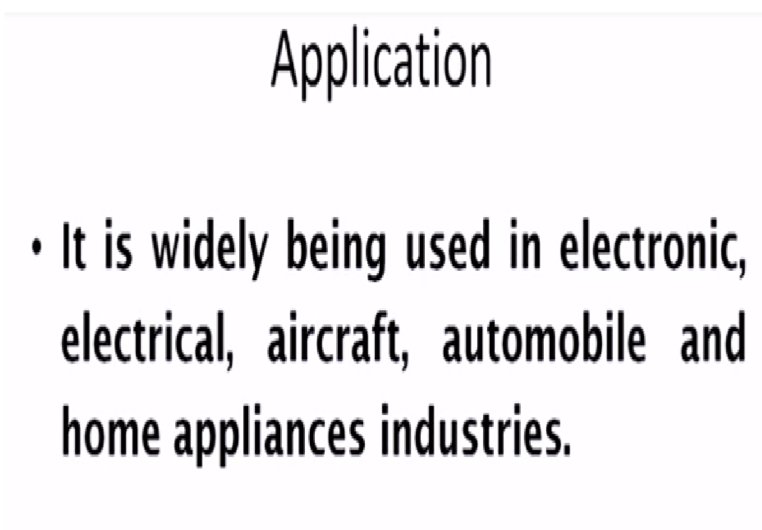

Now we see the application of spot welding, mainly in the field of the electronics, electrical contact, aircraft, auto mobiles and in the home appliances.

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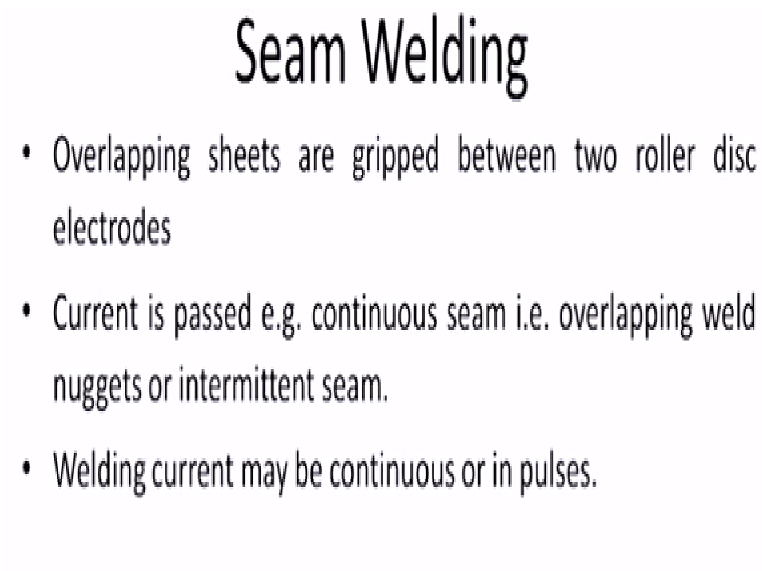

Now we will see the seam welding. I will explain what the seam welding is. Over lapping sheets are grid between the two rollers of electrodes then the current is fed. current may be continuous or discontinuous accordingly the nuggets will be formed either continuous or at certain intervals. So, the welding current as I said will be continuous or it may be intermittent.

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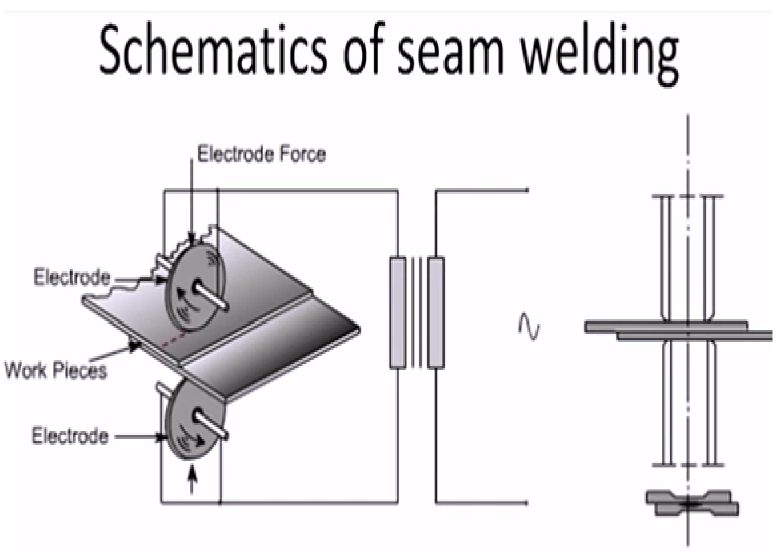

So, the kind of arrangement which is used here is like the two overlapping plates are kept one over and the roller which will be applying pressure as well as feeding the current also. So, when the sheets are rolled between the rollers and the welding is performed now the very joint will be means this when the sheets will be passed through the rollers. As per the kind of supply of the welding current. There may be continuous nugget formation or there may be intermittent nugget formation.

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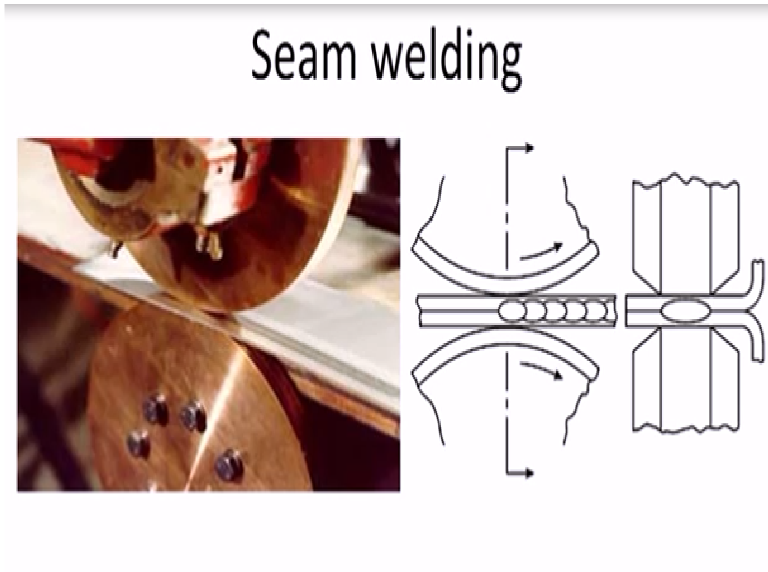

So which kind of nugget it will be formed that is what we will see here. The nugget may be formed with certain kind of overlap like this or this is one of the cross section of the nugget formation. These upper rollers and the lower roller and the nugget is being formed and this nugget is being formed with certain kind of overlap. So, this is the real photograph of the seam welding arrangement.

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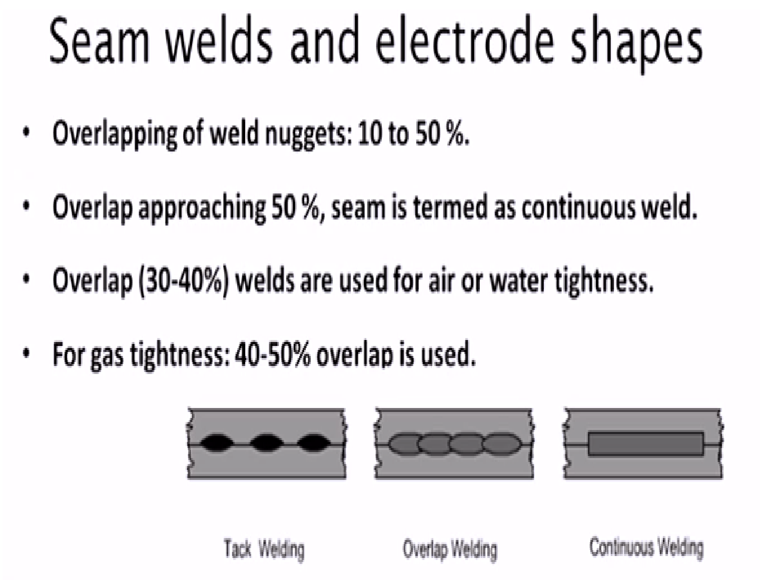

So here you will see the overlapping weld nuggets may be 10 to 50% overlap approaching 50% is termed as continuous weld. Overlap 30 to 40 welds are used for air or water tightness and gas tightness requires 40 to 50% overlap for the welding purpose. And this is the schematic arrangement showing the tack welding. Tack welding means There is a lot of spacing between the nuggets which are formed and then lap weld the nuggets are overlapping.

With the marginal amount may be 5% or 10% in the case of continuous. Now this value can range from 10 to 50%. In the case of continuous it is more than 50%. We will see that there is a continuous nugget formation.

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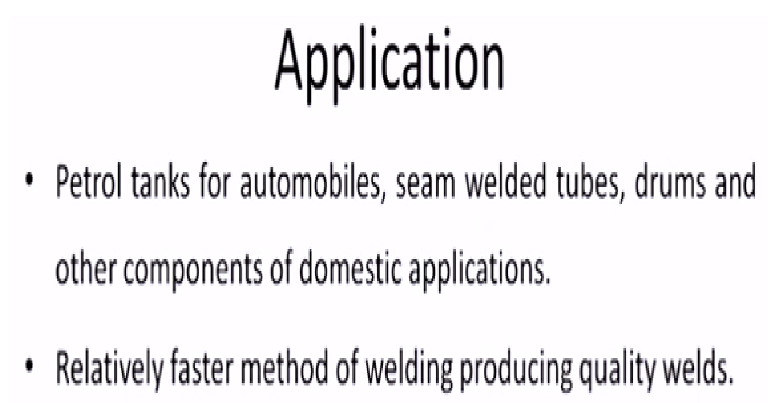

So, this seam welding is mainly used for making the petrol tanks for the auto mobiles, seam welded tubes, drums and other components for domestic application. This process is much very fast. This is very economical for high volume production to produce the good quality.

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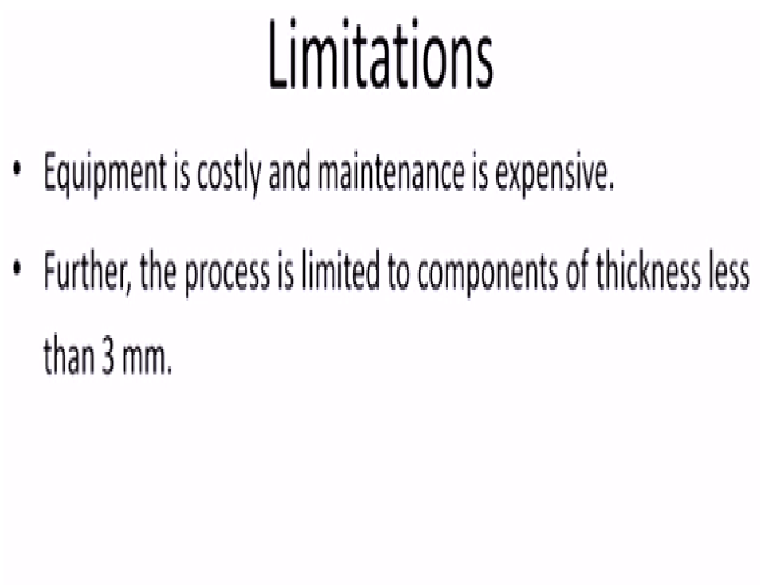

Well it does but the limitation is that the equipment is costly requires maintenance and maintenance is expensive further the process is limited requires thickness less than 3 mm because the thicker plates require much higher amount of the welding current, pressure and much closer control over the process.

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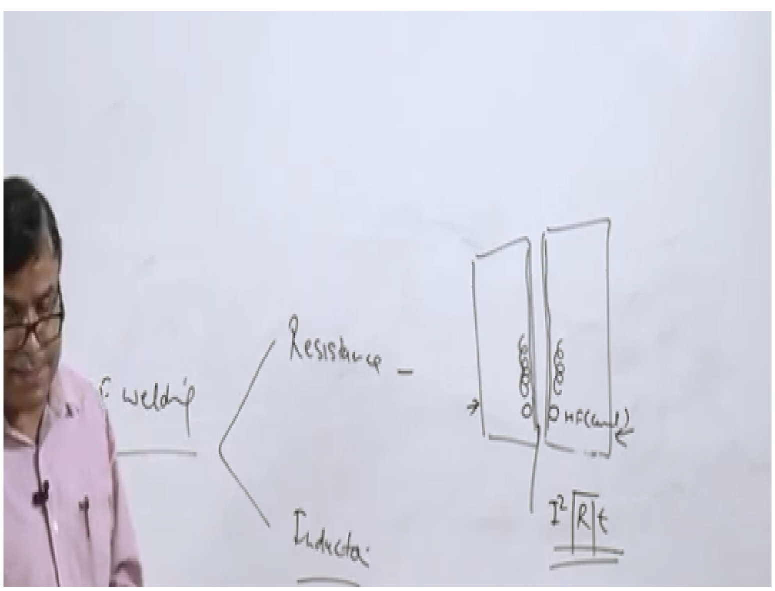

Now I will talk about the little bit the high frequency welding process. High frequency welding process comes in two variants one is resistance waste, and another is Induction waste. In case of resistance type the high frequency welding process the actually contact is there between the components means the contacts will be supplying current to both and then pressure is applied for the welding purpose.

So, this high frequency current basically allowed to pass through the surface. So here this high frequency current basically localizes near the surface wherever we want it does not flow across the thickness or across the cross section. But the current is allowed whenever high frequency current is passed, and it passes through the very near the surface layers and up and this feature is found very useful in the sense that the current will flow to the entire section or entire thickness.

It flows to the near surface layers and which ensures that very small volume will be experiencing the flow of current and even the lesser magnitude of the current is sufficient for generating the required amount of the heat. So I square RT heating becomes effective because the flow of current is through very smaller area and this makes the process effective in the sense the current flows through the very skin thin layer of the metal to be joined.

And once this current flow starts the heating takes place very quickly and a quick heating over a very small area ensures the softening and once the metal is softened the two are forced together using suitable pressure. So, this is one approach. In another approach the coils are brought very close to the surfaces they are not brought in actual contact like where ever the joints are to be made, they are the coils with the required type of the high frequency current.

They are brought in close to the surface where our joint is to be made so again by the induction current the current is induced very near the surface layers and then the current is induced in the very local smaller area or near the thin surface layers that generates the I square R heating. In both the cases the I square RT heating is involved in the flow of generating the heat but the volume of the materials that experience the flow of heat is very limited that is why even a smaller 90 drop current is sufficient for the generation of the heat and soften the metal system.

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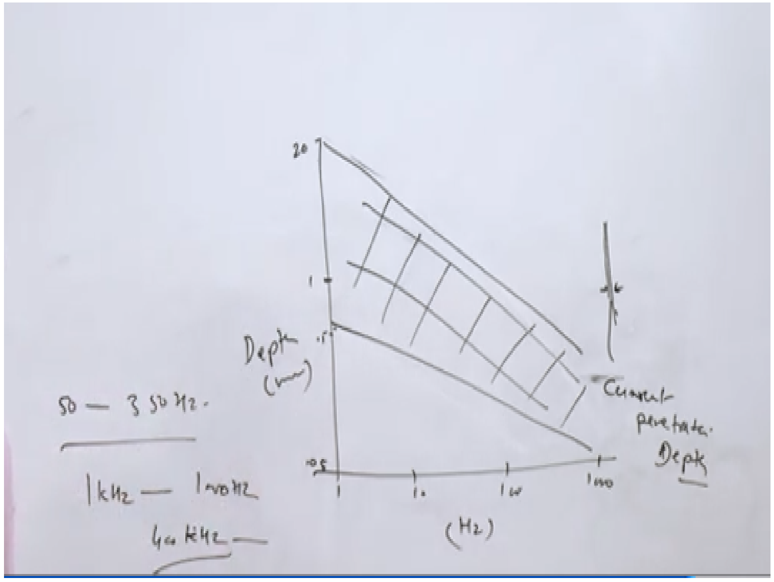

So actually, the magnitude of the current which is required in case of the HF current is very low, so the current value is reduced drastically when it is used because high frequency current will be flowing through the surface layers. not through the across the entire the cross sections or entire thickness of the plates being welded. This is what is exploited in the high frequency welding process and here there is a direct relationship.

Normally spot welding, seam welding processes they use the current of frequency 350 to 350 hertz but in this case, it varies from 1 kilo hertz to 1000 kilo hertz. It is common to work with 400,000 hertz current for the seam welding process. And whenever the seam welding process is used the frequency of the current directly affects the depth out to which current will be penetrating to the surface like if the current is generated here then it will able to penetrate or very small depth.

And this depth very significantly this is called current penetration depth. Current penetration depth and this depth is found inversely proportional to the frequency of the current if you see the frequency here one like say 10, 100 and 1000. It is the kind of frequency of the current which is being fed and in this side if we are getting the depth in MM by which the current will be able to penetrate and here if we say this is .05 MM and here it is like say it is 1.5 and here it is 20.

It is the depth where the current is able to penetrate to the surface so here it comes down directly like this and here it comes down like this so for the different metal systems this is the kind of band which is observed goes in like this. This is fact the metals different metals and the metals in different temperature conditions we will see that these values may vary like this or like this but invariably with the increase in thickness with the increase in frequency of the current there is a reduction in the depth up to which the current will be able to penetrate.

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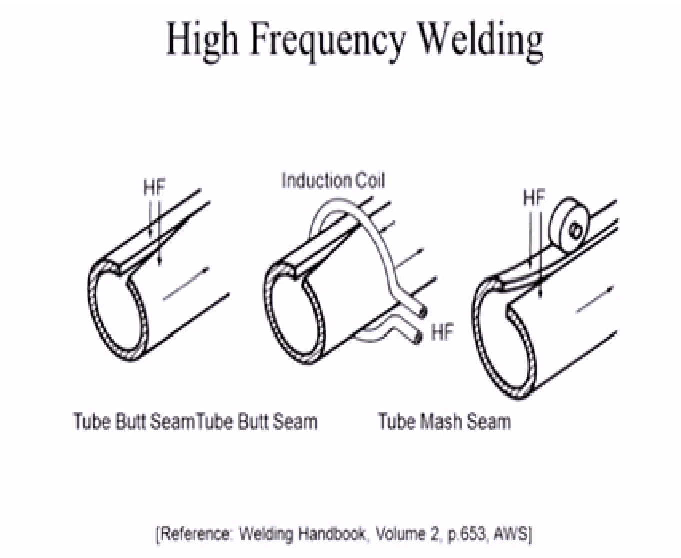

So, like here in case of the high frequency resistance welding, current is fed, and heat is generated, and the pressure is applied. so that the joint is forced, or joint is made in case of the high frequency induction welding system. And the coil is passed so the high frequency current is generated is localized near the surface layer and the heat generated and by the heat generation the surface layers get softened and with the application of the pressure these are forced.

And this is the same thing here high frequency current is allowed to flow through and the pressure is applied through the rollers to in order to develop the joint.

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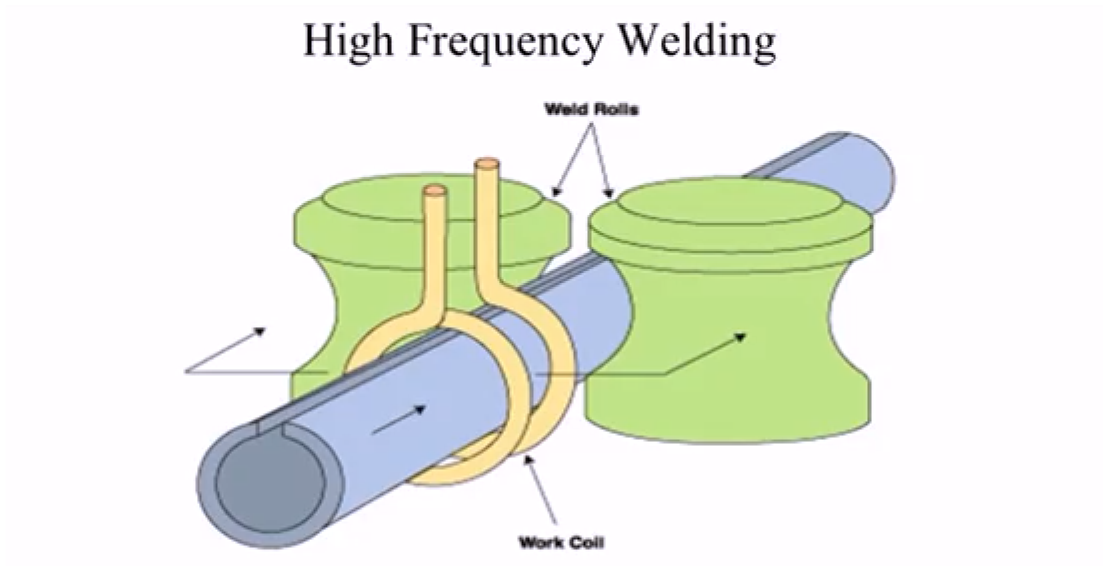

This is another example these are the rollers that forging the things together and the induction coil will be generating the high frequency current in the tubes to be welded. So, this is how we can see is this is for another element of the contact type the earlier one was the induction type arrangement for making the pipes and this is a kind of contact type, so the high frequency current is fed to these coils and the rollers will be forging them together once the edges are softened.

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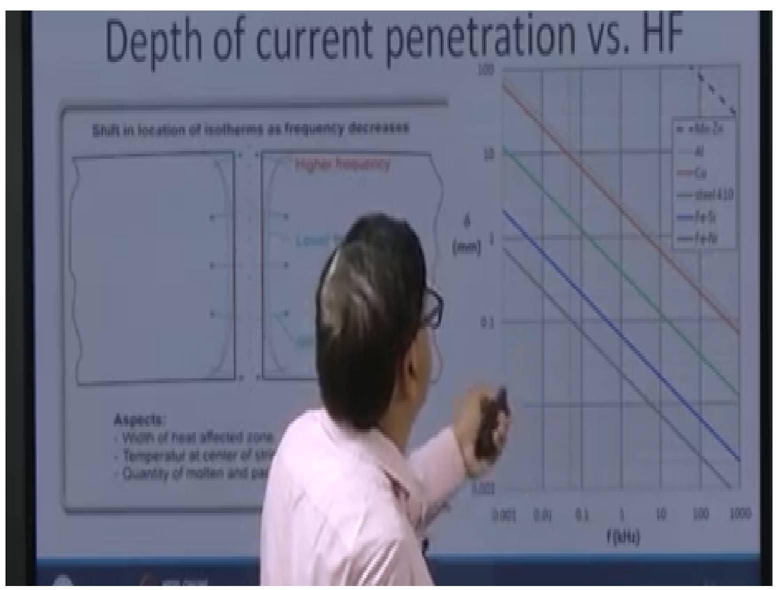

And this is how the high frequency current will be localized near the surface layer. And low frequency current will be localized at somewhat at greater depth as compared to the high frequency and because of this since the current is limited or a narrow area the heat affected zone width is very small and accordingly the quality of the weld is made is better as compared to what we have observed in case of the conventional spot welding process.

What we can see as a function of the frequency of the current the depth of the penetration decreases rapidly. And for the different metal system of course the decrease is different that is what we can see here in this diagram. This line corresponds to iron nickel system and iron silicon systems and for the Aluminum the depth of the penetration decreases in depth of the condition somewhat lesser for Aluminum and copper.

So now I will conclude this presentation in this presentation I have talked about the resistance welding process and three types of resistance welding process one is spot, another seam and the third is high frequency resistance welding process. I begin the lecturer or the presentation with the factors that should to be considered in selection of the important parameters like welding current, welding time and the pressure.

And there after how to calculate the weldability of the metals for the spot welding and thereafter we have been looked into the basic principles of the seam welding, spot welding and the high frequency or resistance welding process and thank you for your attention. In the next presentation I will talk about the solid liquid base process like brazing and soldering. Thanks for your attention.