Welding Processes
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Part 01
Physics of welding arc

So we will have quick recall from last class, so last class we are looking we at the definition of welding process itself, what is welding? And then we will move on to the definition of arc, right. So we looked that a conductor and then if electrons travel is for example let us charge carriers in a travels it dissipate energy, no if it travels through a defined potential difference then the amount of energy is released it is v i voltage multiplication by current v i right.

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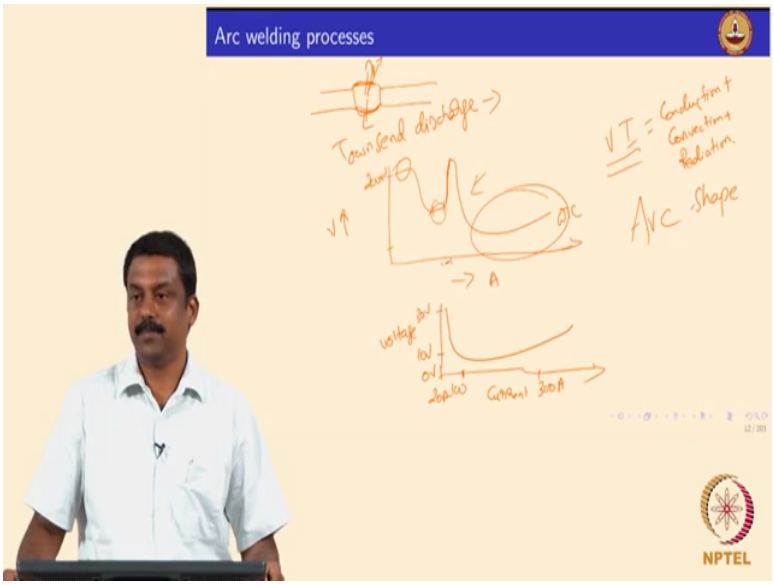

Suppose if you have interruption of flow of electrons, so if you have a conductor we have the conductor is placed between a medium, the passage of the energy carrier is not possible unless you have discharge, right so the medium if it is air or if it is any gas that gas has to have a discharge mechanism by which you generate more amount of the energy carriers, so in (this cage) this case you ionise the air or medium the gas in between the conductors so that you create an energy carriers, these energy carriers transport from one end to other end based on the potential difference, ok.

So we looked that the discharge and what are the discharges that (arec) occurring as a function of voltage and current, right. So we have looked three types of discharges the

Townsend discharge or black discharge or dark discharge, right. So the characteristic of Townsend discharge is it happens in very high voltage, right so vary a voltage extremely tiny amperage, so microamperes you may say that, right.

So this happens in naturally suppose if because of the cosmic radiation or some photovoltaic effect from solar energy, so it can happen but it is very difficult to you know the identify natural way, it Townsend discharge happens now also, so because of the radiation coming from the say for example glow discharge and Townsend discharge it is also happening surrounding this room, it can happen in atmosphere, it is always happening because it is very tiny discharge and if it is happening you know for example if lightning strikes if passes an high energy then me also some discharges, ok.

So the Townsend discharge is characterised by high voltage, very high voltage and the graph I showed you, it happens close to say 2000 to 3000 volts, is not it. This graph looked that it, right, so this is the current and this is the voltage and Townsend discharge happens in close to the voltages of 2000 several thousand volts, ok. So then we looked at the second type of discharge is a glow discharge and which happens in hundreds of volts, ok and the amperage is milliamperes.

So glow discharge we commonly used it for light bulbs, right so where you have a sustained discharge this happening over a potential difference but difference is the voltage is reduced compare to townsend discharge to several hundreds, right and then we looked the third one which is very interesting for us is the arc discharge, so arc discharge happens in extremely small voltages ten is of volts, right.

So ten is of volt happens whereas the amperage the electrons, the density is very high compare to the other two discharges, so it will be hundreds of amperage the amperes will be hundreds compare to the other discharges we have a very high current when you have an arc, right but voltage is extremely small that is the one of the major advantages of you seen in arc because you can handle arc because of the very low voltages, ok.

So the welding processes when you doing welding the potential difference between the circuit is hardly 10 to 12 volts if you are in g t a w not more than any case not more than 30 volts, ok. So if you look at only this part the low part, so if you plot the voltage whereas current, so it can go up to see for example say 20 amperes until 300 amperes, so initially so this will be not more than 30 volts and this is 0 volts, ok.

So initially there is a small drop and then a curve look like this, so if you go up to 300 amperes the voltage so suppose if you are varying from the voltages the amperage from say 100 to 300 and you would see a steady state, you would not notice much increasing voltage, so this will be not more than say 10 volts or so. So that sustained discharge it is very important so you should not increase what is volt again? The definition the volt comes from, so how do you define volt? Ok what is one volt? So how do you have to flat region plato in this graph?

Student is answering: joules per volt.

What is volt when we define? Correct definition and why did you need to have an a plato in this region that come is from energy gain? If voltages increases means then that is mean that what? When the electrons travel they dissipate more energy is not it if voltages is increasing mean what is that mean? So when the increase the amperage if voltage increases dramatically that mean is that the energy dissipated is very high, ok.

So energy gain in the system is extremely high, so you the discharge is not sustained, right. So you cannot use that system for you know for longer sustained time, right. So that is why you need to have plato region, that is why you use a glow discharge whenever we have a plato in this graph that is good for us because even if it increasing the ampere is light increase, the potential difference is not increasing that means the energy gain is minimized, ok that is why you have a plato region the potential difference is not increasing that mean is that even if increase the electron density in the system you will not the increase the energy of system, right.

So that is the advantage of having a sustained distribution, say if we have such a peak even small change in amperage if a system gain is lot of energy than what will happen? then you cannot keep it you cannot make it as a sustained discharge is not it. So that is what happen is now when the amperage is goes high in the glow discharge be on a critical limit, the energy of a system is increases tremendously because the voltage increasing very high then you will have explosion of bulbs, is not it.

So in there the operational voltage define is by this plato, so if it goes beyond certain amperage there is an explosion and this curve can change the range is can change based on gas medium, suppose if you use organ is they will be shift in the voltage and current

characteristic, ok. So if you used neon for example in the bulbs, there will be difference of voltages in currents but then nature of the curve is same, ok. So the values may shift, right.

So because of this nature of this voltage current characteristic and we can make sustained discharge again when we define the arc what is arc? it is sustained discharge of a gas which results in continuous moment of ions and electrons, yes between there potential difference, ok. The sustained discharge is due to the plato, what is seeing this graphs? Yes it is clear. Yes that is what we saw in last class, right we will continue with that.

So we look at more the fundamentals of the arc and then what how do we generate heat in the arc? Ok of course we have sustained discharge how would us this discharge result in heat generation? Right we always say that V I is the energy but how does V I multiplying by becomes joule? What is happening inside? How does heat generate in the arc? But we need to understand, right.

So we look at one by one, when we build up from this fundamentals, we look at what is happening inside the arc, right suppose if you have an arc with an arc energy of V I and this heat whatever the energy heat generated it is should be dissipated, is not it. So how would you dissipate the heat or how would you transfer the heat from one place to other place, what are the way is you can transfer?

Student is answering: conduction radiation energy.

Yes, so if you have an arc energy of V I that must be equal to the heat transfer is not it, conduction, convection plus radiation, ok. So if you know the principles begin the conduction convection radiation of an arc, we can calculate of how much energy is there inside is not it, inside the arc. So if you understand how the heat is conducted from the arc? Or how the conduction transfer the heat from the arc? or how the radiation transfer the heat from the arc? and if you know all these three we can calculate how much of energy is there in the air in the arc? Right.

But that is not straightforward we will see in the course of lecture how we can calculate? How much energy is there inside the arc? The fundamentals are the same discharge, ok. So we generate electrons and ions and we carry the energy from one point to other point or one point to other point with the potential difference of V I, if you supply I how much energy is

generated? Or how this energy is transferred to wherever medium, ok and before that we need to look at the geometry of the system, right ok.

So then we can define the boundary condition, right. So we look at it first before going to that I want to ask you another question, we say arc, right Arc, what is called the arc? Someone called that is it. Why do we call is arc?

Student is answering: path of electrons between two metals.

Yeah, you define it, it is not new the definition word itself, I asked you what is arc?

Student is answering: shape.

Shape is it, what shape?

Student is answering: part of the circle.

Part of the circle that is arc, very good. Where we have a part of circle here?

Student is answering: path of electrons between two metals.

Why cannot be straight path? Why it is taking that shape, ok so your definition is almost there. So that is shape of an arc is not arc, ok. Suppose if you have two conductors when the energy carriers transfer from (one part) one point to other point or potential difference it makes a shape like arc shape, right. Why is that arc shape? Why not straight path or why not triangular path? So the shape of these guy is an arc shape that is why we call it as an arc but why this shape?

Student is answering: emission

What is it.

Student is answering: emission will be.

What emission?

Student is answering: electrons emission.

Electrons emission

Student is answering: electrons emission will be inserted.

See what happens when you strike an arc? In terms of temperature.

Student is answering: positive and negative.

What happen to the gas medium?

Student is answering: ionised.

Ionises, yeah because of the temperature, what happens to the temperature? Right.

Student is answering: pressure reduces.

Yeah exactly. So density decreases for example when you strike an arc there is an enormous amount of heat generator. So then what will happen to the gas medium? Gas is heated up, ok the gas is heated up density decreases obviously it will expand, ok. So that means that the temperature will be distributed whereas you have a high temperature in the middle and then else for boundary conditions say room temperature, so there is a huge density difference.

So that would leave to the expansion of the gas, is not it. So this expansion leading to the formation of the shape, arc shape that is why we call it arc, right. So why we do the gas for example high temperature, low temperature why does the gas flow? Why does gas expand?

Student is answering: heating.

Because of a heating, right and base of that why would does not expand? So in this case you have a shape of a arc form, right you will have high temperature at the middle and elsewhere you have a room temperature for example there is a temperature gradient is not it from centre of the arc to the elsewhere and because of that there is a density difference, you will also have a gradient in density, right.

So these expansions of the gases with respect to temperature which also causes the density difference is not it and that lead to the expansion and become of the expansion we call it a shape of arc, yes it is clear good. So now we look at in detail, so how we can make an arc in a common welding process? Ok, so we can make an arc between two conductors if it is flat in welding case we do not have any two flat conductors, we have one flat plate is not it and another electrode, so now we do not have any uniform expansion, right.

Like (())(16:05) have a complete barrier structure, so the shape can be changed, ok. So we look at in detail how an arc is struck in typical welding process? Right. Ok.

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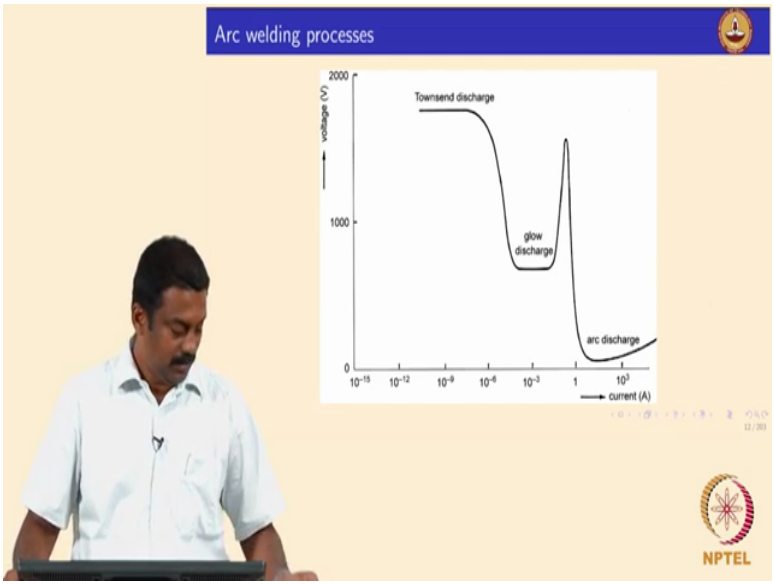

We move on to that, so it is clear this picture, the sustenance, the sustained discharge it happens in three visions, I mean classify the discharges based on the voltage current characteristic. Arc has a very low voltage ten is of voltage and very weak current, ok. So that makes is very attractive for welding applications or cutting applications or whatever applications, ok because it user friendly, they can sustained overall long current, very high current, over the range of currents, right it is clear.

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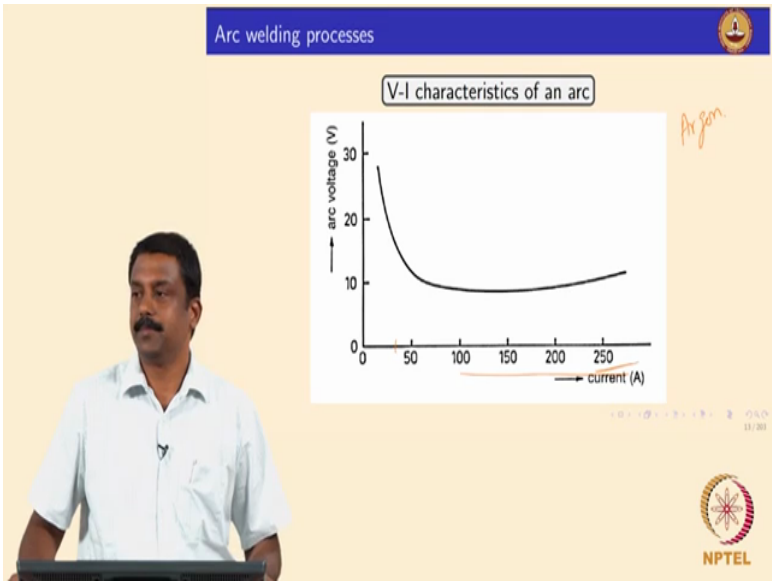

So if you zoom in the bottom regions, so you have the arc voltage as a function of current and there is an a steady decrease when you have a very low current until set 20, 30 amperes, so we only avoid welding in that region, so if you use a extremely low amperage again this (sys) this graph so are all plotted for organ, ok the gas organ. If you change the gas then this characteristic is also change but in commonly it does not change much, so if you change the organ to healium it may change slightly different will come to that letter but you can assume that.

So at low amperage there is a gradient and that is not sustained, so if you use a very low current obviously the voltage the change in voltage can be very significant even if you change the very small current but if you go beyond say 50 amperes until 250 then increasing voltage is very minimal. So will be 10 to 12 maximum 13 not more than that, so that is (opseting) operating voltages often most of the common welding processes, ok.

So if increase amperage to slightly higher for example thousand you may increase to 25 volts not more than that, so if you are welding most of the cases you will be welding the current raises 100 to 300 amperes, if it reaching 3 sheets for example if g t a w, ok So it will be not more than 300 amperes. So early steady state the voltage gain is not that much even if you change the amperage or wide range, yes it is clear good.

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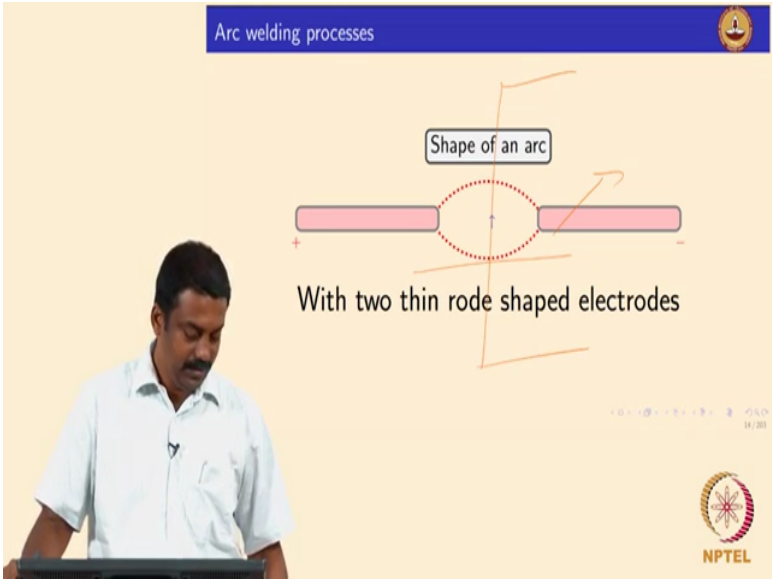

So the shape of an arc is define by the expansion of the gases, ok so the low density to the high density, ok so you have an expansion, the gas expands. So when the medium is actually (sustain) discharge and is keeps on getting ionised and the heat generate more and more

electrons, so obviously so there will be collision between electrons and ions, so the energy dissipated, right.

So that energy can be radiation or can also be heat or can also be any other emission, so we use heat the collision between the electrons and ions, ok so generates it dissipates heat, right. So that heat we use it for our application, right suppose if you have two conductors rode is then you will have the shape like a barrel shape, suppose if you take this guy out and put a flat plate, right what will happen then?

Student is answering: it becomes half.

It becomes half, so that is in a very real welding conditions, it becomes half, yes yeah. It becomes half in a way but the shape of a bell, ok. So if you look at an welding arc the shape of an arc is a bell shape, right.

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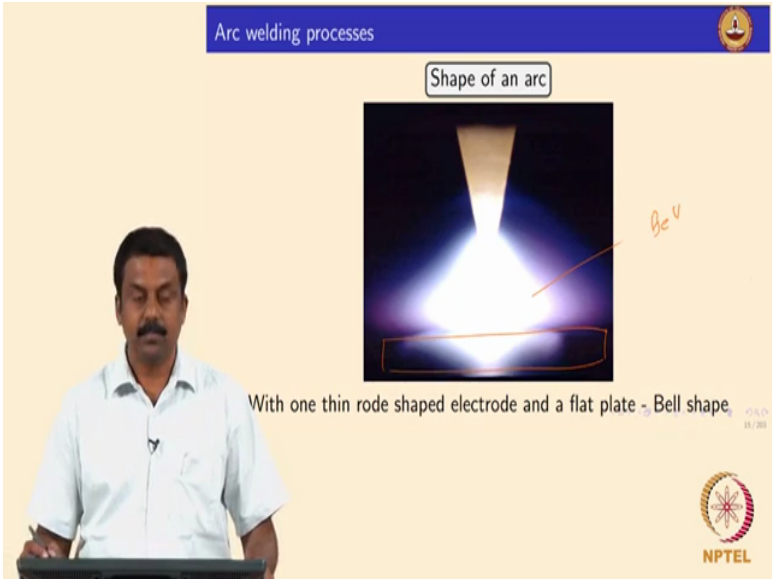

The shape is like this, so we have one thin rode which is an electrode in this case, right and then he have a flat plate which is a works or peace, right. So it can be anything any metal, any metallic object. So instead of having two flat electrodes if we placed the one of the flat electrodes rode electrodes into flat electrode the arc formed will have a shape of a bell.