Welding Processes
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Electrical Conductivity of Welding Arc

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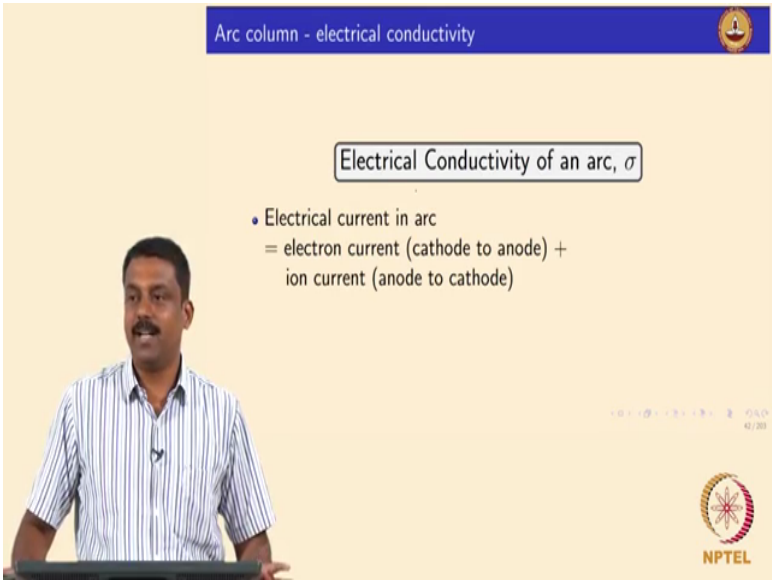

So were looking at the reactions the ionization and dissociation reaction that are happening in the arc right? How it actually controls the temperature distribution of an arc. Suppose now we are going even further you want to calculate the actual heat is generated in the arc. Okay so again many do know the electron density in the arc, is not it? And the potential created by these reactions. In other word if you know that the electrical resistivity okay resistance of an arc, we can also calculate the heat, is not it?

Yeah, because arc determines the resistance for the path of the energy carriers, so obviously more the resistance, they will collide into each other, high energy high collision rate. So it is possible from the fundamental physics to calculate electrical resistance of an arc. It is very simple. So once you know that we can calculate obviously the heat and then we can balance it with conduction, convection and radiation.

Okay I am going to show you very simple derivation okay how we can conduct the electrical conductivity of an arc so if you say the current in an arc okay what is current? Ease the transport of the charge carriers so what are charge carriers we have in the arc? Electrons and Ions the electrons they travel from? Cathode to anode, Ions? Anode to cathode. Okay so the total electric current is nothing but what is that the electron current plus ion current.

That is very simple right? So the total current if you say that that is the current of electron plus the current of ion and if you calculate the current of the electric current and ion current and you can make use of that to calculate so what is the resistance for this current isn't it so if you know the the length area and the mass okay so you can calculate the conductivity or resistivity.

So first look at the electron current so electron current nothing but the amount of electrons travels from cathode to anode. It is nothing but the current density, the density of electrons, number density.

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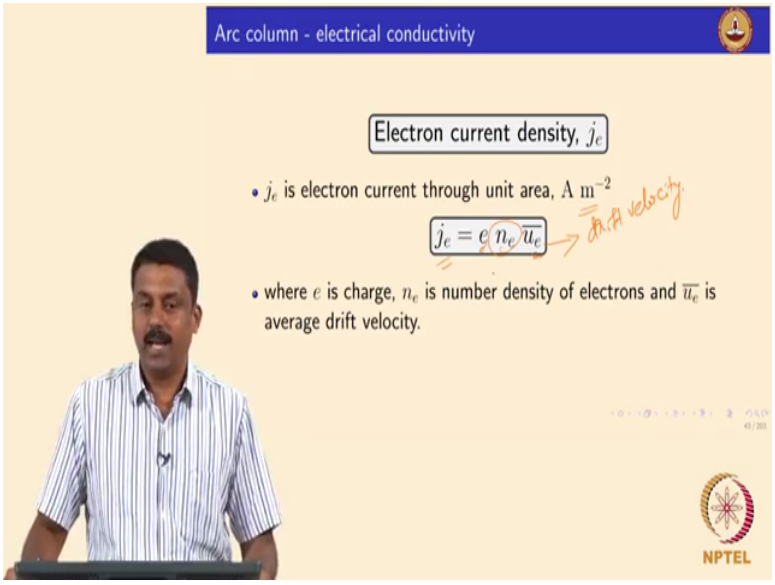

The electron current is defined through unit area right? Amperes per square meter is nothing but current means it is travelling is not it? So velocity. Okay so you have a NE of electrons number of electrons remember density they carry a charge isn't it electron charge E the basic charge of an electron times the velocity that is what current is right so this is the drift velocity. So that is the average deep velocity so current is nothing but how much electrons you have times or far they travel isn't it under this process the each electron carry the charge of E.

So the charge is transported okay by the so and so number of electrons in a given velocity. Right it is clear so if you say the electron current JE is nothing but the elemental charge of electron how do you calculate elemental charge of electron very famous experiment? Yes.

Student: Millikan oil-drop experiment.

Professor: yeah so Millikan oil-drop experiment. Okay plus 2 Physics isn't it so this you get also first equation okay so you the elemental charge of electron times the number of electrons you have number density times the velocity of the drift velocity of an electron will give you the current density current density isn't it so now how do you calculate each term NE we know you can get E Millikan oil-drop experiment.

Okay and then drift velocity so drift velocity is including the collisions okay electrons collides and then get drift and then they go they don't go in a free path so if it is free electron path then it is the average tunnel velocity so in this case it is not the case okay resistance is created by the drift by the collisions so it is not the thermal velocity it is a drift velocity because that determines the electron travel.

If you have a high hindrance for the electron path obviously, you also reduce the drift velocity significantly right isn't it. If a mean clean path is longer, the drift velocity will be higher isn't it because then you have less collisions right. So we can get the drift velocity calculated very simple equation.

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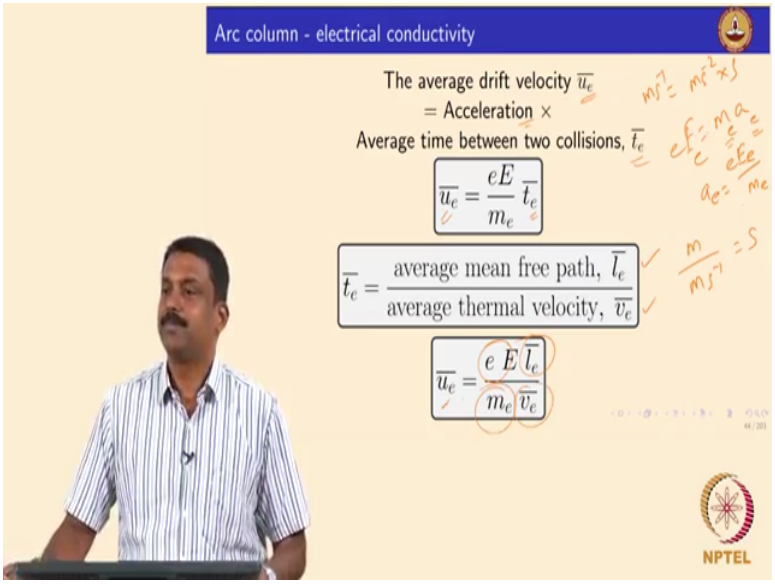

So drift velocity UE is nothing but the acceleration times the time between two collisions. Okay so acceleration is the defined by meter by seconds square isn't it time second will give you velocity isn't it so when you have acceleration multiple be times you get drift velocity and what is this time here the time between two collisions isn't it so we are having meter per second.

So we have acceleration times second because this is a drift velocity that means that after two collisions velocity changes right that velocity determines by how umm how high is acceleration isn't it an acceleration how do we calculate acceleration isn't it? What is F here?

Student: Electric field.

Professor: Yeah it is electric field okay what is M here?

Student: (())(8:01)

Professor: A here?

Student: Acceleration.

Professor: Acceleration of electrons okay so now from this equation A is nothing but. By ME but ME is for 1 but you also have a charge associated with that, okay so you multiply it by, sorry here right? Because the electric field is governed by the charge of the electron as well right. It is clear? So this is the force applied to accelerate a mass ME and if the force is E times E, the acceleration is given by the force by mass.

Is not it simple right so you substitute acceleration in this equation, what will happen here? Now we have an equation for drift velocity is nothing but coming from this equation isn't it? The force, the electric field which determines the drift okay the acceleration of the electrons the how much field you apply between the cathode and anode isn't it? Okay that will determine the acceleration okay how fast the electrons travel from cathode and anode determined by the field, the potential difference you apply. Okay so then TE is time bidding collision that will determine your drift velocity. Again now do you calculate the time between two collisions? It is very simple okay the average mean path over thermal velocity. So again this is meter by meter second and this becomes second it is clear so we can substitute Te from this equation.

So why do you substitute? Because ready fill the calculate the equation between two time between two collisions but we know the one will be main three part that will give a temperature of an electron what will be the average thermo velocity that can be calculated okay for electron. So we substitute that we get the drift velocity as function of the applied electric field and then mean free path, mass thermal velocity okay.

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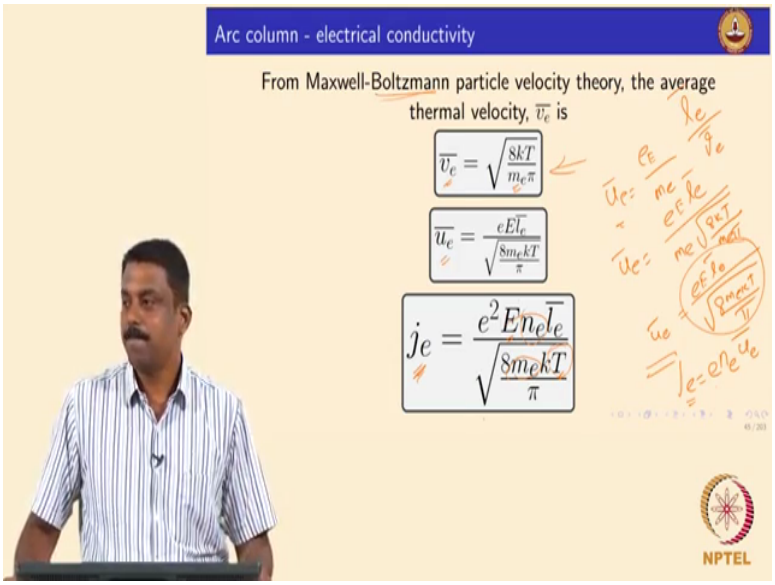

So again the Boltzmann from the Maxwell-Boltzmann equation the average thermal velocity is given by square root of 8 KT by ME pie guess any particles okay so we know the equation for the average thermal velocity, so now we can apply to the average drift velocity. So average drift velocity is nothing but…

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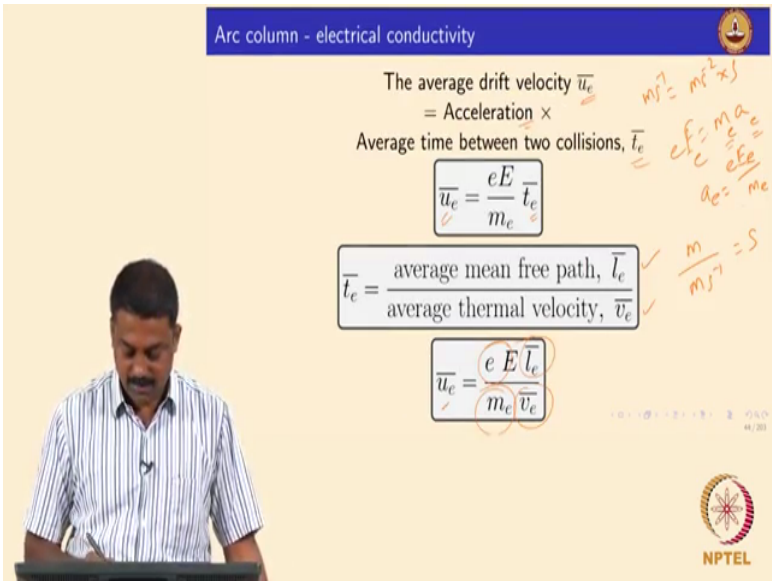

Here okay.

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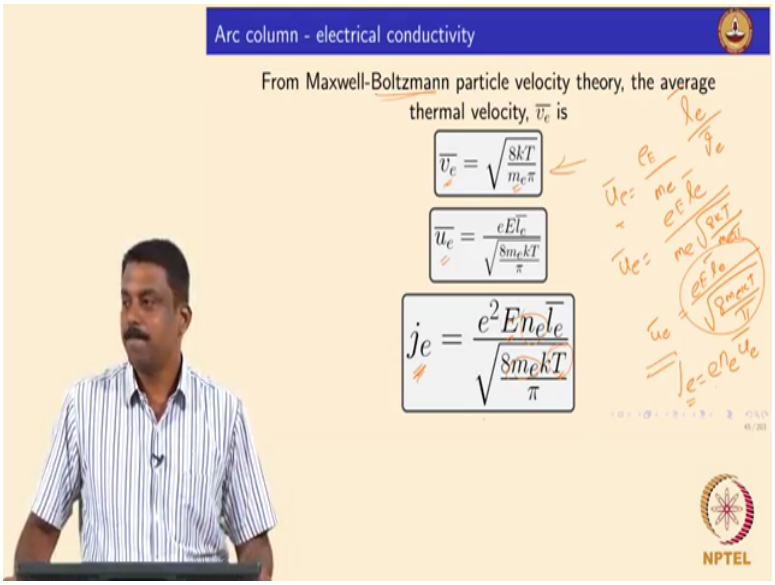

So this is coming from acceleration isn't it then LE is mean free path and then what is this? Thermal velocity okay so if you use that apply that and UE becomes so VE is nothing but square root of 8 KT by isn't it yes so ME is here ME times by ME pie and here we have LE isn't it so overlap in here now we the ball on top of the velocity is extremely important okay this will becomes by pie isn't it because ME goes inside ME square ME in denominator cancels out.

Right its clear from the now we have a equation for drift velocity and now the electron density current density is nothing but the first equation e number density and then drift velocity. So if you replace AE worth this term then we have the electron current density, is not it? So nothing but E over here and E here becomes E square and then the field you apply the number density, mean free path by square root of 8, Me the mass of electron Boltzmann temperature and pi.

Yes its clear so in this equations the electron density is determined by two important variables here. What are the variables here? Which are all constant and what are the variables here? The electric field.

Student: Temperature.

Professor: Temperature, okay they all are for example this is constant okay this is determined number in city so now electron density current density is determined by the field and the temperature so obviously if the temperature is higher so you create more resistance because the collision number of collision incidence increases the drift velocity decreases isn't it?

When you apply high electric field what will happen then? Okay the current can flow much faster the drift velocity increases thus relationship.