Introduction to Mineral Processing
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Lecture – 62
Electrical Separation

Hello welcome. So, in the last lecture we are briefly discussed about the magnetic separator and I had shown you some of the magnetic separators, which have been used commercially. I will show you again another kind of separator, which are being used commercially not extensively, but it is been used.

This is based on the electrical conductivity property differences between the minerals, that is the separation is enabled based on the differences in the electrical conductivity of different minerals. So, they are called electrostatic separators, but the topic what I am preferred here is called the electrical separation.

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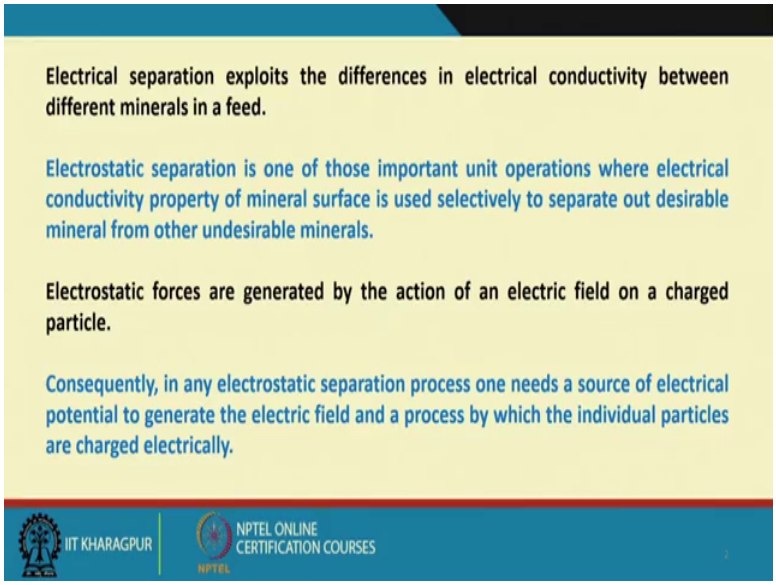

So, electrical separation essentially exploits the differences between different minerals in a feed. That means, the different minerals may have different type of electrical conductivities and we try to separate based on their relative differences in the electrical conductivities. Electro static separation is one of those important unit operations, where electrical conductivity property of mineral surface is used selectively to separate out desirable minerals from other undesirable minerals. I repeat it electro static separation is

one of those important unit operations, where electrical conductivity property of mineral surface is used selectively to separate out desirable minerals from other undesirable minerals.

But question is, how do you generate the electro static force and how much of that force is required for separating a specific group of minerals and again the your commercial designs like the issues are identical with magnetic separator or any separators that is your feeding system, and then your how do you collect the separator products all sorts of things. Electro static forces are generated by the action of an electric field on a charged particles consequently, in any electro static separation process one needs a source of electric potential to generate the electrical feed and a process by which the individual particles are charge electrically is a very important thing to understand in this type of electro static separators.

So, electro static forces are generated by the action of an electric field, applied on a charge particles to have a better a separation. So, what we need? We need a source for electro static forces generation, electric field generation and we also need a process to induce electrical charges on to the surfaces of the particles of my targets.

So, there are two distinct forces, which may be considered in the context of electrical separation what are these two distinct forces? One is called electrophoretic force. So, electrophoretic force is one of the force experienced by charge particle under the influence of an electric fields. So, it is on a charge particles; the force experienced by charge particle under the influence of an electrical field. There is another kind of force that is called dielectrophoretic force. So, dielectrophoretic force is the force experienced by neutral particles, it is not by charge particles by neutral particles in a fluid, when subjected to a non-uniform electric field.

So, electrophoretic forces essentially applied to a charged particle and dielectric forces are which I applied to neutral particle or I would say that they experience the particles the charge particle experience the your force that is called the electrophoretic force and the neutral particles that is called the dielectrophoretic force. The dielectrophoretic force is somewhat analogous to magnetic force as it relies on the polarization of a neutral particle into an electric dipole as well as a non-uniform applied field.

Now the deliberate use of the dielectrophoresis is almost nonexistence in mineral processing; however, as the electrophoretic force is much stronger because why it is not being used that much in mineral particle separation? Because the separation process is requires to handle large quantity of materials.

So, the kinetics of this separation process has to be faster. So, to catalyze the process or to have a faster separation kinetics, the dielectrophoretic forces are hardly used normally the electrophoretic forces are used because. So, what we what we try to say that, to first charge the particles and then try to separate them based on the your applying the electrical forces.

Because this is much more stronger and when this is stronger so; that means, the particle separation will be much more faster. So, the residence time required by the minerals to be separated and this type of separator when the dielectrophoretic force principle is used is much less. So, that per unit volume we can process much more higher quantity of material per unit time.

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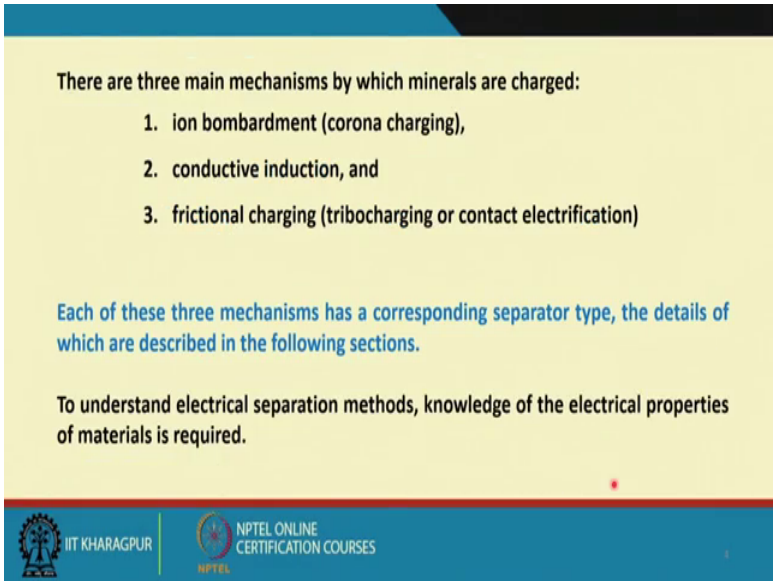

There are three main mechanisms by which minerals are charged that is we said that it is on charge particles, but how do we charge the particles there are three main mechanisms one is ion bombardment that is called carona charging, number two conductive induction and number three frictional charging or we call it tribocharging or contact electrification we discuss briefly of this because this is a very important part to understand this type of

separators when applied to mineral processing field. So, each of this three mechanisms as a corresponding separator type; that means, the even the separator designs, they change based on the mechanism through which we try to charge my induce surface charger on the particle mineral particle surface.

To understand electrical separation methods, knowledge of the electrical properties of materials is required.

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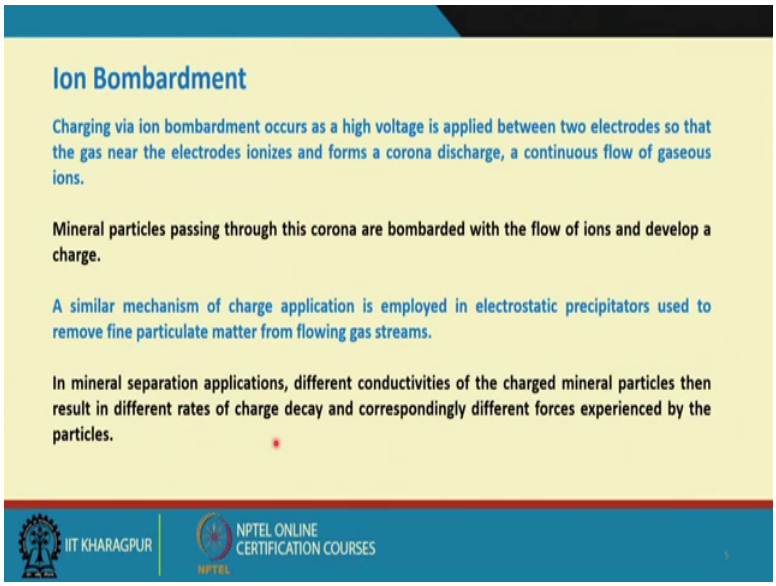

What do I mean by the knowledge of the electrical properties of the minerals is required; that means, what are the electrical conductivities of the different minerals, we have to understand at various operating conditions. So, one process is called the ion bombardment that is we are discussing about the charging mechanism. Charging via ion bombardment occurs as a high voltage is applied between two electrodes like if I have got two electrodes, one is positively charged another one is negatively charged and we apply a huge voltage.

So, that the gas near the electrodes ionizes mostly it is a and forms a carona discharge that is a continuous flow of gaseous ions. So, what we are trying to say? That ion bombardment is like, we have got two electrodes and we pass a very high voltage. So, what will happen? The gas mostly the air in this case there will be a at gas ionized and you forms a carona discharge, you call it as a carona discharge at it nothing, but a continuous flow of gaseous ion should be there.

So, mineral particles passing through this carona are bombarded with the flow of ions and develop a charge. So that means, we are trying to induce charge first on the gas, gas phase that is the air and then this gaseous ions with the mineral particles pass through that region will develop a charge on to the surfaces of the minerals, that is how we do the charging. A similar mechanism of charge application is employed in electrostatic precipitators like esp if you have taken a course on environmental engineering, esp is very important separator these days for controlling the air pollution that is to separate out the contaminants from the air that is where this principle is being used.

Now, in mineral processing also the similar type of separators are also there, but here it is not a separation between your that is for the purification processes of my atmosphere, it is for separation of two different minerals where you have differences in their your electrical conductivity electrical conductivities of different minerals. So, in minerals separation applications different conductivities of the charge mineral particles, then results in different rates of charge decay.

So, and correspondingly different forces experience by the particles. So, what will happen? The depending on the your electrical conductivities of different minerals when you are trying to induce a charge on that. So, the this charge will be decaying, but the rate of this decay will be different, but different minerals based on their electrical conductivities.

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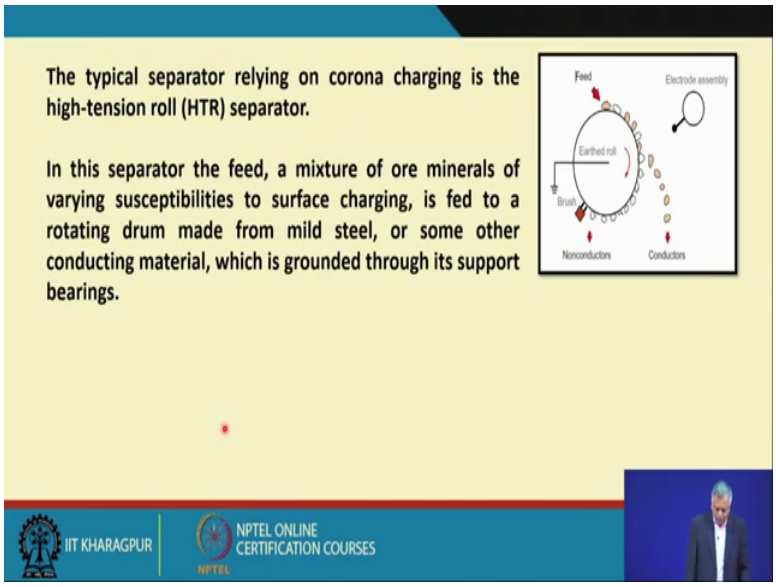

Now, let us see that how this principle is being used to separate the minerals. The typical separator relying on carona charging is the high tension roll separator. So, what happens here? Now suppose you have got a again your similar to your drum type magnetic separator, you have got a your rotating drum and then this is earth this one at the feed enters here on to the surface of the drum. Now there is an electrode assembled here. So, what will happen? The non-conducting materials; that means, which are non-susceptible to this applied field of electrical force. So, they will be transported up to this region because of the with the rotation of the drum and they will be disclosed here that is the nonconductors.

And the materials which are electrically conductive, they will be thrown out because they will try to get attracted towards this electrodes.

But the distance is quite is a made in such a way that, they will be not able to reach upto there, but they will be lifted out they will be taken out from these assemblage and they will fall back here. So, that is called the conducting materials. So, how much of that your voltage and how much of that your degree of ionization is there, that to you require that will depend on the conductivity of those materials or those minerals, which you want to separate from that assemblage and then what should be the distance between this roll and electrode assembly that will also be decided based on the lifting force of these particles lifting force acting on the this particles, based on these your electrical charges applied.

So, in this separator they feed a mixture of ore minerals of varying susceptibilities to surface charging is fed to a rotating drum made from mild steel or some other conducting material, which is grounded to its support bearings there all mechanical designs aspects and then that is how it is been separated.

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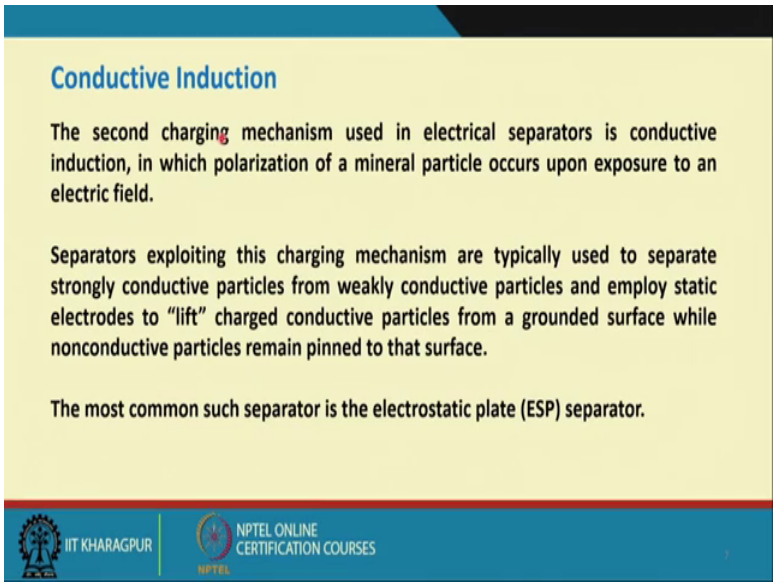

There is another way of charging the material, that is called conductive induction. So, this conductive induction mechanism used in electrical separators, in which polarization of a mineral particle occurs upon exposure to an electrical field. Separators exploiting this charging mechanism are typically used to separate strongly conductive particles from weakly conductive particles and employ static electrodes to lift charge conductive particles from a grounded surface while non-conducting particles will in pinned to that surface.

That is just like your simply what do you observe while you code a hand magnet that example I have given, that is you have got magnetite and quartz particles there and you have got a hand magnet a held on top of that and if you even if you have a certain distance the magnetite particles will be lifted will be trying to get attracted towards the magnet.

So, and if I have a mechanical version of the this, that is your material is being transported in a drum and you have a magnet here. So, these material should be your highly magnetic particles, which trying to get added to the surfaces all the non-magnetic particles will be collected through a different regions. The most common such separators is the electro static plate separators.

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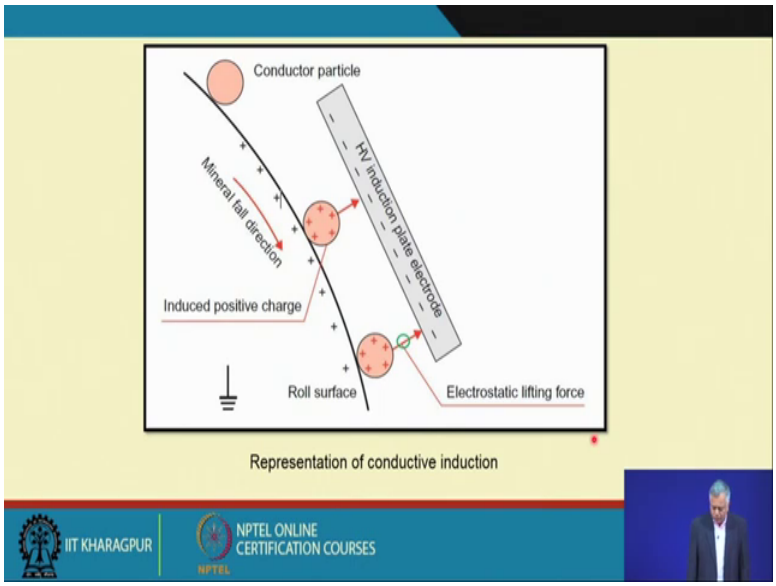

How it is being done? Now suppose this is the mineral fall direction and we have induced positive charge that they are charge particles, and this are basically conductive particles. So, first you have charge them. So, we have induced the positive charge and there is the induction plate electron and while the material is charged, now they will try to get lifted out lifted out from this surfaces and the non-magnetic particles will be carried up to this and then they will be falling here and this particles can be collected through that. Because this your plate electrode the intensity we can vary and based on some mechanism you can separate them out, but the principle remains the same.

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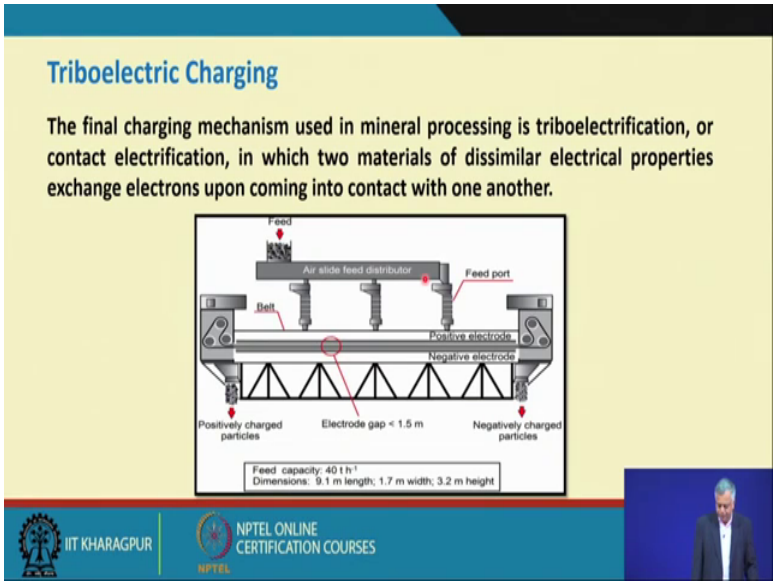

There is another group of separators which works on the principle of triboelectric charging, this are related in your development. So, here the final charging mechanism used in mineral processing is tribo electrification or contact electrification, in which two material of this similar electrical properties exchange electrons upon coming into contact with one another.

So, what you do? Now this is your feed and this is your feed poll and we have got two different electrodes positive electrode and negative electrode and there is a gap between this two, that is around say less then generally kept less than 1.5 meters and then what will happen? It is the positively charged particles and we have got a belt, that is how you are being transported the materials are being transported over this the belt and we are continuously having some high voltage passing through the at.

So, the positively charged particles because we have got two electrodes, that is positive and negative electrodes. So, the positively charged particles will be more attracted towards the negative electrodes and because of this moving in this direction. So, these particles will be collected here positively charged particles; and negatively charged particles will be added to this positively electrode and then they will be collect from the. So, they will be collected to that region. So, and the belt is continually moving in this direction.

So what will happen then positively charged particles are separated here negatively charged particles are separated here and this are the some dimensions given that is a ribbing separators and the fed capacity could be up to 40 tons per hour, the dimensions could be 9.1 meter length, 1.7 meter width and 3.2 meter height.

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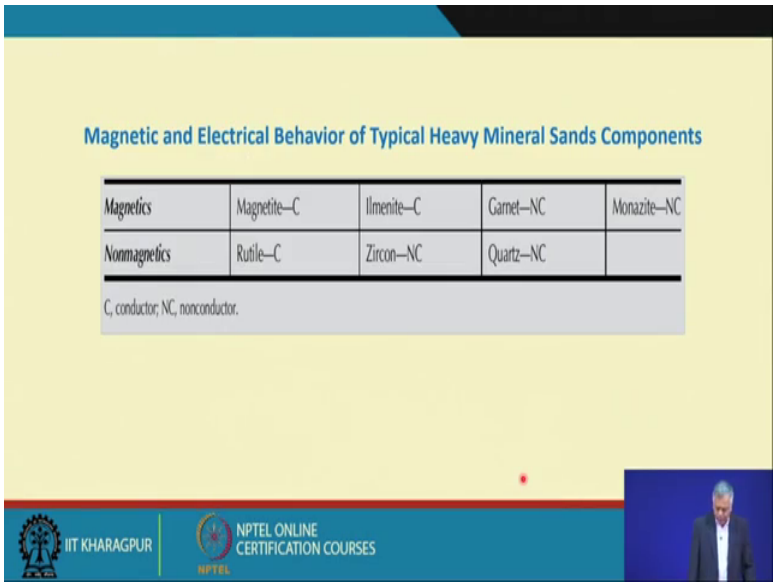

Magnetic and electrical behavior of typical heavy metals and components; that means, where it is being used. It is extensively used in heavy mineral separations when we talking about the flow sheet development, we will discuss more on this that is how they are being used, but here also I would like to show you that your heavy mineral sand components, where you have got a mixture of different eh or heavy minerals which are all wanted.

So, it is being used extensively for separating the different wanted minerals based on their electrical conductivity differences. So, some of the magnetic particles which are conductive and non-conductive they have mentioned here like magnetite is a conductive material, limonite is a conductive material, granite is non-conductive monazite is non-conductive am I go the non-magnetic particles rutile is a conductive, zircon is non-conductive and quartz is non-conductive. So, we apply this principles to separate them from each other.

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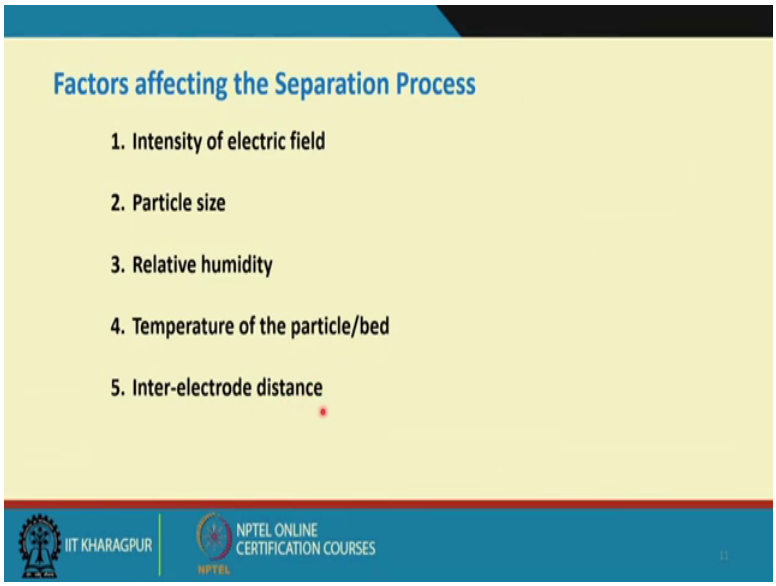

Now what are the factors, that effects the separations process? It is the intensity of the electric field that is the how much what is the intensity of the electric field you have applied and that will we decided based on the what type of electrical conductivity differences you have in your particle mixture, where you want it separation and then how fast you want that separation to occur; that means, that what is the capacity you require. Then what is the particle size?

Because what will happen if the particle sizes are bigger then you have to induce sufficient or electrical force on to that. So, that they are lifted. So, the particle should have some lifting force. So, if the particle is bigger, you need more intensity of the electric field. So, that the different layers inside that particles is also may be induced to that otherwise the material will remain will not response to this your separation mechanism.

And may be because of your same wet it will just be transported along with the your non mech, non-conductive particles. Relative humidity because there is there may be a resistance to this electrical conductivity. So, what is it is called the resistivity. So, how much is the relative humidity, that is at what type of environment we are trying to separate this materials are the material surfaces are dried or not. So, normal when we use this electrical separation, we normally try to dry the material before we put into the separator and if the material surfaces are not if they are wet; that means, we have

moisture, then the natural floe ability of the minerals also will be effected. Temperature of the particles and the bed it is also very important one and then inter electrode distance, how much of distance you have between the two electrons; because the your in between the electrodes, the air has to be your ionized. So, greater the existence more the intensity of the electric field you require.

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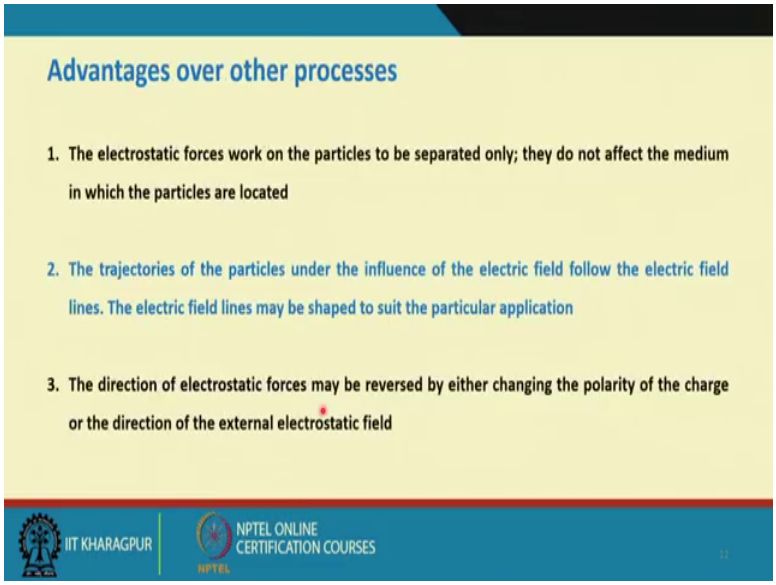

What are the advantages of the electrical processes over other processes? The electro static forces work on the particles to be separated only because it is very selective. They do not affect the medium in which the particles are located. The trajectories of the particles under the influence of the electric field, follow the electric field lines; that means, the trajectory can easily be predicted.

So, that I know that where my collection device has to be kept. The electric field lines may be safe to shoot the particular application. The direction of electro static forces may be reversed by either changing the polarity of the charge or the direction of the external electro static field. So; that means, it can easily be your the design parameter can easily be changed depending on the nature of the particles you want to separate.

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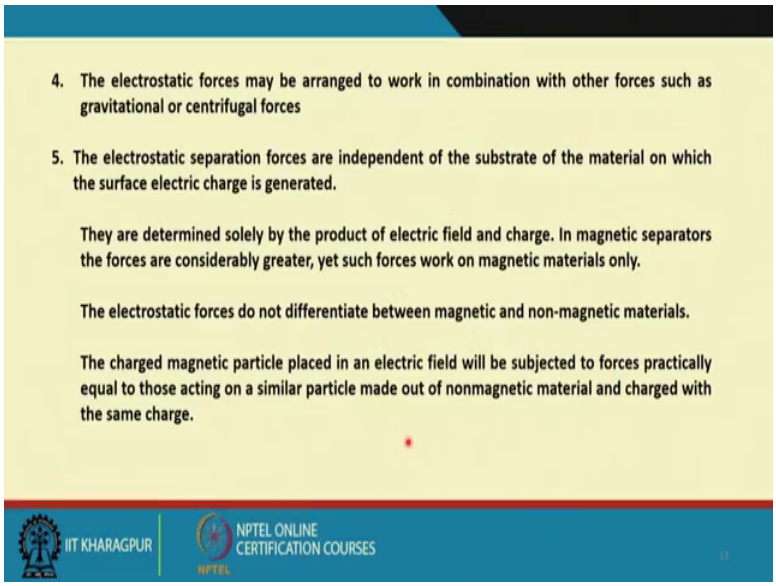

The electrostatic forces may be arranged to work in combination with other forces such as gravitational or centrifugal forces to promote separation. The electro static separation forces are independent of the substrate of the material, on which the surface electric charge is generated. They determine solely by the product of electric field and charge in magnetic separator the forces are considerably greater, it such forces works on magnetic materials only.

The electro static forces do not differentiate between magnetic and non-magnetic materials; that means, whether the material is magnetic or non-magnetic, the electro static separators they do not have any differentiation based on that. It is just simply based on the electric conductivity of that particle will decide that how effective will be or your separation based on your this methodology.

The charge magnetite magnetic particle placed in an electric field will be subjected to forces practically equal to those acting on a similar particle made out of nonmagnetic material and charged with the same charge. That means, whether it is magnetic or non-magnetic particle it does not matter. So, the it is solely dependent on the electrical conductivity of that mineral.

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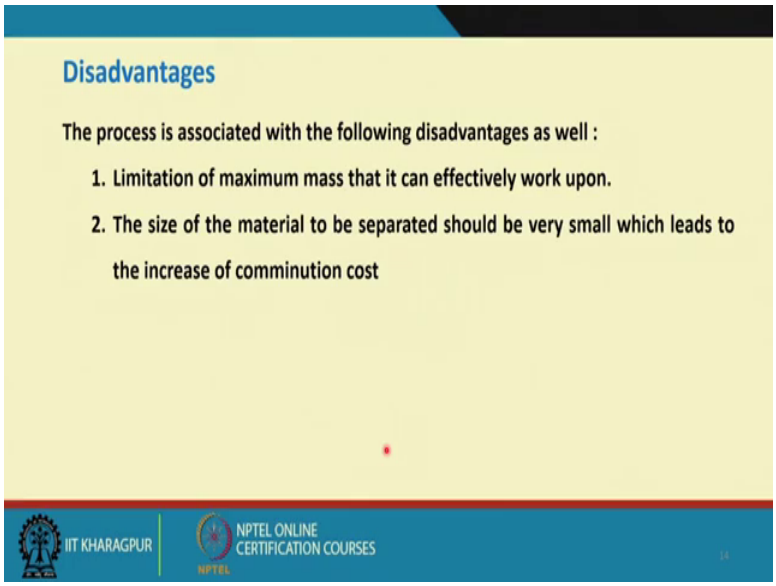

What are the disadvantages associated with it? Limitation of maximum marks that it can be effectively work upon because if they are not evenly sprayed; that means, essentially requires a monolayer of particles, otherwise the particle may be may not be rejected out from that mixture, that is your lifting force may be very weak. The size of the material to be separated should be very small; that means, they are applicable only for very small particles as I had already explained you, that if it is a course particles that will be difficult to induce there electrical force into the entire mass.

Which leads to the increase of comminution cost; that means, it requires that the material has to be ground to very finer sizes and when it requires that the materials has to be very finer sizes so; that means, your comminution cost will go up and these are the disadvantages and advantages with the electrical separations. So, you see that this magnetic and electrical separation are very selective separation processes, which can be applied to minerals mineral processing, when they have when the tube mineral particle type they have distinct differences either in their magnetic properties or electrical conductive properties conductivity properties.

For electrical separation the mineral particles has to be ground to finer sizes and this is the these are the reasons that why the application of these two separators are very limited. Whereas, in modern mineral processing plant the magnetic separators are finding much more wider separations than the electrical separations.

So, this is in narsell the topics of what I wanted to cover in this course. Now before I go to the next topic of lecture that is the last topic, I would like to show you some of these commercial electrical electrostatic separation equipment. Either say it in the last lecture that I would like to show you some of the electro static separators, which have been used commercially.

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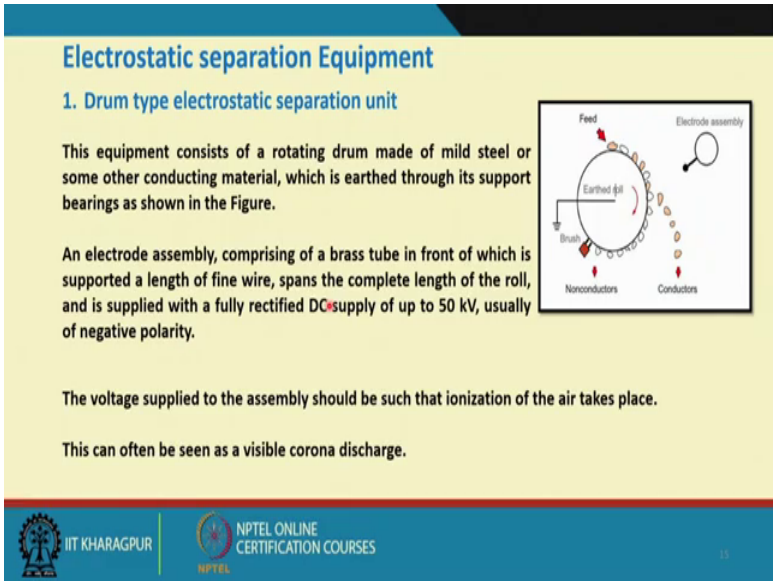

So, again it can be a drum type electro static separation unit, this is what I have already shown you. So, this equipment consist of a rotating drum made up of mild steel or some other conducting material, which is earthed through it support bearing such shown in the figure. And electrode assembly here comparison of a brass tube in front of which is supported a length of fine wire that is a fine wire is supported.

Spans the complete length of the roll that is rotates and it supplied with a fully rectified DC supplies of upto 50 kilo volts usually of a negative polarity, that is for charging the voltage supplied to the assembly should be such that ionization of the air takes place. This can often be seen as a visible carona discharge.

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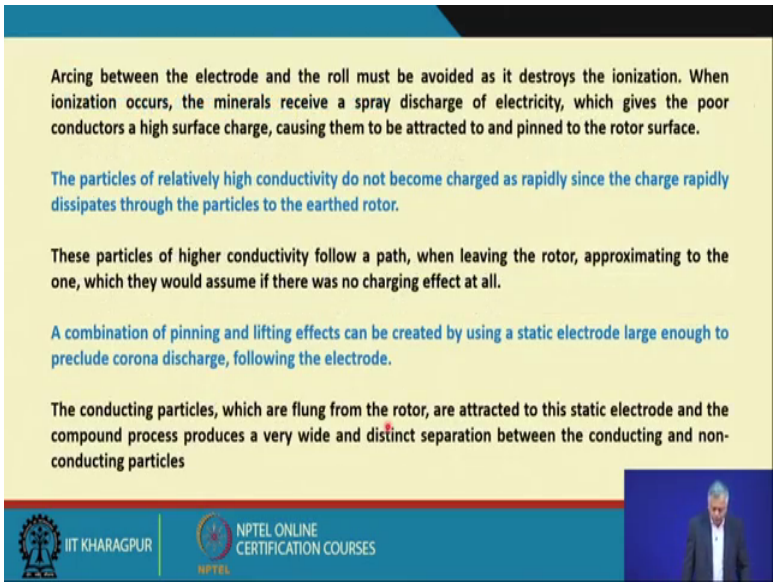

Now, acting between the electrode and the roll arcing between the electrode and the roll must be avoided. There could be arcing in between the electrode and the roll as it destroyed the ionization. So, arcing is not wanted; when ionization occurs the minerals receive a spray discharge of electricity like your spraying nature, which gives the poor conductors ya high surface charge was in them to be attracted to and pinned to the rotor surface.

The particles of the relatively high conductivity do not become charge as rapidly, since the charge rapidly dissipates through the particles to the earthed rotor. This particles of higher conductivity follow a path when leaving the rotor approximating to the one which they would assume if there was no charging effect at all.

So, a combination of pinning and lifting effects can be created by using a static electrode, large enough to preclude carona discharge following the electrode. The conducting particles which are flung along the from the rotor are attracted to this static electrode and the compound process produces a very wide and distinct separations between the conducting and non-conducting particles I think I have already discussed this.

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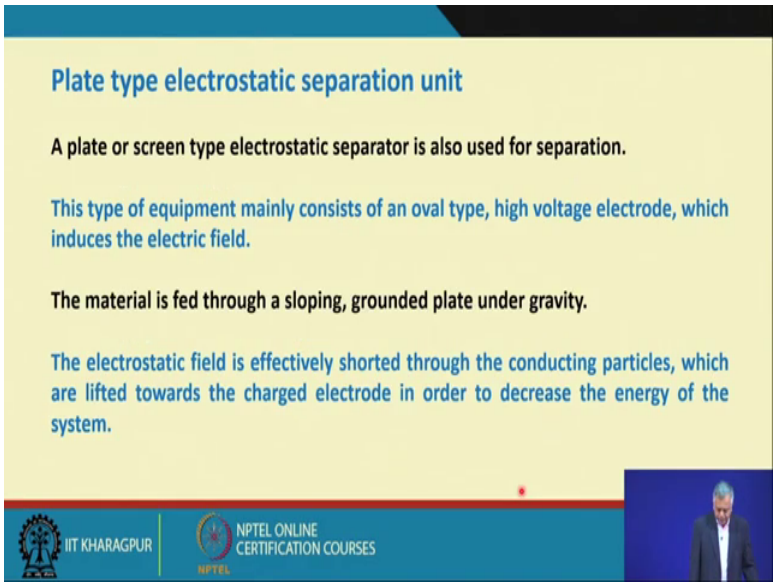

A there could be another type of separator that is called the plate type electrostatic separation unit, it is also I have already discussed, but I will show you that how do they I will explain you bit again how do they work.

Now, the a plate or screen type electrostatic separators is also used for separation, this type of equipment mainly consist of an oval type high voltage electrode, which includes the electric field like we had already seen it in that your when I gave the example of esp separator, that is your electro static precipitators. The material is fed through a sloping for material your transport, grounded plate under gravity; that means, the it is an that plate should be your grounded and the electro static field is effectively sorted through the conducting particles, which are lifted towards the charge electrode in order to decrease the energy of the system.

So, these are the various designs. So, essentially what I need that is a charging mechanism and then we should have your a kind of your electrical forces to be applied or induce the lifting force on the particle, which I want to separate of this principle.

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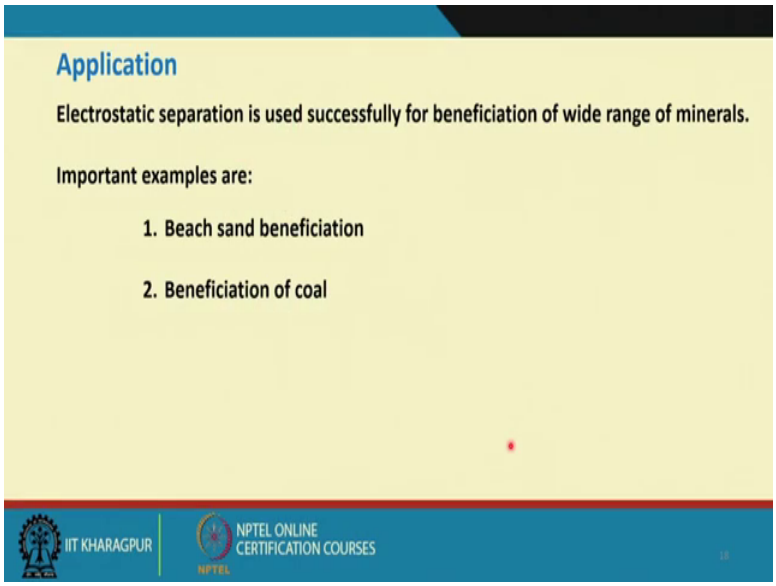

So, what are the applications? Electro static separation is used successfully for beneficiation of wide range of minerals; important examples are beach sand beneficiation and beneficiation of fine coal. So, next lecture we need to talk about flow sheets development, I will show you that how these electrical and magnetic separator a magnetic separators there been used for beach sand beneficiation till then.

Thank you very much.