Power Plant Engineering
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Lecture – 12
Ash Handling

Hello, I welcome you all in this course on Power Plant Engineering. Today, we will discuss Ash Handling. Ash is the unburnt part of the coal, which is used in the power plant for the heat generation. So, topics to be covered in today's lecture are; first of all we will discuss about the ash handling systems, ash disposal and uses of ash in the last.

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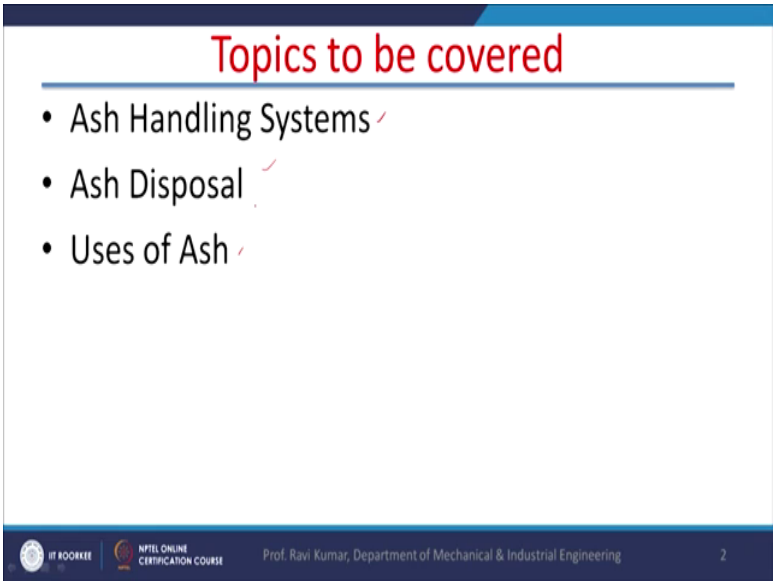

As I said earlier, ash is the unburnt part of the coal, which remains in the power plant and it has to be disposed. Disposal of ash is nowadays a big issue in the thermal power plants.

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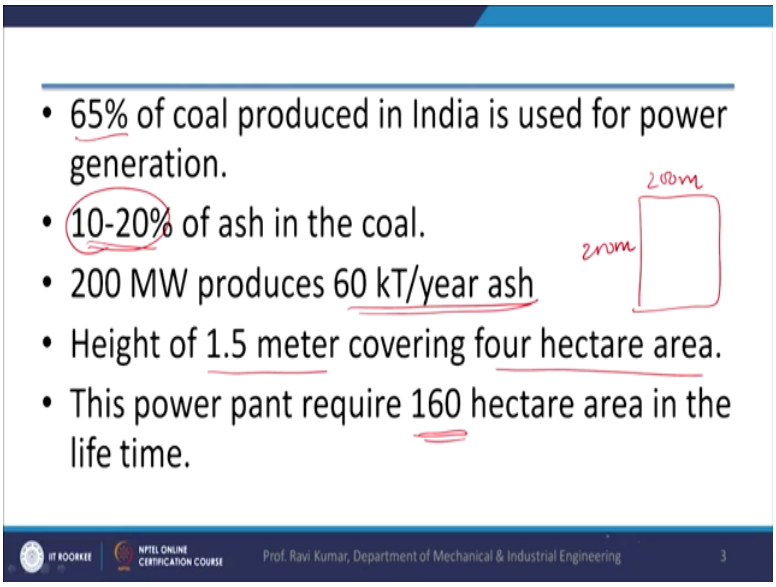

65 let us have some data on thermal power plants. 65 percent of the coal production is used for the power generation in India. So, approximately two-third of coal is used coal production is used for power generation in India, and the coal may contain 10 to 20 percent; very high grade coal may contain 5 or 6 percent ash also. But normally, coal which is used in the power plants 10 to 20 percent of the coal contains the ash. If you take a 200 mega Watt power plants so, it produces 60 kilotons per year; 60 kilo tons of ash per year, it is per year.

If you want to have idea about the ash, it is it covering 4 hectare area; height of 1.5 meters approximately 5 feet height, covering 4 hectares area; 1 hectare is a 100 square meter. So, if you take area of let us say 200 by 200 meters; 200 meters by 200 meters, this much of area will be covered by the ash produced in a 200 mega Watt plant in 1 year. So, this power plant

normally, the life of the thermal power plants is approximately 40 years. It varies but, on average comfortably we take 40 years as the life of the thermal power plant.

So, 160 hectares will be required during the lifetime. So, the quite large area is required for the ash. So, nowadays, I mean there is thinking over how to make the best use of ash which is produced in thermal power plants. Now, ash has to be handled and it has to removed from the grid or the from the boiler and it has to be dumped somewhere else.

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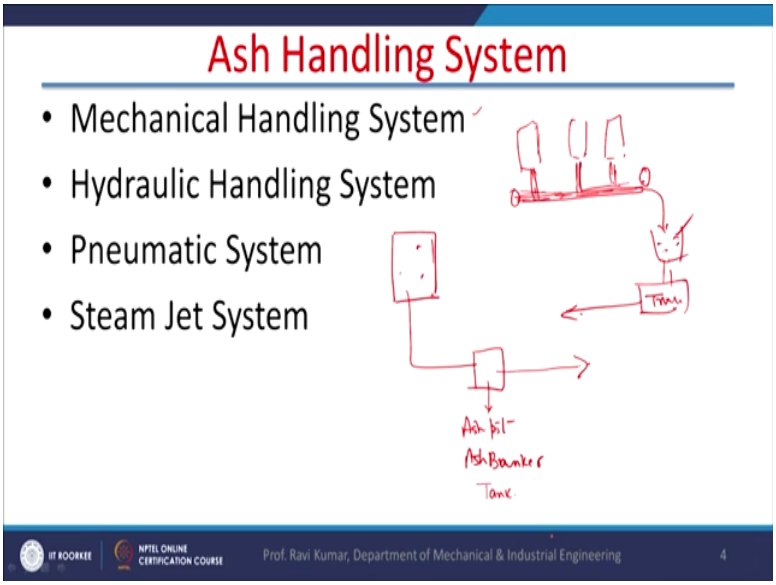

So, there are ash handling systems because, first of all, suppose there is boiler where the coal is burned. The coal is burned then, ash handling system will come into the picture through ash handling system, it will be transported to somewhere else. And, ash handling ash handling system it can be a mechanical system, it can be hydraulic system, it can be a numeric system or

it can be a steam jet system. So, it will go to the ash pit or the ash bunker so, there may be a ash pit or ash bunker.

Where or, some tank can be used for that and here it is transported. So, it may be transported by a truck or the railroad and then, it will be transported for dumping or for the further use. So, ash disposal we will discuss later on. So, first of all we will start with the ash handling systems. So, mechanical handling system, hydraulic system, pneumatic system and steam jet system.

Now, in mechanical systems there is a conveyor belt; and there are combustion chambers where from the ash is coming and it is falling on this belt. And, there is a water turf is a narrow lane, where the water is flowing and the water and ash mixed slurry. And, this slurry is transported to subsequently to ash bunker and from ash bunker it is transported to it is sent to the truck and transported to somewhere else.

So, this is a mechanical handling system, where conveyor belt is used; conveyor belt is used and on the conveyor belt there is a water turf, on the water turf, the ash comes from the different combustion chambers; it mix with water turf slurry is made and then slurry comes to the bunker and then to the truck and they are transported to some other place.

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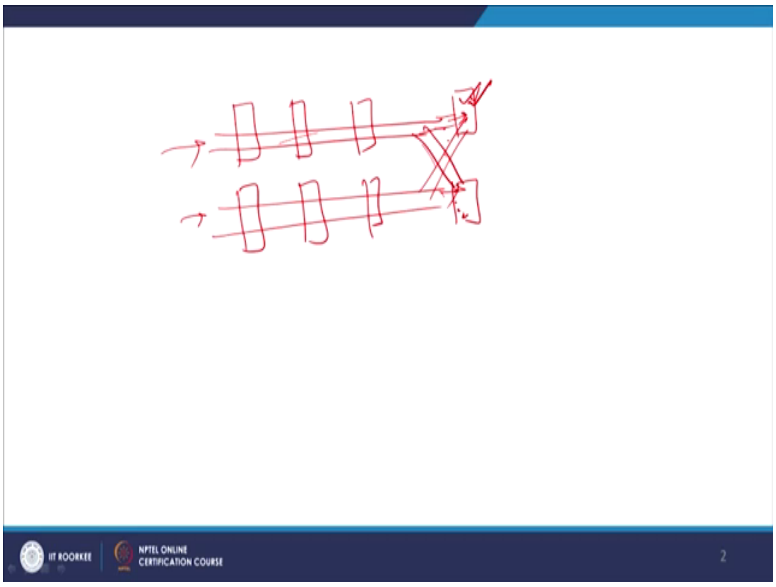

Now, there is a hydraulic handling system also. In hydraulic handling system, again there is a water turf, there is a water turf; and you can have number of water turfs and on each turf, the coal comes from the source right and water comes from this side. There is a force circulation right water comes from this side and there are sumps right and water is dumped into the sumps.

Sometimes, we take more than more than 2 or 3 sumps so, that 1 sump is filled then, the if the flow is diverted to another sump where the dumping of this ash takes place and meanwhile this the ash which is dumped in sump this sump is removed. So, alternatively also they can be used right. So, this is a hydraulic system which is used for handling the ash in a thermal power plant.

There are pneumatic systems also, where the ash is removed under the pressurized air right; and there are steam jet systems, where steam injected on the ash. When the steam is injected on the ash again, it will make slurry and the slurry will be removed from the thermal power plant. They are all low velocity systems right and they can dispose off.

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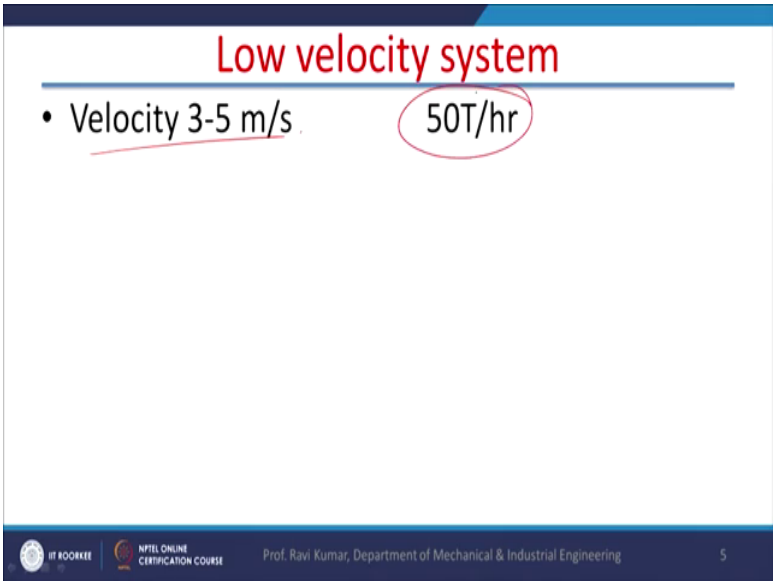

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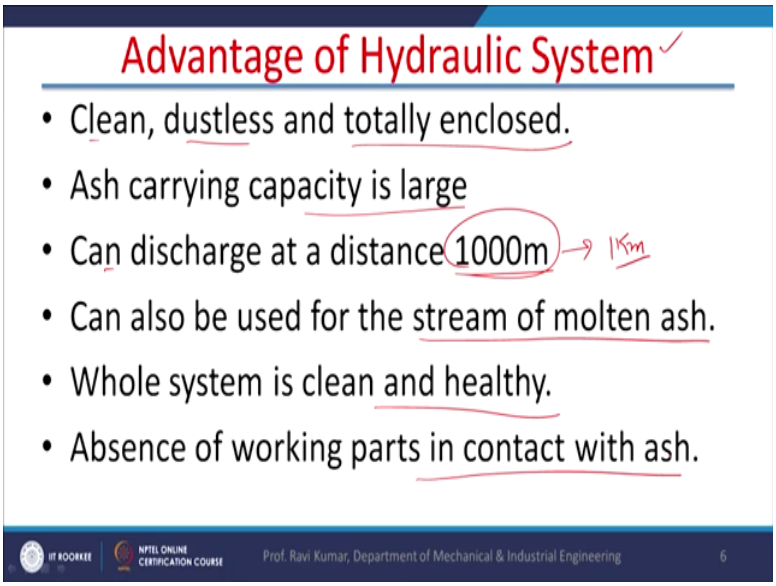

Especially the mechanical type of system it can remove 5 tons of ash per hour; that is a limitation of the mechanical type of ash handling system. But, there is and hydraulic system; let us talk about the hydraulic system, there are certain advantages of a hydraulic system. Hydraulic system, first of all it is clean; there is no dust, it is dust less, clean and the system is totally enclosed right.

Ash carrying capacities is large therefore, as I said earlier there was a limitation for the mechanical type of system but for the hydraulic system, the ash carrying capacity is large. We can increase the water velocity and then we can carry away the more ash from the water turf, and this ash can be discharged at a distance of 100 quite away from the plant. 100, 1000 sorry 1000 meter means 1 kilometer.

So, ash can be dumped 1 kilometer away from the power plant, that is the major benefit of hydraulic system. It can be used for a stream of molten ash; whole system is clean and healthy, absence of working part in contact with the ash. There is no working part in contact with ash

that is the, that is also an advantage of this type of system. Water requirement is low velocity plant is more.

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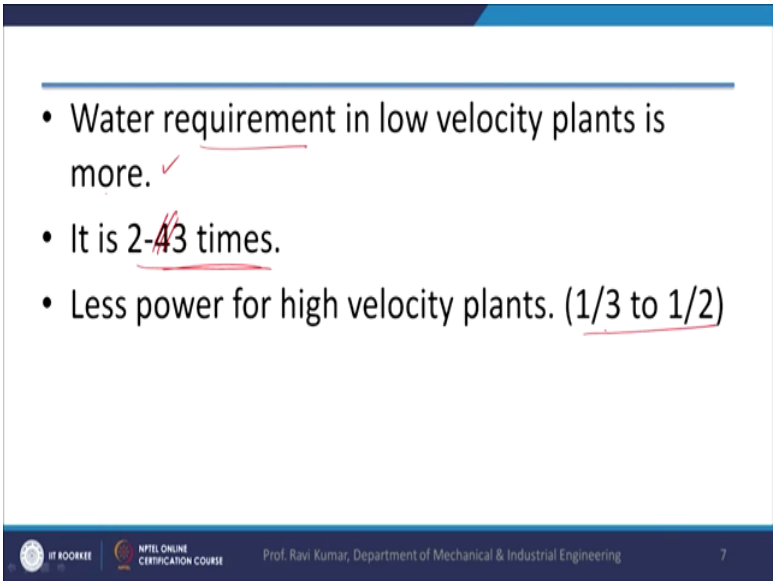

When the low the plant when the velocity is low in that case the water requirement is high. It is 4 to 2 to 4, 2 to 3 times, which is required for the mechanical handling system. So, in hydraulic handling system, it is 2 to 3 times and less power is required for high velocity plant. It is obviously 1 by 3 to 1 by 2.

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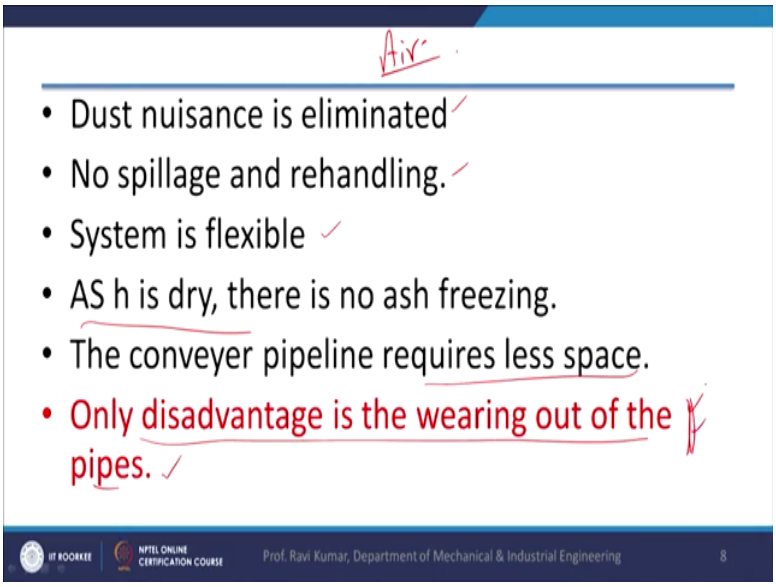

Here, the dust nuisance is eliminated. No spillage and re handling, system is flexible; ash is dry; there is no ash freezing; this is about the air system. Ash is dry in the air system right. The ash is dry; the conveyor piping requires less space because, air and ash these two things are to be handled right.

So, only piping is required and ash will come to the pipe and it will be removed by the forced air right. So, only disadvantage is: wearing out of the pipe. That is the main advantage of the system where, air is air handling system this is pressurized; this one pneumatic system; for the pneumatic system, that wearing of the pipe wearing of the, wearing out of the pipe is high.

Because, there the particles the ash, the ash particles they work as abrasive material. So, abrasive material and the wearing of the pipe take place due to abrasive action of ash particles

and they move with a very high velocity. So, for this reason and so, the frequent maintenance is required in such type of systems.

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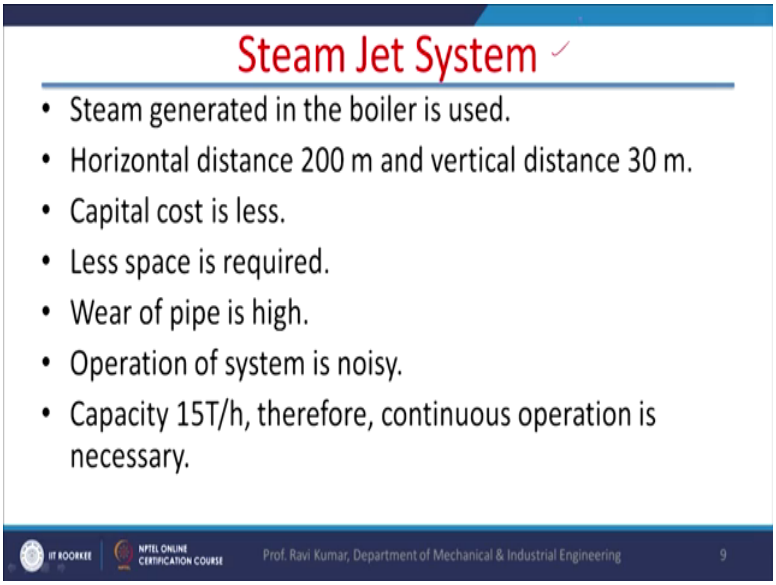

Now, the last one is the Steam Jet System. So, in the steam jet system first of all a steam has to be produced somewhere, if you want to use a steam. So, a boiler is used or steam generated in the boiler part of that steam can be used for the ash removal.

Normally, separate type of steam generation system is used for this purpose. It is the steam generation system and is kept at a horizontal distance about 200 meters and the distance of vertical distance about 30 meters. In this system steam jet system because, steam contains very high energy, enthalpy level is very high for a steam and so, less amount of this steam is required.

So, capital cost is less. Less space is required. But, here also the wearing of pipe is high as in the case of pneumatic systems. Operation is noisy. The pneumatic system also, the operation is noisy. So, where if we deal with the gases at high velocity; noise is a big issue; noise is a problem; even in the air condition system, there is a major limitation; noise is the major limitation for the duct design.

So, here also in the power plants wherever or not only power plants in any plant, if the air velocity if you have to deal with the high air velocity, the noise becomes the major issue. And, it is a major limiting factor for the air velocity in any pipe and any duct and capacity is also 15 tons per hour. So, steam jet system; so, it has to be continuous, it has to be continuously in operation.

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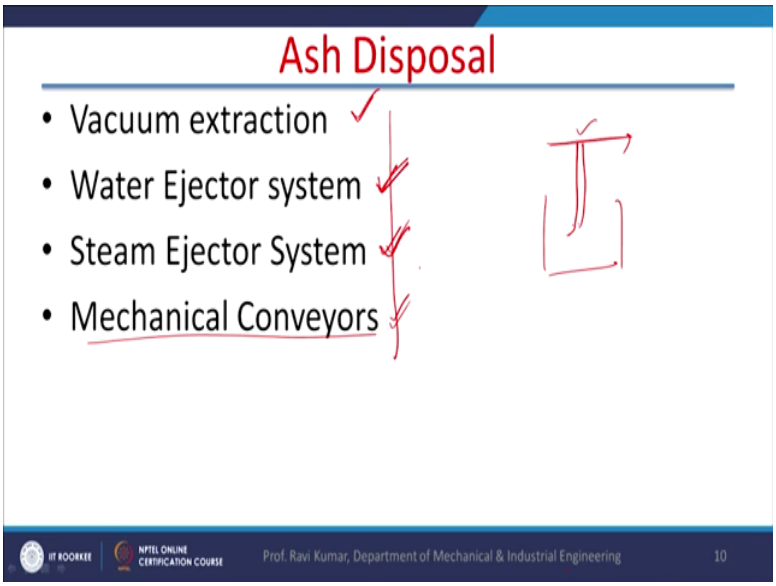

Now, ash disposal for the disposal of ash, there are 4 methods: one is vacuum extraction, water ejector system, steam ejector system, mechanical conveyors.

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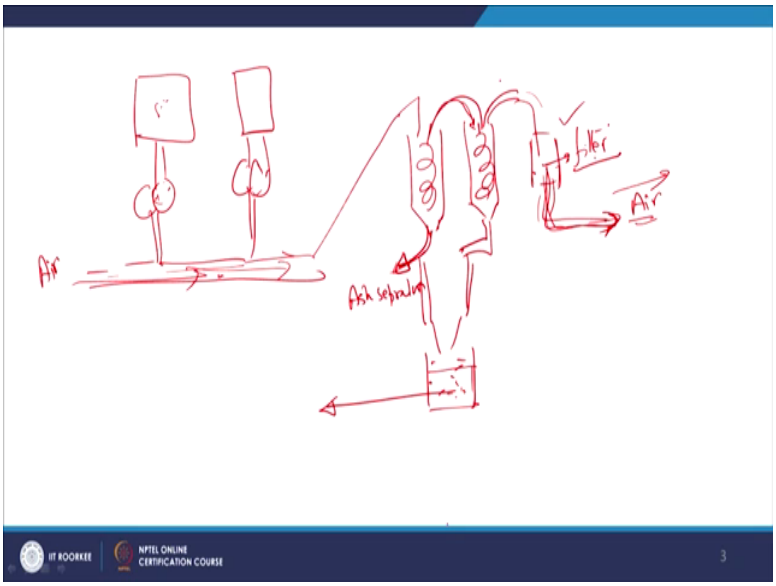

Now, for this pneumatic ash handling system; so, in pneumatic ash handling system, from the boiler, there are boilers and from the boilers the ash is sent to the crushers; where ash is further converted into the fine particles. And, these fine particles they are connected to a pipe, where high velocity air enter, air with high velocity enters the pipe.

Now, after entering the pipe, this I mean multi phase system that is a solid and air, two phase system this goes to a cyclone because, this is the cyclonic separator; there can be a number of cyclonic separator. This is one and extract from one can go to second one. So, here the separation of solid and gas takes place in cyclone. Due to their inertia, the solid ash particles

are removed and the gas leaves the cyclonic carburetor, this is they are known ash separate also ash separator.

And then the gases emerging from this separator they enter the another separator where again this cyclonic reaction takes place and remaining part of the ash is taken away. Both ashes from both the sides they are collected in a bunker or and they can be directly collected, in a collected in a truck and the removal of ash takes place and remaining part of the air, this may contains some part of the ash.

So, this gas emerging from here is sent to the filter and from filter the gas, which is free from the air which is free from the ash particles it goes to the air. So, you are starting from here, where the ash comes from the boiler to the crusher and the after the crusher it is mixed with the air. Now, this air mixture of air and solid particles often they go to the ash separators.

Due to centrifugal action the ash the solid particles of ash are removed in 2, 3, 2 or 3 stages depending upon the design; and the final exhaust is sent to the filter where filtration infiltration takes place. And, solid particles remaining traces of the solid particles are removed and the pure and the remaining part of the gas or the air is sent to the atmosphere.

So, this is a pneumatic system. Now, we have discussed a steam now ash disposal. So, ash disposal is; firstly, vacuum extraction. Through vacuum, the extraction of ash is done but, it consumes high energy. One is water ejector system. In the ejector system, what happens? The high velocity in principle the high velocity of fluid is flown over the surface right; and due to high velocity low pressure is created. When low pressure is created, the movement of fluid or the solid from the bottom takes place in upward direction.

Now, this working fluid can be water and working fluid in this case can be steam. So, any type of system can be used. So, in so, any working fluid can be used whether it is the water or whether this steam. There are disposal for mechanical conveyors can also be used for ash disposal but, the mechanical conveyor the initial cost is high and there is a limitation for the distance also and the maintenance of conveyor is also required for such cases.

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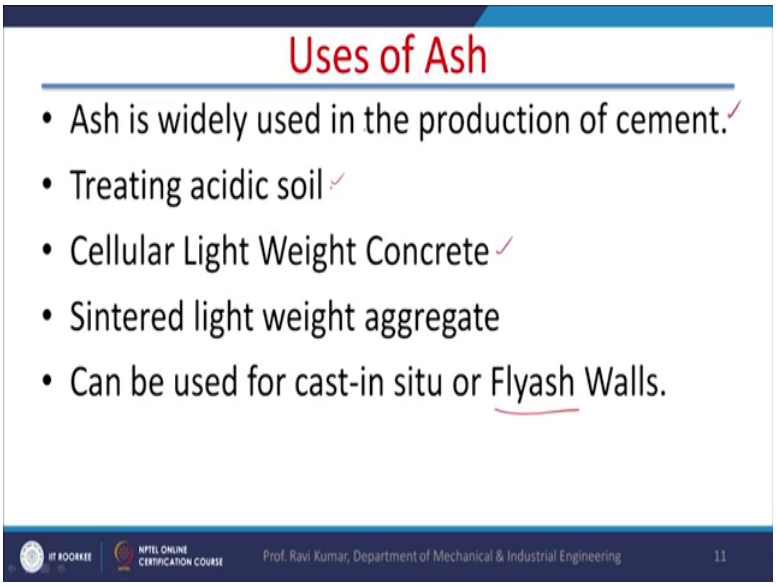

Now, uses of ash; now, ash is widely used in the production of cement. In the cement industries, nowadays it is mandatory to use fly ash but, I mean and it is nowadays it is widely used in the production of cement the fly ash. Now the fly ash, this ash can also be used for treating the acidic soil, if the soil of any area is acidic in nature right.

So, it reduce the acidity issue. In order to reduce the acidity of the soil ash can be spread out or mixed with the soil that will reduce the alkaline level of the sorry acidic level of the soil. And nowadays, a lot of research is going on the modification of the concrete. So, for the cellular and the lightweight concrete for the manufacturing of the cellular and the light weight concrete, the ash form power plant is being used.

Now, sintered or lightweight aggregate also for the construction work. It is mainly used for the construction where can be use for cast in situ or fly ash walls also therefore, also made of

the fly ash. Nowadays fly ash bricks are also coming I mean, a lot of work is going on to make the fly ash bricks. So, if the fly so, the purpose is to have a win-win situation, once we have ash which is generated in the power plant and the disposal of ash is a big issue.

Ash handling is a big issue because, it is low cost; it is a sort of low cost high bulk item. So, now, here there is a requirement there is a huge requirement of cement in the country while soil is also become is becoming acidic. So, in such type of applications fly ash can be used. Now, we have amply discussed the ash and ash, uses of ash in the power plant. In power plant what we have noticed there is a lot of dust also.

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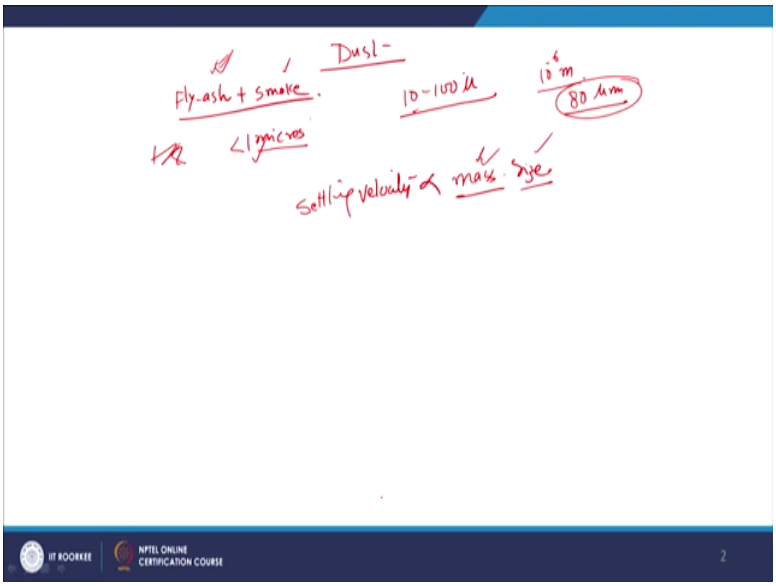

So, dust is they are in the power plant and this dust necessarily constitutes the fly ash plus smoke right. Now, they can be differentiated a smoke and fly ash can be differentiated through the particle sizes, the smoke particle is normally less than 1 micron.

The size of this smoke particles is less than 1 micron. They are very tiny particles and that is why for this reason, for a long period of time they remain suspended in the air. And then another is fly ash. The particle size of fly ash ranges between 10 to 100 microns; 1 micron is 10 to power minus 6 meter; this is known as micro meters. Size of for a radial difference, size of your hair is approximately average size is at 80 micrometer. So, the size of the hair is 80 micron.

So, when we talk about 1 micron it is not visible. So, smoke particles are not visible but, collectively they make, they effects the transparency of the gases, that is why we are not able to see through the smoke, but the part we cannot see the individual particles, because it is less than 1 micron. If you compare the size of your hair, hair your size is 80 microns. But, fly ash particle you can very well see because, fly ash particles of the size varies between 10 to 100 microns. And pulverized coal, where the plants where pulverized coal is used a lot of fly ash goes out with the exhaust gases right.

So, there the problem is more severe; they have certain settling velocity also and settling velocity of any particle in the air that is; settling velocity is proportional to mass of the particle and size of the particle; both settling because the size of the particle will decide the buoyancy force acting on the particle right. And, mass of the particle will decide the gravitational force which is working on the particle. So, it is a function of mass and size as well.

So, there are dust collectors in the power plants because, if dust has to be removed we cannot leave the surroundings full of dust. So, in the power plant, dust has to be removed. So, they are dust collectors; dust collectors; the basic purpose of dust collector is to collect the dust.

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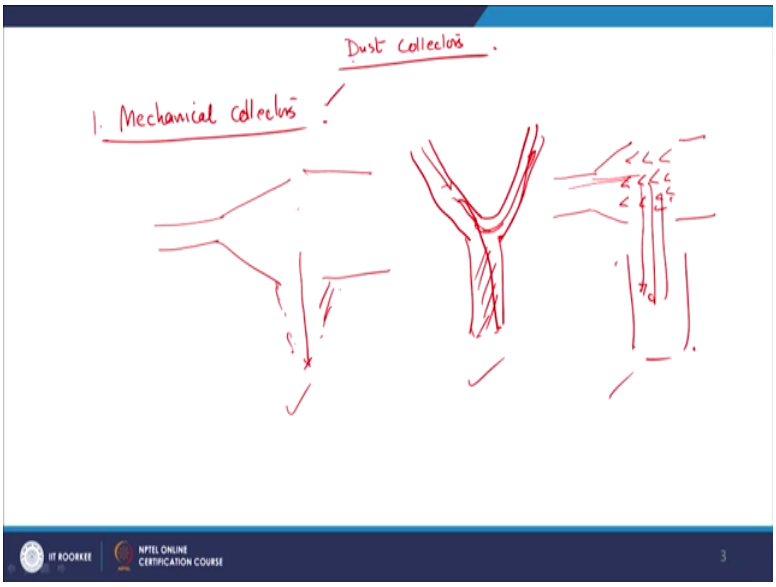

So, the easiest one is mechanical dust collector. Now, in mechanical collectors as it is clear from the name itself, they are devices which depend on the mechanical processes and here a typical mechanical dust collector will be something like this if you in a duct, if the dust is coming through it the dust is sucked through a duct right, and all of a sudden if you increase the cross section area.

If all of a sudden the cross section area is increased, then the particle will be suspended in the air and they will tend to settle at the bottom side of the duct. So, that is one way of collecting dust. Second is, if you change the momentum of the flow; suppose, the dust, air full of dust is moving in this direction, and all of a sudden if the direction is changed; particles are solid they have high density in comparison to the gas.

So, due to inertia, they will continue to move when the air is moving in this direction out of the inertia, the particle will continue to move in this direction. And, they will be later on they will be settling in the bottom and the air will change the direction because its inertia is less, air will continue to move in this direction. So, through this principle the dust particles it can be collected or in a duct, suppose there is a slight enlargement in the area and baffles are provided they are obstructions.

So, what happens in this baffles, when the dust particles they strike this baffles, they would lose their momentum; the moment they strike this baffles, they will lose their momentum and immediately they will settle down; and they can be collected somewhere here. So, there are three methods, which can be used for our which are being used for as a mechanical dust collectors. Another type of dust collector which are known as wet type of dust collectors.

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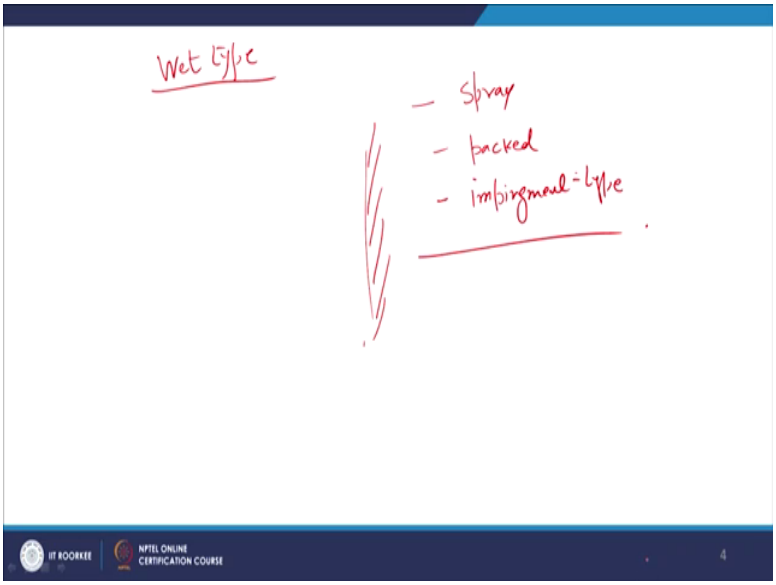

Because, particles if there is a wet cloth and if we pass the smoke to the wet cloth, number of the particles will stick to the wet clothes right. So, a wet surface is provided right and water is continuously sprayed on the wet surface and when the smoke is passed through this porous surface; porous wet surface, particles they stick on the surface. And when the particles it is just to ensure that the particles do not block the porous surface, continuous water is sprayed is made on the surface.

So, this water which is sprayed on the surface for 2 purposes: first is removal of the solid particles; second is maintaining the surface wet. So, there are 3 types of wet surfaces: one is a spray type; second is packed type; and third one is impingement type. Where, dry type surfaces also which are used for like a filter which is a dry filter; those dry filters are also used for removing the dust particles. But, the most efficient way of removing the dust particle is through electrical dust collector; electrical dust collector.

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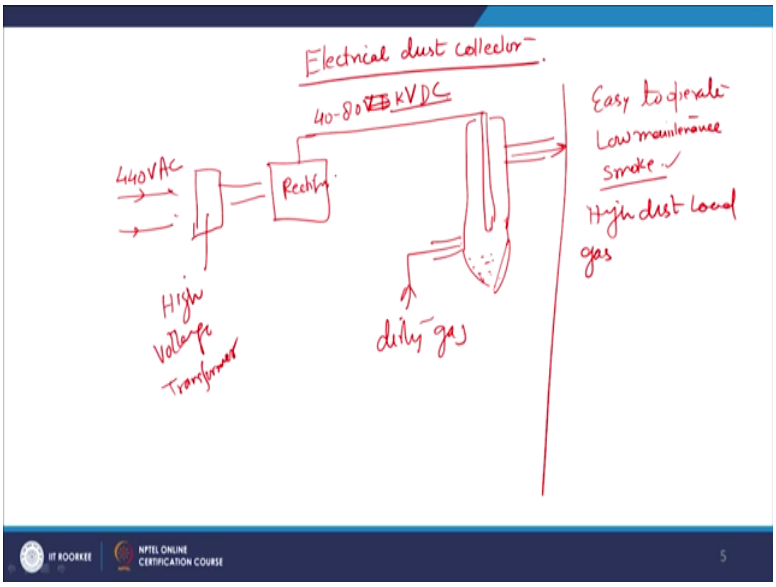

Now, in electrical dust collector, we take, we remove the dust particles by using high voltage. So, first of all three phase 440 volt current is used. This is supply and this 440 volt is converted into very high volt; very high volt means thousands of volts right. So, this is used by using high voltage transformer or this type of transformer.

So, 440 volts is increased to very high voltage then, a rectifier is used. Now, this rectifier converts the AC to DC because, the electric supply is AC; this is AC, and this is AC is converted to 40 to 80 volts, sorry this is kilo volts; kilo volts DC 40 to 80 kilo volt DC.

Now, this 40 to 40 to 80 kilo volt DC is supplied to a emitting electrode housed in a tube or in a cylinder and this emitting electrode and this is dirty gas or the smoke or sorry the dirty gas; and when it comes into the contact with the electrode because, it this space is highly charged

ok. Due to this, the precipitation of the dust particle takes place and a clean gas comes out from the other side right.

So, this is sort of electrostatic dust collector because, it uses the principle of electrostatics. Now, there are certain advantages of this dust collector; first of all easy to operate right because, there is no moving part in the entire system; there is no pump and all. So, it is low maintenance right and this type of system can effectively remove the small particles.

Because, it works on the electrostatic principle, very fine particles can be removed which cannot be removed by another process; for example, mechanical processes or wet type of system. But here, because it works on the principle of electrostatics all even this small very small particles they can all they can be removed; even the smoke particles can be removed, smoke particles cannot be removed by other techniques but here, smoke particles can be removed easily.

Very effective with the high dust loaded gas, dust loaded gases; when dust limit is very high in the gas, if you use this type of dust collector all the dust will be removed from the mixture and finally, the dust is collected in the dry form; there is no wetting of the dust. So, it is collected in the dry form, if you want to transport dust you can mix water make it wet and you can transport it to in a slurry form. Now, there are certain because once there are advantage there has to be certain disadvantages also.

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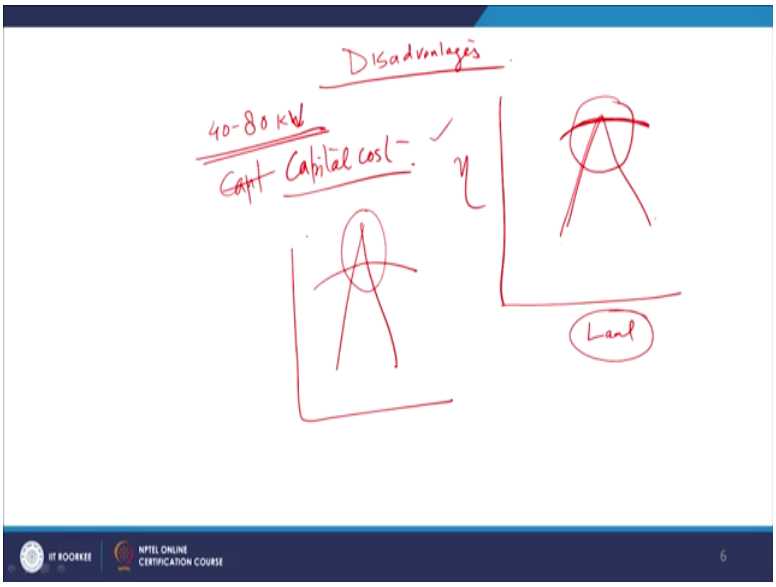

So, the disadvantages are: now disadvantages are: space requirement is more because, you need a transformer, a transformer followed by a rectifier, rectifier followed by the entire electrode systems. So, this occupies space and quite substantially spaces is occupied by the system and the system should be spark proof because voltage is very high; voltages of the order of 40 to 80 kilo volt.

So, the entire system should be prevented from this path. So, this path should not be there right. So, this special type of fittings have to be provided for this type of system. Running charges are high because, we are using electrical energy right. So, running charges are high, if you compare with the other type of dust collection system.

Running charges are high; capital cost is also high, capital cost because, here this is the rectifier and the transformer they are higher end items, where a lot of copper is used in making

these items. So, their capital cost is high and if you look at the off design conditions efficiency, if the every machine any every instrument is designed for a particular load. So, this system is also designed for a particular load.

So, if you deviate from the load, the efficiency should not fall to shuffle. I will give you an example; for example, this is a load and here is efficiency. So, at a particular load, instrument is giving a very good efficiency. But, we do not sometimes; we do not run a system on design load sometimes, we deviate from the load. So, in that case efficiency should not be much effective. Suppose, the load changes plus minus 10 or 20 percent. So, efficiency should not be very much affected, but here in this case there is a sharp fall in efficiency right.

So, for this reasons this is one of the disadvantage of this type of equipment. I will give you a live example; if you compare the efficiency of the gas turbine and a reciprocating engine 4 stroke engine, the efficiency of gas turbine is much higher than the IC engine.

But, the off design performance; if you look at the off design performance, the reciprocating engine will give this type of performance and gas turbine will give this type of performance. So, off design conditions performance is very poor and as you can understand, we rarely drive any vehicle on design conditions; we always run them on off design conditions.

So, not only efficiency is important for any instrument; the off design efficiency is equally in fact, is more important. So, here in this case, off design efficiency is poor. So, because this is the static system so, this system should be operated preferably operated on the design conditions; that is all for today.

Thank you very much.