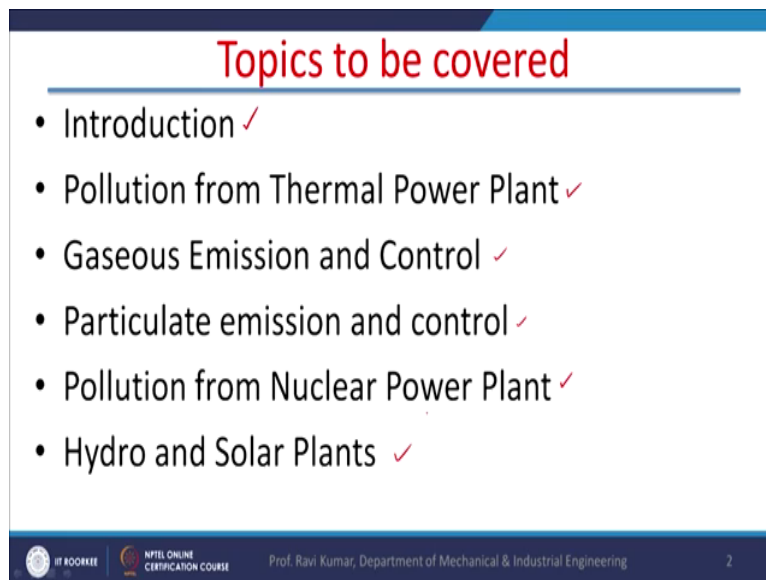


Power Plant Engineering
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Lecture - 39
Environmental Aspect of Power Generation

Hello, I welcome you all in this course on Power Plant Engineering. Today we will discuss Environmental Aspect of Power Generation.

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Topics to be covered

- Introduction ✓
- Pollution from Thermal Power Plant ✓
- Gaseous Emission and Control ✓
- Particulate emission and control ✓
- Pollution from Nuclear Power Plant ✓
- Hydro and Solar Plants ✓

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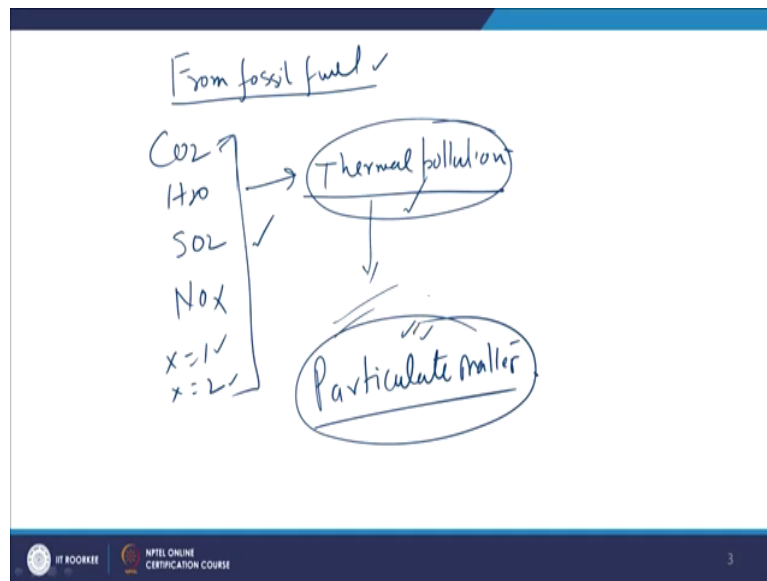
In this lecture I will be covering first of all I will start with the introduction, then pollution from thermal power plant, gases emission and control, particulate emission and control, pollution from nuclear power plants hydro and solar power plants as well. It is about the pollution from hydro and solar power plants. All the power producing unit, I mean every power plant it has impact on the environment. Whether it is a nuclear power plant or a thermal

power plant or hydro power plant or even solar power plant or any other non conventional power system, all of them have bearing on the environment right.

And not bearing. In fact, it is a bad effect on the environment. So, and this pollution of the environment or disturbance on the environment is inevitable. I mean once we and we need power also we cannot live without power and for this high grade of energy we have to pay cause in terms of decay in environment or damage of the environment.

So, this damage of the environment has to be minimized, I mean the power generation should be made in such a manner there are damage of the environment has to be it should be minimized it cannot be made 0, but it should be minimized and in order to restrict the power generators to damage the environment worldwide there are legislations. We are also having laws on the environment right. So, no power generation unit can violate those laws of environment.

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Now, the pollution first of all for the fossil, fuel fossil fuel points. In fact, they damage in some sense they do a lot of damage to the environment right, because in fossil fuel plants the fossil fuel, that is coal which is normally coal is used and which is burnt. When the elements of the coal they burn oxides are created like carbon dioxide, water is sulfur dioxide, N o x, x maybe be 1 or x maybe 2 right. When there is incomplete combustion there is N o 1 and there is complete combustion there is a N o 2.

And many more other gases in traces which are which have been found in the flue gases; flue gases they come out of the chimney and when they come out of the chimney and they mix with the environment air and that is how they pollute the environment air. In addition to this thermal pollution is also there, thermal pollution by fossil fuel plant because, in the fossil fuel

plant when the heat is generated entire heat is not converted into the electricity part of the heat is converted into the electricity.

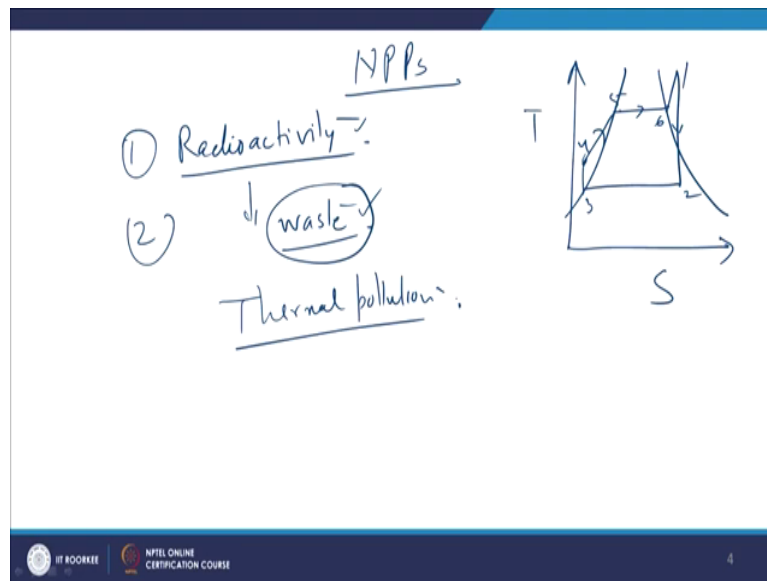
And the substantial amount of heat is liberated to the surroundings in form of radiation convection, conduction or with the exhaust gases a lot of heat goes with the exhaust gases right. So, this a localized heating takes place in the surroundings that is also a pollution right. So, a thermal pollution they make and they particulate matter; particulate matter also is sent to the environment or surrounding air and this particular matter when a person breath it goes into the lungs and that is how it without going to the lungs it can also damage.

Because, some of the elements they are very poisonous in nature even they come into contact with the risky and it will cause irritation right. So, these are the broadly these type of this type of pollution which is created by the fossil fuel plants. Though the technology has improved, many of the toxic gases they are trapped before going to the atmosphere. And even technologies are available with pure air is sent to the atmosphere all the elements are I mean filtered out of the flue gases right.

But still I mean when these elements are filter out they will go somewhere in the nature. So, they are not going to the air, but they will be tolerating somewhere else. And similarly for a thermal pollution if the product efficiency is high definitely the heat liberated will be less, that size we can say the thermal pollution can also be reduced, but it cannot be made 0.

Particulate material which goes to the atmosphere if all the elements are filtered out then particulate material will not be there in the air, but 100 percent efficiency is difficult to obtain some of the particulate material definitely enter to the atmosphere.

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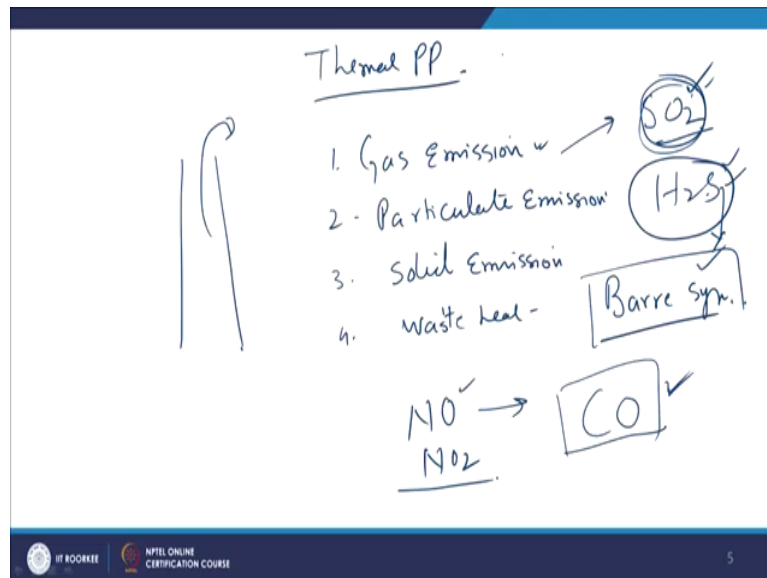


Another is nuclear power plants, in nuclear power plants there is no exhaust gas because the heat is generated if you look at the Rankine cycle of power generation which is used for in a elastic super heat cycle. In a thermal power plant fossil fuel plant or in nuclear power plant the cycle is like this. So, this process 4 to 6 it takes place inside the boiler where the fossil fuel is burnt right.

So, this process 4 5 6 takes place inside a nuclear reactor, where nuclear fission reaction takes place so, there is no exhaust from nuclear power plant. But in nuclear power plant there first of all there is the issue of radioactivity, there is issue related with the radioactivity release radioactivity released then radioactive waste disposal of radioactive waste is a major issue nowadays right.

We can use the radioactive material that is for power plants, but when the waste which is coming out of the nuclear power plant it has to be disposed off and it is highly radioactive right. Here also there is a thermal pollution, thermal pollution is there hot water normally hot water is taken from the river whether it is a fossil fuel plant or the nuclear power plant. Hot water is taken from the river and for the cooling purpose it goes back to the river temperature is increased in a range of 7 to 10 degree centigrade and that high temperature water which is going into the river they forbids growth of many of the Marconi's plants and animals right so it is not desired in fact.

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Now again in the thermal power plant, in a thermal power plant the pollution comes through chimney; main pollution comes through chimney right. And this emission which is coming out

of the chimney can be classified as gas emission, then particulate emission as I told you earlier, then solid emission and 4 waste heat; I have already discuss with you.

Now, this gas emission is most a troublesome right and I said earlier as said earlier the main is the sulfur dioxide. How to remove sulfur dioxide there is a another poisonous gases hydrogen sulfide right and sulfur dioxide what does it do actually, this is acidic in nature sulfur dioxide. It causes irritation as the sulfur dioxide comes in the contact with your eyes it will cause irritation in the eyes if you inhale irrigation sorry irritation in throat and it is corrosive in nature.

Suppose it comes with a contact with a pipe also it will corrode the pipe. So, it is highly undesired gas in atmosphere or any gas which should contact come in contact with the human being. Now, another gas which is very dangerous is hydrogen sulfide, it has I mean a Barre syndrome a disease Barre syndrome Barre syndrome. The immune system the immune system of the body starts damaging it is own nervous system.

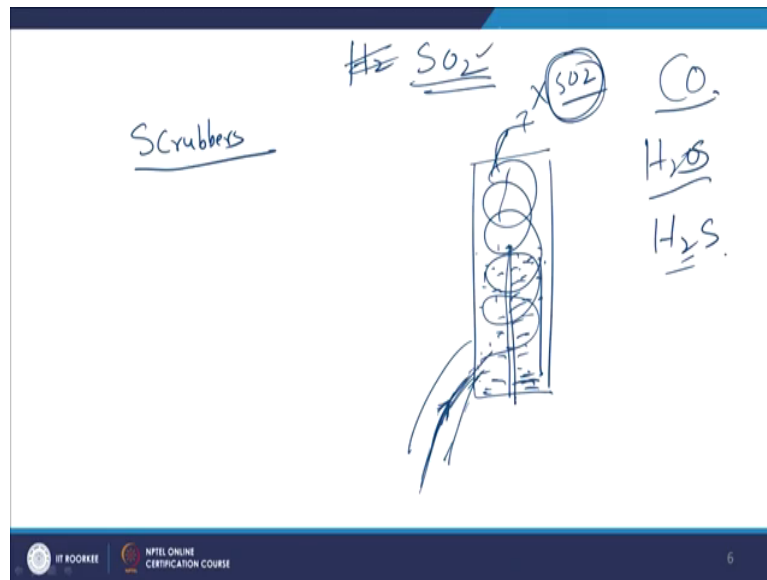
So, is a very I mean severe disease. So, that is caused by H₂S is one of the reason. Inhalation of H₂S maybe one of the reason for such disease and it again it attacks your immune system, then irritation in eyes and lungs in addition to that is done by hydrogen sulfide. Oxides of nitrogen and N₂O and N₂O₂ so and this also causes irritation and bronchitis. I mean they are all they are directly affect the health of the human being.

All these poisonous gases which are coming from the chimney of a thermal power plant carbon most dangerous is carbon monoxide. Carbon monoxide I mean it is colorless and odorless you can inhale the carbon monoxide and you will not come to know you have inhaled the carbon monoxide. Slowly it will absorb your I mean oxygen in the body and the person will become subconscious and subsequently may die. So, this is very dangerous case one has to be very careful about the carbon monoxide.

In many of the houses early I do not know now people are using it that LPG based geysers. So, when they are fitting LPG based geyser and LPG is consuming air oxygen from the extracting air oxygen from the air in the bathroom, in that case sometimes it has been found

that there was a scarcity of the oxygen and the person who was taking bath became unconscious and this can be fatal also.

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So, one has to take care one has to be very careful about the carbon monoxide. Because either if you go for the H_2S gas, H_2S gas will give you a very pungent smell when immediately sorry H_2S . So, H_2S will give very pungent smell you can easily identify leakage of H_2S , but leakage of CO cannot be identified.

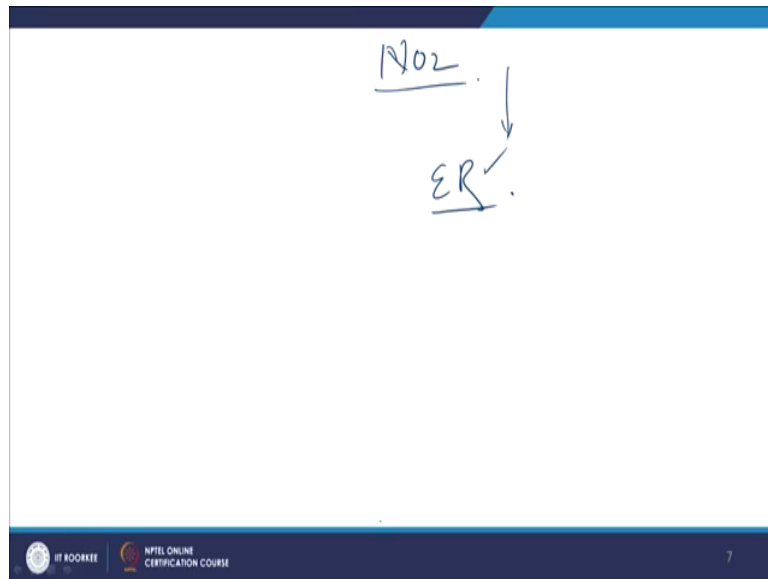
So, how to remove H_2S or not H_2S sorry SO_2 ? Now previous SO_2 it is not H_2S . Sulfur dioxide for the sulfur dioxide scrubbers are used you will find in many of the industries I mean not only power plant in where the fossil fuel is burnt. Scrubbers are used right or we are the boilers are used for some other purpose for example, glass industry right scrubbers are used

Now, scrubber is a hollow cylinder it can have; it can have any shape, but it is a cylinder. And the exhaust or the flue gases they enter from one side of the cylinder, in the center there is a pipe right and this is a perforated pipe. So, the water spray is made all around the surrounding, this place is filled with the tiny water droplets right.

And when SO_2 goes enters this scrubber and when it comes into contact with the water droplets, it gets filtered out from the gases and here you get the gases and it is not a straight motion; it is a spiral motion. And at the exhaust you get no SO_2 , SO_2 remain sulfur is collected here in scrubber and later on it is collected at the bottom and subsequently it is removed from the scrubber.

So, not only one they are number of scrubbers which are put in the industries to remove the sulfur they call it sulfur, sulfur from the exhaust of this fossil fuel. Now, in scrubbers the gas because sometimes you have to reuse this gas thus gas is cooled to such an extent that it has to be reheated. There is maybe one of the drawback of the scrubber because this water is sprayed at the normal temperature.

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So, this is how we get rid of sulfur in the exhaust gases they are other methods of getting nitrogen oxide as I said earlier NO_2 we can what we can do we can reduce is resident period inside the system. That one thing we can do and what it does it increases the equivalent ratio presence of NO_2 increases the equivalent ratio in combustion chamber and that is also not desire.

So, in presence of NO_2 otherwise I mean if all the gases can be taken out by it will increase the cost of the overall cost of the plant right. So, mainly focus is done on the removal of the sulfur because it is highly dangerous.

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The slide contains handwritten notes under the heading "Particulate Emission". It lists four types of emissions with their corresponding particle diameters:

- 1. Smoke : $d < 10 \mu$
- 2. Fumes : $\approx 100 \mu$ (with a checkmark next to the word)
- 3. Fly-ash : $\approx 100 \mu$ (with a checkmark next to the word)
- 4. Anders : $> 100 \mu$

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Now next is particulate emission. Now, this particular material you must have heard or you must have seen in the news also it is also quite damaging in for the health. And first of all is smoke, smoke which is coming out of the chimney it has particular material of diameter less than 10 micron, 10 micrometer. Very tiny particles are there in this smoke there are fumes which are also dangerous fumes may term from the coal or they come from the metal as well.

The diameter is much much less than the diameter of this smoke the fumes are also dangerous any kind of fume is not good I mean for the health. So, it can term from the metal also right and they are reactive sometimes fumes are reactive also do react with your skin right or with some metal so they are highly undesired.

Number 3 is fly ash, fly ash disposal of fly ash is also an issue in a power plant, but otherwise fly ash is also another environment hazards the diameter of the particle diameter of the fly ash

is approximately 100 microns or less than 100 micron. They are not more than 100 microns, 100 microns mean 0.1 mm. So, you can see visually you can see the particles in the fly ash and fly ash disposal.

Now fly ash is used now for by the construction industry, construction industry is using fly ash for the purpose of construction of purpose of bricks making bricks also right. So, that is one of the best and the convenient way of disposing of the fly ash making bricks and using it in a construction of the building.

Fourth is cinders have diameter of the particles is greater than 100 micron. Easily you can see cinders moving in the air and ultimately they get settled because they are heavier they get settled.

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$$\text{Collector } \eta = \frac{\text{mass removed}}{\text{mass of present}} \times 100$$

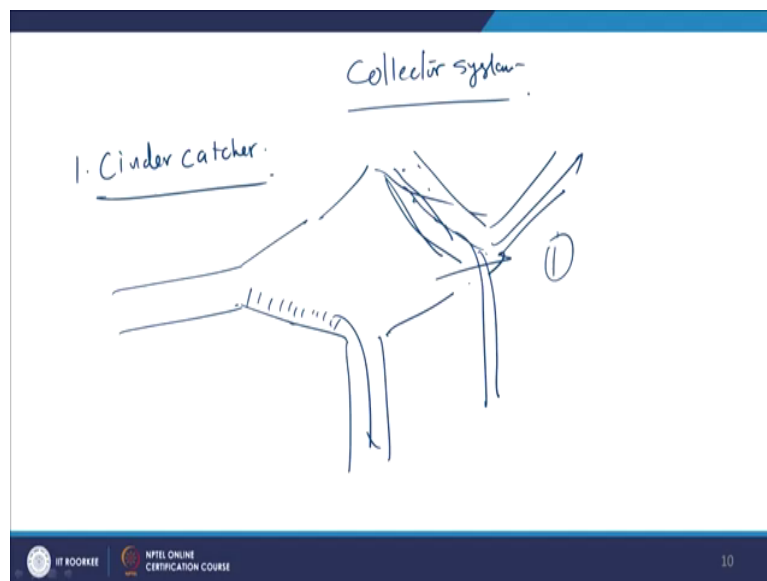
90%
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Collector efficiency there is always a collector of emission. Collector efficiency you can take a scrubber or any other device which is used for taking out the poisonous gases or poisonous material from the flue gases. So, it has certain efficiency and efficiency is mass of the dust removed divided by mass of mass present in the gas suppose N k g is coming 0.7 k g is removed right. So, efficiency is; obviously, 70 percent.

So, it can never be 100 percent normally scrubber it is scrubber can have 90 percent efficiency which is it is scrubber is highly efficient system after removing sulfur in the from the gases. And if you go for the electrostatic precipitation there is a I will explain you different systems electrostatic precipitation that is also goes up that also goes up to 90 degrees 90 percent efficiency.

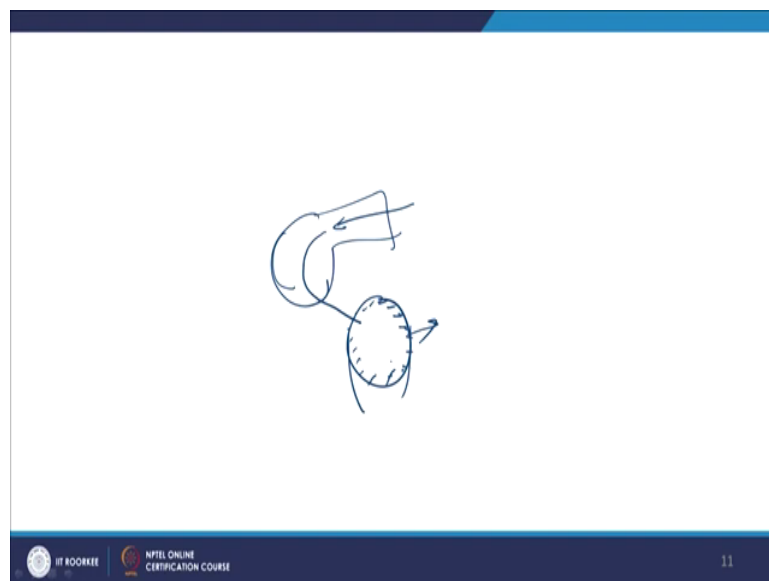
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Now, collector system one is cinder catcher, right in cinder catcher what we do we use the second law of motion changing the direction of motion right. For example the cinder is coming with the gases in this direction you change direction of the motion. Because, they are solid nature it will go here and the gas will move from here.

So, that is one way another way the cinder is coming in a pipeline all of a sudden there is an expansion when all of a sudden there is an expansion, it will try to stick to the bottom side of the expansion and here you can provide a passage where it can be removed from the gases right.

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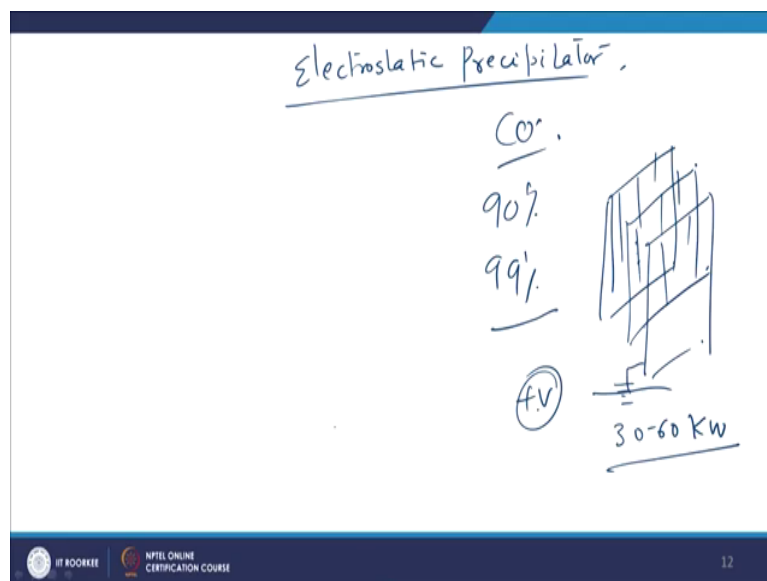


And you can have number of arrangements, you can have I mean if fan a blower type of arrangement as well air will enter from this side and it will leave from the center when it leaves

from the center the cinder will be stick sticking to the wall of the pipe or wall of the collector where it can be removed right.

So, there can be many ways of removing the cinder from the gases, but it is not a very efficient system. Now, if you want to have efficiency system you can go for electrostatic precipitator; now electrostatic precipitator.

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Now, in a electrostatic precipitator there are number of plates and these plates are grounded and there are wires hanging wires in between the space between these plates right. And gases are blown and the voltage in the wire is 30 to 60 kilo volts; voltage is quite high. So, when the gases they pass through this wire they get negatively charged because, they have electrical electrons there plenty of electrons on the wire right.

So, they get negatively charged and when these negatively charged particles they come into the contact with the plates and plates are grounded. They come in to the contact to the plates give up the charge and they get settled down. So, they are automatically removed from the gas.

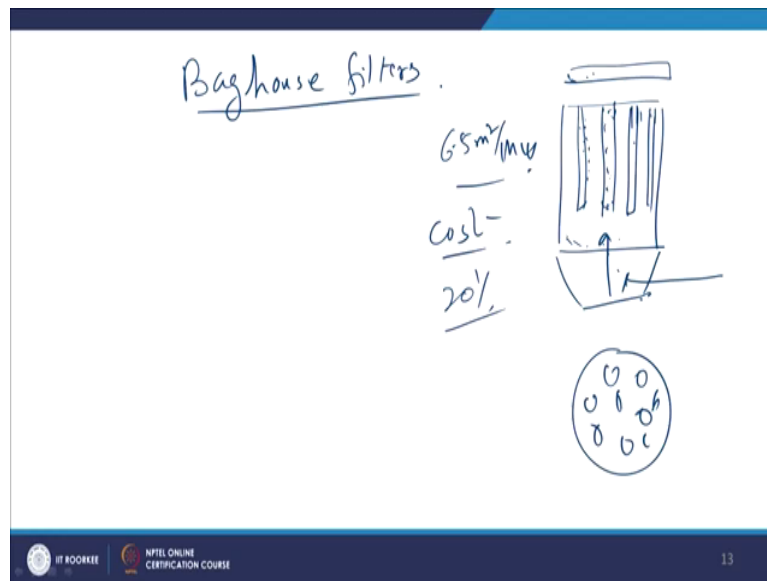
So, there is there a compartments there number of compartments plates all are grounded in between passage the wires are hanging when the flue gas is blown through the passage, the gas the particles in the gas they come into the contact with the wire get charged, the moment they get charged they are attracted towards the plates because the plates are grounded.

And the movement they are get attracted to the plate they stick to the plate give the charge to the plate and they settle down. That is how it works and later on this charge is sometimes they do not get settled down there is a steel plug. So, it steel plug periodically it removes the particular or the particles from the surface of the plates right.

But care has to be taken care has to be taken here is that whatever gas you are pushing in the precipitator it should be completely burned gas if it is unburned gas suppose Co is there or some unburned material is there, it is possible it is charge inside it is there is a charge there is a possibility that this (Refer Time: 21:44) system may blow out or it may start burning.

So, care has to be taken that unburned gases should not enter the electrostatic precipitator. Otherwise, it is the possible there is a possibility it may explode as I said efficiency is 90 percent normally, but if it is properly designed then efficiency can go up to 99 percent for the electrostatic precipitator. And it is specially suitable for the power plant where the fly ash density is very high in those power plants it is very effective.

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Another is bag house filter, in bag house filter the process is very simple in a box; in a box there are number of bags they are hanging from the header right and in the box the flue gas which enters from the bottom it comes into the contact with the bags and when this flue gas because they are connected at the same header top.

If you look for the top it will be; it will be looking like this and all the pipes are connected with the header right. So, when it comes with the contact with this bags and the fly ash particles they get stick to the bags right and this is a I mean very passive type of system that is why the high filter area is required, approximately 6.5 meter square per mega Watt of area is required for this type of system.

Installation cost is also high because passive systems are normally bulky systems. So, installation cost is very high and mainly this is cloth filter which is being used here it costs you

around 20 percent of the total cost. So, it is a costly item right and finally, it is blown this bag is blown and the dust particle which are stick on the bag they are bag they are collected at the bottom.

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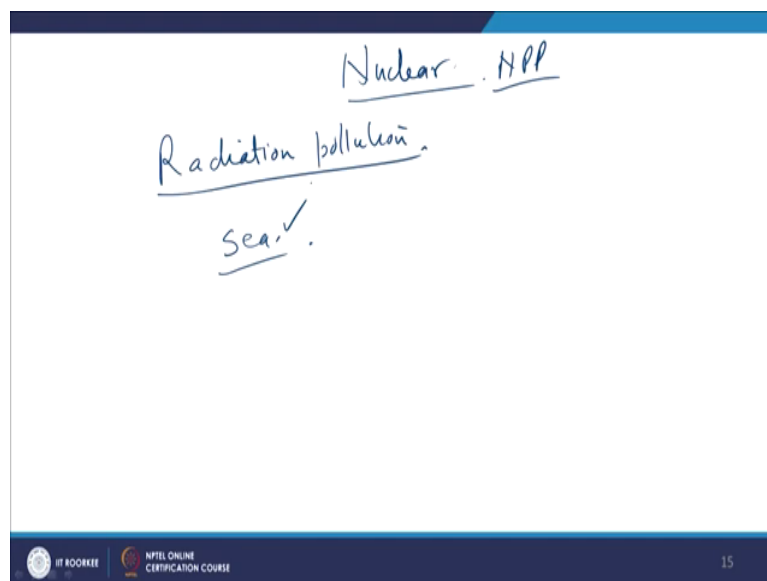
The slide contains handwritten text and a diagram. At the top, it says "Thermal pollution." followed by the formula $TDI = \frac{\text{dis. to environment MW}}{\text{electrical power MW}}$. Below the formula, the word "Reduce" is written and underlined. To the right of the text is a hand-drawn diagram of a cooling pond, represented by a circle with an arrow pointing into it from the left and an arrow pointing out of it to the right, with the label "Cooling pond:" written inside the circle.

The next is as I stated earlier is thermal pollution. Now, there is a thermal discharge index because everything has to be quantified. So, in thermal discharge index is discharge to environment in mega Watt divided by electrical power same unit has to be used mega Watt if you are using a kilo Watt here you will have to use kilo Watt.

So, heat discharged to the environment divided by electrical power generated. So, this gives us idea for per unit kilo Watt or per unit mega Watt electrical power generation how much heat is going to or being discharged to the environment it is simply quantification of the thermal pollution. So, how to reduce the thermal pollution?

Now, the issue is how to reduce the thermal pollution. The thermal pollution can be reduced we can have instead of discharging coolant into the river, we can have separate lake a separate lake or dedicated lake can be made for this purpose right or some cooling pond maybe there are some cooling pond maybe there; right which from which we can extract the water right and after cooling the or after the after condensation in the condenser it is sent back to the cooling pond or we can go for the cooling tower that is also another option.

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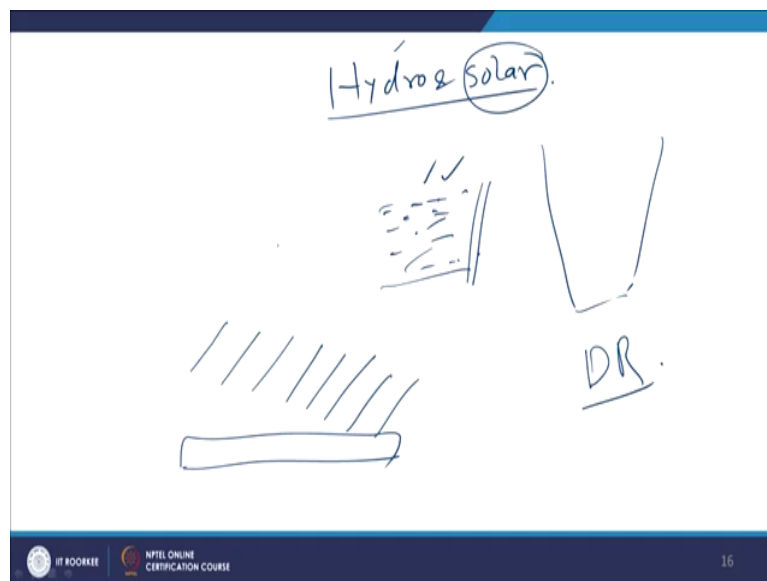


Now, after this thermal power plant we can discuss about the nuclear power plants nuclear power plants also the heat dissipation problem is same. In fact, the water requirement is more in a thermal power plant it requires a lot of water main problem is radiation radiative pollution radiation pollution which comes from the waste material right.

So, now, scientists are trying to reuse the waste material or left over fission material in a nuclear power plant and hopefully in future we may get fuel for the nuclear power plant which will generate which will not; which will not generate the waste it will also it will generate the fuel which can be used in some other form in a nuclear power plant.

Now, nowadays what we do nowadays the concrete blocks this fuel is filled and it is disposed in the sea, it can be diluted also there are so many ways, I mean the material can be we can do atmospheric dilution sea dilution absorption by the soil the best way nowadays is the disposal of this nuclear waste material into the sea in concrete blocks.

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There are pollution there are environmental issue with the hydro and solar also. Hydro and solar appears to be less damaging the environment right, but if you look at the hydropower plant especially when the dam size is large there is a lot of the submerged area is high and this

submerged when the area surrounding area normally it is made in a gauge; gauge is identified where by blocking the flow of the water the dam is made.

When the dam is made the water level in the river upstream river rises and it submerges surrounding areas. So, it affects the ecology of the area definitely it affects hydropower plant effects, the ecology of the area and when there is a large body; water body the large water body it damps the temperature variation right.

So, people are studying this also how large dams are affecting the local environment because is it damping the damping means the maximum is temperature is less the minimum temperature is rising. So, day range D R; D R means maximum and difference between maximum and minimum temperature in a day. So, whether it is shrinking or not? Due to presence of this water body large water body in this area.

And second is solar; solar is also a considered to be the very environment friendly, but what is happening when the when you planting because the solar the energy density of the solar heat is not very high; solar radiations is not very high. So, for a small power generation you have to occupy a substantial area and when you are putting an array of solar collectors. So, that area is not receiving any heat soil is not receiving any heat and that also has some effects on the environment right.

And many of the other things that disposal of the solar panel nowadays we are fixing the solar panel maybe down the 20 or 30 years these solar panels will become ineffective they have to be disposed off. So, when how these solar panel will be disposed off that is also an issue that is also an environment issue. That is all for today on this topic.

Thank you very much.