Fundamentals of Environmental Pollution and Control
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Lecture No. # 35
Emission Control

Today, we will discuss about this emission control as the, as you have seen the on the subject name. Here in this emission control you know we will think I will discuss few very important things you know before but before going in to that, before going into that we will, I will try to classify emission control into two, two major areas.

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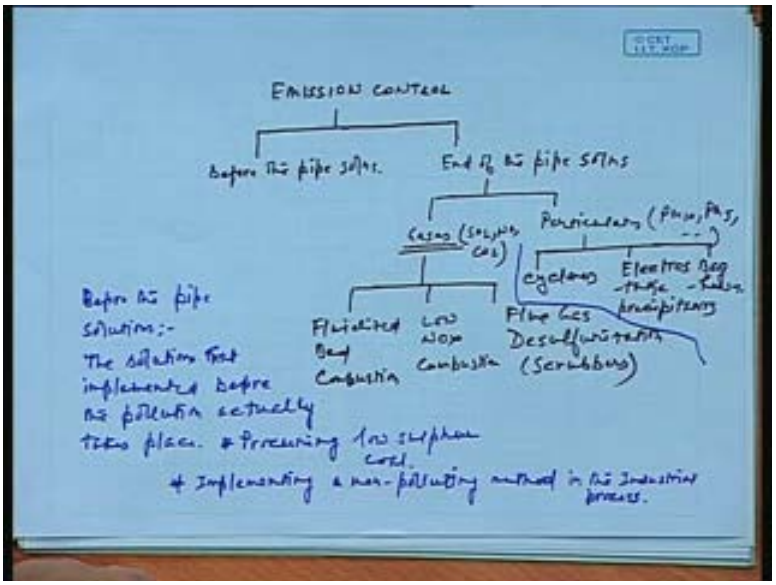

The one is the before the pipe solution and the end of the pipe solution, right. Before the pipe solution is says before of the pipe solution are, before the pipe solutions this the solutions, the before the pipe solutions are the solutions, here the solutions means solutions for emission control solution before the pipe solutions the solutions that are, that are, that are implemented, implemented before, before pollution actually before the pollution actually takes place. So, let me give an example then it would be clear. Suppose you know a procuring say that the number one step the procuring, procuring low sulphur coal right, then implementing a non-polluting, non-polluting method, implementing a non-polluting method in the industrial, industrial, in the industrial process, in the industrial process.

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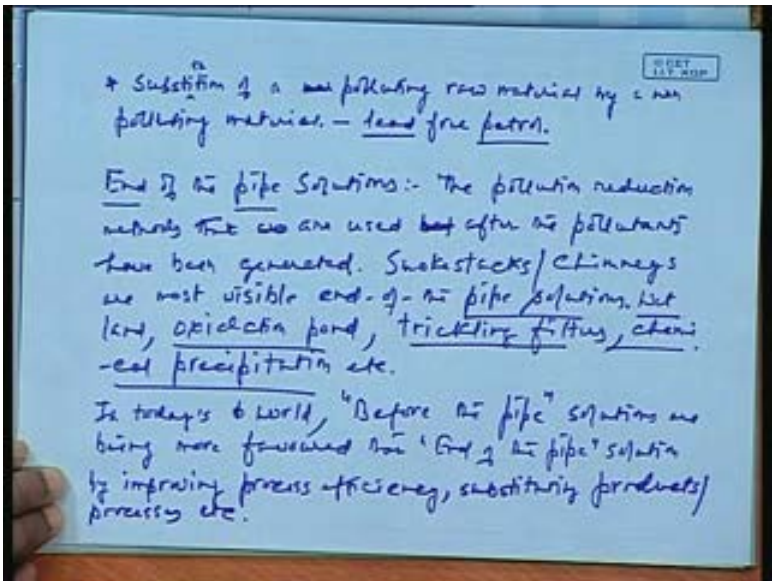

Suppose, you know or say for that matter, for that matter another example that we can think is substitution, substitution of a polluting product, polluting raw material by a non-polluting, non-polluting material, by a non-polluting material. So, there are three things that we have been talking about is a procuring say is say low, low sulphur coal. So, you know you are in the, in the beginning itself you are reducing the chances of production of sulphur dioxide during the burning process of coal okay. So, this is one, this is called the before the pipe solution, this is number one case examples like that we generally try about implementing a non-polluting method in the industrial process in the non-polluting method in the industrial process.

Suppose, in the process itself there are some, some methods which are highly polluting in nature changing that implementing a non-polluting method like you know in many cases like I tell you one thing, the one of the reactants you know something like cyanides which were generally being used are now being replaced by non-polluting methods particularly for say recovery of gold. So, in mining gold mining recovery non cyanidic methods are being implemented in place of cyanidic methods which itself can reduce the pollution to a great extent. So, substitution of a method by a non-polluting method, this is the second option that we can try of. Substitution, substitution, substitution of a non of a polluting raw material by a non-polluting material say you know just see you know this is lead free, lead free petrol, lead free petrol.

So, what we are trying to do is the petrol used to, we used to have lead in it, used to have lead in it which was at times was mixed with the petrol also just to you know for its fuel efficiency, to improve the fuel efficiency. Now it is being the process itself has been changed in a matter that we do not require a leaded petrol anymore, we can use lead free petrol for our own purposes for the same efficiency not only that there are various other kinds of you know mechanism methods are being adopted something like you might have heard of hybrid cars. The hybrid cars they are, there would be the hybrids are like is a one process is basically a burning, fuel burning process like you know petrol using petrol another is would be by the battery.

So, combination of these two, so the battery powered batteries, semi battery powered and semi fuel powered vehicle a mix of that would be polluting less. So, this is the idea. So, there are various new kind of fuels are also being applied. So, these are called you know before the pipe solution. So, you know before the pipe means the pipe here is the total process, industrial process. So, before the process whatever checks you can do to reduce pollution, this is one of the greatest areas of environmental control today. So, before the pollution actually takes place, you would try to control the process in a manner that the pollution becomes less or the process itself is so made that the pollution becomes less. So, this is what is the before the pipe solution. End of the pipe solutions are generally, end of the pipe, end of the pipe solutions are end of the pipe solutions are the pollution reduction methods that are used before sorry that are used after the pollutants have been generated, after the pollutions have been generated.

So, we have not made any change in the process say something like what you see is something like say the one particularly if you go to any plant like nowadays you know if you are just going for say chimney stacks or the smoke stacks you know smokestack, smokestacks or chimneys are most visible end of the pipe solutions, end of the pipe solutions say is the particularly like that what we have heard of what we have mostly discussed say something like say something like say the wet land, pond, wet land then say oxidation pond, oxidation pond, trickling filters, filters then say you know just try to think of say a chemical precipitation, chemical precipitation etc are called end of the pipe solutions.

So, the mostly, mostly you know mostly all this are chemical precipitation. It is also important to say at this point, at this point it is also important to say at this point that you know to the mostly, most of in the, in today's world, in today's world before the pipe solution, solutions are being more favoured than end of the pipe solutions, end of the pipe solution by improving process efficiency, by improving process efficiency, substituting products and processes, substituting products and processes etc. So, here you can see now that this is what is that you know we would personally we would see that the pre-eminence of or the growth of this concepts before the pipe solutions are being more favoured than end of the pipe solutions, okay. Now having to see that I think this is understood to you, so you know one of this is you know one process talks about after the pollutants have been generated how to contain them, how to dispose them, how to reduce their effect, it's okay but the pollutants have been generated.

Another process is before the pollutants are formed, before the pollutants are formed the process is so modified or so designed or so altered that the process itself would produce less pollutants by means of the, by means the method apply. So, here as such you know if you are going on to further on this, so you know if we just trying to see this, this is the before the pipe solutions and end of the pipe solutions. So, solutions, this is solutions, we can now subdivide this emission control methods as you know the gaseous, gaseous you know which is generally this is fluidized bed combustion, fluidized bed combustion boilers, ABC boilers, no low NOX combustion and flue gas, flue gas desulphurization, flue gas desulphurization okay. And if this is about the most prominent methods of you know dealing with, mostly dealing with this and the particulates in terms of particulates we generally what we use mostly is the cyclones that you know is a river, the typical cyclones that we use cyclones. Then we can, we use electrostatic precipitators and we call that you know this, this mostly the bag, bag houses, bag houses.

So, if it is let me again further go into that, you know emission control I said then you know before the pipe solutions and end of the pipe solutions will be, not be able to talk about them because you know say, say the scope of the course doesn't belong to that but you know as I have said the basic principles I have already said how these methods are developed I have said you know what has the underlying principles that we have discussed. End of the pipe solutions we will discuss more clearly on them, more in detail on that. There is a gases, for the gases generally it's a gasses like as you know mostly the concerned gases that we would be interested is NOX then we know would be also be interested at one point time about CO 2. So, fluidized with combustion, low NOX combustion, flue gas desulphurization, this is flue gas desulphurization. So, this is, these are the, three methods flue gas desulphurization or you generally call them as scrubbers also, this scrubbers and in the particulates, particulates that I have talked about say in the particulates of say PM 10, PM 5, so for those particulates say you know PM 10, PM 10, PM 5, this is the particulates that you can use the cyclones, electrostatic precipitators and bag houses, bag houses and bag house.

Let me you know just deal with this you know each of them in, in some details, so that you know you have general idea about what are the things generally used in terms of air emission control in industries. Mostly, what we are discussing is emission control in industries. So, remember this, this is, this may be quiet different than the domestic appliances in cases, in industries emission control in industries and further than on this you can discuss on all these aspects with a and their useful, how they are used and where they are used.

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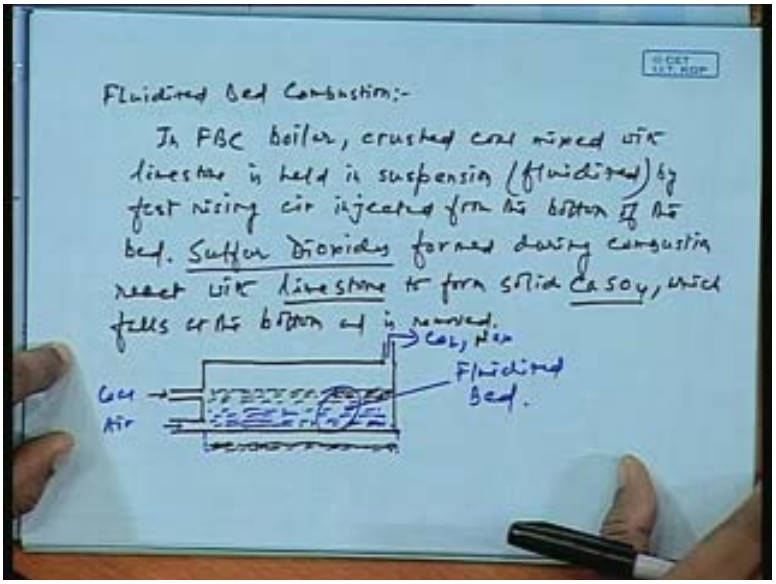

So, the first is fluidized bed combustion, fluidized bed combustion, fluidized bed combustion you know is a basically in today's world it is becoming more and more common as such as a method as an generation of power generation methods. You know many, many a number of plants today, number of plants today are for their captive plants their using a FBC's fluidized bed combustion method.

Here what is done is generally why it is called fluidized is the idea is that you know the time when the, this coal particles are being burned, coal particles are being burned, they are in the state of a, state of fluidity. The state of fluidity means they would be suspended, mostly suspended in air, suspended very fine particles mostly suspended in air so that their surface area increases. As their surface area increases they are, they are more efficiently burned and the output of, output of heat energy is suddenly more than standard combustion methods and as a result of which when they are, they are mostly remained it suspended you know how those generally is done is very fine coal particles are remained suspended on a stream of air. So, as just, just as if thinking of a train of air and on top of that the, the coal particles would be almost would remain in suspension or would be in the state of flow. So, this is how this has got derived the name fluidized bed combustion. So, understandably as you can see in a particularly when the all surfaces of the coal particles are exposed to combustion, the heat thermal efficiency would improve.

This is particularly important, particularly important for coals having high inert material. Mostly, you know in all countries throughout the world the quality of the minerals are going down because you know the best quality minerals perhaps we have already mined or we have already worked on. So, as the quality is deteriorating, this kind of methods where the energy efficiency is more than the standard methods are now being brought in and in this, the fluidized bed combustion methods what we generally try to do is basically in a, in FBC boiler, in FBC boiler, this is FBC boiler, in FBC boiler crushed coal, crushed coal mixed with, crushed coal mixed with limestone mixed with limestone is held in, held in suspension fluidized, fluidized by first rising air injected from, from the bottom of the bed, fluidized by first rising air injected from the bottom of the bed. Sulphur dioxide, sulphur dioxide formed during combustion react, react with limestone to form, form solid calcium sulphate, calcium sulphate which falls at the bottom and is, and is removed and is removed.

So, we can see this you know mostly, mostly if you just observe the, the point of burning in, in a fluidized bed combustion, this is where this very finely ground coals, finely ground coals would be, would be, would remain be suspended, there would be occasionally fed in to the boiler, occasionally fed in to the boiler and the air that would be entered through this, the air that would entered through this would remain would keep them suspended, would keep them suspended. And so, and so you can, you can see this, see this is the air that would go in. So, finally this would be, there would be a trap here I think you know I have not drawn that. So, you just trying to think of a trap where this the calcium sulphate that we have said the calcium sulphate and all other things would be all other inert material would be deposited, all other inert material would be deposited and this the other air, the air outlet the after combustion the air containing carbon dioxide NOX etc will be emitted outside through the, through the boiler.

So, here itself so this is air, this is coal, this is air and this is the fluidized bed. So, this would be, if you just observe this is the FB fluidized bed, this is the fluidized bed, this will be the fluidized bed that we are generally try, we would be in a position to observe. So, here as you can see know this is what is a conceptually a fluidized bed I mean this is good enough just we say you know this is as we know to remove sulphur dioxide, the sulphur dioxide we generally make them to react with limestone to form solid calcium sulphate which form falls at the bottom and is removed. So, this is one way of reducing sulphur dioxide from the flue gas, from the flue gas.

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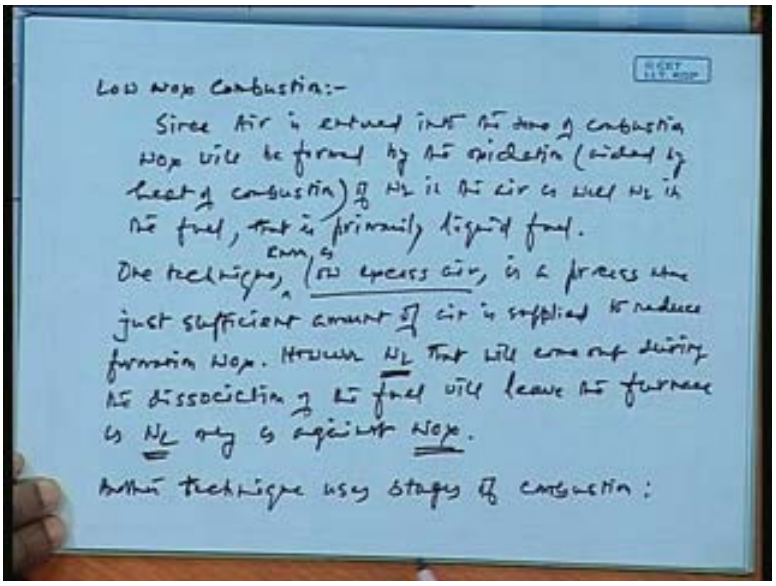

So, this is about another is low NOX you know one important thing about low NOX combustion, low NOX, low NOX combustion. So, as you know, you know since, since air is, since air is entered into zone of combustion, NOX will be formed by the oxidation of oxidation is this oxidation is only possible because of the heat generated, combustion heat aided by heat of combustion, aided by heat of combustion. Since, air is entered in to the zone of combustion NOX will be found by the oxidation of nitrogen in the air as well as nitrogen in the fuel, the fuel that is that is primarily, that is primarily liquid fuel. Particularly, there are you know perhaps some of you might be knowing that you know there are the power plants which are also I mean run by the fuel either by gases or by the liquid, liquid LNG's that you know liquefy the natural gasses. So, these are also one way of generating electricity, not only that in many coal power plant also whenever there is you know the energy drop along with coal, along with coal diesel is entered into to the blast furnace, diesel is entered into the blast furnace, this is known as surcharge oil surcharge.

So, this oil actually supplements the loss of heat due to poor quality of coal. So, it's particularly for the boiler to maintain a particular pressure of water I mean vaporized a vapour particular in a particular pressure so that the turbines can turn, it has to have a particularly a very high amount of, very high amount of steam to be generated. So, this high amount of steam to be generated would be only possible when there is a steady supply of heat. If the supply of heat goes down the air pressure would not be, the vapour pressure would not be sufficient would on the turbine. So, this is with these you know sometimes the liquid fuels surcharge is generally given to that. So, here so this can produce, this can produce NOX, this can produce NOX.

One technique for this, one technique known as low excess air, known as low excess air, low excess air one technique known as, known as, known as, known as low excess air is a process where just sufficient amount of, just sufficient amount of air is supplied, supplied to, supplied to is just supplied to reduce, supplied to reduce the formation of NOX.

However, nitrogen that will, that will come out, that will come out during the dissociation of, will leave the furnace as N 2 only as against, as against NOX, as against NOX. However, N 2 will come out during the dissociation of fuel will leave the furnace as N 2 only, so N 2 would not be changed, N 2 would not be changed. N 2 would be, the air would be supplied in such a quantity so that the combustion takes place but yet N 2 does not get oxidized into NOX and leave the furnace as N 2 as against NOX in other processes okay. This is called one technique, that is called low excess air. Another, another technique uses, another technique uses, another technique uses stages, stages of combustion, stages of combustion where another technique, another technique uses stages of combustion.

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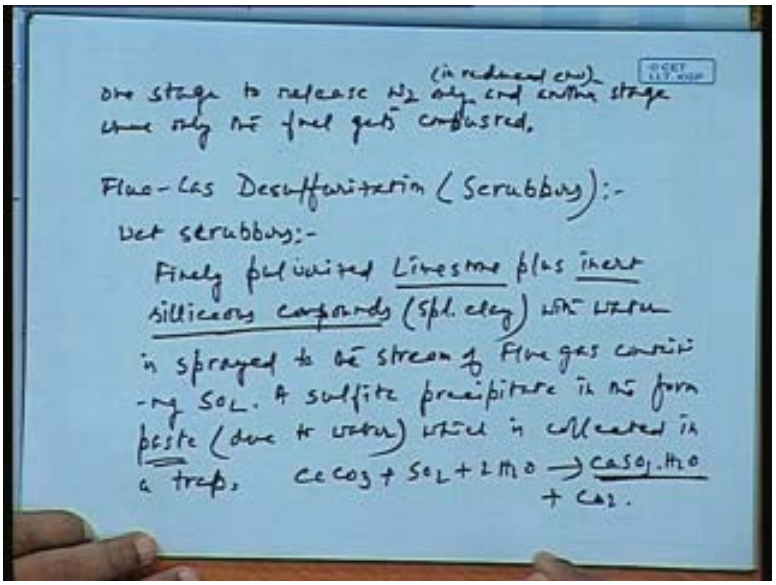

One stage to release N 2 only and another stage where only the fuel gets combusted well the fuel gets combusted like what we do you know is basically what we do generally in the caking of coal. This is basically what we generally try to do is if you just, if you just heat the coal say at 70 degree centigrade or 80 degree centigrade. What do we expect? You only expect the volatile matter to go. So, the carbon, the fixed carbon does not get oxidized till at that temperature so after that the fixed carbon would be put into another chamber where it would be then oxidized. So, the, in the first place similar case is done here, the fuel in the nitrogen locked in the fuel would be dissociated from the fuel itself in the first stage where it would leave as N 2 nitrogen only but then the oxygen in a, in a if this would be all in a reduced environment where there would be little oxygen in the first stage.

After that in a completely oxidized state but since N 2 has already left so there would be a little, very little NOX would be found in the second stage okay, so the release only the stage where the only fuel gets combusted. So, the one stage is there you can see is this is in reduced environment and another stage where only the fuel gets combusted, fuel gets combusted. So, this is low NOX combustion process where how we can make reduce the, we can reduce this generation of NOX. Another method that we generally use is an introductory part of that flue gas desulphurization. These are scrubbers, these are also known as scrubbers. We will not discuss about the dry

scrubbers, we will just discuss about the wet scrubbers. Wet scrubbers most commonly used wet scrubbers are like this most commonly used wet scrubbers is here the same the finely pulverized, finely pulverized, finely pulverized limestone plus, plus inert siliceous, this is special clay, this is basically a special clay where purely finely pulverized limestone plus inert siliceous compounds are with water, with water is sprayed to the stream of flue gas, flue gas containing sulphur dioxide, containing sulphur dioxide.

So, the particularly a, the, a sulphite, a sulphite remember a sulphite precipitate in the form of paste due to waters. Since, we have added water so it forms a paste otherwise basically as you can see you know it would be a sulphite that would be formed, the sulphite CASO 3, these CASO 3 in the presence of water would form a paste which, which is collected in a trap, which is collected in a trap, so which is collected in a trap. The usual reaction is CACO 3 plus SO 2 plus 2 H 2 O and forming CASO 3 H 2 O plus CO 2 plus CO 2. So, here you can see that you know this is what is what I said the paste which is forms in the paste which is collected in a trap.

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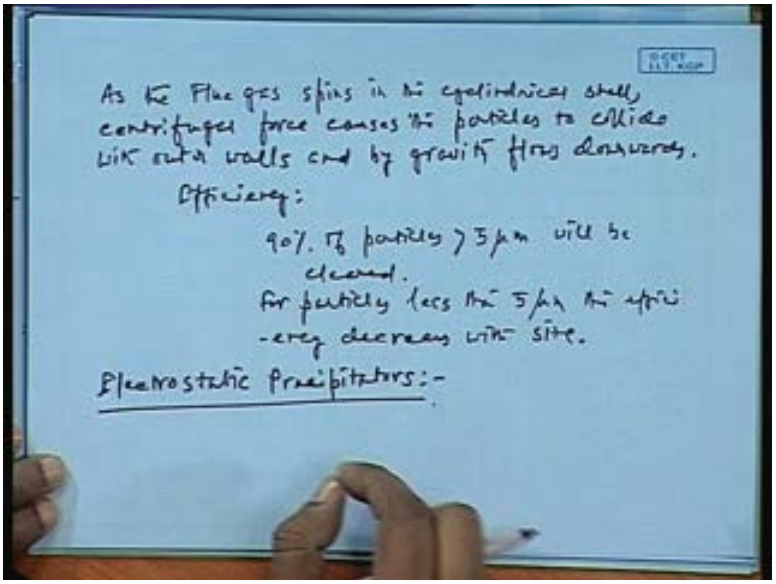

So, what is generally done is as you can see, so if you can say a stream of fluid gas, a flue gas, a stream of flue gas say is containing the flue gases, a stream of flue gases then this would be at a particular portion here at a particular place this would be here. So, you can see this would be, there you would offer you see the vapour here and we would inject CaCO 3 that is you know say powdered lime, powdered lime. So, this the air passes like this but you know at the same time you will find say if it is, if it is being sent like this, this the paste settling on top.

So, this is what is the CASO 3 H 2 O paste, this is say this Just a very simple schematic diagram you know how it works. So, the, what are this is, this particular air as you can see is relatively free of free of SO 2, free of SO 2 all right. Now, having to say this you know then we can further go on to say is a say about, about this thing that we have already discussed about this flue gas desulphurization.

We would now discuss about something about this particulate control, the particulate control, particulate control say a typical schematic of a cyclone I think you know you must be knowing what is a cyclone by now. Say let me just give you a small example how it works in a say typically a small cyclone would be like this here. So, not exactly of this dimension it should be about this but nonetheless you can very well understand here. This is there are two aspects of it, one is this is the inlet, this is the inlet is the inlet and this is how this air would actually revolve you know is it would work as a centrifuge and on top of that this is be, this is how the air flow would be inside and here also there would be an another air flow that should be generated. This is something like a quiet similar to an exhaust fan that would be formed here.

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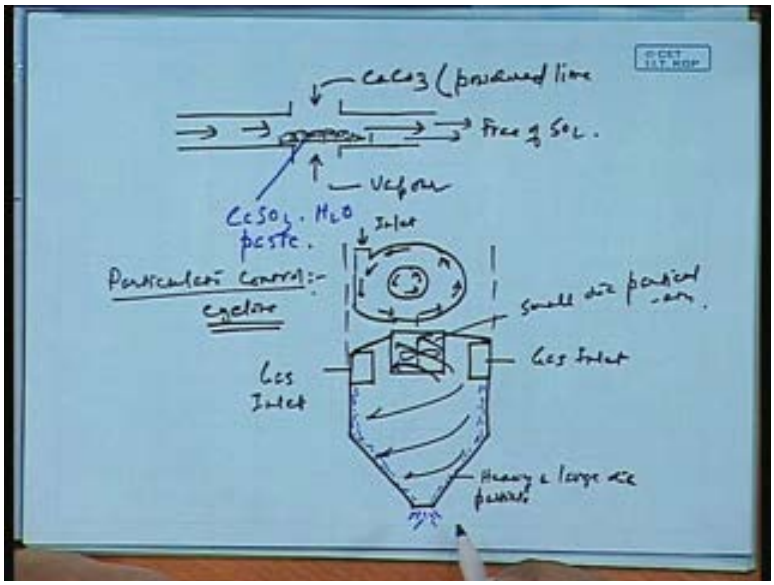

So, here as you can see this, this gas inlet, see this is the gas inlet is, these are the gas inlets. So, this gas you know there would be, this is one aspect of you know this is how this gas should be this is the centrifugal forces as you can see if the air is thrust into this, so it would form a centrifugal force. This centrifugal force would be you know another counter centrifugal force should be given which is just on the other side which would be in the, in this place here. So, this would be in two different directions. So, as a result of that you know it would form a cyclone which of this cyclone and as a result of that this as the centrifugal forces, as you know the lighter heavier particles would go towards the sites, towards the sites.

So, the heavier particles would be clouding here, clouding here and would, as they would they would come you know impinge on the outer surfaces many of them would begin to go down like this and this is where they would mostly come out. So, the heavier particles, so the lighter fractions go, so the heavier particles, heavy particles, heavy particulates, heavy and large diameter, large dia particulates and the small dia particulates, the small diameter particulates would leave, small dia particulates would leave okay understood. So, is just you know this is how this, this is how this air would be taken two streams, two streams of air that I have said two streams of air that would take place and as a result of which you know this would be, this would

form the air would be, the lighter fractions would be taken out through the top and the heavier bottom fractions would be taken from the bottom, okay.

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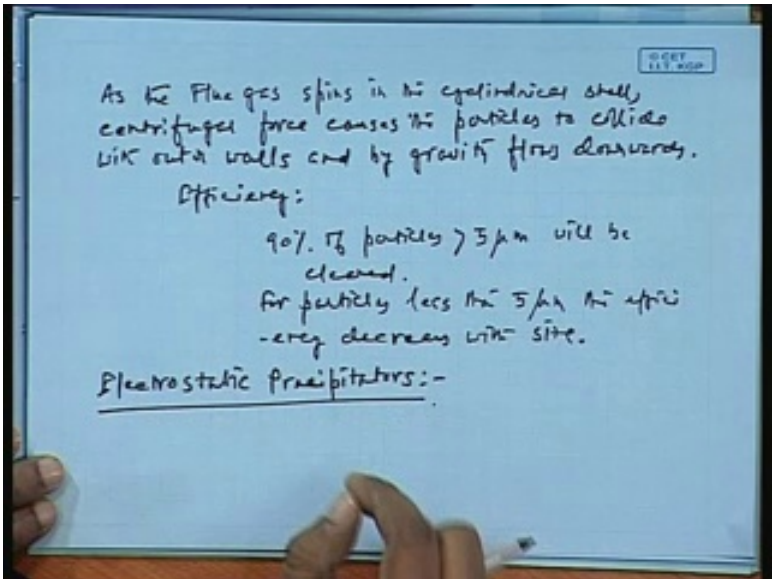

Now having to say that's the basic principles is you know just to explain this as the, as the gas, as the flue gas spins in the cylindrical, in the cylindrical shell centrifugal force, centrifugal force causes the particles, particles to collide, collide with outer walls that I have said and by gravity flows downwards, flows downwards. Efficiency, efficiency 90% of particulates, particles that is more than, more than 5 micron size, 5 micron size will be cleared. For efficiency, efficiency decreases with size, efficiency deceases with size, efficiency deceases with size okay efficiency the next we would discuss is electrostatic precipitators okay. In the next class just after 5 minutes all right.

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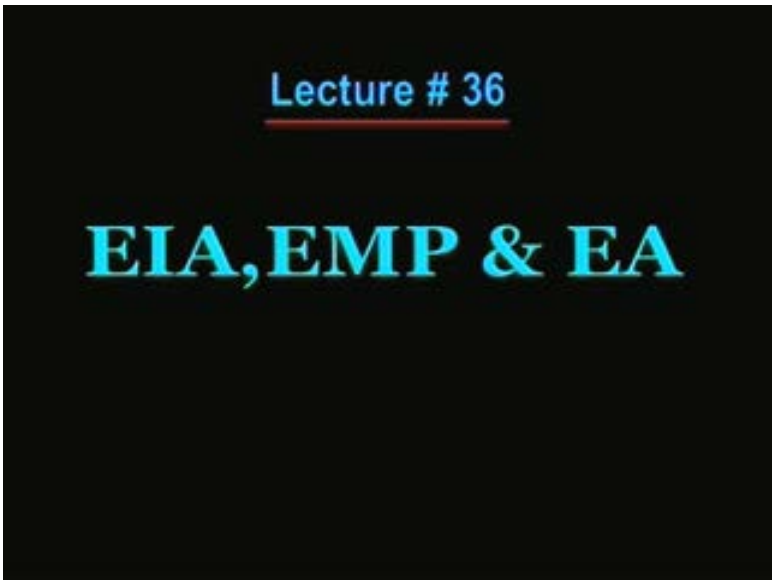

See, this you know the, the topic is EIA, EMP and EA. We will come back to that I mean before we conclude this and I will talk about all of them because you know these are also very import aspects nowadays.

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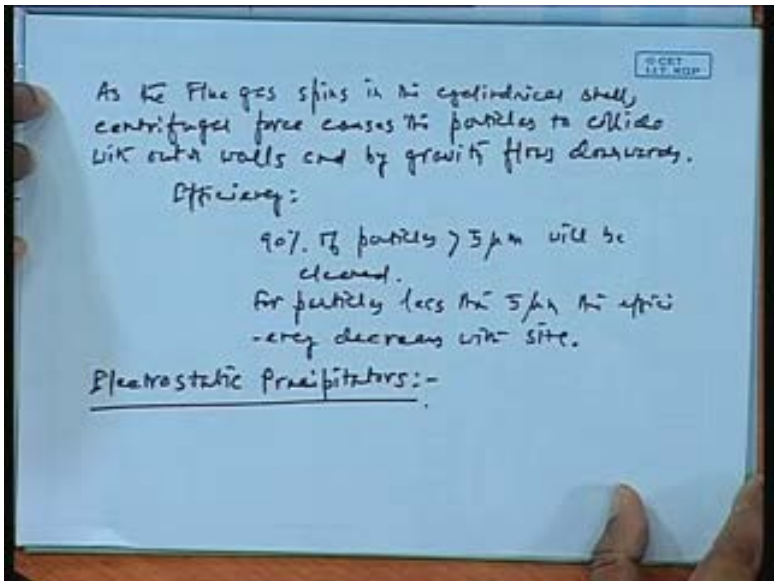

One important thing that is you know electrostatic precipitators that we have been talking of to see an electrostatic precipitators you know how it looks like is the what is the generally please take this diagram down.

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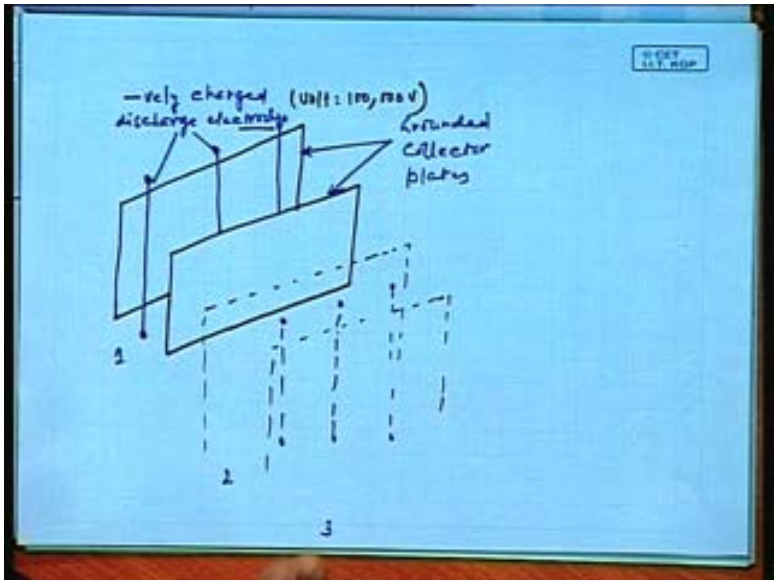

You see this is what is you know we generally in all cases as you can see in all cases we have to, we have to create charge you know potential difference mostly for, for this one is required for the case of this electrostatic precipitator and as you can see what I has these two are important where these two are repeated only on this kind that the dotted portion is only a repeated I mean only the repetition of these two blocks.

What is this say this grounded collector plates, grounded collector plates. So, you have a negatively charge discharge electrodes this is about say this one, this discharge electrodes these are the electrodes, these are the electrodes that you can see, these are the electrodes and these are the grounded collector plates, grounded collector plates. So, what happens here is you know this is just to understand that this is not a single column, it will be a multiple columns of this in the, in the electrostatic precipitator. Say there may be say about a thousand such blocks where there will be two grounded blocks insulated by another grounded, two grounded blocks and in between there would be 3 say 3 or 4 positively negative charged discharged electrodes and the potential difference as you can see can raise up to 100,000 volts, 100,000 volts.

So heavily, so heavily charged electrical grounded collector plates would be used through which, through which the air would be passed, so through which the air would be passed. So, you can see the movement of air, movement of air would be from here before they are allowed to operate. For most of the industries particularly any large industries where there would be a some kind of production, some kind of manufacturing there is a, it's mandatory now to have environmental impact assessment to be carried out, being carried I mean environmental impact assessment has to be carried out, so as to get certification to carry on with the manufacturing or production job.

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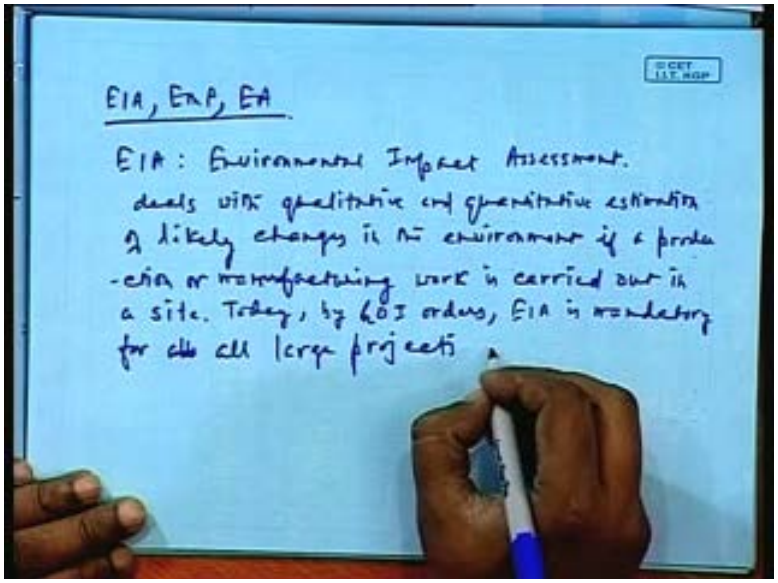

Now, what is this environmental impact assessment deals with is a basically deals with, deals with, deals with qualitative and quantitative, quantitative estimation, estimation of likely changes in the environment if, if a, if a production or manufacturing, manufacturing work is carried out in a site. In today, today by government of India GOI, government of India orders EIA is mandatory for all large projects, all large projects, all large projects. If we are, if we, if it's producing water of a is very poor quality, it would has to say that I am going to bring down they say BOD say the BOD from the 10,000 milligram per litre to 1000 milligram per litre that it has to mention in the EMP itself and then finally the EMP has to be implemented. EMP is a standard regular day to day exercise that the mind generally carries out, okay.

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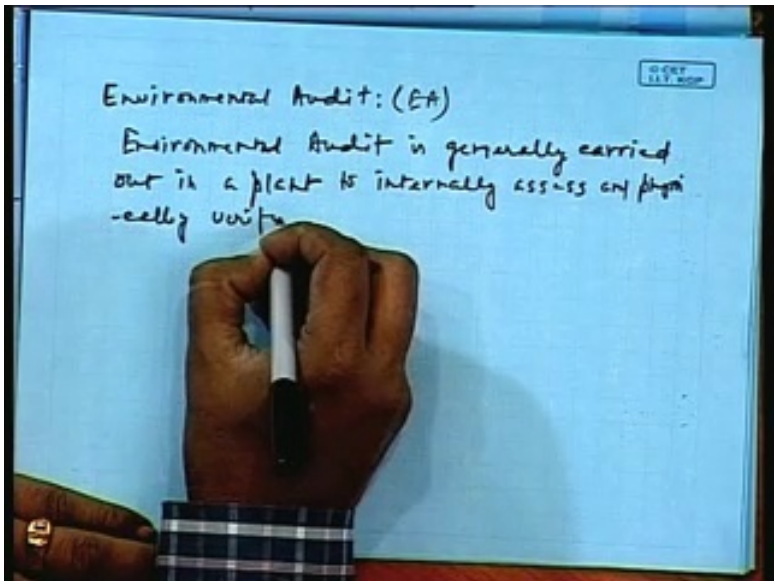

The final this, the topic that we of the course is environmental audit, environmental audit. Environmental audit are also known as EA that is environmental, environmental audit in a plant to internally assess this may not, this environmental audit may not be a statutory requirement it's not necessary, is not necessary that it has to be a statutory audit. Environmental audit is generally carried out in a plant to internally, to internally assess and physically, physically and physically verify...