Energy Resources and Technology
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Lecture - 9
Thermal Power Plants (Contd.)

Last class, we had introduced the basic idea of the structure of a power plant and this is where we were.

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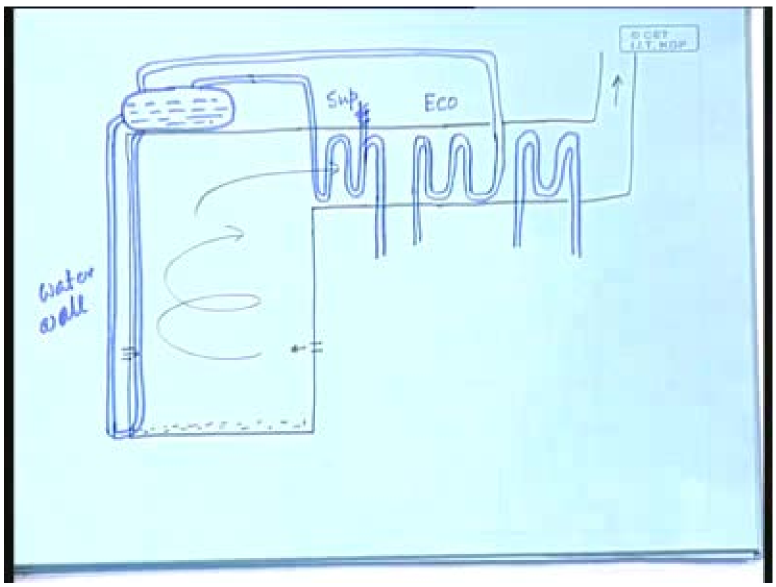

Just to recapitulate what is what, here is the boiler drum; boiler chamber, here is the boiler drum, here are the down comers - these are called the down comers through which the water comes down outside the boiler drum and goes up through the water walls. So, it goes up through the water walls normally by natural circulation, but there can also be forced circulation if you want faster movement. The coal air mixture, coal powder air mixture, is inserted through ports like this and the orientation, the direction is such that there exists a, a vortex is created, so that there is a possibility of greater churning and complete burning and you have the flue gas going out like this. While the flue gas goes out, there are three stages in which the heat is extracted from there.

The first stage is the super heater. Well, normally the reheater stage comes after this and economizer stage comes after that, but nevertheless, since we were exposing in a particular way, we have drawn it as the economizer first and the reheater next.

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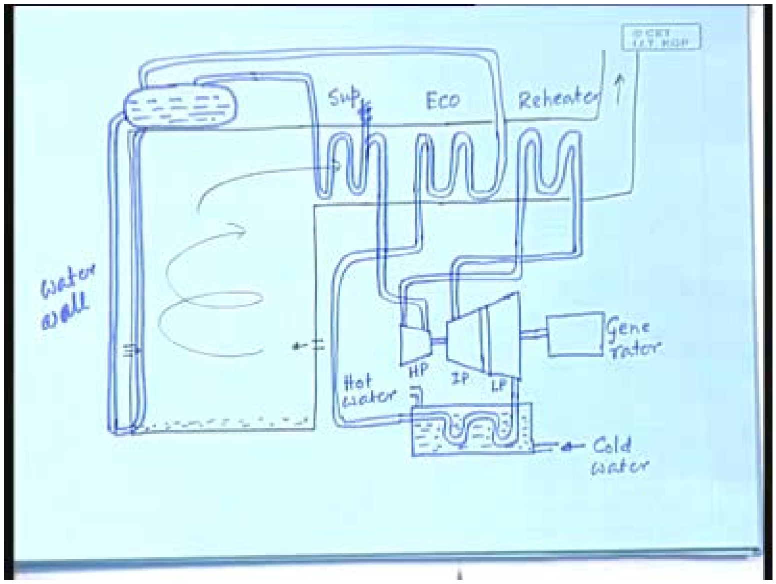

So, here is …. So, now we are in a position to complete the diagram. We have the high pressure turbine like this, which is connected to the low pressure turbine. Let me divide into two parts and then we will do that. So, here is the intermediate pressure and the low pressure turbine stages and this whole thing is then connected to heat generator. So, the superheated steam comes, where? It comes here, right. After the first stage, you take it out and that is what goes into the reheater and the reheater output is fed into the ….. Is the structure now clear? Probably, I could have drawn little more simpler, so that there is no overlap, but nevertheless you can understand what it is. The super heater output, let us start from here, the boiler drum produces, through the boiling process here produces, steam water mixture and naturally the steam that is here is saturated steam. That steam goes into the super heater, gets into superheated stage and that is what goes into the high pressure turbines input.

High pressure turbines output goes to the reheater and that is fed into the intermediate pressure and the output, what happens to the output, output of the low pressure stage? That has to go to the, to the condenser. So, that has to go to the condenser. So, you have here the condenser stage. So, you have this as a process going and here you have the cold water inlet and here you have the hot water outlet. So, you have the condenser here. In order to depict correctly, let me put this symbol of water here, so that you understand this is all filled up with water and this, after it comes out of this, is water and that has to be fed back to drum is it, does it have to be fed back directly to here? No; it should go through the economizer. It should go through the economizer to the … because, it has to be heated up to the temperature close to the temperature inside the boiler drum and that therefore this point should be connected, all right. So, more or less, this is the structure. So, here is the generator. So, this is the HP stage, this is the IP stage and this is the LP stage, clear and all these are connected in the same shaft. So, the power output goes directly to the generator. So, this is more or less the structure of the thermal power plant.

In addition to this, let us relate all this again to the T-S diagram.

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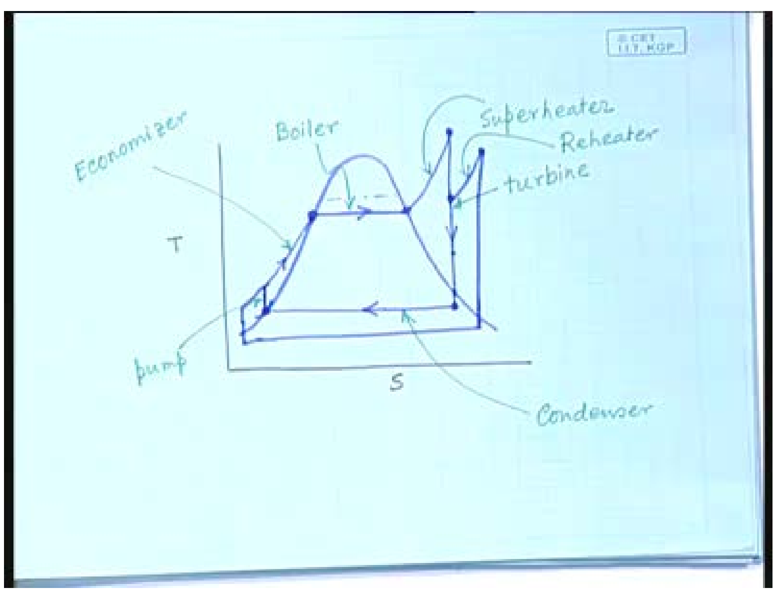

In order to recapitulate, after we have obtained this changed cycle, we have the boiling process here, inside the boiler, inside the water walls. The super heater process here in the super heater. Here is the high pressure turbine, here is the reheater, here is the intermediate and low pressure turbine and finally it is taken out and this is the process inside the condenser. Here is the process in the pump. So, I have to put a pump somewhere here.

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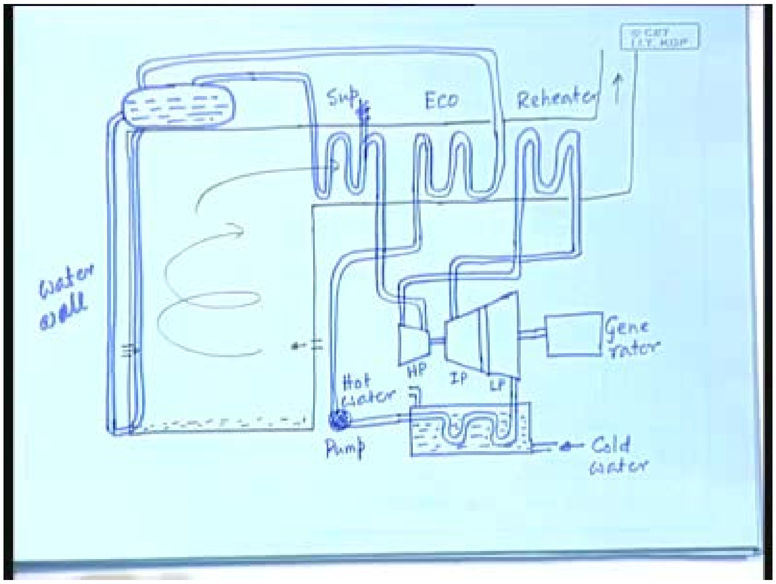

So, let us put a pump here. It has to be pumped, right, at this stage.

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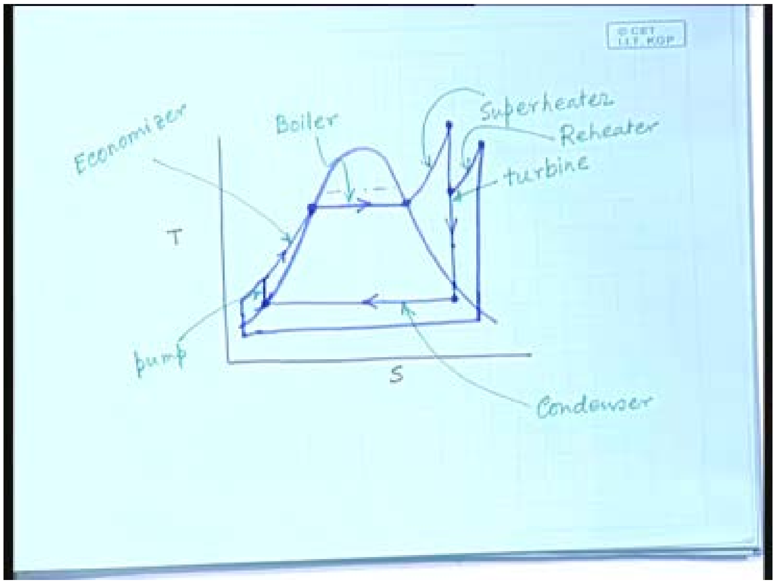

There is a pump and then you have this process going in the economizer. Finally, you bring it here and put it inside the boiler drum, clear.

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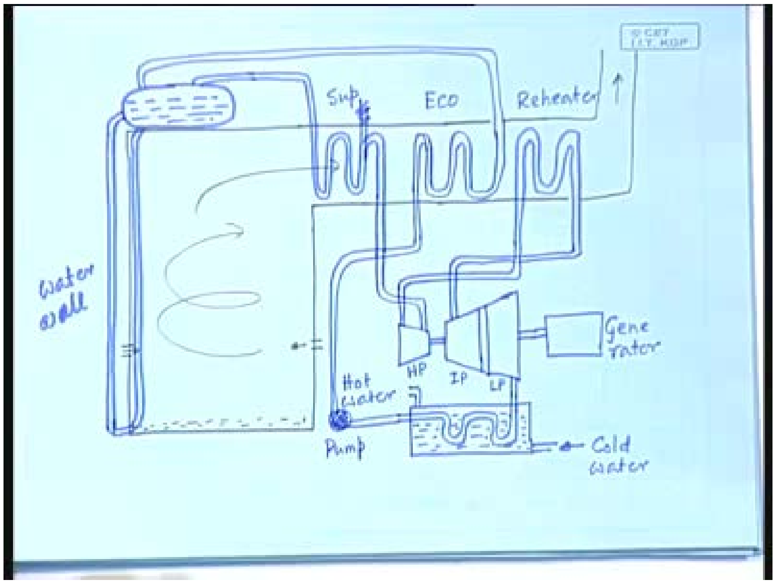

There is one more thing that is mostly incorporated in modern power plants. That is you can see here, the heating of the cold water to this temperature is shown here to be entirely done in the economizer. As I told you, normally the economizer is placed later;

nevertheless, try to understand this. But in reality, a part of that process is done by a different means that is done by taking a part of the steam out of the, in between the intermediate pressure and the low pressure stage there it is still hot, so a part of the steam is bled out; it is like bleeding, you know, part of the steam is taken out and that is mixed with this water, so that the water goes to a higher temperature. So, this process is called regeneration. So, a part of this is difficult to depict here, because it will be too cluttered, so I am not showing. But for your understanding, in actual practice you will find in a power plant something called a regeneration system, where you have a part of the steam being bled out, mixed with this, this steam that is going, so that is the first stage and that goes into the economizer. So, that is the standard way of doing it. It has been shown that that process improves the overall efficiency of the system; that process improves the overall efficiency. So, how will you depict this?

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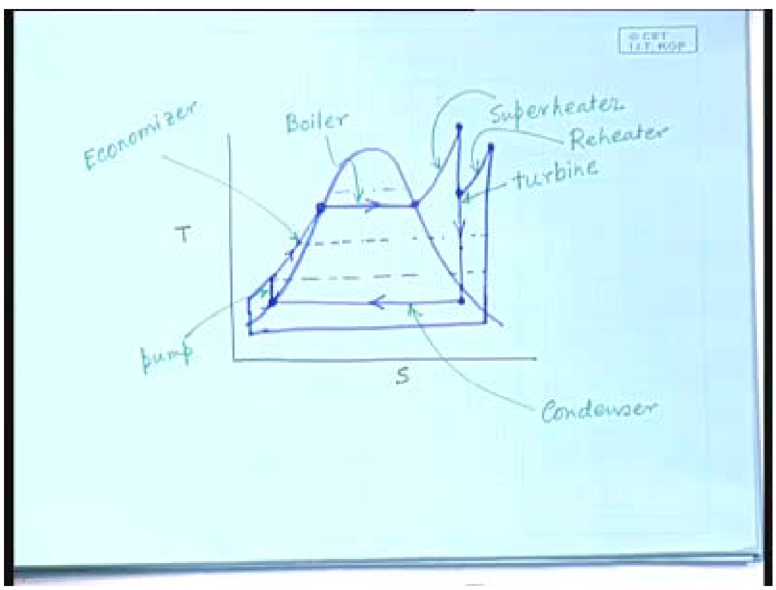

It is something like bleeding a part of the steam to be mixed here; again, another part to be mixed here. So, that is what is done, clear.

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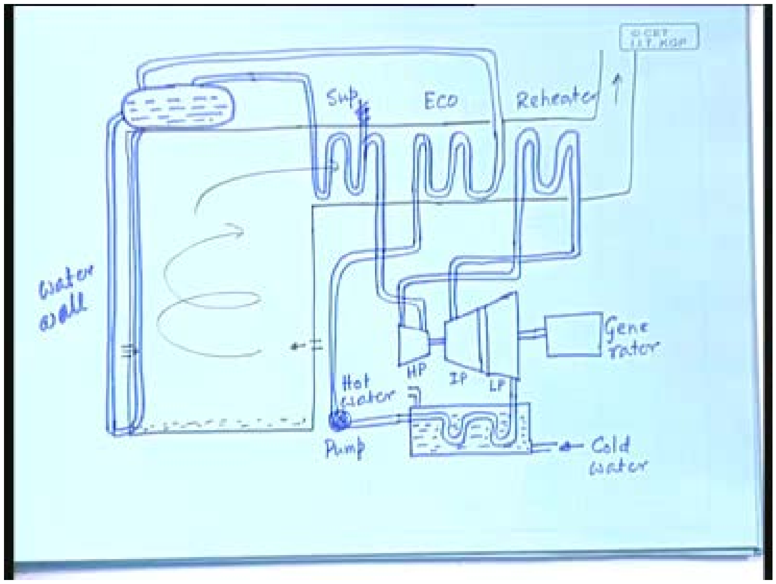

So, here in this course, our objective is not in the main to have a detailed discussion on the thermal power plants. No; that is not the objective, because those of you who will be mechanical engineers, will be studying it in mechanical engineering course. Those who will be going into the, into the detail thermodynamics classes, you will learn in detail there. So, you need to learn how to calculate various things from the T-S diagrams, but we will not take up that specifically in this course.

In this course, our, the line of understanding that we have to develop is how to further improve this system, from the point of view of energy engineering? So, what are the sources of the loss here? Obviously, that is what energy engineers are concerned about; something that you want to reduce – obviously, the amount of heat that is being generated. One thing I should mention here. The reason that the power station also consumes oil, it is that when coal powder and air is put into this thing, it does not fire by itself; it has to be put on top of a fire, so that it ignites. So, initially oil and air mixture is oil, you know, it is called atomized that means it is sprayed in a very small droplets into the chamber that is ignited; temperature builds up and only then can coal particles catch fire.

So, whenever there is a startup, you need input of oil. After the startup, the oil injection is no longer necessary. It is the coal that can sustain the fire, so that stops. But every time you startup, you need a lot of oil, clear and normally these are the relatively heavier ends of the petroleum products that is used here. So, here there is a heat generation and that heat is, part of it is, taken out fruitfully, but then part of it is still there, right. Can you bring the temperature of the flue gas here down to the temperature of the, down to the room temperature, so that no heat is really left out? Is it possible? Let us add this, this question. That would be obviously one way of improving the efficiency. I do not allow any heat to go out.

One source of inefficiency is here. A lot of energy is really released into the atmosphere through the condenser. But, we have already learnt thermodynamically that cannot be helped; it will always be there, so this cannot be helped. But, can we arrest any escape of heat through the flue gas. There will be two problems here. The first problem is that how does the flue gas go out? It goes out through a chimney.

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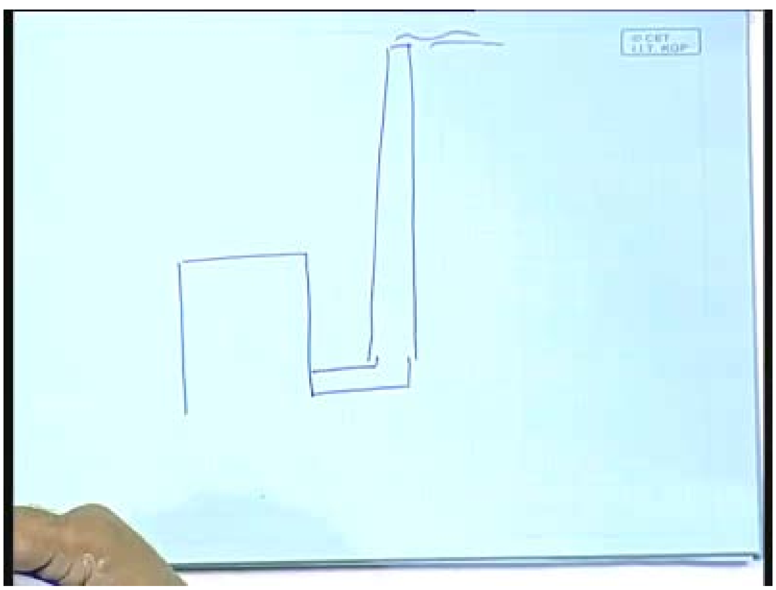

So, imagine that you have a power plant here and then it goes out to a long chimney and finally it goes out like this. Why should it go up? Why should it go up? It has to go up by some kind of a pressure difference. Else, why should it go up and the pressure difference can be created only if there is a temperature difference, right. So, this is one reason why you need to have a temperature here. Else, there will be no draft. Because of the long chimney, there is a draft; there is a force, there is a suction kind of effect that is created. So, unless there is a temperature here, it will not rise up and in order to make the flue gas flow, you will put, you will have to put in more amount of energy in pumps.

You will have to pump in the, you have to make the air flow by means of some energy assisted means; obviously that is not productive. So, it is convenient to have some temperature, allow some temperature to be there and that is normally calculated such that the flue gas by its own accord goes up. Not only that, rises up a bit and then gets carried away by the air. So, that is one reason why you have to allow the flue gas to have some temperature.

The second reason is that if, as I told you earlier, the coal contains some amount of sulphur, true Indian coal contains less sulphur, but still some amount is there and the coal also contains hydrogen, which when burnt in presence of, coal also contains hydrogen, do you understand that, because it contains hydrocarbons also, which when burnt in presence of oxygen produces moisture. So, moisture is number one, already there in the air and number two, some amount of it is added by means of that burning and there is also sulphur content which produces sulphur dioxide, sulphur trioxide. So, these things are there. Obviously, the moment you allow the dews to form that is called the, if the temperature goes below the dew point, then sulphuric acid droplets will form. Sulphuric acid and sulphurous acid droplets will form and as a result when that droplets form, it will start corroding everything that is on its way. So, that is another reason.

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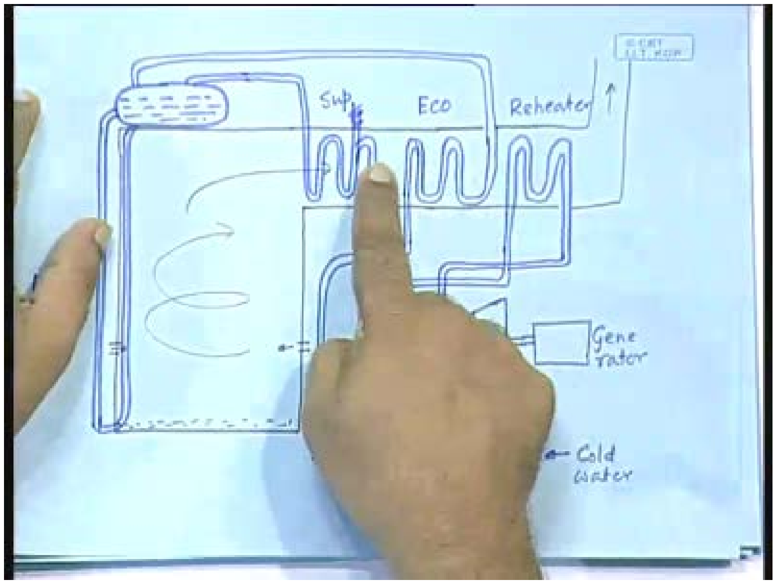

Suppose you are, you hope to bring down the temperature so much here then all these, you know, tubes will start to corrode, because sulphuric acid will deposit on that. You cannot allow that. So, the temperature of the flue gas has to be above the dew point of the sulphuric and sulphurous acids. So, these are the two reasons why this temperature has to be somewhat high. It is not, it cannot be brought down to the room temperature. But nevertheless, you should understand two things – one, that the means by which the air flows that needs assistance still. So, there are actually two fans; two fans, one placed here, another placed in order to push the air in. One is called the forced draft fan, FD fan and the other is called induced draft fan, ID fan and the power input to these two fans have to be so adjusted, so that the pressure inside this boiler, what should it be?

It should be slightly less than the pressure outside. Why because, suppose it is slightly more than the pressure outside what happens? Wherever there are leakages, the flame would try to leak out through that and you cannot allow that. So, the pressure inside the boiler, the pressure here, the pressure here, everywhere has to be less than the atmospheric pressure. So, if you only run a fan in order to push the coal air mixture in, then obviously the pressure here will be higher. So, there has to be another fan here that sought of sucks out and the balance of these two are maintained in such a way that the pressure inside the boiler is less than the atmospheric pressure. So, these two fans are anyway there.

What I mean to say by having a temperature is that the power level of this fans would give go up significantly, if you allowed the temperature to go down. So, the actual induced draft is assisted by the temperature which produces an upward movement of the hot air. So, here there has to be temperature. So, that is out; you cannot really bring the temperature down much here, you cannot really do much here. Whatever is the temperature here must be used. But, you can do one thing obviously; you can cool down in such a way that the pressure here is very low, like vacuum pressure. So, normally you would feel that it is a very high pressure and goes down to the atmospheric pressure here and then goes here; no.

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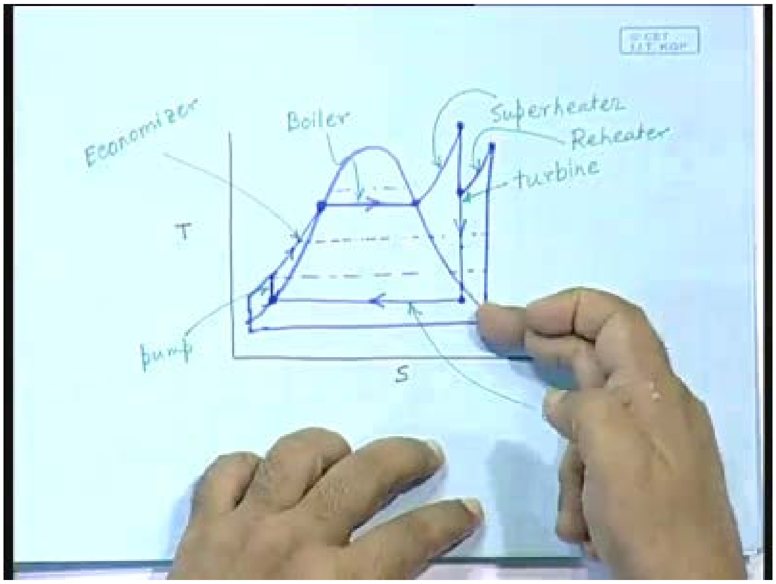

Another way of improving the total output is to allow it to go into almost a vacuum stage, so that when it comes here, it is far low. So, you add some area here by having relatively colder temperature here.

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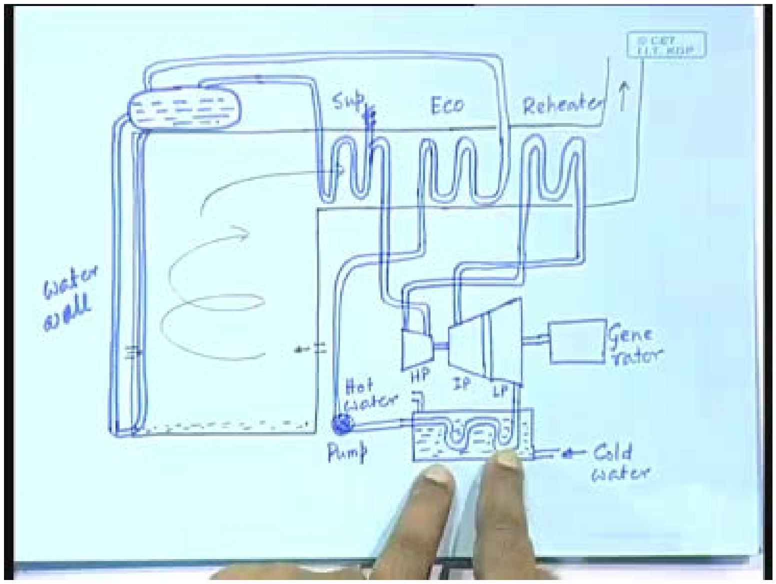

That is why the temperature, the overall efficiency of the system improves if this water is even colder. What produces the vacuum here? The condensation of the steam into water and the colder the temperature, the better the whole thing is. That obviously also follows from the thermodynamic consideration 1 minus T 2 by T 1. T 2 is this temperature, so the lower it is the better. Is there any other place where you can improve? There are, but I will come to those things a little later.

One thing is to bring the temperature or pressure here further up and those, as I told you, cannot be done if you use a boiler drum. So, some of the super thermal power plants today use no boiler drum and in its place there is, after the economizer there is, a pump that circulates it through the water walls. Instead of the natural circulation from the boiler drum there is a pump that circulates, as a result of which there is some amount of power input into the pump, all right; but, what it is circulating, what is pumping is essentially water. So, that is not all that expensive in terms of energy, but what happens is that then the whole thing is made up of tubes only. The whole water circuit is made up of tubes and nothing else but tubes. As a result, you can have higher pressure. Higher pressure means higher temperature, higher 1 minus T 2 by T 1; that temperature higher, this point higher, you can see the area goes up. So, this is one of the, one of the improvements that is sometimes done in relatively larger power plants like the super thermal power plants. This is called the once through kind of cycle, clear. Is there any question on the structure?

Well, now let me go into another issue that energy engineers have to bother about. That is pollution, the environmental effects. Obviously, there are a lot of environmental effects of any coal fired power plant for various reasons. Can you identify those, the specific ways in which pollution is created?

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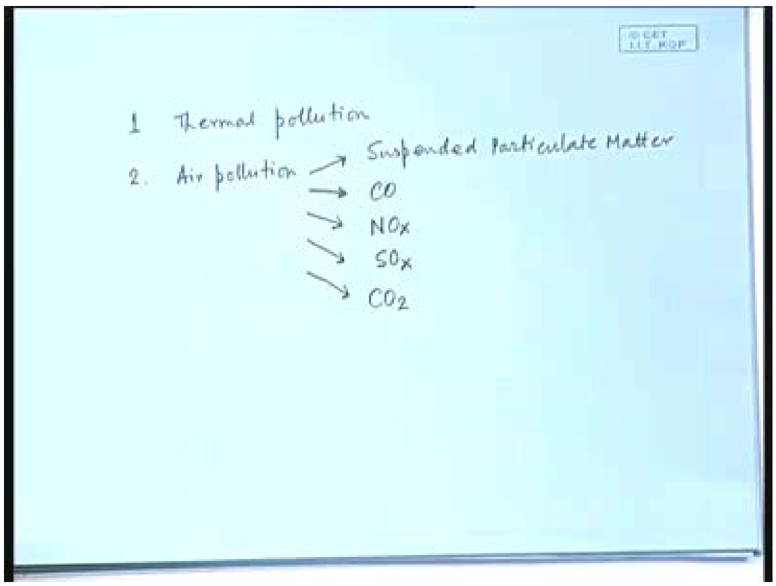

1 - thermal pollution, 2 - air pollution, by what means you have to specify that. So, let us see air pollution. 1- suspended particulate matter, SPM which is the ash suspended in the air. You see many of the power plants, if you look at the chimney you see a thick black soot coming out of that. So, that is what suspended particulate matter. Then, what is the other source of air pollution? CO, NO x; well, CO 2 also, but you can do nothing about it; that is what you are doing anyway. CO 2 is not a pollutant in the sense, but it effectively contributes to global warming and in that it is a pollutant, indirectly a pollutant because you are also exhaling CO 2, so you cannot say that you are polluting the atmosphere; no, we cannot say that, but it is in an indirect sense also a pollutant.

CO, unless the power plant is run by a completely incompetent people CO production is almost negligible. That can only be produced if there is incomplete burning. Incomplete burning is essentially arrested, if you have sufficient stoichiometric ratio of oxygen. Normally higher than that stoichiometric ratio is put in, therefore normally the possibility of production of CO is really very small. So, let us not concentrate much on CO, it is a simple problem; simply by having the right temperature and having the right amount of oxygen, right amount of air, you can overcome that problem. So, CO is not a problem.

Suspended particulate matter, that is a big problem, because Indian coal that is for example, the coal that is burnt in the power plants in West Bengal for example, these are the ones that have been obtained from the Jharia, Raniganj belt. That means the coal mines that are there in Jharkhand, Bihar and western West Bengal and this coal contains a large amount of ash like 40 to 50% ash. There is a large amount of ash. That ash obviously results in the suspended particulate matter. In what form?

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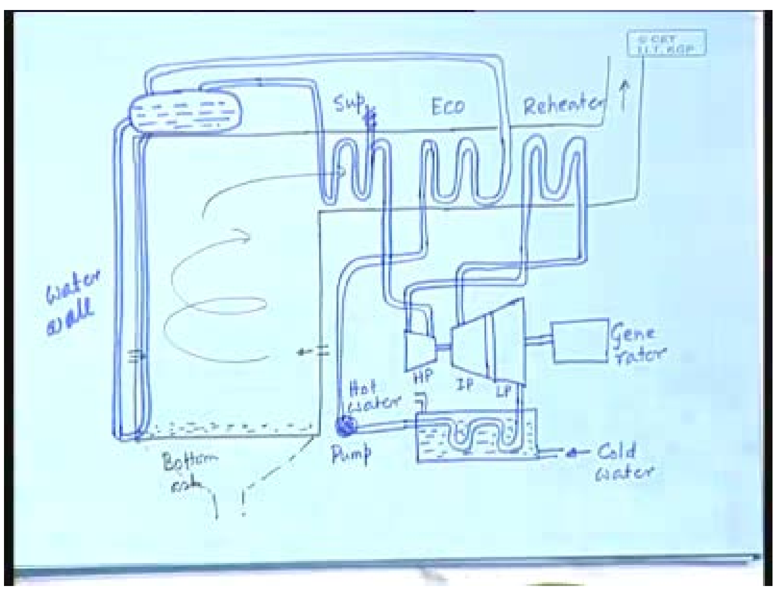

You notice that some part of it, some part of it settles down here, as this is called bottom ash, this part is called bottom ash. This bottom ash is normally after sometime it is flushed out. That means the structure would be something like this and there would be a collection point. So, bottom ash can be easily collected and bottom ash produces some kind of a solid waste. It is a waste that flies called fly ash that is the main problem. So, the fly ash goes along and finally finds its way along the chimney, so something has to be done to that. Fortunately, now we have reasonably good measures to arrest the fly ash. That is called electrostatic precipitators. So, you have large chambers in which wires are there and those wires have very high voltage, as a result of which this high voltage is conveyed to the particles and then in the next stage, there are negatively charged plates on which they attach. So, this is a very efficient means of taking away all the suspended particulate matter. So, we have the electrostatic precipitators. Is the structure understood?

I am not going to the details of it, but the concept is simple that you somehow make the particles positively charged or negatively charged and then you have got opposite charged plate on which they normally would be attracted and get attached. Could you please help him a bit? So, that is a bit disturbing for me. So, you have the, after this stage it really does not go into the chimney, it goes through the stage of electrostatic precipitators. But, the main problem is if out of the whole amount of coal that is coming for power generation, 40 to 50% is ash, it is huge amount of ash, what do you do with it?

The problem is that initially when a power plant is installed, nobody really thinks about this problem. They start thinking when it becomes really a problem like 5 to 10 years later. Initially, all these ash, both the bottom ash as well as the fly ash, is mixed with water, made into a paste like thing and that is carried into, by means of pipes that is carried into some ponds. These are called ash ponds and naturally it keeps on accumulating in the ash ponds and after sometime, the ash ponds fill up and that is exactly what has happened in most of the power plants that you see around, right. If you see great expands of ash, they were actually at one point of time simply ponds dug out, but now they are filled up. After that what you do? There is no way. So, actually the solution to the problem is making some fruitful use of the ash and that there are many ways of making use of the ash.

For example, it can be used for construction material, it can be used for land filling purpose, it can be used for whenever there is a construction of highways or railway lines, you need to elevate the soil; it can be used for that purpose. So, there are many ways. It can be made into bricks, so all these are possible, but the problem is of planning. If this ash is seen as an asset, then you have one kind of planning. If the ash is seen as a problem, you have no planning really. That is exactly what has happened. So, in most of the power plants in this state at least, you will find that there is only halfhearted attempt to have some brick plants. So halfhearted, that out of the total quantity of ash that is produced, the brick is made out of only 1% or so and the rest 99% is still there. So, that creates a lot of problem, in two ways.

That is why in the vicinity of most of the power plants, like here there is one big power plant in Kolaghat, there is another big power plant in Bandel; in those places, you will find in the vicinity there is a, there is a lot of problem. Firstly, the ash pond that has water in it and with all the rain, you have more water in it. So, whatever is the soluble content of the ash, that gets into the water and that gets into the ground water, seeps into the ground and gets into the ground water and that is often somewhat toxic. It contains many material, many minerals that are not good for the human health and in the vicinity of those areas, wherever you have tube wells or bore wells, whatever it is, that toxic kind of water comes out. So, that is one problem.

Another problem is in the dry season. The ash ponds dry up and these are all you know, powder like things; so, with the air, that blows off and naturally a vast expanse along the way of the blown air, you will find is full of ash. Ash would settle on your head, ash will settle on your skin, ash will settle on your clothes, so everywhere you will find ash. That is one major problem that the people of the localities are facing. Obviously, the remedy is simply to make use of ash rather than put it there. So, as energy engineers, you should know that ash is not really a problem, it is an asset. It can be used for various purposes, but if it is looked as a problem, then obviously the bricks that are made out of ash and the bricks that are made out of normal clay, you have, you know, if the ash bricks are made in a halfhearted way, they do not economically compete.

But, if there are big industries to use the ash, obviously that will economically compete. Unfortunately that has not happened. So, in India at least, the use of ash bricks you will find only, have you seen many houses made out of ash bricks? No, you will not find. Is any of the houses that you know being built with ash bricks? You will not find; big housing complexes you will not find, because that has not gone into our psyche that it can also be used. In fact, ash bricks in every sense are better than the normal clay bricks. So, you have, the point is that it is possible to make fruitful and productive use of what is today seen as a menace. So, that should be the proper way of approaching the issue.

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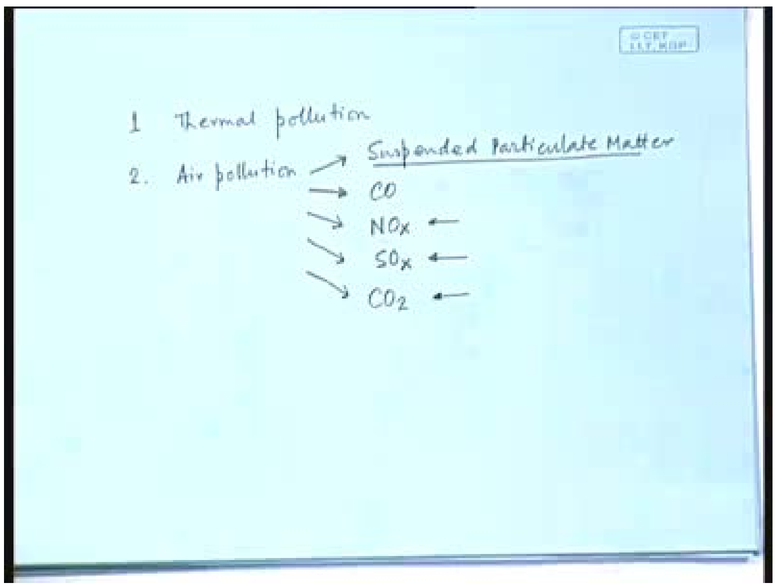

So, suspended particulate matter is now understood. Two forms, bottom ash, fly ash, both now taken out of the power plant by means of slurry, mixed with water, put into an ash pond, but then they should directly be used to manufacture something, which is not done today. SO x, as I told you Indian coal has relatively less amount of sulphur and so, for Indian coal, for this specific condition, SO x is not a problem. CO 2, as I told you nothing can be done about it; that is what you are doing any way. You are burning coal to make CO 2. So, you cannot really look at CO 2 as a problem. The only way you can look at it, is to reduce the dependence on coal as a source and since we are discussing coal based power plants, we cannot really treat it as a pollutant at this stage.

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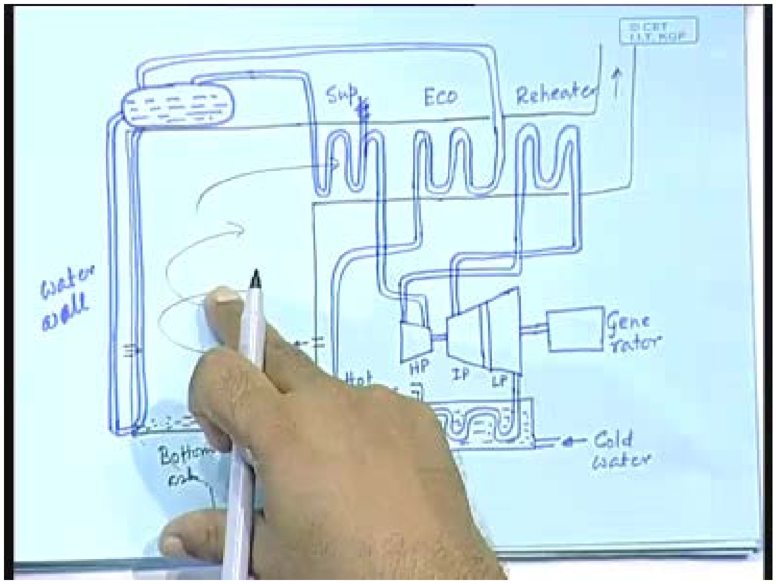

NO x, NO x is a problem, because the temperature inside the chamber is high, then it will inevitably result in the production of NO x. Because, what is happening? The actual burning is taking place here. Heat is being radiated from there into the water walls and then only it is being absorbed in the water walls. So, the distance between the absorbing place and the place where the heat is being generated is quite large. As a result, at that point, there can be a very large temperature. So, that is what creates the NO x and most people are not aware of it, because NO x has no colour, no odour and unless you feel the overall effect of the NO x in the atmosphere, this really goes out of attention.

So, what can be done about NO x? Let us consider this problem. The alternative that is coming is something like this. The NO x is there, because you have pulverized the coal and if you have pulverized the coal, it goes along with the flue, along with the gas and naturally in this part, a large temperature is produced. So, the solution must be in a way that changes the structure of the boiler that allows you to extract the heat from where it is created. The way the solutions are coming are something like this - that is instead of pulverizing the coal, make, instead of making into powder, you make into smaller chunks about a centimeter in size. So, the characteristic, you cannot obviously break them all into the same size, so you break them into smaller pieces; the characteristic size will be of the of the order of a centimeter, so that these are chunks, not powder.

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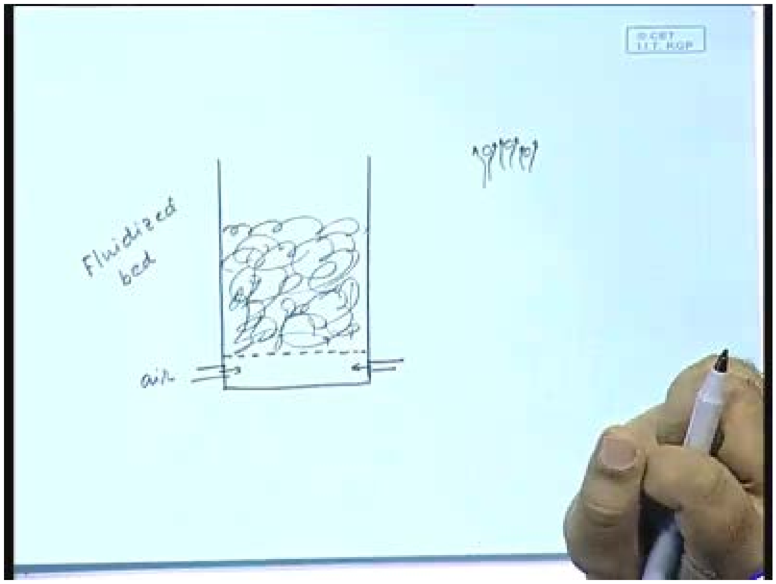

Now, these are put inside a chamber like here; that means the thing that I am drawing like this is essentially collection of small pebble sized coal particles. Now, you allow air in and here is a sieve mesh. So, this is the place where you allow air. So, air will go into this part and it will rise through the mesh, right, through the coal. These coals are, as I told you, small sized, pebble sized, about a centimeter size chunks. As it rises, it will also push this bed to sort of, it will make the coal particles float in the air. So, the coal particles have some weight that will work downwards and the air that is rising will push them upwards and it will maintain a balance. Then, sort of each coal particle will be floating in the air. As a result, the whole bed will behave like a fluid. As a result the whole bed will behave like a fluid.

If that happens, then the whole thing is called a fluidized bed; the whole thing is called a fluidized bed. That means here each of the particles are like this and air is being blown like this. Because each of the particle is up and we ….. maintain, so that if it is too ……, then it will blow off; it will tend to blow off. If it is too small, they will tend to settle. So, you allow that particular air inlet which will make a balance and you have a balanced fluidized bed. Now, in this state, if there is burning that means you introduce heat into it and you burn it, then obviously, the coal particles are not settled. They are all floating in the air. So, there is a, there will be a very high burning. That means you can ensure complete burning even if the particles are not pulverized. So, in fluidized bed you can ensure complete burning.

The second advantage is that since it is not pulverized, the flue gas does not contain all that much ash. So, it is easily taken out. The suspended particulate matter problem can be almost eliminated. All this can be taken out from the bottom as chunks of ash which can be much easily handled. So, how do you do that? The boiler earlier was like this.

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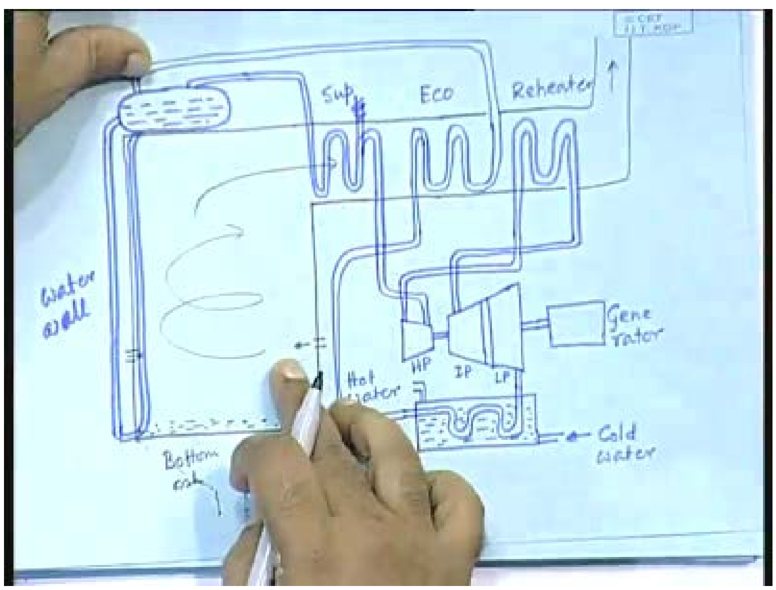

Now, the boiler is like that.

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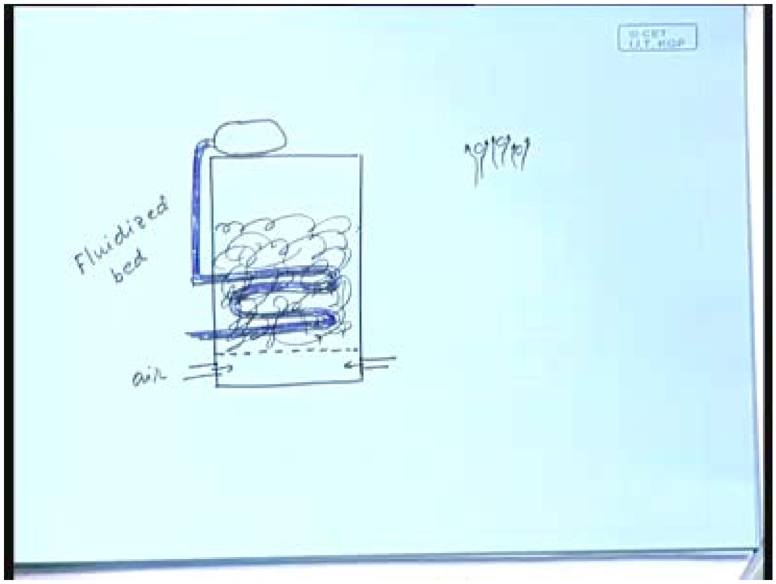

Here also there would be the boiler drum and now the difference is that, now you can bring the down comer like this and have the tubes going like this. Can you see? Let me draw. You can have the tubes inside; you can have the tubes inside the boiler. As a result, if the moment heat is generated you are taking it out, you do not allow the heat temperature to go beyond the point at which NO x forms, so the temperature here would be lesser than the temperature inside a pulverized coal boiler and you can then arrest the production of NO x. So, you can have a fluidized bed boiler in which the same effect is there. You do the boiling, but at the same time the advantage is that the NO x production is almost arrested.

If there is any amount of SO x production that means you do have some bit of sulphur, then that can also be arrested. How? Simply by mixing a bit of limestone along with the coal; along with the coal particles make the same size of limestones. What will happen? At that temperature, it will first become lime and then it will absorb any acidic vapour that goes into it. So, acidic vapor contains sulphur dioxide, sulphur trioxide, so that will be absorbed into the lime. That is another way to arrest any production of SO x. So, SO x and NO x, both are arrested by means of the fluidized bed burning.

After that the structure is the same. That means you essentially replace the actual pulverized coal boiler with the fluidized bed boiler. The rest of the structure all remain the same.

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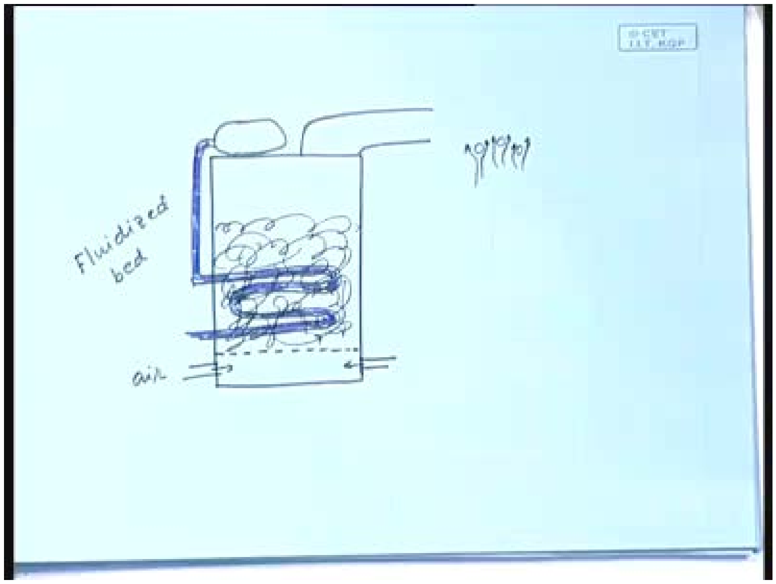

That means here the flue gas will go out and the flue gas path will contain the super heater, the reheater, the economizer, everything and it will go out. The only advantage is that, now the amount of fly ash will be far less and therefore, you can make do with a smaller size of electrostatic precipitator. So, many of the power plants that are coming up are now of this type, fluidized bed type, because we want to get rid of the problem. The other problem is, let us look at it in another angle.

There are power plants in western India especially in Maharashtra and Gujarat, where you have access to gas, natural gas from Bombay high regions. Then, you do not need the coal. What is put in here is essentially the natural gas and air mixture. So, this is a very clean system, right; very clean process. If complete burning is ensured, there will be no carbon particles, no suspended particulate matter, very clean process and what one would really like that. That is why the gas based power plants that are there in western India are much environmentally benign. The only problem that has is the NO x production problem, because the temperature is high. Therefore, NO x production is there, but nevertheless that is much more cleaner than coal based power plant.

There is one suggestion which is very interesting that is in such a fluidized bed power plant, if say you give an insufficient amount of air, insufficient amount of oxygen, what happens? Carbon monoxide will be formed. That means have you, have you studied in chemistry the concept of producer gas, water gas, those things? Yeah; if you have incomplete burning you have production of producer gas. So, that will happen here. So, as a result, what will go out of this is hot, but at the same time it is also fuel. If at that stage, you have the electrostatic precipitator and whatever small amount of coal particles are there if you can take it out, it again becomes a clean gas, gaseous fuel which you can use, which you can use in a same type of power plant that uses the gas, a very clean system and if you mix a bit of steam with that air, what happens? You get water gas.

So, the producer gas production system is exothermic, water gas production system is endothermic. So, if you have the proper ratio of air and steam as the input, then what happens? You can maintain the same temperature. There has to be a feedback control system, so that if the temperature goes up you put more steam into it, if the temperature goes down you put less steam into it, but nevertheless you can do that, right. So, what goes out is a very rich fuel, gaseous fuel.

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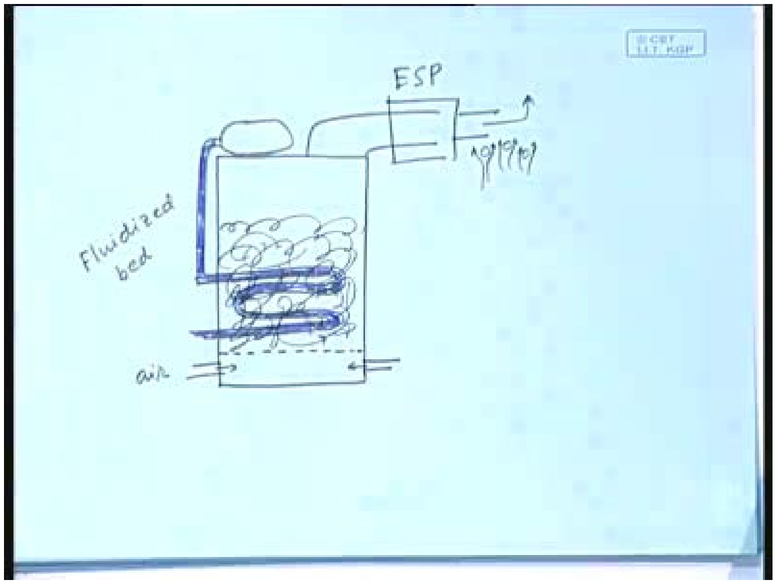

So, at that stage, if here you have the electrostatic precipitator, then what goes out is a very clean gaseous fuel obtained out of coal, right. Now that, after that you can have the same stage in a very clean way; you can have very clean way, you can have the same stage. So, when it was here, you could arrest the production of NO x simply by having the temperature below that level and you can do that by putting adequate amount of steam into it. So, NO x production is arrested. SO x production is arrested by putting appropriate amount of lime; that is also arrested. The amount of dirt that is there in the coal that means the ash that is all collected here and that does not go in the next stage; that is also a much cleaner process.

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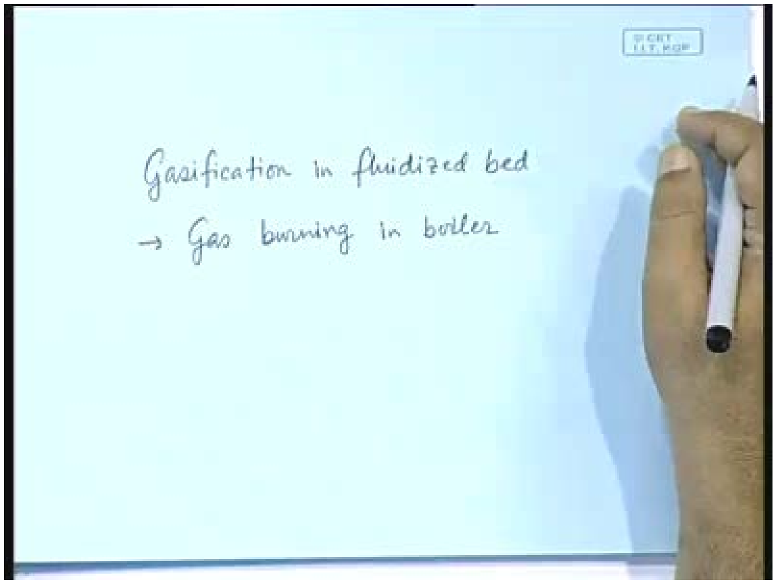

So, the coal gasification to gas burning cycle, gasification in fluidized bed, then so that becomes a more environmentally desirable, environmentally benign process, right. We do not have this kind of power plant in India as yet, but since in future you will become engineers, you should have an idea that this is the more desirable form of power plant. That is that can get rid of most of the polluting effects of coal fed power plants. So, is that concept understood? You will have the, have the same structure here, so far as the boiling part is concerned. Here the input will be the gas, gaseous fuel and air mixture and here will be a separate process, in which the gaseous process fuel is produced and that is done in fluidized bed kind of process with electrostatic precipitator not at the end here but the electrostatic precipitator goes before.

So, after the electrostatic precipitator, you obtain the gaseous fuel, clean gaseous fuel. So, that is the process that is coming up today and possibly by the time you become full-fledged engineers, you will have some, some of them. So, as far as the polluting effects of thermal power plants are concerned, let me tell you one thing that coal is a very dirty, nasty fuel. Unfortunately in India, that is the fuel we have. Many of the Middle Eastern countries have petroleum and their relatively thicker products are used for electric power generation. We do not have that luxury, we have to use coal and that is why, we, the engineers, should be aware that it is a very dirty fuel and naturally we should take, we should know what measures can be taken in order to contain its problems. So, are these clear, what are the problems?

Remember, very carefully, most people even do not know that NO x is produced. You should know; you should know that NO x is produced and how the production of NO x can be arrested. How can it be arrested, let us see. By lowering the temperature below that point and how can you do that? By using, fluidized bed; by using fluidized bed that is how you can really do that. Steam and other things are different. That is where you are doing a …, actually, I have taught in different stages, do not mix them up.

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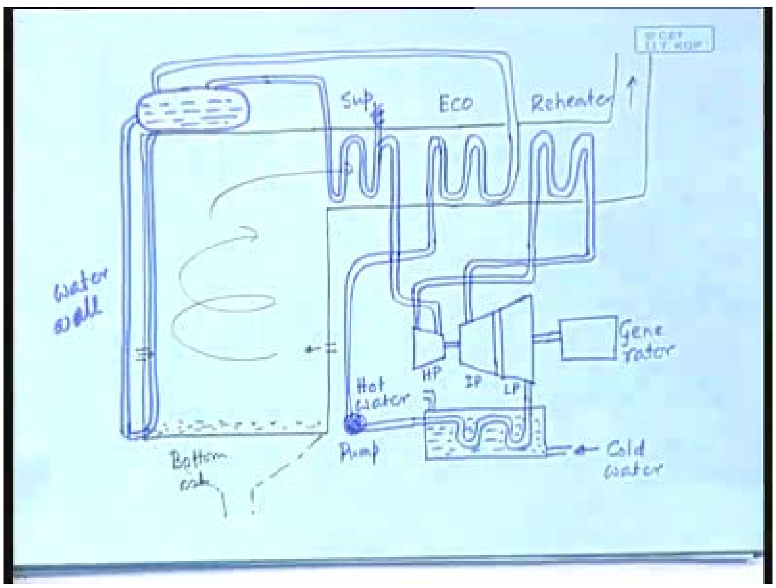

The first stage was where I talked about the actual power plant as it is today.

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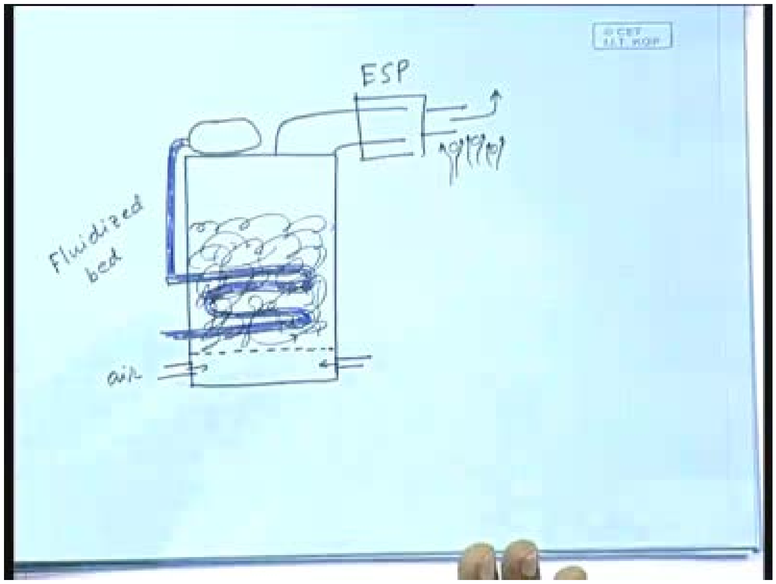

Then, I said that this can be replaced by a fluidized bed which actual does the burning of the coal. So, what goes out in that stage is simply flue gas, CO 2 and the burning is done where the tube, water tubes are inside the fluidized bed that is what takes the energy out. So, it is only a replacement of the boiler. In the third stage, I say do not mix them up, third stage I said that, now suppose we do not have the boiler here, rather the fluidized bed is used only for the production of a gaseous fuel which means the boiler drum will not be here, the tubes will not be here. Here, we will be using it only for the production of a gaseous fuel and there the temperature will be maintained by means of putting a mixture of steam, air; do not mix them up, clear.

This is much a futuristic technology; we do not have them yet. But, the fluidized bed burning is there. So, fluidized bed burning is there, so that technology is very much matured. So, we have that kind of power plants. So, what I am saying is that you can do the same; use the same process in order to produce a more environmentally benign process, where you first produce the gas and then burn the gas and the gaseous fuel can also be used for other purposes; that can be sold, that can be used for cooking. So, you can have a larger amount of gas production facility than is really required for the power plant.

Many cities earlier used to have the coal gas. All the European cities used to have the pipelines coming and they used coal gas. Have you read some of the Sherlock Holmes novels? That was used also for murdering, right, by keeping it on, right, because that contains CO, it is still there. So, that can be used for various purpose, industrial purposes; this gas can be sold and that is what is being done in some of the places, like in West Bengal there is one facility in Dankuni, where this system is there to produce gas and to sell the gas, but it has not really found favor with the consumers even though its it costs less than the LPG. So, that is all about the class today.
Thank you.

That is all about the class today, remain here.