Thermal Engineering: Basic and Applied
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Lecture - 23
Cochran Boiler Operation, Boiler Attachment

I welcome you all to this session of thermal engineering. And today we shall discuss about the operation of the Cochran boiler. So if we recall, in the last class we have discussed about the Babcock Wilcox boiler. We have seen the working principle of the Babcock Wilcox boiler. We have also seen that there are different cycles of two streams. And finally, we have discussed about the objectives rather functionalities of the components, which are there in the Babcock Wilcox boiler. So today before going to discuss about several other issues related to the operation of boiler, let us first discuss about the Cochran boiler.

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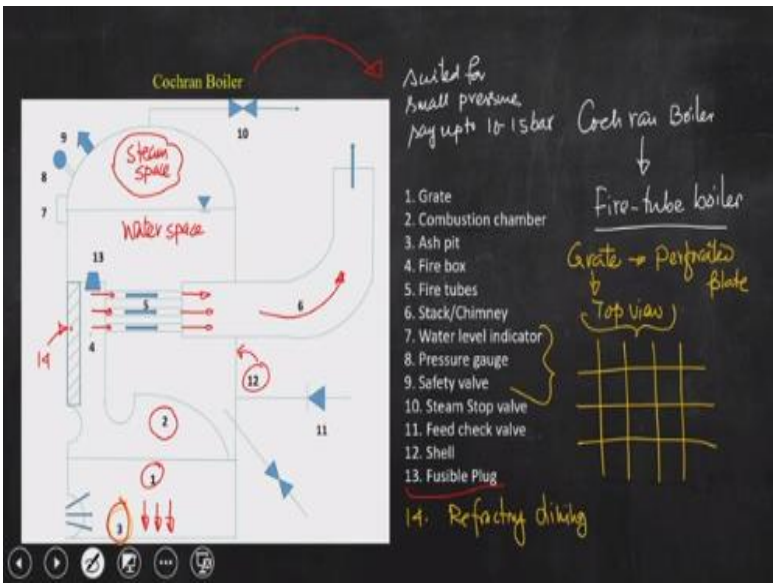

So I am not going to discuss again, because we have discussed the importance of boiler in the steam power plant. We all know that this is the device which is used to produce steam and while steam is getting produced in the boiler, we need to supply heat by burning either coal or other fuels. So Babcock Wilcox boiler is a water tube boiler, because water is allowed to pass through the tube and the flue gas or the high temperature products of combustion flow through the cell.

But in the slide we have shown the boiler which is called as the fire tube boiler. So Cochran boiler is a fire tube boiler. So from the name itself that is the fire tube, we can understand that the hot flue gas will pass through the tube while water will be allowed to pass through the cell. And when these two different streams are allowed to pass, they will exchange heat and water

will be converted into steam upon taking heat from the high temperature products of the combustion that is the flue gas.

So similar to what we have done in the previous class, let us first identify the flow direction of both water stream and the flue gas stream. So there are several components. I have tried to label those components in the boiler itself and I have also listed down the name of the components. We can see that the boiler is having hemispherical roof. Here in the diagram, you can see that 1 is grate. In the last class when we have discussed about Babcock Wilcox boiler, we have seen the chain grate stocker. So there chain itself is acting like a grate. Grate is nothing but a plate which is perforated. So if we try to have a look at the top view of this particular component, it would be clearer to us.

So if we take a top view that grate looks like as shown in the slide. Why it is like this? I mean do we have to fabricate this perforated plate? Yes, because when coal is taken over this plate, coal should be allowed to be in contact with the air for taking oxygen from the air which will be supplied for the combustion to get completed. So only to make sure that sufficient amount of oxygen will be made available during the entire combustion process, the plate on which coal is taken for the combustion is perforated. So the air will come from the small holes which are there in the plate. So I hope you understood the objective behind this perforation.

Now you can see the ash pit labeled as 3. So when the entire combustion will be completed in the grate, then there will be the ash deposition at the ash pit, 3. 4 is fire box that is shown in the diagram. Then there is the combustion chamber. So entire combustion should be completed within this chamber. Then the flue gas which is produced because of this combustion will be directed to move towards the top of this device and that is why this particular arrangement is there. The sole purpose of this arrangement is only to direct the hot flue gas towards the top of this device and it will go through 4 and eventually it will move in the right direction through the pipes which are shown in 5.

So you can see there are 3 different tubes and these three tubes are the fire tubes. So depending on the requirement, the number of tubes that will be there in a boiler is selected. Now the flue gas is allowed to pass through the tube and surrounding the tube, there is a cell, through which water will be allowed to pass.

So you have studied in heat transfer course that this is a kind of cell and tube heat exchanger. Now water is coming in contact with the pipe and the outer surface of the pipe is having high

temperature. And because of the heat exchange phenomenon, water will be converted into steam.

So in this fire tube boiler, most importantly you can understand that hot flue gas passes through or is allowed to pass through the tube and water is passing through the cell. So the amount of steam, which is getting produced because of taking heat from the hot flue gas, will be in equilibrium with the water that is there in the cell. And the consequence is that steam that we are going to get from this particular type of boiler is always wet steam.

So the steam, we are getting in a Cochran boiler is always wet steam. But if we try to recall what we have discussed in the last class that in a Babcock Wilcox boiler, if we can somehow increase the length of the tube, we may get superheated steam. In such a case, it is not necessary that we should have separate arrangements like superheaters that is convective superheater and radiative superheater. But in case of a Cochran boiler, it is very unlikely that we are going to get superheated steam because steam produced will be in equilibrium with the water that is there in the cell, and as a result of which we will always be getting wet steam. So this is one of the disadvantage of this particular type of boiler.

Another important aspect is there, let me discuss that here only. So the tubes are there only for the flue gas to flow, while water is taken through the cell. Now you have understood that boiler is a device which is operated at a high pressure. So that means, steam that we are going to get from the boiler will be having high pressure. If we need to have high pressure steam from a Cochran boiler, then the cell diameter will be very high and the thickness of the cell should be very high. That means, if the cell needs to withstand that high pressure, diameter as well as its thickness should be very high. Now if the thickness and diameter are very high, it is very difficult to accommodate such a larger as well as bulky cell in a boiler, as it will invite another problem from the maintenance as well as initial installation point of view. Accounting for this particular issue, this Cochran boiler is typically used for an application where pressure should be restricted to 10 to 15 bar. So this is very important that the Cochran boilers are suited for small pressure up to 10 to 15 bar only.

Why? Because I have already explained that since steam is produced in the cell and cell should be able to withstand that high pressure of steam, so the diameter as well as thickness of the cell should be very high. So these two are the two different disadvantages of this particular type of boiler.

So now coming to the remaining components, so there are the fire tubes labeled as 5. 6 is stack/ chimney. You can understand that all these pipes are connected between two ends. In one end that is 4, the fire box, through which flue gas is coming into the pipe and other end of the pipe is connected to the chimney. I mean for all pipes, the ends are connected. So outer ends are connected to the chimney from where flue gas is taken out.

So two things we have discussed till now. First of all, we cannot produce superheated steam using a Cochran boiler. The reason is steam which is getting produced is in equilibrium with the water. So the steam that we are going to get from this boiler is always wet steam. Second thing, since the high temperature products of combustion or the high temperature flue gas is allowed to pass through the tube and water through the cell, so to withstand the high pressure of steam, cell diameter as well as the thickness of the cell will be larger. Hence the system will be bulky and it may not be always possible to accommodate such a bulky arrangement inside the boiler because of the space constraint. And as a result of which we need to restrict the application of these types of boiler typically to the pressure which is 10 to 15 bar.

Next is water level indicator, pressure gauge and safety valves. So about these three, I have discussed in the previous class in the context of Babcock Wilcox boiler. So these three are basically provided only to increase the safety of the boiler as well as its operator. As someone will be there to operate the boiler so his/her is very important part, and so is the safety of the boiler. Because if pressure increases beyond a threshold value, then all components will start to malfunction, together with that the cell will rupture. So considering the safety of the boiler as well as its operator, these components are integrated.

So as I told you, the objective of placing a water level indicator is to always check the water level in the drum. If water level falls below that particular level, then it is a kind of indication for the operator to take special or preventive measure. Because if water level falls, that means the entire space will be automatically occupied by the steam then all components will be you know exposed to that high temperature steam. And that particular temperature may lead to the generation of thermal crack and the components will start malfunctioning and the lifetime of the components will reduce. So water level indicator is there only to indicate that the drum is having constant water level.

If this particular boiler is suited for 10 to 15 bar application, so the pressure gauge will give us a reading that this boiler is operating at a particular range. So this particular water level indicator is an added safety that is provided so as the pressure gauge. If water level falls, pressure will automatically increase. So that is an indication. So these two components, pressure gauge and

the water level indicator, are responsible to check the pressure inside the boiler. And safety valve labeled as 9 is given, because in any case if water level falls, pressure will increase, so the operator will be in a position to open the valve to remove the steam from the boiler essentially to save the boiler from the expected accident.

Next is steam stop valve. So you can understand, there is basically steam space and water space as shown in the slide. As steam being lighter than water, steam will be collected at the top of the water. And the collected steam will be taken to the turbine through the steam stop valve. Number 11 is feed check valve and 12 is the cell. I was talking about this cell that if pressure increases in the boiler that cell may rupture. So this is not expected. I mean that is why 7, 8 and 9, these three components are provided to increase the safety of the boiler as well as the operator of the boiler.

Feed check valve is labeled as 11. Basically you can understand, this entire space is filled with water and that water is coming from a feed water pump. You know basically from the condenser, we collect the condensate and that condensate is pumped back to the boiler using a feed water pump that we have studied earlier. So when that water is pumped to the boiler, this feed check valve is provided. The feed check valve is a one way valve, so it allows water to go only into the boiler but it does not allow that high temperature water to go back to the pump. So this is a kind of one way valve.

And number 13 is basically very important component that is called fusible plug. Before that let me discuss about this particular component I would like to mention over here that called refractory lining. So this refractory lining is labeled as 14. See, basically you can understand that the high temperature products of combustion or the flue gas is coming from the combustion phase to the fire box. So high chances are there that through this place, heat will leak from the boiler. In fact, in the last class, I have talked about the boiler efficiency. So you can understand by burning fuel, whether it is a coal fired boiler or diesel fired boiler, we are providing energy to the boiler. At the cost of that input energy, we are going to get some amount of change in enthalpy of the working substance and water will be converted into steam.

Now in this process, if sufficient preventive measures are not taken, then that heat, which is coming out from the combustion product, will leak from the boiler surface. And that is why this lining is given, so that this particular layer acts like an insulator and it does not allow heat to go out from the boiler.

Now let us briefly discuss about the two different cycles. One is hot flue gas cycle and other is water steam cycle.

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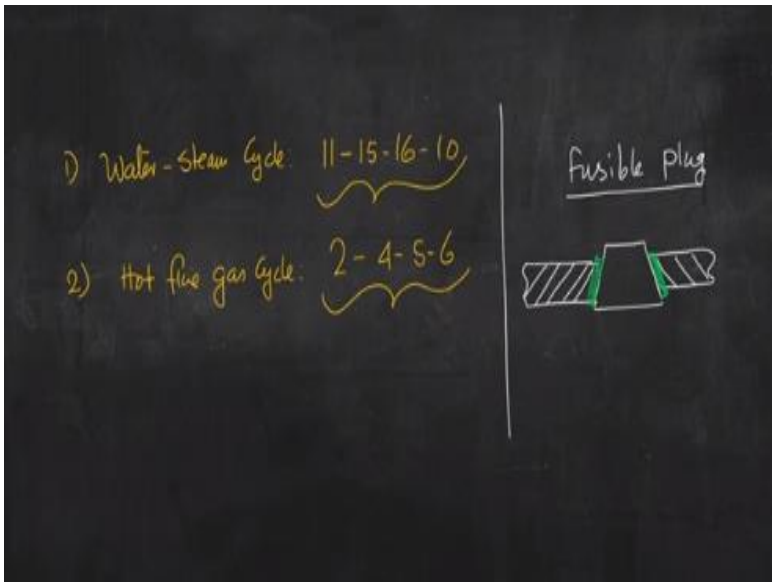

So it is very important to understand the flow path of these two different streams. The hot flue gas is coming from combustion space to the fire box, then goes through the fire tubes and ultimately comes out through the chimney to the surroundings. So 2-4-5-6 is the hot flue gas cycle. What about water steam cycle? You know that here we have seen that this entire space is filled with water. I mean this water is coming from this feed water line and the water is allowed to pass through the cell. The steam which is getting produced is collected at the top of the water surface.

So basically water is in the cell, steam is produced and that steam is collected at the top then finally that steam goes into the turbine through steam stop valve. So I can label 15 as water space and 16 as steam space as shown in the slide. So basically 11-15-16-10 is the water steam cycle. So this is not only water cycle because initially up to 15, it remains as water, but when it is coming to 16, it is steam. So this is water steam cycle.

Now let me briefly discuss about the fusible plug. So this particular component fusible plug has been drawn separately in the slide. From the name itself you can guess that it will fuse. Let us see what it will fuse. So in the diagram of the fusible plug, the fusible material is shown using another color.

So let me discuss what the purpose of this is. Say water level indicator is not functioning properly. So it is very difficult to understand by an operator, what is happening inside the boiler. If water level indicator is not working perfectly well and if water level falls, because of any

reason, what will happen? So the steam, which is collected at the top will try to occupy the water space that is 15. So the reduction of the water level inside the boiler may be because of any reason like maybe the feed water line is not working properly. So as I told you, it is not advisable that all these components will be exposed to high temperature steam.

If it is the case, then at that high temperature, there is a possibility of having the thermal crack in the components and that is very detrimental for the boiler operation as well as for boiler safety. And if water level falls and it goes below 13 then this particular plug will be in contact with the high temperature steam. Now this plug is welded to a material that has low melting point temperature. So when the plug is in contact with high temperature steam, that material will melt and this plug will drop. If the plug drops then it creates an opening for steam to go into the combustion chamber.

So let me tell you again. So the water level is reduced, steam has occupied the water space, this particular component plug is now in contact with the high temperature steam. As this component is welded a wall using a low melting point temperature material, that material will melt and this plug will drop. And when the plug drops, we are getting an opening and through that opening the steam will occupy the combustion chamber and the steam will try to arrest the further combustion that is going to happen. If combustion stops then perhaps boiler can be saved from an undesirable accident. And the function of this fusible plug is to again provide additional safety to the boiler operation.

So to summarize today's class, we have discussed about the operation of the Cochran boiler. We have tried to find out the disadvantages feature of this particular boiler in the context of the steam power cycle. Then we have discussed the objectives of all the components which are there in this particular type of boiler. So with this I stop here today, and we shall continue our discussion in the next class. Thank you.