Thermal Engineering: Basic and Applied
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Lecture - 24
Boiler Attachments

I welcome you all to the session of thermal engineering, basic and applied. And today we shall discuss about the boiler attachments. If we try to recall in the last two classes, we have discussed about the fire tube and water tube boilers and we have seen the working principle, rather the operation of the boiler in particular. Since boilers are used to generate steam, we had identified two different streams cycles, steam water cycle and another one is the coal and products of the combustion cycle.

In the context of the boiler attachments, we shall try to group those components into two different categories. One is known as mounting and another is known as accessories.

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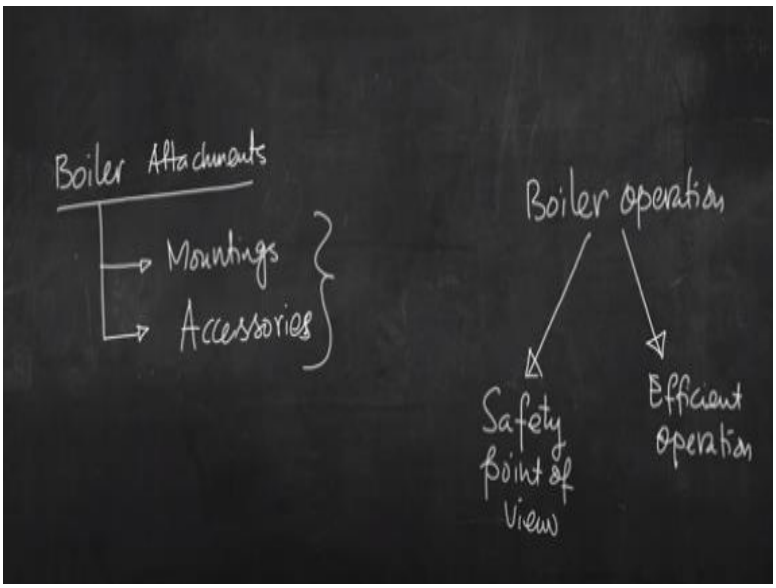

So boiler attachment and this is having sub classifications; mountings and accessories. So you can understand that the components, which we have discussed in last two classes are essential for the operation of the boiler. Now we shall try to figure out which components are responsible for the safety operation of the boiler and which are not directly related to the safety of the boiler and its operation, but still those components are required for the efficient operation of the boiler. So now let us discuss about this part briefly.

So when we talk about boiler operation, all these components are attached to the boiler essentially to ensure that boiler operation is safe. So from safety point of view, a few

components will be needed. And for the efficient operation of the boiler, we will also require a few components.

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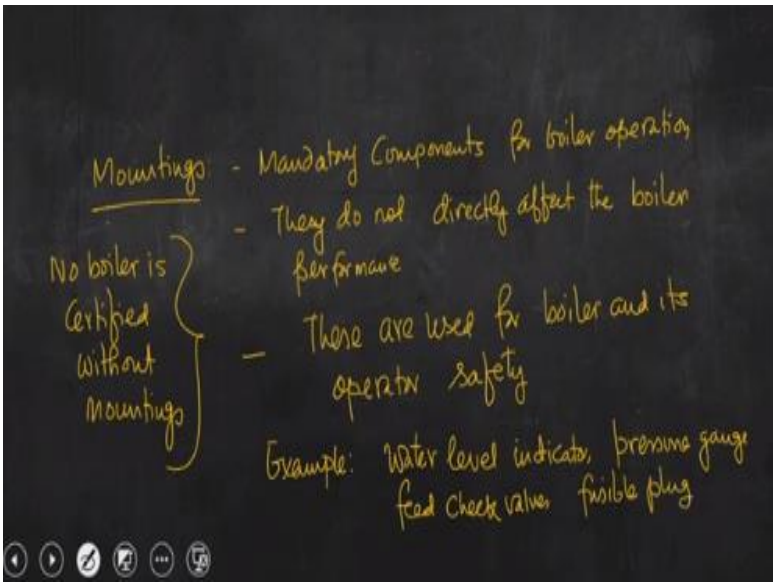

Mountings are mandatory component for boiler operation. These components do not directly affect the boiler performance. But as I told you so there are a few components which are mandatory components for the boiler operation and without these components no boiler is certified. So no boiler is certified without mountings. Basically, a boiler should have all these components. These do not directly affect the boiler performance but these components are used for the safety of boiler and its operator. Examples of mountings are water level indicator, pressure gauge, feed check valve, fusible plug etc. So all these are the mountings. One important thing is, though these components are not needed as they do not directly affect the boiler performance, but still these are required. Because we need to ensure that safety of the boiler as well as the operator of the boiler, when boiler is in operation. And to ensure that mountings are mandatory and no boiler is certified without mountings. Next we are going to discuss about accessories.

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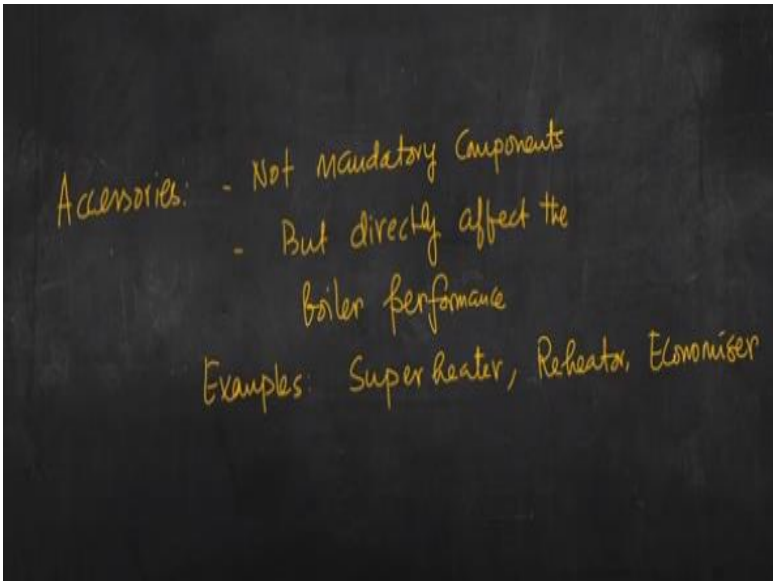

Accessories are not mandatory component. But these components directly affect the boiler performance. As these are not mandatory so a boiler can be certified even without accessories. But these particular components are needed because they directly affect the boiler performance. So earlier we discussed about classification of boiler attachment. We have also discussed about several components of the fire tube and water tube boilers. Out of these components, a few components can be grouped together and are known as mountings while the remaining set of components can be grouped together under this particular group known as accessories. So this classification is based on the fact that a few components in the boiler directly affect the boiler performance.

So basically these are needed essentially to ensure that the operation will be efficient. Why? Because we are supplying water and our main purpose is to convert water into steam. In particular, if we try to recall the thermodynamic cycles that we have studied, we should try to get superheated steam from the boiler. So to ensure that, water which is circulated through the boiler should be converted into superheated steam. And this particular aspect is very much needed to be looked at and that is called efficient operation. While safety operation is also important, because boilers are normally operated at a high pressure. And boiler is essentially a kind of closed vessel type device, so to ensure the safety of the boiler most importantly the safety of the boiler operator, a few components are attached to the boiler and those are known as mountings.

So superheater, reheater, economizer are basically known as the accessories. So these components directly affect the boiler performance. You can see that from the name itself. For example superheater; we have discussed that there are convective superheater and radiative superheater. These two superheaters are placed inside the boiler and the entire purpose of

placing these components is to get superheated steam. And that means we are trying to increase the efficiency of the boiler.

Similarly reheater; we have discussed about the reheat cycle. The entire purpose is to have the entire expansion of the steam into two different stages of turbine that is high pressure stage turbine and low pressure stage turbine. So after doing some amount of work, steam is taken again into the boiler and the steam is allowed to pass through the reheating coil, so that steam temperature is again increased and then it is taken to the low pressure stage turbine. So the reheater is again another accessories which is needed to increase the efficiency of the cycle.

And finally economizer, though this word I am introducing today, I will discuss today the purpose of this particular component in the context of the boiler operation. So these are the accessories. So now let us briefly discuss about the accessories.

So we have discussed about the superheaters that whether it is a convective superheater or radiative superheater, these two superheaters are placed inside the boiler. The steam which we are getting from the boiler is saturated. Even if it is saturated steam, we need to take that saturated steam through the superheaters to get superheated steam at the exit of the boiler.

Now let us briefly discuss about the economizer. So we have seen in the boiler that the coal is taken to the combustion chamber wherein in presence of air combustion takes place. So it is because of this combustion, we are getting flue gas which is having high temperature. The flue gas is taken either through the tube or the cell depending on the type of boiler, where the flue gas exchange heat with the water stream. And upon releasing heat, flue gas is taken through the stack and from there it goes to the surroundings.

But it is very essential that exit temperature of the flue gas should not be very high. Why? There are two different reasons for that. First is that if release high temperature flue gas from the boiler, then it will increase the temperature of the surrounding air. So it is not allowed because of the environmental issue. On the other hand, we are getting the high temperature flue gas at the cost of some input energy, I mean by burning coal. So the objective should be to utilize the temperature of the flue gas to the maximum extent possible inside the boiler, so that the entire process should be efficient. So basically the process efficiency will increase which in turn will increase the efficiency of the boiler.

So the objective should be not to release flue gas which is having high temperature because of this environmental issue. And second is the temperature of the flue gas should be utilized to

increase the temperature of water, even temperature of steam. Temperature of water will be definitely increased, so that it will be converted into steam. And finally temperature of the steam will also be increased, so that we will be getting superheated steam. And this utilization of temperature of flue gas should be as high as possible, so that we can increase the efficiency of the process.

One way definitely we will be utilizing the temperature of flue gas to increase the temperature of steam which is coming out from the boiler. Another way of utilizing the temperature of hot flue gas is the use of economizer. Let us briefly discuss about it.

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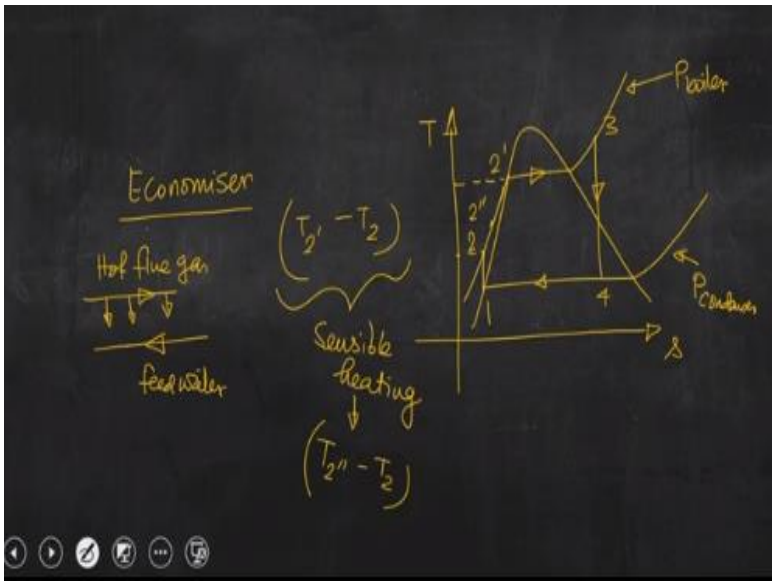

Economizer.

This is basically a type of heat exchanger and the entire purpose of this device is to increase efficiency. So if we try to draw the T-s plane, then we can plot the state points 2, 3, 4 in it. So there is $P_{condenser}$ and P_{boiler}. So you know that, this 1 is basically at the exit of the condenser and that is the saturated liquid. And that is pumped back to the boiler and this 1 is the inlet condition of the working substance before it enters into the boiler. Now 2-2' with corresponding temperature T_2 & $T_{2'}$ represents the amount of sensible heating is required initially.

So the idea is that, if we can use the flue gas temperature, which is otherwise be leaving from the boiler, then that heat can be utilize to increase the temperature of feedwater, so that this amount of sensible heating can be reduced. So there is hot flue gas and we also can take another stream that is feed-water. So whether these two streams will be taken following a counter flow arrangement or parallel flow arrangement is again an important issue. But the main idea is to

utilize the temperature of hot flue gas and that temperature will be taken by the feedwater so that we can increase the feedwater temperature from 2-2". And that is done using, by using another device which is known as economizer.

So economizer is again a type of heat exchanger in which these two streams are allowed to pass either following counter flow arrangement or parallel flow arrangement depending on the requirement. But the main purpose is to utilize the temperature of hot flue gas which is leaving from the boiler. And our objective should be to increase the temperature of feedwater by taking that heat, before it enters into the boiler.

So if we can increase the temperature now up to 2" before it enters into the boiler, then perhaps the sensible heating will be now $T_{2''} - T_2$. So basically the amount of sensible heating required given is getting reduced with the fact that all other conditions are remaining same, so we can increase the efficiency of the boiler. And that is why the word economizer is coming. That means, you are trying to economize the entire process. So this is all about the economizer. We can see from today's discussion that we can utilize the high temperature of the flue gas to increase the temperature of feedwater with an objective of economizing the process. So this is another way of utilizing the high temperature of the flue gas.

Another possibility of the utilization of the high temperature of the flue gas is to increase the temperature of air and that is called air preheater. So in this context, let us briefly discuss about air preheater.

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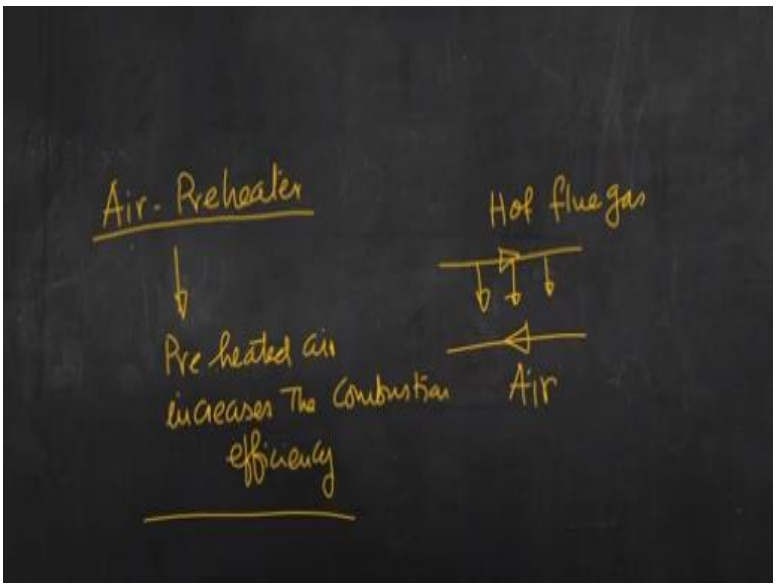

Air preheater

You know that air is essential for the combustion of the coal. So when coal is taken inside the boiler, we also need to have arrangement so that sufficient air will be allowed to go therein to have efficient combustion. So when air is taken for the combustion of coal, air is preheated again by having one arrangement. Here, the temperature from the hot flue gas will be utilized to increase the temperature of air so that heated air can be now taken for the combustion of coal. Using this process the combustion efficiency will be increased. So this is another way of utilizing the temperature of hot flue gas before it goes out from the boiler.

So basically this preheated air increases the combustion efficiency. By how? You know that if we supply preheated air for the combustion of coal, then the moisture which is there in the coal will be taken by this heat or high temperature air, so that the combustion process will be more efficient. Or we can say the overall efficiency of the combustion process will increase.

And that is how this particular process works. So this is the air preheater and finally coming to the superheater and reheaters.

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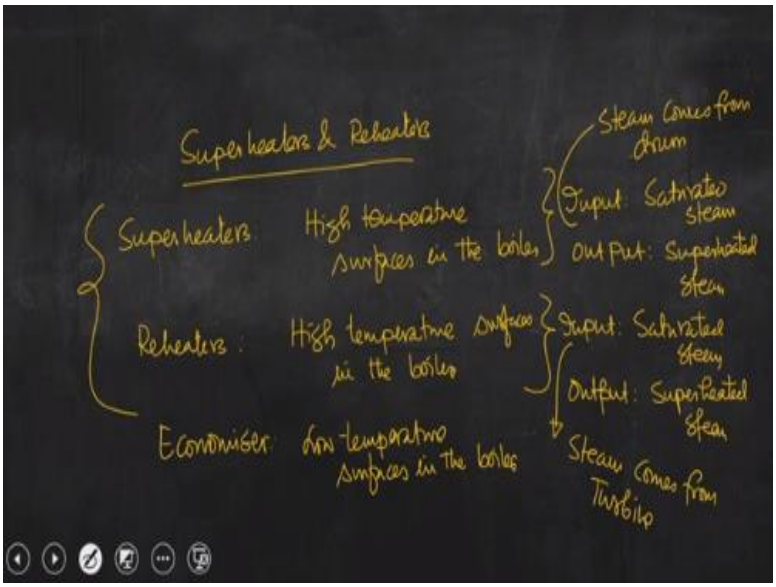

Superheaters and reheaters

So these superheaters and reheaters are the high temperature surfaces in the boiler. You know that for the superheater, input is saturated steam, it can be either dry saturated steam or wet saturated steam, but output is superheated steam. For the reheaters, if we try to recall, after doing some work, steam is taken to the boiler and steam is allowed to pass through the reheating coil. So input is again saturated steam but output is superheated steam. So basically for the

reheater, the saturated steam is taken from the turbine. So this is the difference. For superheaters, the steam comes from drum.

And finally this economizer that we have discussed in the last slide, is the low temperature surfaces. Because after releasing heat to the water and again to the saturated steam, the temperature of the flue gas is again further extracted to increase the temperature of feedwater in the economizer. So superheater, reheater and economizer, all are surface heat exchanger. But the temperature at which these devices are working is not the same. So superheaters and reheaters are basically high temperature surfaces and economizer is the low temperature surfaces in the boiler. And basically all these are attachments.

We shall be now discussing about the superheaters because superheaters play a crucial role for the overall efficiency of the plant, as the entire objective is to get the superheated steam. But before going to discuss about the classification of superheater and their arrangement, let us also briefly discuss about another two different types of attachment, called as regenerative heaters.

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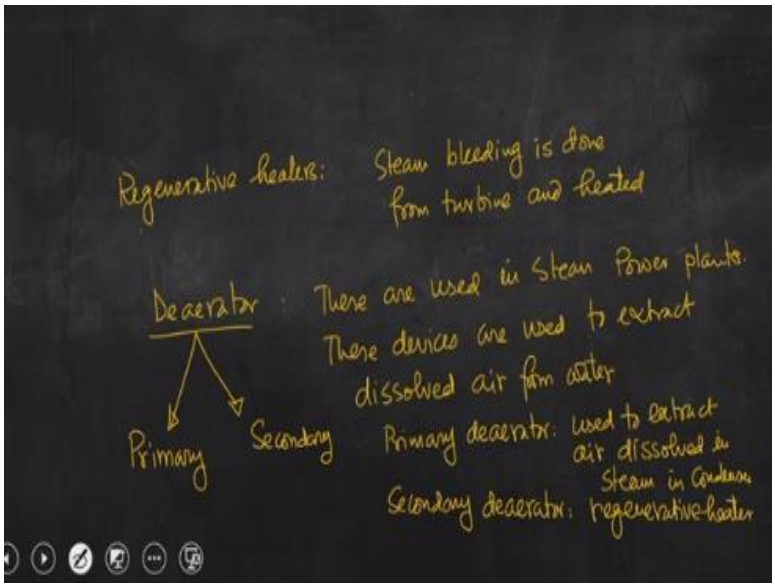

Regenerative heaters

I am discussing about this because we are discussing about the boiler attachments. So we have discussed about closed type feedwater heater and open type feedwater heater. Again whether it is open type feedwater heater or it is a closed type feedwater heater, it is essentially a type of heat exchanger in which two different streams are allowed to pass. In an open type, these two streams mix together in that particular device. In the closed type, two different streams are not

allowed to mix together. So in these regenerative heaters, steam bleeding is done from turbine. And finally, another one another important attachment is deaerator.

Deaerator

Now I am first time introducing this word deaerator. You can understand from the name itself that it is used to de-aerate that means to remove air. But to remove air from where? So deaerator are used in steam power plants and these devices are used to extract dissolved air from water. This deaerator is classified into two different categories. One is called primary deaerator, another type is called secondary deaerator.

Primary deaerator

We have discussed in the condenser that we are taking air, and also the coolant. And condenser are operated at a pressure which is less than the atmospheric pressure. So chances are there of having air leakage into the condenser. If air leaks into the condenser and if it mix with the condensate, then that deteriorates the condenser performance. I shall be discussing this in one of the classes of this particular course. But this dissolved air should be removed from the condenser, otherwise chances are there that in the condenser, heat transfer rate will be affected. And if the dissolved air is again pumped back to the boiler then that air will try to create another problem from the operational point of view. So basically the primary deaerator is used in condenser. So primary deaerator used to extract air dissolved in steam in condenser.

Secondary deaerator

You know that we are bleeding steam from the turbine and that steam is now allowed to mix with the condensate which is pumped. So by mixing these two different streams we can remove air. So secondary deaerator is a regenerative heater. So that means, the air is present in the condensate, as I told you that condensers are operated at a pressure which is less than atmospheric pressure. So chances will be there of having air leakage into the condenser. If air leaks into the condenser that air will disturb the heat transfer. It will affect the heat transfer performance by having a thin film appear in the condenser tube. And not only that, if air dissolves with the condensate that will again create a problem when that condensate is pumped back to the boiler.

So you know our objective should be to remove air which is dissolved in steam in the condenser and primary deaerators are used to serve that particular purpose. And secondary deaerator basically regenerative heater. So condensate which is coming from the condenser is still having some dissolve air within it. So to extract that dissolved air, steam is extracted or bleeded from

the turbine and that steam, which is bleeding from the turbine is allowed to mix with this condensate and the extracted air is removed. So basically secondary deaerator is a regenerative heater. That we have discussed in the context of open type feedwater heater.

So next we will discuss about the classification of superheater and also we shall see the different types of superheaters used typically in the boiler and their arrangement. We shall discuss this particular aspect in the next class.

To summarize, today we have discussed about the boiler attachments. We have tried to discuss about the objectives of several components which are attached to the boiler. These components can be grouped together and one particular group is known as mountings which are mandatory components. No boiler is certified without mountings, though these components do not directly affect the boiler performance. But these components are essential for the safety operation of boiler as well as its operator safety.

Another few components can be grouped together and this particular group is known as accessories. Though accessories are not the mandatory components, but these components directly affect the boiler performance. And so these components are very much needed because our objective should be to increase the process efficiency.

Then, we have discussed about the accessories like superheaters and reheaters. We have introduced economizer, which is again another important device in the context of boiler operation. And finally, we have discussed about the regenerative heaters and deaerator because these devices are again important for the complete operation of the boiler.

So with this I stop here today, and we shall continue our discussion in the next class with the classification of superheater and their operations. Thank you.