Power Plant Engineering
Prof. Ravi Kumar
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 04
Fossil Fuel Steam Generator II

Hello, I welcome you all in this course of Power Plant Engineering. We will continue to discuss today, the Fossil Fuel Steam Generators and specifically today, we will discuss the high pressure boilers. So, high pressure boiler is a topic to be covered today. Now, there are many benefits of the high pressure boilers and nowadays in the industries high pressure boilers are used.

As, I told you in the previous, in my previous lecture, the high pressure boilers are mainly water tube boilers. They are mainly water tube boilers. They have a very high efficiency, the high pressure boilers have efficiency more than 90 percent and nowadays green boilers are also there. The green bottles have efficiency more than 98 percent.

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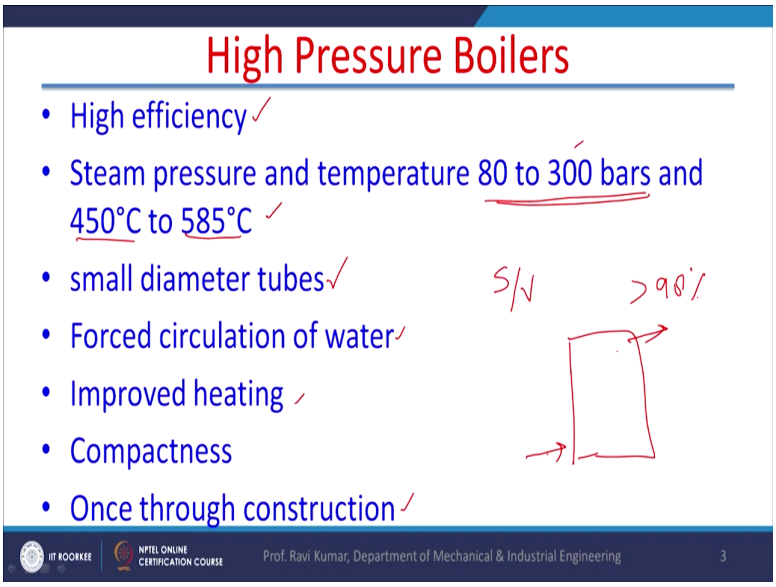

So, the green boilers, they have efficiency more than 98 percent and very low level of NOx solution to the surroundings. Regarding the pressure and temperature as I said earlier high pressure boilers have pressure more than 80 bar. So, the pressure varies from 80 to 300 bars and a temperature of steam 450 to 585 even it exceeds 600 degree centigrade. So, high pressure boilers have you can have the temperature of steam up to 600 degree centigrade, pressure up to 300 bars.

So, it can go up to 300 bars. Normally it is between 200 250 bars. They have a small diameter tubes. The smaller diameter tubes are taken for this boiler for a purpose because when the tube diameter is small, then surface to volume ratio is high. When surface to volume ratio is high, more heat interaction will take place between flue gases and the water which is flowing inside the tubes.

But at the same time if you take a smaller diameter tube, more pumping power will be required; more power will be required to pump the fluid through the tubes. But at the same time the more heat transfer will be there. There is force circulation of water inside the tubes in high pressure boilers. Heating is high, there are several arrangements. So, that there is an improved heating in the boilers. They are compact, some of the high pressure boilers do not have any drum.

So, drum constitutes a considerable amount of mass in the boilers. So, when there is no drum, at least 15 to 20 percent of the mass of the boiler is reduced. So, some of the boilers do not have any drums; so, they are compact. And, some of the boilers are once through construction, once through construction means in the boiler house steam is a water is a feed water is entering from one side and steam superheated steam is leaving from another side. So, these type of boilers are known as once through boilers.

We will start, we will take some classical high pressure boilers.

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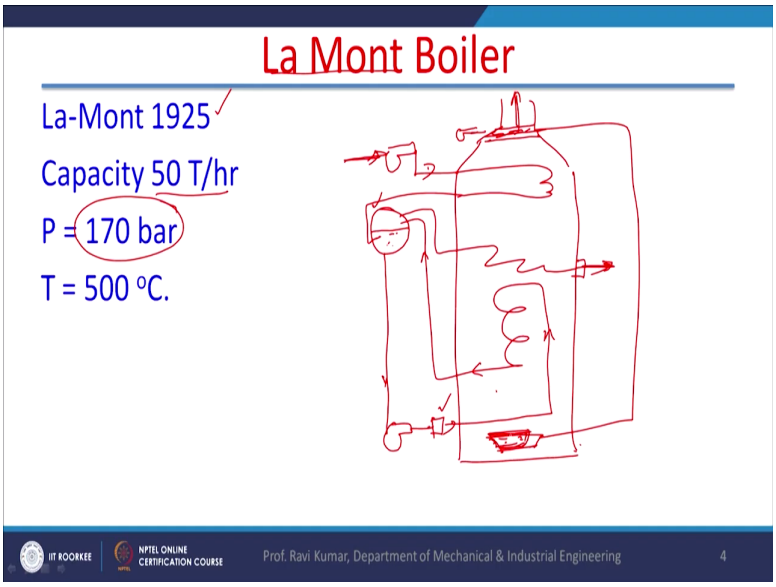

So, the most popular boiler is La Mont boiler which was introduced in 1925. The steam generation capacity of La Mont boiler is 15 tons per hour, pressure is 170 bar and temperature it can it take up to 500 degree centigrade. In a La Mont boiler, there is a boiler shell right and it narrows down from the top and this is the place for flue gas to leave the boiler. And, fuel is burned at the bottom of the boiler in fire wait.

So, there is a fuel burning place here, these are the fuel burns. There is a drum in the boiler, any drum there is a stratification, bottom side is occupied by water, top is occupied by a saturated steam. From drum, this water this is known as feed water. Feed water is sent to the boiler with the help of a pump. So, there is a pump here and there is a header. I am showing only one tube, but there are several tubes.

So, there is a header here, distribution header here. After distribution header, the water enters the boiler right and the wall of the boiler is covered with the firebrick. So, there is no heat transmission to the surroundings right. The water when enters so, from header then it is going to the drum. So, movement of the fluid is like this right. When the water enters the boiler, the heat transmission to the fluid is by radiation heat transfer.

In high pressure boilers, the 60 to 70 percent heat transmission by radiation heat transfer right. After radiation, heat transfer there is convective heat transfer here. Convective transfer between the flue gases and because this because the when the fuel is burning here, the entire area is filled with a flue gases hot glue gases. So, first the water entry into the boiler it is. It is actually tubes are embedded in the wall of the boiler this tubes. I am just showing the schematic otherwise when the water is entering the boiler, the tubes are embedded in the wall of the boiler and heat transmission is by radiation not by a convection right.

When the tubes, when the flues when the water reaches here and then in this zone, the convective heat transfer takes place. In this zone, the convective heat transfer takes place right then, again I will have to use erase. Now after taking convective heat, the steam enters the drum where separation of water and steam takes place and it is a closed cycle right.

Now here, now we want superheated steam from the boiler. So, again the steam is taken from here and there is a super heater and from here, we get there is steam supply port and from this side superheated steam is supplied. So, again the steam is passed through the flue hot flue gases. So, that it can trap heat for the flue gases and get converted into the superheated steam and still after superheating there is a lot of heat is going with the flue gases, it has to be trapped.

So, there is an economizer, economizer is an accessory, but now in high pressure boiler, it is almost essential part of the boiler. Now what economizer does? Now, the hot gases which are going with the hot sorry the heat which is going with the flue gases can be trapped by feed water. So, this heat which is going to with the flue gases, there is a suppose there is a pump feed water pump and this feed water pump feeds the water in this area.

Now, when it is feeding water in this area, the feed water gets heated. So, that is an advantage. Suppose to the boiler, we are supplying feed water right 25 degrees centigrade. Now, with this economizer the temperature can be increased from 25 degrees centigrade to 70 degrees centigrade. So, that is the amount of equivalent amount of heat will be saving while converting water into the steam.

So, the water instead of supplying water to the boiler here at 25 degrees centigrade, we are supplying water at 70 degree centigrade. So, again there is a closed loop here and water is coming and the feed water is coming from this side. So, this is economizers. So, after connective heating, there is a coil which is economizer coil and the purpose of economizer is to heat the feed water with the help of flue gases.

After the economizer still there is a lot of heat which is going out of flue gases because purpose efficient desire of the boiler is more and more, how much amount of heat we can try from the boiler. Now, here air preheater is required provided. Now, the purpose of air preheater is to preheat the air. So, air is circulated in the preheater and this hot air is emerging from this side. Suppose there is a fan or the blower in this side and the hot air which is emerging from this side is supplied to the combustion chamber right for burning the fuel.

Reason being this heat which is coming with the hot air; suppose, we are using normal atmospheric air at 25 degrees centigrade for burning the fuel that is case 1 and the case 2. When this hot air is also which is hot air maybe at let us say 100 degree centigrade or120 degree centigrade, this hot air is also; this hot air is used in the second case this hot air is used for a burning the fuel. So, definitely in the second case trapping of heat is more.

So, basically the purpose of this arrangement is to trap the heat. First the water is entering in the shell, radiation heat transfer after radiation heat also there is a convection heat transfer between the tubes and the flue gases then economizer to heat the preheat to preheat the feed water. And then there is air pre heater to heat the air which is being used for combustion.

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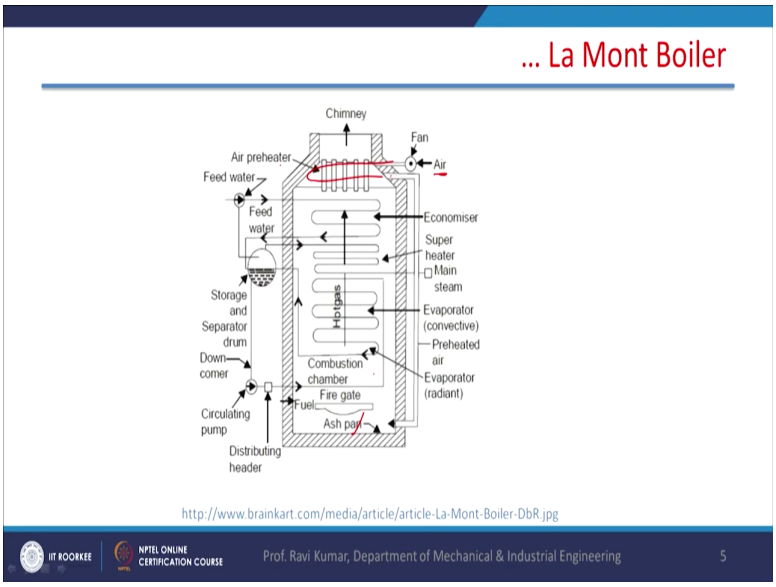

So, this is the arrangement of a La Mont boiler. This is the schematic arrangement which I have explained you here, they have put the air pump here. Again it is a u type of I have put air pump here. It does not make any difference and air is used for preheating ok. After the La Mont boiler, we will take up Benson boiler.

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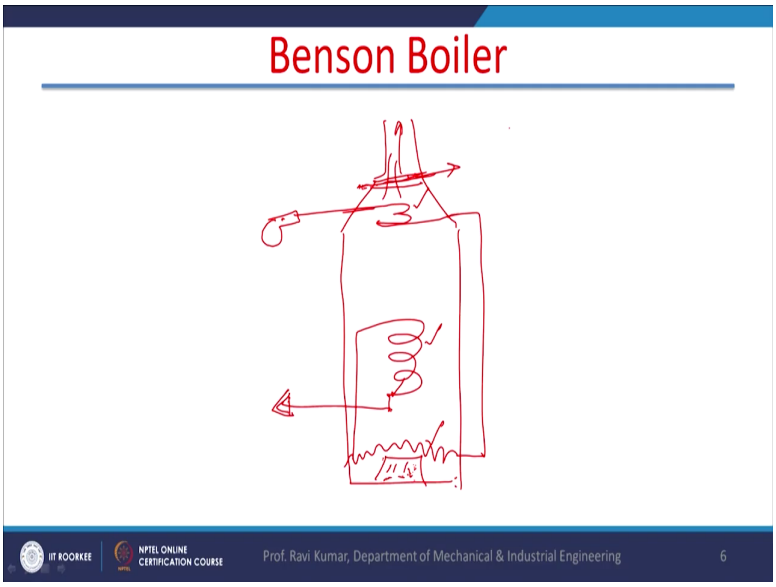

Now, Benson boiler is a drumless boiler it does not have any drum. So, it is a once through boiler. So, I will make the same type of schematic here also, there is a shell, there is a neck of the shell and then exhaust of the gasses right. It is a once through boiler. So, feed water feed water will be entering from the top because economizer has to be at the top economizer below that the convective heating, below that radiation heating.

So, water is entering here in economizer and after entering economizer, the water is this tube is coming out and then there is ash pit there is a grate n and the furnace and here it is again radiation heat transfer is taking place. The tube is embedded in the wall of the furnace and radiation heat transfer between the tube and the flue gases is taking place. It is the once through boiler. So, the steam will not come out. So, after digging heat, there is a convection heat transfer. Flue gases are moving in upward direction.

Now, I will explain you again feedwater is coming from here this is the economizer. After economizer, the feedwater is going is entering from here. It is coming out to the boiler this feedwater tube and then again it is entering the boiler. Then it is there is a radiation heat transfer, then convection heat transfer and after convection heat transfer, the superheating has to be taken right. After this superheating of the steam if required, it is always required here.

So, super heated superheating of the flue this steam takes place and after superheating takes place here and after superheating, it emerges from the steam emerges from the boiler. So, if this boiler has different components, this is economizer. There is radiation heat transfer, there is convective heat transfer and at the same time there is a super heater and after superheating, the steam is supplied from the side.

Now, air preheating is also required here. So, for the purpose of air preheating again, there is a fan or blower which makes the air flow through the pipe and this pipe is surrounded by the flue gases, hot flue gases and the air is heated and then this air is again supplied to the combustion chamber.

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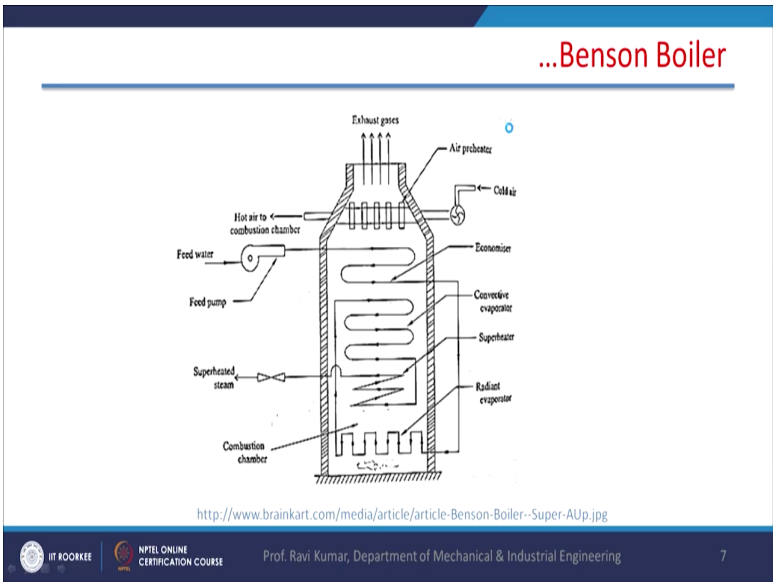

Now, a schematic of this boiler is shown here. This cold they have shown pump this side. So, cold air is coming from this side living from this side and this air is used for burning the fuel here in the grid. This type of arrangement is shown. This is a, this is embedded tubes in the wall and the radiation heat transfer is taking place between the tubes and the flue gases. So, this is the arrangement of the Benson boiler. This boiler does not have any drum to collect the feed water to collect the steam.

So, it is a once through boiler, feed water is entering from one side and superheated steam is leaving from another side.

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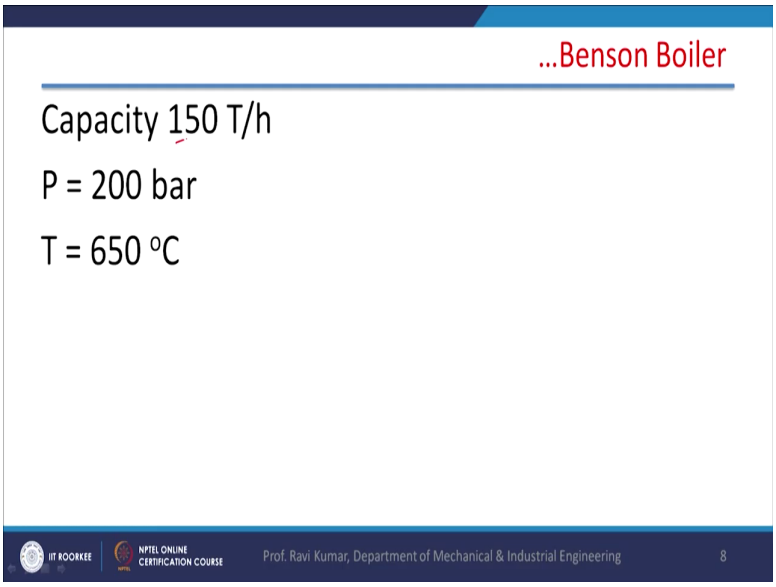

The capacity of Benson boiler is 150 tons per hour, pressure is 200 bars quite high and temperature also we can attain 650 degree centigrade.

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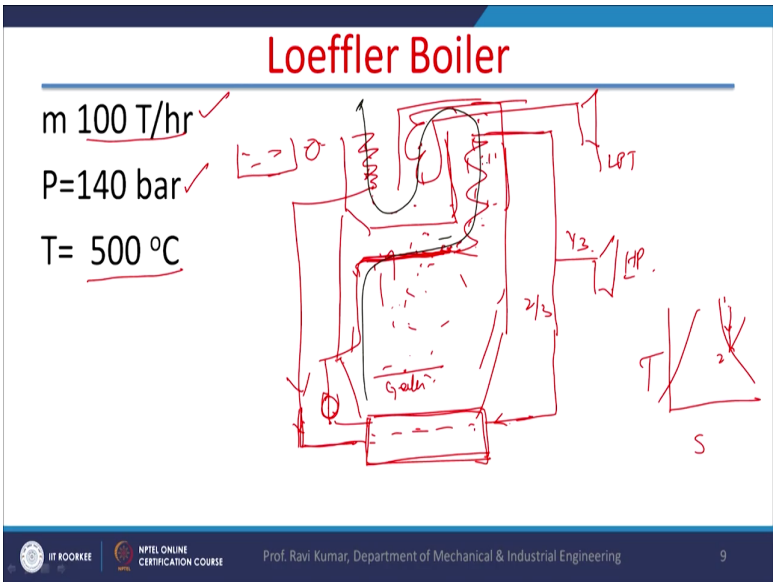

Now, after the Benson boiler, we will take Loeffler boiler. So, this boiler has, I mean higher capacity you can go up to 100 tons per hour steam generation in this boiler. Pressure is 140 bar pressure and it can provide a steam at 500 degree centigrade right. So, this boiler has arrangement like this, there is a one u, another u and there is an evaporator in this boiler. The beauty of this boiler is a steam generated with the help of superheated steam. So, even salt water can be used here because and there is no problem of shooting at all because generation of steam it is India, direct generation of a steam and generation of steam is with the help of superheated steam.

So, there is a evaporator here. We are mixing of superheated steam. Suppose superheated steam is coming from this side and water is spread from this side right feed water is coming from the side and here mixing of water and superheated this steam takes place which results

in generation of steam right. This steam is pumped, this is a boiler house. This steam is pumped through the boiler and this is economizer.

So, in this boiler the flue gas there is a grate the fuel which is burned here. So, this area is filled with the flue gases. So, this area is filled with the flue gases right. So, this is economizer and for the purpose of superheating for the purpose of superheating, the water tubes is sent here is passed through this is super heater. I will I will explain it again. This is evaporator; we are mixing of superheated steam with feed water takes place which results in generation of a steam.

Now, this steam is pumped through this combustion area this flue gases area and in this area there is an economizer or convective heating not economizer. Sorry I am sorry, this is not economizer this is convective heating of the. So, the steam generated in the evaporator is circulated in this area where convective heat transfer takes place between hot flue gases and the steam.

Then steam is goes steam goes to the super heater, this is super heater area; this is super heater. After rebirthing from the super heater, the steam is divided in two parts. One-third part is used for power generation and two-third part of the steam this is high temperature high pressure steam, this high temperature high pressure steam goes to the evaporator.

Now, this one-third part goes to the high pressure turbine. So, if you look at the Rankine cycle temperature entropy diagram. So, expansion of takes place from state 1 to state 2 right. Now exhaust of this goes to the reheater reheating takes place. So, this is reheater. So, here the reheating takes place and after reheating, it goes to the low pressure turbine.

So, one-third of the exhaust it goes to the high pressure turbine, two-third of the sorry not exhaust; one-third of the superheated steam goes to the high pressure turbine to generate power. Two-third of the steam goes to the a evaporator for generation steam. This steam again goes to this chamber takes the heat and become superheated steam. Now, exhaust of the

high pressure turbine again goes to the side of the boiler to take heat and to generate steam in the low pressure turbine. Now this side of the turbine is economizer.

So, there is a water well or it is called a hot well in the hot well water is pumped and this is economizer. Now, from here the heat is taking because this is a feed water which is coming here. Feed water, it takes heat from the hot flue gases and the hot flue gases are moving. So, hot gases are moving like this from here. So, first convective heat transfer to the tubes, then superheating, then reform the purpose of reheating and for economizer and then they are leaving the boiler right.

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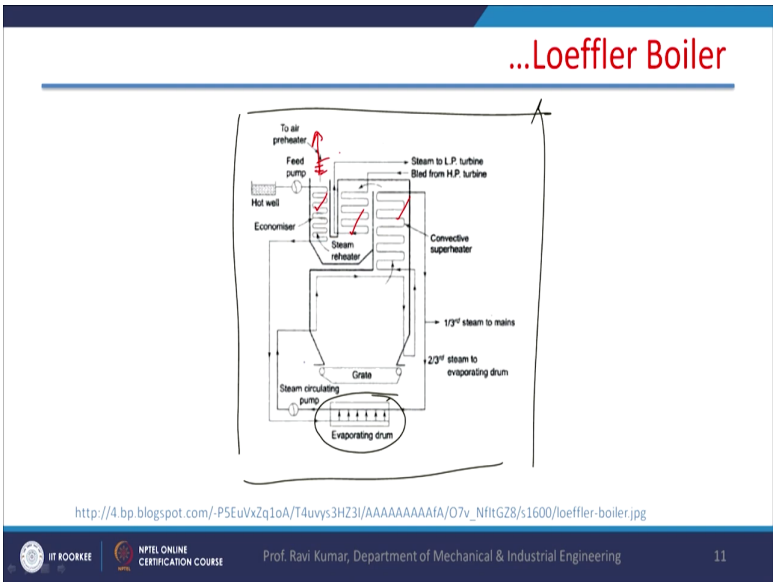

This is a schematic of this Loeffler boiler. Here you can see that this is grate, this is evaporated drum, this is super heater and here it is reheater for the purpose of reheating steam and this is economizer and from here, air preheater is also provided because after economizer

air preheater will also be provided to preheat the air to trap the maximum amount of heat from the boiler right.

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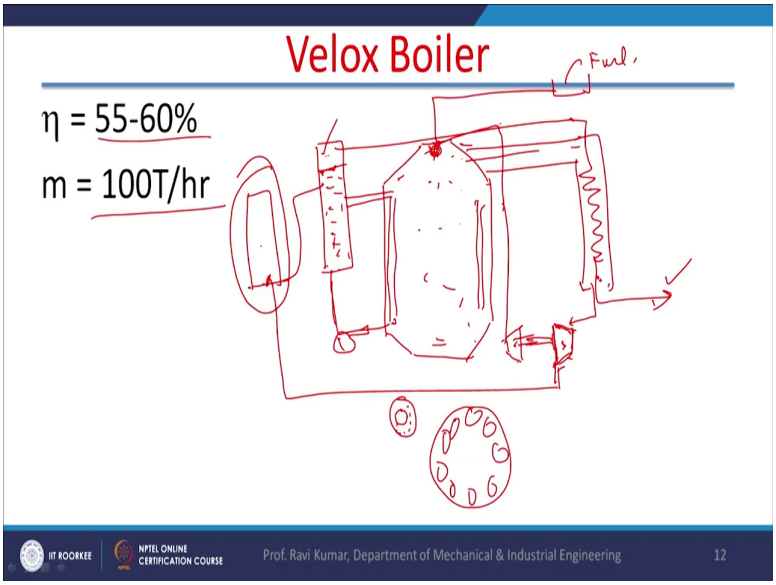

So, this is the arrangement of Loeffler boiler and the last one which I am going to discuss is Velox boiler. In Velox boiler, the efficiency of the Velox boiler is not high. It is between 55 to 60 percent and the chemistry of the Velox boiler is 100 times per hour. Velox boiler, it has again a big huge combustion chamber and it has number of tubes. Actually it is a circular area of the tube along the wall of the tube and in each array, in enrollee space concentric tubes.

These are concentric tubes and in these concentric tubes the enrollee space is filled with water and inside and outside tube, there is there are flue gases right. And there is a drum or a steam separator, the steam from the bottom side. This steam is separator is connected with these so, that the number of tubes, I am showing only two tubes and from the bottom side, it is

connected with this and there is a close loop a pump is there to circulate the water in the enrollee space.

So, in a boiler shell, there is a array of suppose this is a boiler shell. There is an area of circular area of tubes. It is a assembly it is not a security, but it is assembly of tube there are two concentric tubes. So, in the enrollee space, there is water right and this water picks heat and the entire space is filled with flue gases. But how this flue gases here? The generation of flue gases is different.

There is a fuel tank fuel tank and from fuel tank with the help of a pump, fuel is supplied to the boiler and for burning of these fuel, high pressure air is supplied. The pressure of air is approximately three bar and that is with the help of a air pump and velocity of flue gasses is very high. It is supersonic maybe 500 or 600 meters per second. It is very high the velocity of the flue gases is very high and they leave boiler from this arm and as in the case of other boilers, there is also a super heater here right.

So, a steam which is being generated is collected here in this drum because there is a close loop. So, water which is in enrollee space will get evaporated and it will be collected in the upper half of this steam separator. From steam separator, the water will go to the super heater and here the sorry this steam will go to the super heater and from here the super heated steam will be supplied. But still a lot of energy is remaining with the flue gases. So, that energy has to be trapped.

So, for that purpose what is being done, the exhaust which is coming from the superheated a still it is a very high velocity. The velocity of this exhaust is approximately 125 meters per second sorry; yes, the velocity of this exhaust is 125 meters per second, it contains a lot of energy. So, in order to trap the seat, it turbine is gas turbine is provided. So, the exhaust of this boiler runs the gas turbine and gas turbine is coupled with a compressor.

It is coupled with a compressor and this compressor provides the compressed air for burning the fuel here. I am just repeating the exhaust of the super heater. It is at a very high velocity the velocity is of the order of 100 125 meters per second. This exhaust runs the turbine. It

turbine the gas turbine, this gas turbine is coupled with a compressor and this compressor centrifugal compressor or axial compressor, it compresses air and supplies air to burner for burning the fuel. Because fuel supply is high and we require sufficient if sufficient amount of air is required.

So, this sufficient amount of require air at three bar pressure is supplied to the burner and an exhaust of this gas turbine is also at a quite high temperature and this heat can be trapped in the form of economizer. So, for the purpose of feed water which is feed water which is supplied here and this feed water is heated with the help of the exhaust from sorry not from here; exhaust from the turbine, exhaust from the turbine heats the feed water.

So, exhaust of the turbine is feeds the feed water in a in a heat exchanger. This hot feed water goes to this separation dub drum and from separation drum. It is circulated inside the boiler. This saturated steam is generated; this saturated steam goes to the super heater right. And, the flue gases after this gases which are leaving this drum through this through the super heater, they go to the turbine. Turbine the power is generated to run the compressor, exhaust sort of turbine is used for heating the feed water or used in the economizer.

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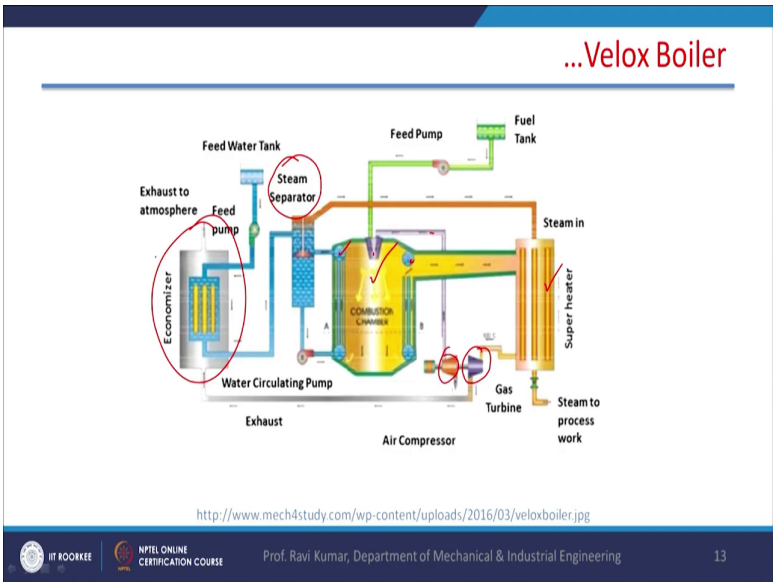

Now, this is the arrangement of Velox boiler. Here combustion chamber is shown. This is super heater, this is turbine compressor which supplies air for burning the fuel, then number of tubes you can see here and there is the steam separator. This is an economizer and this is the entire arrangement for the Velox boiler.

So, today we have completed a four classical high pressure boilers. Today, we have discussed four classical fossil fuel steam generators. In the next class, we will start with the poundings on boilers.

Thank you.