Power Plant Engineering
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Lecture – 03
Fossil Fuel Steam Generator - I

Hello, I welcome you all in this course on Power Plant Engineering. Today, we will discuss Fossil Fuel Steam Generators. Now, fossil fuel is the fuel which is made in billions of years when the vegetation is buried under the ground and in millions of years may be 100 or 200 million years; this vegetation is converted into the mineral oil or the coal or the natural gases. And this source of energy is nonrenewable source of energy.

And the major drawback of this source of energy is that; when the heat is liberated at the same time when we burn this fuel heat is liberated at the same time carbon dioxide is also liberated and which causes the global warming. However in India more than 60 percent power generation is through the burning of fossil fuels.

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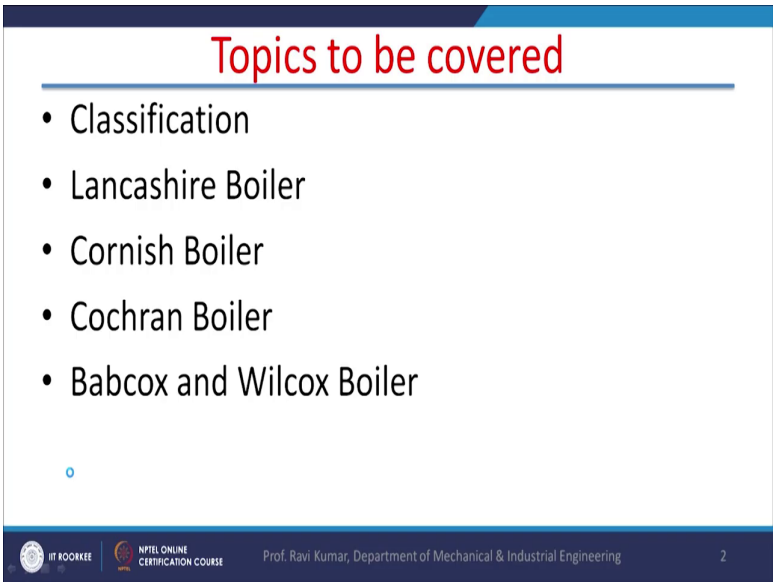

Now, topics to be covered today are; first of all, we will do the classification of steam generations and then we will discuss the working of a few of the classical steam boilers mamely Lancashire Boiler, Cornish Boiler, Cochran Boiler and Babcox and Wilcox boiler.

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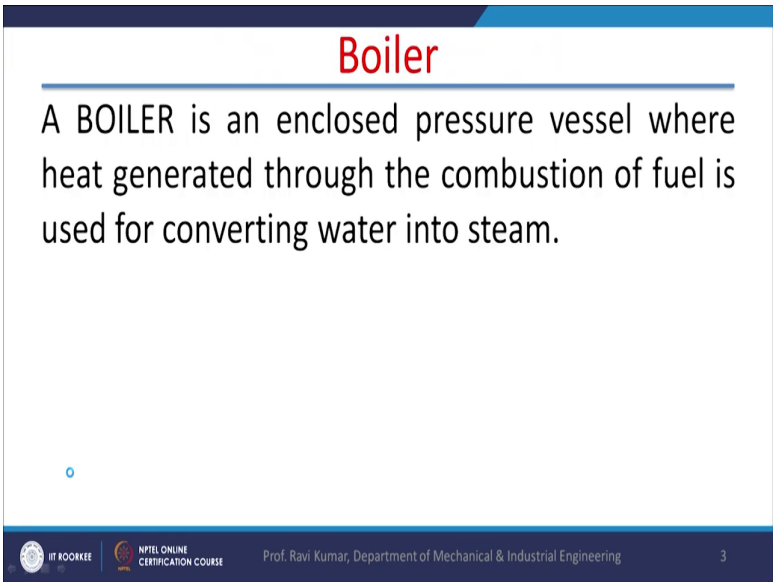

Now, what is a Boiler? The boiler is an enclosed pressure vessel where heat is generated through the combustion of fuel and this heat is used in conversion of water into the steam. So, primarily the boiler is enclosed vessel and the main purpose of the boiler is to generate a steam higher the pressure more work extraction from the steam.

So, boilers there is a tendency to have higher pressure in the boilers. So, that more work can be extracted from the heat of the steam. Regarding the classification of the boilers and there are several classification of the boilers, but broadly they are classified evens fire tube boilers and the water tube boilers.

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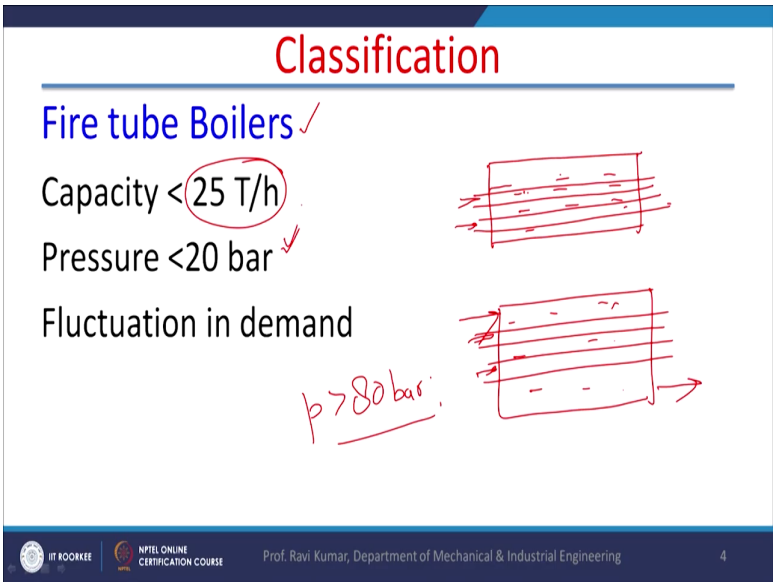

In a fire tube boiler; So, in a boiler necessarily there is a shell and in this shell if we fill this shell with water at a certain level and through this shell there are number of may be a single tube or may be a number of tubes. If they are passing through this shell and in these tubes the flue gases are flowing flue gases are the gases which are generated after burning the fuel and they are very at a very high temperature.

So, when these flue gases when they pass through the shell the heat exchange takes place between these gases and the water which is filled in the shell and steam is generated. So, these type of boilers are known as fire tube boilers; because there is a fire inside the tube.

If fire is outside the tube; contrary to this suppose in a shell the shell is filled with the fuel gases flue gases are entering from one side and leaving from another side and their number of

tubes which are passing through the shell and in these tubes, if the water is flowing then it becomes a water tube boiler.

So, the fire tube boiler; normally they have capacity less than 20 5 tones per hour. Pressure, they are normally low pressure boiler. So, boilers can be classified based on the pressure also. So, the all the boilers which are having pressure less than 20 bar are known as low pressure boilers right high pressure boilers then the question arises what are high pressure boilers.

So, high pressure boilers are those boilers where pressure is greater than 80 bar. So, those boilers are high pressure boilers and between 20 to 80 they are intermediate pressure boilers. So, fire tube boilers are normally low pressure boilers. The reason being, when the shell is filled with the steam, steam is at a high pressure. So, robust design of the shell has to be made and for that a I mean it is not very cost effective, the boiler also become heavy and they are safety related issues also.

So, normally high pressure boilers they are made of water tube boiler. Because, once the water tube boiler is there the high pressure of fluid will be inside the tube only. Inside the number of tubes only and the shell will be filled with the flue gases and the flue gases are at atmospheric pressure. They are not at very high pressure or not at high pressure at all I mean they are at a atmospheric pressure.

So, so the normally the high pressure boilers are water tube boilers, but the benefit of the fire tube boiler is; because there is a large pool of a steam is there because, large pool of a steam is there. If there is a fluctuation in demand so, this demand can be met by these fire tube boiler the water tube boiler is also possible, but several controls are required right.

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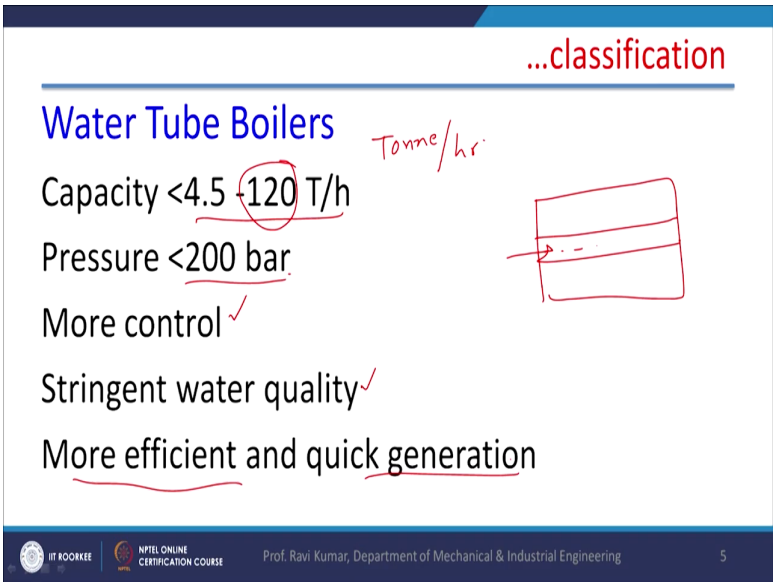

Now, this is about water tube boiler capacity it can go up to 120 tones per hour steam this is steam generation capacity 120 tones T o double n tones per hour. That is the steam generation capacity of the boiler this is the range 4.5 to 120. Pressure; it can go up to 200 bar right controls more controls are required. Because, the water is flowing inside the tube suppose there is a obstruction in the flow of water then accident may take place right.

So, if there are fluctuations and demand also in that case also in that case we go for normally for this fire tube boiler, but in these type of boilers controls more controls are required, more safety is required in water tube boiler. And stringent water quality has to maintained, because the water is flowing inside the tube. In these boilers water tube boilers the water is flowing inside the tube.

If any scaling takes place inside the tube or water is contaminated it has mud suppose for example, it will grossly hamper the heat transfer. So, for that reason water quality has to be maintained in water tube boiler and they are of course, they are more efficient and steam generation is quick. And, we have certain water tube boiler they are (Refer Time: 06:35) through boiler. I mean water is entering from this side, and we are getting a steam from another side. So, there are no drums in those boilers.

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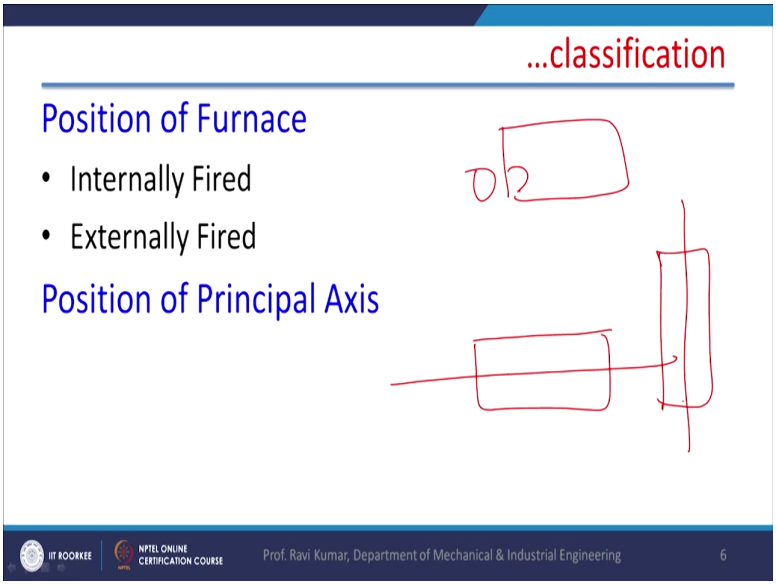

Position of furnace; that is another way of classifying the boilers whereas, boiler is internally fired or it means the furnace is housed inside the boiler or it is outside the boiler. So, there can be a I mean number of classification position of principle axis the boilers are is a horizontal, it means the principle axis is horizontal, boiler is vertical principle axis is vertical.

So, there can be a number of classification, but the main classification is fire tube boiler and water tube boiler, high pressure boiler and low pressure boiler.

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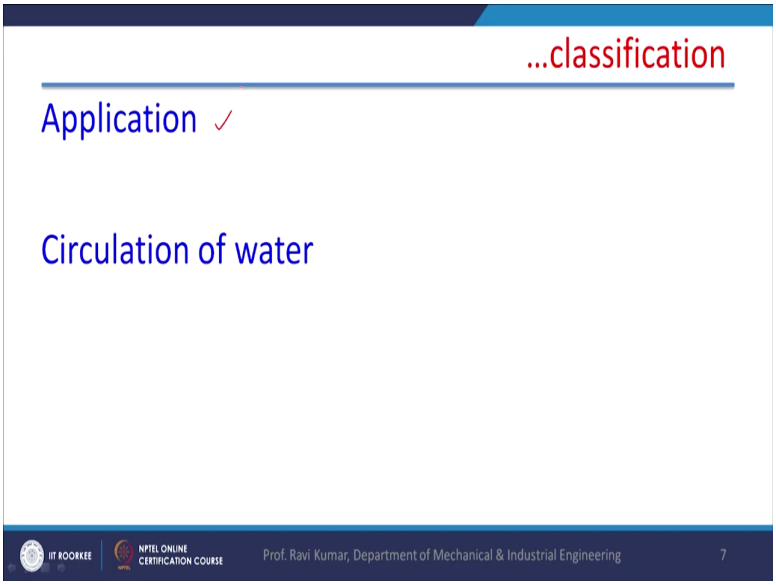

Now, depending upon the application some boilers are; mobile boilers, like locomotive boilers some are stationary boilers. Circulation of water; how water is circulated in the boiler? It is a natural circulation or the force circulation for the purpose of force circulation sperms will be required, for natural circulation no external energy will be required. So, this can be another classification of the boilers

Now, we will start with lancashire boiler. It is a very I mean popular and classical boiler it was introduced in the year 1844. Length of this boiler is between 7 to 9 meters. It can go up to ten meters also there are no I mean a strict dimension control in this boiler. So, it can be 7 to 9 meters or 10 meters diameter 2 to 3 meters can be 4 meters also.

So, there is a shell and shell has length of 10 meters or sorry 7 to 9 meters.

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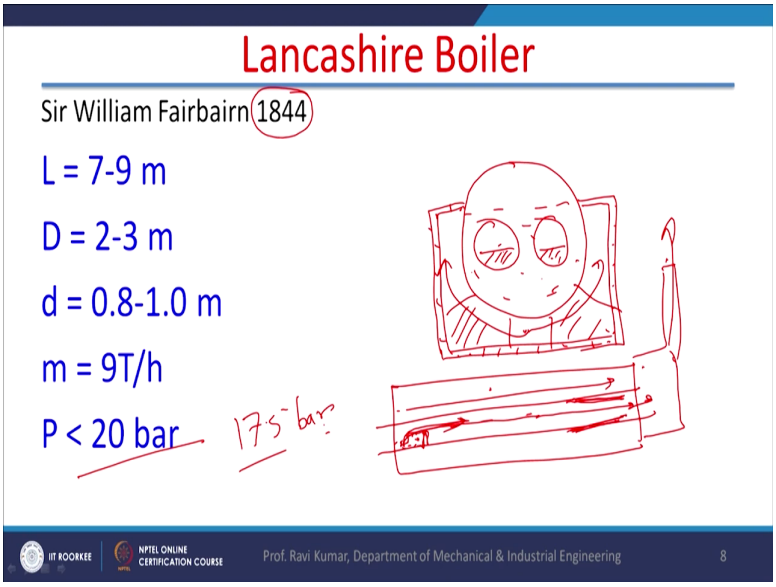

Diameter of the shell is 2 to 3 meters, so there is a shell. And it is a remember it is a fire tube boiler. So, shell will be filled with the steam and the flue gases will be flowing inside the shell. In inside the tube which is fixed inside the shell.

So, there are 2 tubes in this boiler there are 2 tubes. And if we look at the side view I mean side view it is going to be like this, A side you will see only one tube. So, there is a burning place; which is known as date this is fire wall ok. And after burning the flue gases are moving in this direction. So, in both the tubes the fuel is burning here and it is moving perpendicular to this board or in this direction.

Now, is this shell is pleased in a brick masonry. So, there is a brick masonry. And after going to be rear at the last it takes U turn it takes U turn and it travels from the bottom and comes into the front. So, it emerges from here. So, flue gases flue gas or flue gases when they are moving in this direction after reaching this end they take U turn.

So, from suppose flue gases are moving in this direction. So, they take U turn and come to the front from the bottom side. And so that heat transmission because this boiler is filled with water. So, heat transmission while moving in this direction heat transmission takes place to the water and when after taking the U turn the bottom side is also heated right. And water is of course, the water is converted into the steam.

A t the fag end of these tube it is slightly tapered it is slightly tapered. The reason being when the flue gases are moving in this direction the temperature of flue gases comes down because heat is transmitted to the water when the temperature is reduced their velocity is also reduced.

So, in order to maintain the velocity proper velocity the cross section area is reduced. So, that is why the tubes are slightly, there is a reduction in slight reduction in diameter at the fag end of the tubes. After emerging from the fund, still the flue gases have a lot of heat content with them.

So, after emerging from the front they are again sent to the side way side way. Now they are they move in side suppose I will draw a planning for this boiler suppose ok.

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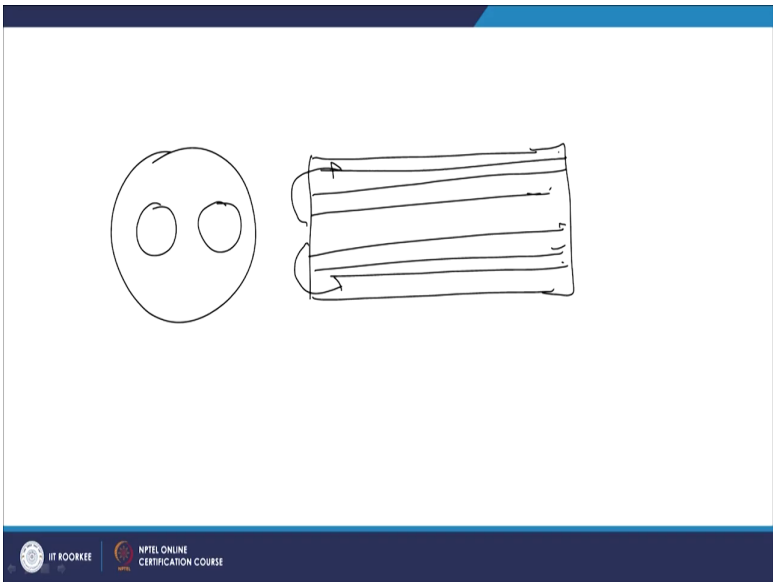

Now, I am drawing the plan. So, when I am drawing the plan they are L C 2 tubes right because, side view is like this. So, when I see the plan I will see 2 tubes.

So, the flue gases emerging from the front; they will move side way and we will move in this direction right. When they are moving this direction and coming here then there is a chimney and exit for the flue gases. So, there are 3 times they move across the length of the along the length of the boiler; first when the fuel is burnt, if the flue gases move in this direction then they come from the bottom side come to the front and front to the side way. The diameter of these tubes ranges between 800 mm to 1000 mm.

Capacity of this boiler is approximately 9 tones of a steam per hour. So, it can generate. It depends upon the size also, but grossly it generates around 9 tones of a steams per hour and pressure is less than 20 bar it is approximately 7.5 bar precisely in lancashire boiler.

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So, this is a photograph of a used lancashire boiler here you can see the grate where the fuel is burnt. Now, the flue gases are through the along the axis of this tube now emerging from here because this entire this vessel is pleased in the brick vessel real. I will show the photograph ok.

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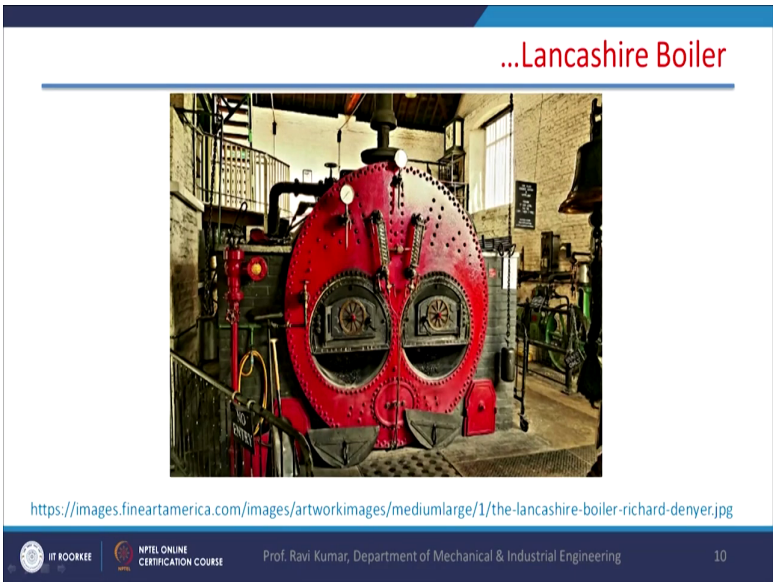

This is brick masonry right.

So, the entire boiler is placed in the brick masonry. So, after emerging from this side, the flue gases travel from the bottom to the front. And after coming to the front they travel side way and then they leave from the chimney. There is a blow of cock which is used for when the boiler is not in operation for draining out the water and sledge from the boiler.

So, all these accessories will be mountings and accessories we will be discussed later on. Right now, we will discuss only the working of the boiler.

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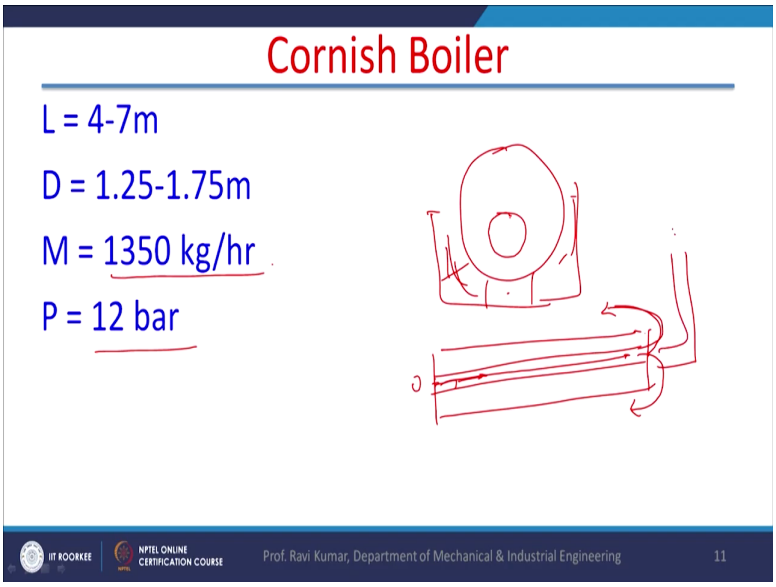

So, after the lancashire boiler we will discuss the cornish boiler. So, cornish boiler is smaller in size. So, here the length is varying between 4 to 7 meters diameter of the drum is 1.25 to 1.75. So, it is smaller in size and it has only one tube that is the difference between lancashire boiler and cornish boiler. And this tube is also centric it is not centrally placed right.

A steam generation rate is 1.3 tones per hour much less than the steam generation rate of lancashire boiler. And pressure is 12 bars. So, it is smaller in size right and in this boiler, now regarding the movement of flue gases. In this boiler also the flue gases suppose there is a tube inside flue gases they move in this direction first of all.

In lancashire boiler they take U turn come from the bottom. In this case, in the cornish boiler; first after reaching on rear end. They are divided into 2 parts one part goes in this direction

one part goes in this direction and first of all the heat of side of the vessel they come into the front they emerge in the front they emerge in the front.

And from the front then the gases move into bottom side. So, only direction of the flow and there is change in the direction of flow. In lancashire boiler along the axis then bottom and then emerging from the front and then going to the sides and leaving from the boiler house.

Now, in cornish boiler the flue gases move first of all they moves along the axis of the boiler, then they are bifurcated the heat of sides of the boiler. They combine in the front and in the front again they enter the bottom of the boiler. And at last they leave from the boiler house.

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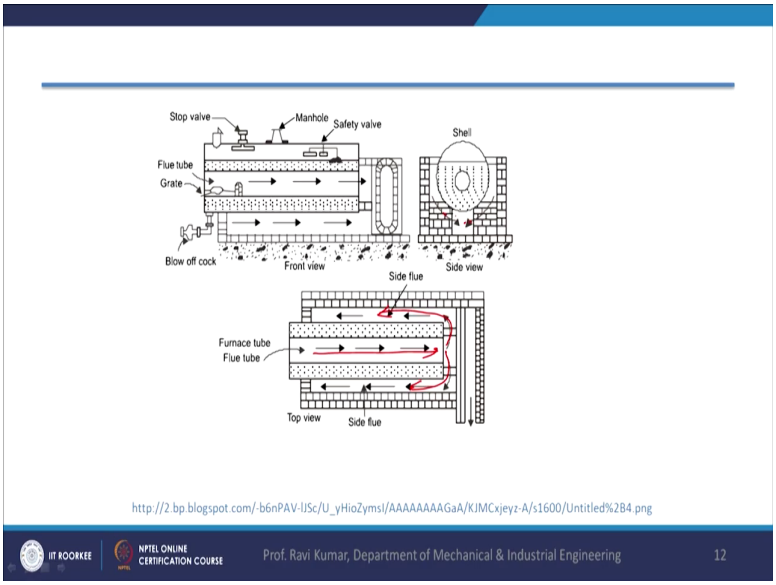

This is the movement a schematic movement of the flue gases. This is furnace tube the flue gases are moving in this direction.

Then we are bifurcating coming to the front. And after reaching the front again, they are heating the bottom and leaving the boiler house.

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Now, this is the photographic view of cornish boiler. This is the single tube which is being shown here right it is smaller in size a steam generation rate is less pressure is of also approximately 12 bar. Lancashire boiler has pressure approximately 70 17.5 bar, but both the boilers are fire tube boilers and both the boilers are low pressure boilers.

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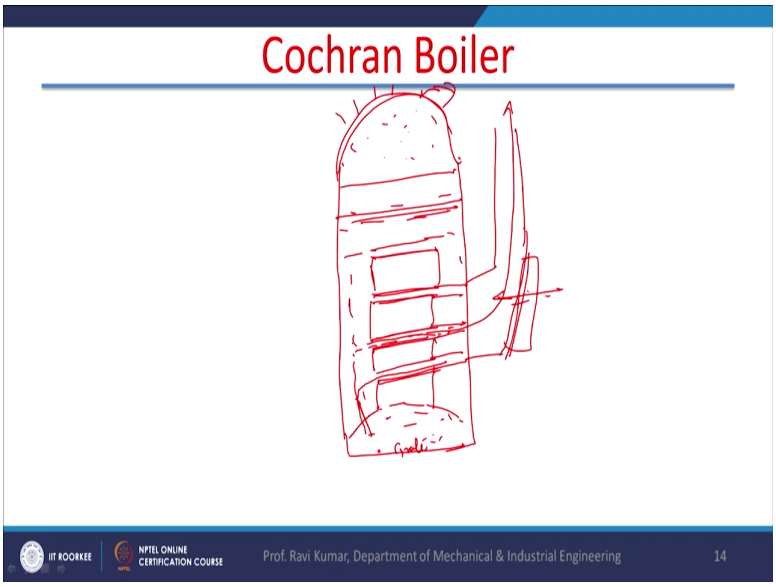

After cornish boiler; we will discuss the cochran boiler. Now, in this boiler, this is the vertical boiler. Previously we have discussed the horizontal boilers this boiler is different from the previous 2 it is a vertical boiler and like axis is vertical. So, boiler axis is vertical it has fire box where the burning of fuel takes place this is fire box and blow the fire box there is a grate. This is the area we are burning of fuel takes place this boiler is also a fire tube boiler and it has a dome at the top like this.

Now, it has number of fire tubes; in lancashire boiler or cornish boiler they had one or 2 fire tubes this boiler has number of fire tubes. So, there are number of fire tubes. I will show only 3 or 4 fire tubes ok, one more and. The flue gases which are emerging from here they will pass through these fire tubes. And there is a chimney here and gases emerging from here they will pass through this fire tubes and they leave through the chimney.

Shell is filled with water shell is filled with the water. So, when the heat transmission takes place from the flue gas through the water this steam is generated and steam is collected in a dome. And dome has different mountings. Now every boiler must have a mounting or should have number of mountings. Mountings are necessary to operate a boiler and for the safety of the boiler safe operation of the boiler.

So, a boiler must have 2 safety walls. And a boiler must have a number of mountings those mountings I will be discussing later on. Right now, I will just explain you the function of the because when we need a steam we need a wall to supply the steam thus we need a steam stop wall right. Boiler the water has to be fed to the boiler. So, there has to be a wall outside the boiler which can control the feed of the water to the boiler that is known as feed check wall.

So, there and every boiler must have a man hole it is mandatory. Because, the man hole allows I mean such a big boiler allows the inspection and maintenance because regular maintenance is required in a boiler regular inspection of a boiler is required. So, a boiler must have man hole also. So, that a person can enter the boiler and do the inspection and necessary maintenance work.

So, here so the it is filled with the water up to here for example, and the steam is collected in the dome and when the steam is required it can be supplied through a wall to for the useful purpose. Now, this is chimney in some of the boiler here door is provided one can enter if the boiler through this door and do the inspection and maintenance work.

So, this is a fire box here is the combustion chamber and this is the complete description of the boiler.

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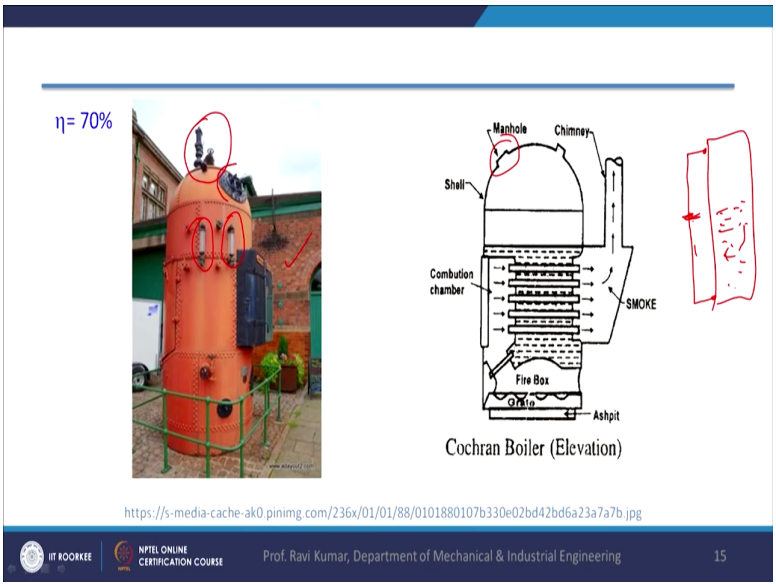

I will show you the photograph of the boiler. This is the photograph of this boiler right here you can see these tubes their water level indicators. Through the water level indicators you can judge the level of water inside the boiler the principle is simple. Suppose the boiler is filled up to here. And we provide a transparent glass tube on this side connected at the top and the bottom. So, whatever the level of water is maintained here same they will maintain in this tube also and this tube is outside the boiler.

So, we do not have to just make arrangement for seeing inside the boiler it is not possible in high pressure boiler. So, you just simply just looking at the level of the water in the tube, we get idea about the level of water in the boiler right. And here you can see in this there are certain mountings right on the boiler for the operation of the boiler this is a schematic of the

boiler which I already which I have already explained you here, there is a man hole, man hole is here where a person can enter and do the inspection and maintenance work.

So, after this cornish boiler sorry cochran boiler; the efficiency of the boilers is are approximately 70 percent this is not very highly efficient boiler. The next boiler is; we will discuss this babcox and wilcox boiler.

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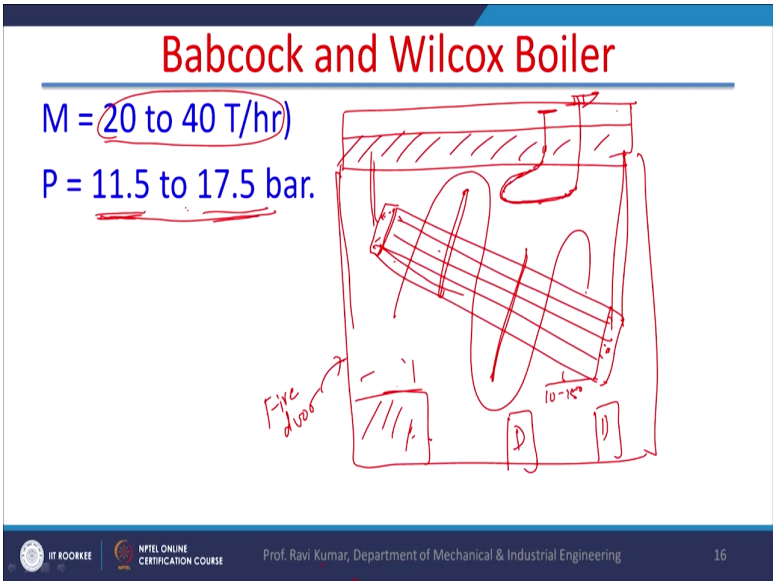

So,. So, in the largest boiler, it produce I mean capacity of this boiler is 20 to 40 tones per hour and pressure also can vary between 11.5 to v 17.5 bar and this is a water tube boiler it is not a fire tube boiler.

So, there is a bank of tubes in this boiler and the tubes are inclined at a certain angle there is a bank of tubes right. And tubes are inclined at a certain angle of 10 to 15degree and there is a header here. Header means flow of all the tubes will be accumulated in header.

So, or we can say these tubes are connected in parallel right. So, parallel connection there has to be header where all the flow, flow coming water flowing in all the tubes is accumulated here and subsequently it is transported to a drum there is a drum right. So, water entering from this side, it is now this area is filled this is the boiler house, suppose this is boiler house it is filled with the flue gases right Water entering from here right. Water entering from here it is moving in the tube which is inclined at 10 to 15 degree and then leaving at the top right. And again it is coming from here to this so there is a close loop.

Now, fuel is burnt somewhere here right. There is a fire door to feed the fuel in the furnace and it has baffles the function of the baffles is to deflect the flue gases. So, that they spend maximum time in the boiler and it also improves the heat transmission from flue gases to the water flowing inside the tubes right.

Now, after this circulation; the water is accumulated in the drum and there is a stratification between steam and the water right. Now, this boiler has provision of getting superheated steam also. So, super heating of a steam can also be done in babcox and wilcox boiler. So, for the purpose of super heating there is a anti priming pipe here, which separates water from a steam and this anti priming pipe this steam travelling through the anti priming again there is a super heater. And this super heater is connected to main stop wall this is main stop wall here.

Now, how is a super heating is done? Suppose, this boiler shell has a stratification and upper half will is filled with the saturated steam. The saturated steam may have quality 1. It may have quality 0.7 0.8 or point for whatever quality. It can have it can have any quality. So, normally it is 0.8 to 0.9.

Now, this steam this steam, now this provision for super heating in the boiler is done to supply superheated steam for the purpose of may be for the purpose of a power generation.

Now, this saturated steam it is not necessary that steam is dry it is quality may be less than 1 right. So, this steam is again passed through this area where flue gases are there. So, when the more heat is added the steam becomes superheated and now this main stop wall we get superheated steam.

Now, it has number is a huge boiler. So, it has number of doors for inspection purpose and pressure gages and mountings are provided on the shell for the purpose of monitoring and operation of the boiler.

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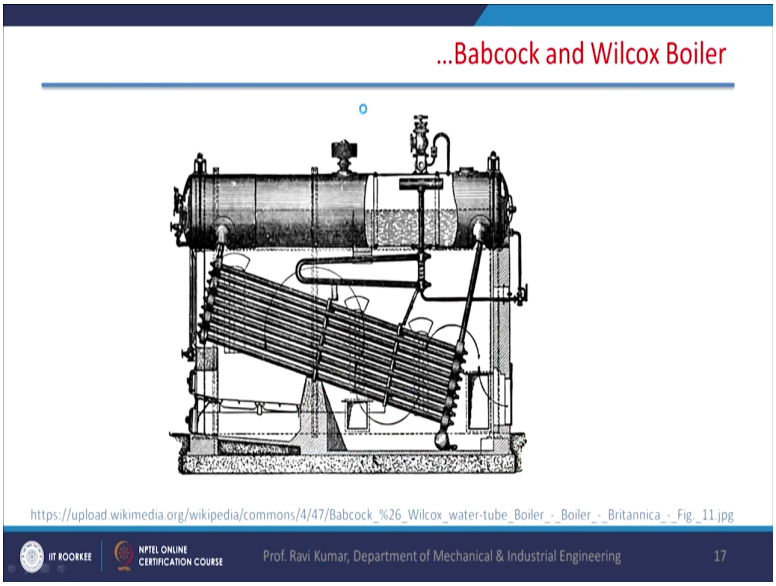

This is the schematic of the boiler; you can see these tubes are inclined there are inclined at a degree 10 to 15 degree. And, there is a super heater which is taking steam from here and steam is circulated in the super heater and this steam after coming from here it goes through the.

So, it is a very big boiler and baffle plates the main attraction of this boiler is it can maintain pressure between 11.5 to 75 17.5 bar and it can supply superheated steam and the steam generation rate is quite high 20 to 40 tones per hour. So, in induction I have explained you these 4 classical boilers that is all for today in the next class we will take up the high pressure boilers.

Thank you.