Steam and Gas Power Systems
Prof. Ravi Kumar
Department of Mechanical and Industrial Engineering
Indian Institute of Technology - Roorkee

Module No # 02
Lecture No # 07
Fire Tube Boilers

Hello I welcome you all in this course on steam and gas power systems today we will discuss different fire tube boilers.

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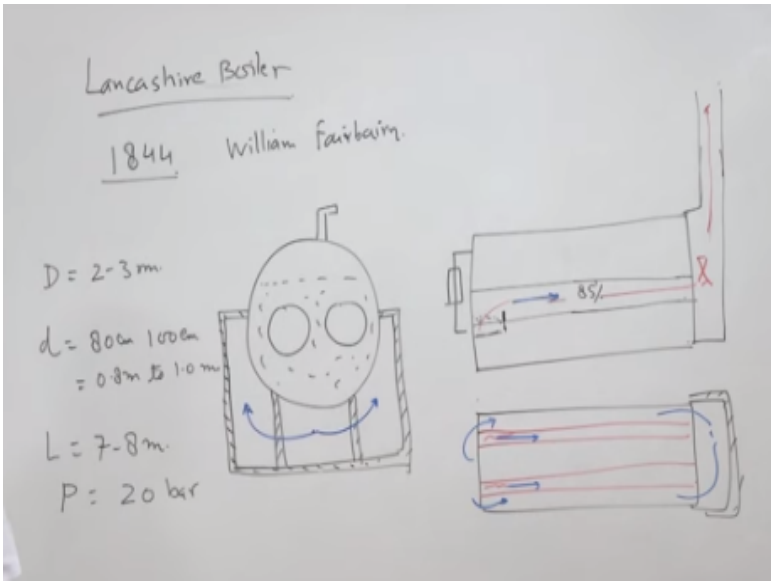

We will start with the LANCASHIRE boilers then we will discuss on CONISH boiler COCHRAN boiler and locomotive boiler.

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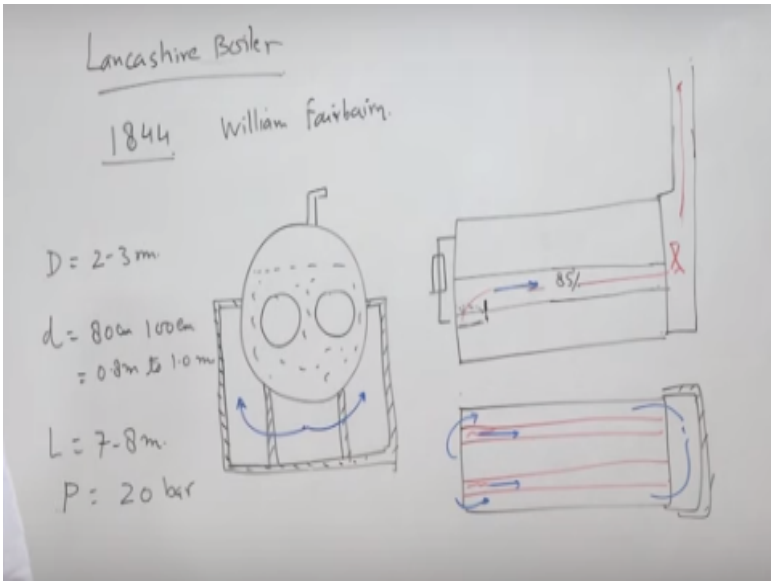

So LANCASHIRE boilers was widely used in earlier days and it was very popular steam boiler Lancashire boiler it was invented or it was fabricated in nineteen sorry eighteen forty four by WILLIAM FAIRBAIRN in earlier days it was it used to be very popular boilers it consist of it shell because it is a fire tube boiler it consists of a shell diameter of the shell is in a range of two to three meters inside the shell there are two fire tubes of same size and the diameters if these fire tubes varies from 80 centimeter to 100 centimeter or 0.8 meter to 0.9 meter.

Then length of this boiler is I mean length of the cylinder is 7 to 8 meters in this boiler because the flue gases or the gases after burning the fuel passes through this tubes this shell is filled to a certain level is filled with the water the rest of the place filled with the water and steam is stored at the top.

The pressure of the steam can go up to 20 bar pressure in this boiler and if I draw a this is the side view if I draw elevation of this boiler it is because these two tubes from the elevation they will appear to be single tube now fuel is burned here in this portion as I explained you earlier a grate is a platform it is a perforated platform or a platform having a number of rods okay.

And in this platform the number of rods the perforated platform and in this platform the fuel is burned and below the great there is ash pit from where the as can be removed. So below this there is ash pit and here the fuel is burnt and this is known as fire bridge. So the fuel cannot go to

this direction because this is the tube at this tube does not uniform section at the side end it diameter of this tube is reduced in in order to increase the velocity and the ash is collected here.

Now if I look at the plan of this boiler this is side view okay the plan will be here in first angle plan of the boiler now in the plan of the boiler two tubes will appear and I will draw tubes with different colors. Two different tubes are available they are fired tubes and the few gases they flow inside these to tombs now the movement of flue gases flue gases. Now this gases is placed in a refractory there is a machinery work around this boiler like this so this is all brick work these are refractory brick right.

Now fuel is burnt here and the flue gases move in this direction in both the tubes of you look from the top the flue gases they move in this direction right at the end they take U turn from the top you take U turn if you look from the elevation they take U turn at the emerge from the bottom you are getting my point here there is a flue passage for the flue gases and from the elevation if you look at there is a chimney here there is a chimney to remove the flue gases.

So there is a flue gases no fan is used in the boilers so flue gases generated here they simply be from the not simply leave from the family after circulation in the boiler finally they leave from the chimney and there is a natural circulation the board of the flue gases is controlled by the temper. So a temper is provided here so temper control the flow of flew glasses so that will discuss later.

Now here let us discuss the movement of flue gases so first the fuel is boiled here flue gases are generated they go to this end and at the fag end or at the last end and other end of this tube they take U turn and emerge from the bottom at the front. So moving from this side to another extreme then coming from the bottom to the front. Now when they come to the front these gases are bifurcated one go to this passage another go to this passage because physically this length of the tube these passages are physically separate from each other.

Gas from these passage from cannot go here directly here so it has to come into the front and the from the front it is they are bifurcated and they move from bottom and then they move sidewise

on the side flue and finally they rejoin each other here and leave from the gym. That is how the movement of flue gases takes place and why these arrangements are done these arrangements are done in order to maximize the heat transmission from flue gases to the water or okay.

In order to generate steam and 85 initially 85% of the heat is transmitted in the first passage mean passage remaining 50% of the heat is transmitted through side passage in the bottom passage right. So from the front mean passage it goes to the bottom passage from bottom passage it emerges from the front by circuit and then reunite and leave from the chimney.

Now in this boiler steam which is collected here is saturated steam right and there are several mounting there number of mountings which are places here say for example I want to know the water level of the boiler. So water level indicator is provided here in order to see the level of water in order to release the steam a steam stop value is provided here.

So there are number of accessories and the mounting on the boiler which facilitates the functioning of this boiler.

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Now I will show you a photograph taken from Wikipedia the actual photograph of a used boiler. So here you can see this is the area of great where fuel is burned right and there are few tubes which is the boiler shell and you can see on the shell they are riveted joints. Because riveted

joints are used here instead of welding because the riveted joints are reliable joints even in the aircraft for joining the components riveted riveting is done.

So fuel is burned here at the below there is a ash pit in order to remove ash the flue gases passes through this two tubes through this boiler and then because big machinery has not shown here it is only RM point of the boiler is shown then then flue gases from the other side will travel from the bottom of the boiler and then they will come to the front they will bifurcate and they will go side wise and from the other side of the boiler they leave from the chimney.

This is the total movement of flue gases inside a Lancashire boilers now there are certain features of Lancashire boilers which need to be mentioned here.

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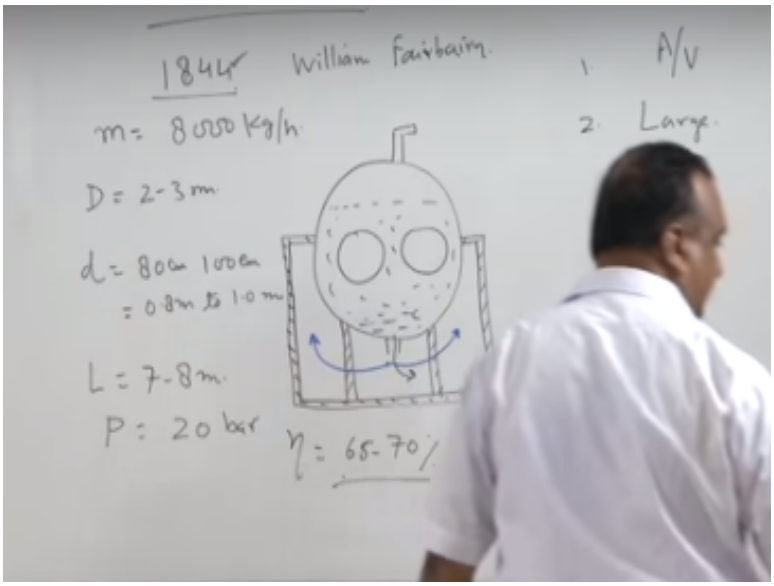

First is the feed pipe water feed pipe is perforated in the boiler so that there is a uniform distribution of the water heating surface area per unit volume is large in any boiler if this is large this is always beneficial because this increases the efficiency of the boiler now for this boiler the efficiency is 65 to 70% it is not very high now a days boiler have more than a 90% but that is boiler it was it was fabricated in the first time it was fabricated in eighteen forty four efficiency that time it was 65 to 70%.

The steam generation rate is important in the boiler a steam generation rate in the boiler is approximately 8000 KG per hour. So 8000 KG per hour of the steam is generated in this boiler at 20 bar pressure it is a stationary boiler and as I told you because brick work as to be done either as stationary boiler and classification wise it is a stationary boiler it is a horizontal boiler right because the shell of the boiler is on horizontal direction.

And the circulation of flue gas or in the circulation of the air in the boiler is natural circulation. So there is no frame used in this boiler now for this boiler the maintenance is easy in the front you can see there is a man hole right for the maintenance purpose and this value arrangement is very important in working in any of the this type of boiler because sedimentation takes place at the bottom of the boiler.

So periodically this sludge have to be removed opening a wall in order to improve the effectives of this otherwise heat transmission from this portion of the boiler will be reduced. So periodically this blow of cork is open and the steam mixture of the steam water and sludge is removed and the mixture of sludge and water is removed from the bottom of the boiler. This boiler is suitable where large amount of steam is required even for the hot water purpose even for forgetting the hot water this boiler can be used.

In this boiler there are certain accessories like economizer we will discuss in subsequent lectures so per heater and the economizer. So super heater and economizer can also be installed in the boiler a smaller version of this type of arrangement is another boiler which is known as Cornish boiler.

Now Cornish boiler arrangement is more or less same but in this boiler there is only one fire tube. So if we start with the Cornish boiler Cornish boiler is older than the Lancashire boiler.

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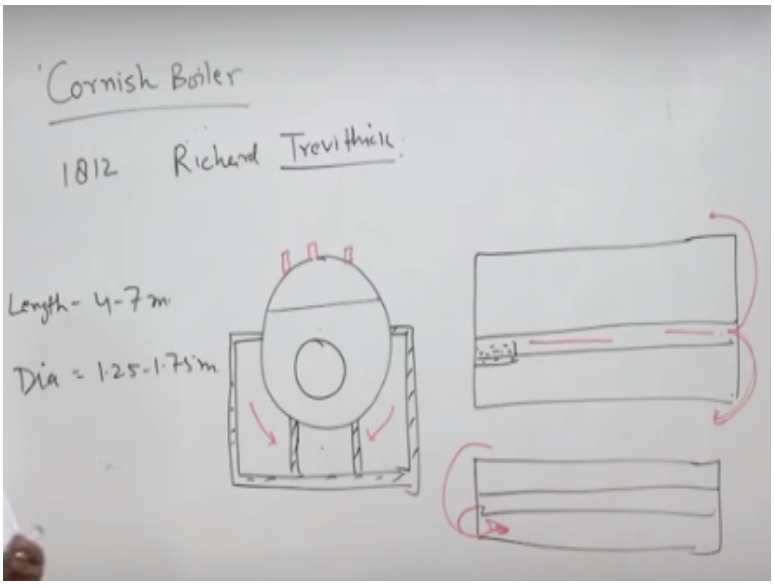

So Cornish boiler was first time fabricated in the year eighteen hundred and twelve so it is more than 200 years old.

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The smaller version of Lancashire boiler is a Cornish boiler it was first time fabricated by RICHARD TREVITHICK in this boiler it is shell it is also a fire tube boiler it is a fire tube a stationery boiler with natural circulation and it has only one fire tube and one fire tube is not concentrically fixed but it is off set from the center. It is offset from the center being because this shell is never fulfilled with the water.

So some space has to be left for steam right so accordingly this tube is fixed so that it is almost in the middle of the water filled area. Now in this boiler the size is comparatively smaller the length of this boiler is 4 to 7 meters and dia of this shell is 1.25 to 1.75 meters.

Now if you look at the elevation of this boiler it is all going to be like this there is a fire tube and again it has a I mean fuel burning the grate for the fuel burning and the ash pit most of the things are same but the movement of the flue gases in this boiler is different now I have drawn the elevational draw the plan also plan on elevation are more of same because there is only one tube and then here also it also has a big brick work there also this the refractive bricks.

Now here in this case the flue gases when the flue gases go to the other side in the Lancashire boiler they are coming from the bottom side. Now in this boiler Cornish boiler they come from the side. So the flue gases which are moving in this direction they are bifurcated some of them go to the left and some of the almost half of the flue gases go to the right and they emerge from here.

And bifurcation and coming from left from right they move from the bottom to the other side so then they move from bottom to the other side of the boiler right. So the arrangement is slightly changed in this Cornish boiler if you compare with the Lancashire boiler here the flue gases flow to the other end they are divide into two path from travel to sidewise side flue and from the slide flue they go with the they come to the front and from the front they reenter to the bottom flue right.

And they do have mountings are necessary in the boiler for example water level indicator pressure gauge are all mountings without mountings the boiler cannot work like steam stop wall to supply steam I am naming the few mountings water level indicator which shows water level in the boiler steam stop sorry it is not here yes steam stop wall which is provided at the top of boiler in because we have to take our ultimately we have to take out the steam from the boiler.

So steam stop wall has to be provided safety walls have to be provided there number of safety walls in the mountings. So some safety walls are have to be provided in to operate these boilers.

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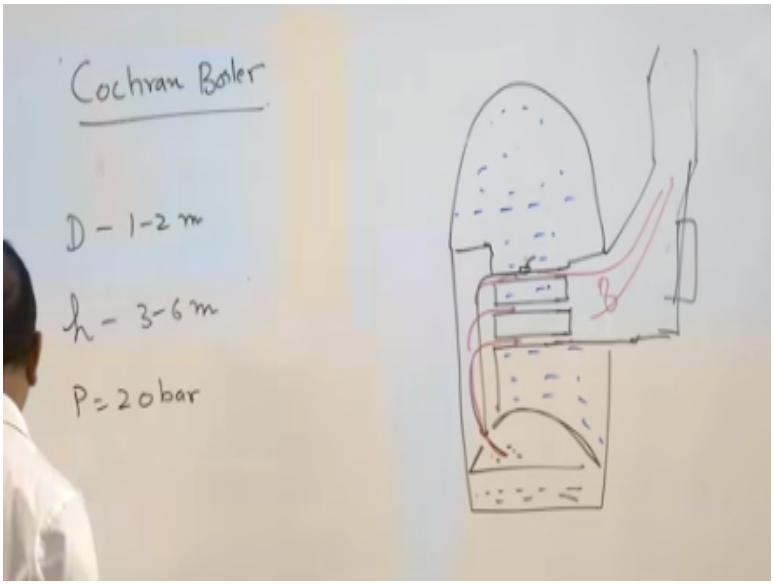

So this is how the Cornish boiler works after the Cornish boiler another type of popular boiler is Cochran boiler it is a vertical boiler and this Cochran boiler does not any missionary work. So it is a vertical boiler vertical fire tube boiler or I will make a bugger sketch having a dome as you can see from here also in this photograph there is a dome of Cochran boiler and the diameter of the Cochran boiler is 1 to 2 meter this diameter of Cochran boiler this height may vary from 3 to 6 meters.

So it depends on the extreme requirement you want to design a desire boiler is there available in different sizes. So the diameter ranges from 1 to 2 meters and height 3 to 6 meters it is a fire tube boiler pressure can go up to 20 bar. So pressure is 20 bar now fire place is here because at the blower there is ash pit and there is a dome. In this dome the burning of fuel takes place it is a there is no joint in this dome burning of fuel takes place and here we can burn the fuel and there number of fire tube and flue gases after burning here they enter the fire tube.

And these fire tubes later on they join the smoke box and it is connected to chimney I have shown only 2, 3, 4 fire tubes there can be five six seven depending upon the design of the boiler rest if the place the rest of the space is field with water right. And the hard gases which are emerging here they pass through these tubes and from the other side they leave for the chimney like other boilers here also a damper is provided in order to control the movement of the flue gases and heat transmission to the water.

The steam generated in this boiler is collected in this dome right suppose I want to have superheated energy what I will do I will try up some amount of heat end this again is circulated through the flue gases. I will take some amount of saturated steam right I will tap the steam from here and I will circulated it this steam pipe through the flue gases.

So when it comes again it contact with the flue gases a steam will become superheated so this technique is adopted in almost all the boilers so here also we can superheated steam there are certain mountings like water level indicator it is visible in the photograph also water level indicator there is a smoke box it has a door. In this door in the smoke box is used for inspection purpose actually this is something like vertical.

So there is a door here so door can used for inspection purpose and an important mounting I forgot to tell you in most almost all the boilers is fusible plug. Fusible plug is provided on the tubes of the boiler especially the fire tube boiler somewhere here.

So if there is interruption in the supply of water or the water level goes down his fusible plug will melt or water is overheated then fusible plug is held will melt and subsequently this boiler

will get extinguish this working of the fusible plug I will explain you when I will explain you the mountings and necessary of the boiler okay. So this is the functioning of Cornish boiler sorry this is function of Cochran boiler and the last one is last on of the fire tube boiler I would like to discuss is steam locomotive or locomotive boiler.

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Locomotive boiler is and it is externally fire boiler so if you look at the schematic of this boiler it has in fact I would like to show you a photograph also of this old boiler it has a large fire space.

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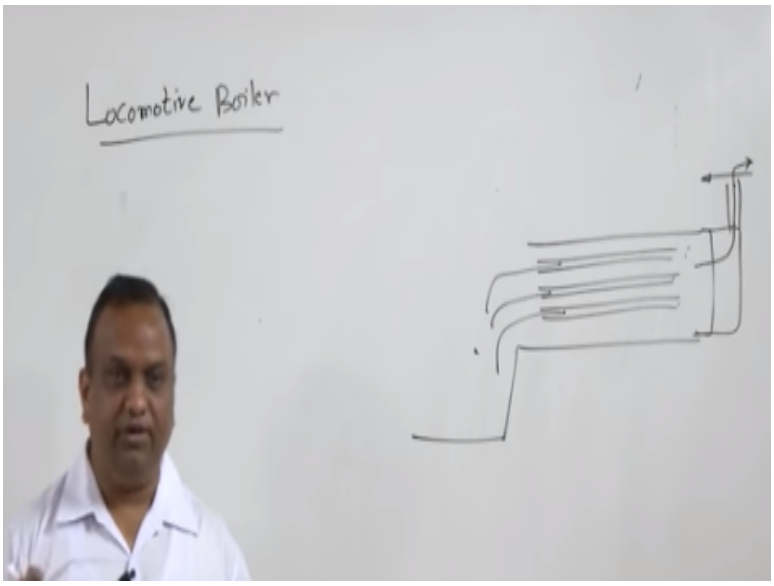

Locomotive boiler so it has also fire area and there is a shell for inter shell and this shell consist of a number of fire tubes as shown in here in this photograph the fuel is burned here they flue gases which passes through the shell and on the other side there is a stake locomotive boiler do not have chimney where chimney is not practical they have stacks on the other side stake on the other side and flue gases are removed through the stake.

In stake is a very short chimney of a very short length since because we do not required a chimney in a in a very locomotive boiler because it is locomotive boilers. So boiler itself is moving with the very high velocity the boiler is moving with the 60 kilometer per hour 70 kilometers per hour. So there is always a movement of air over this stake and if you use the BERNOOULLI's theorem you can find a temperature drop and there is a substantial pressure drop between this great this to this deck.

To the movement of the fluid pressure drop takes place so chimney is not required in such boilers and most of the things are same mountings are same and the fire tubes it has a number of fire tubes in comparison to the other boiler through which the flue gases flow right and this boilers also shell is not completely filled with the water it is partially filled with the boiler and top portion of the shell is filled with the steam that is all for today and in the next class we will start with water tube boilers