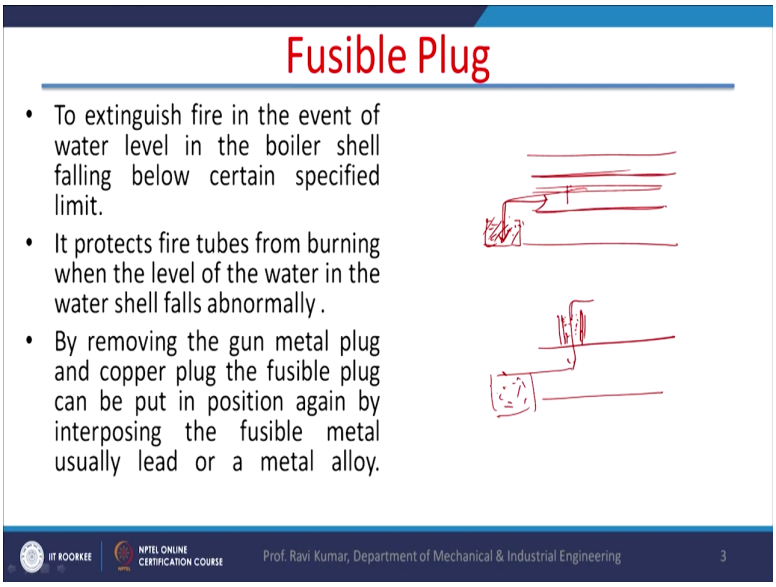
Power Plant Engineering
Prof. Ravi Kumar
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 06
Mounting & Accessories – II

(Refer Slide Time: 00:33)

I welcome you all in this course of Power Plant Engineering. Today, we will continue to discuss the Mounting and Accessories of steam generators. Topics to be covered today are the boiler mountings, remaining boiler mountings. Some of the boiler mountings we have already discussed in the previous lecture, and some of the boiler mountings will be discussing in the current lecture, and some of the boiler accessories we will be discussing here.

(Refer Slide Time: 00:50)



So, let us start with a boiler mountings. There is a fusible plug which is required in almost all fire tube boilers. If fire tube boiler is a boiler, where in the shell the water is filled and there is a tube that maybe 1 tube or maybe 2 tubes or 3 tubes which are carrying the hot fuel gases which are burned in the combustion chamber of the boiler and these hot gases are surrounding by the water.

Water is not filled up to the top, it is filled up to the certain level, right, in certain level is maintained. And, when these gases they when they pass through those fire tube the heat is surrounded, heat is transmitted to the surroundings mainly through convection and the water is subsequently converted to the steam and this steam is supplied. So, in a fire tube boiler fuel gases, hot fuel gases they flow inside the tube and tube is surrounded by the water and the whole assembly is fitted in a shell.

So, now, what happens? Suppose we have certain safety arrangements. So, we have safety walls, we have water level indicators, suppose all these mountings fail, the worst case scenario, I mean the all of them the mounting fails and operators is not able to know the level of the water, right. So, the walls they do not function, the potter level indicator it does not function in that case in order to avoid any mishap fusible plug. This is the last safety, the boiler fusible plug is provided. Now, the fusible plug is provided on the surface of fire tube boiler, this is a plug, right.

And when the water level goes below the fire tube, right; so, fire tube is not able to transmit heat to boil through the water. So, temperature of the fire tube starts rising and beyond the certain value the metal which is filled with the fusible plug it is filled with the gun metal, ok. It is this is a copper cap and it is filled with a gun metal, this metal melts and the water in the shell, right or a steam in the shell, not water because water is not there.

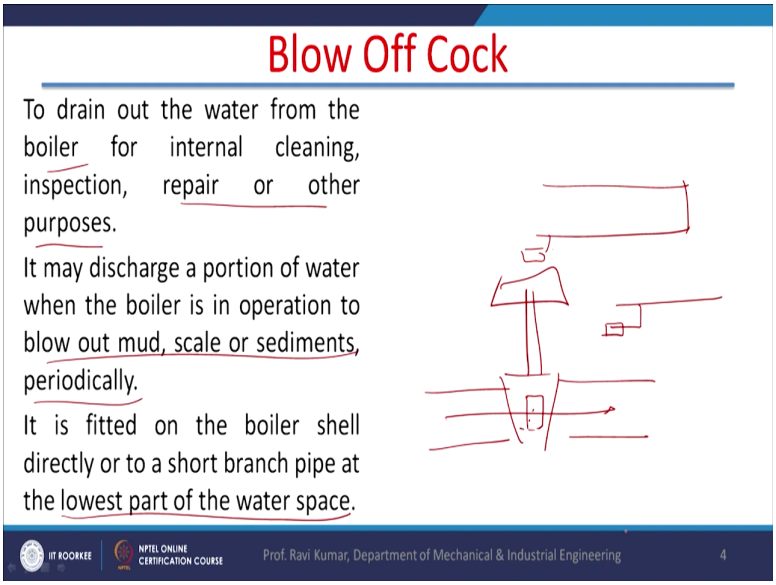
So, steam in the shell it enters the fire tube and subsequently it goes to the burning place combustion chamber and it extinguishes the fire. So, when this wall becomes operative the operation of the boiler automatically stops, right. So, these fusible plugs they are for the protection of the last protection, they are for the last protection of the boiler when the level of the water goes down, right and the fire tubes are exposed to this steam.

So, subsequently they start the temperature of the steam it starts raising, right and a beyond a certain value it melts the filling in the fusible plug that is normally gun metal or any other metal it depends upon the temperature, right and that metal fills when this metal melts an opening is created through this wall for the fire tube. So, steam which is occupying the upper half of the shell it will enter the boiler through this passage and ultimately it will go to the fireplace or the combustion chamber and it will extinguish the fire.

Now, after when this fusible plug becomes operative, we cannot continue the boiler operation, boiler operation has to be stopped. Now, this fusible plug has to be replaced by new fusible plug and it is a very long days I mean it takes days together to make the boiler operative. But it is a protection, is a protection of the boiler, otherwise some accident may take place. So,

this is also a mandatory part, a mandatory part of the boiler and it is very important mounting because this is the last defense against any an, any mishap during the operation of the boiler.

(Refer Slide Time: 04:57)

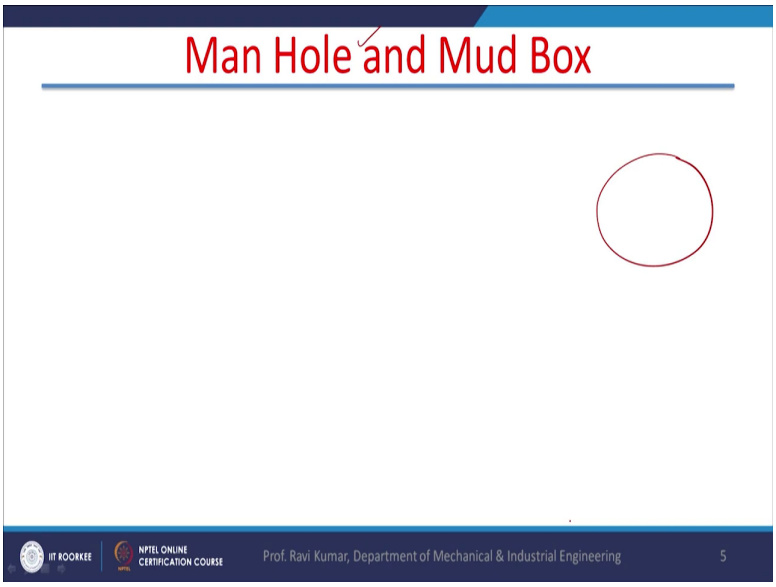


Now, another mounting is blow off cock. Now, blow off cock is normally provided at the bottom of the shell. Suppose there is a shell, boiler shell blow off cock will be provided somewhere here, right. It is normally for the cleaning of the boiler because they drain out the water from the boiler and repair another purposes. Sometimes during operation also it is opened, crack opened to blow out mud scale and sedimentation periodically and it is fitted in the boiler shell directly or the short branch pipe lowest part of the water space. So, it is placed at the bottom. Or what happens?

There is a shell and there is a branch out of the shell here, the blow off cock is placed and it is the simple wall this is a gate type wall, right, there is an opening, and there is a lever, when

you turn the lever this opening comes into the line with the passage through this pipe and the blowing off water or a steam water mixture or sedimentation takes place out of the boiler. So, this is also, a blow off cock is also one of the important mountings in a boiler.

(Refer Slide Time: 06:17)



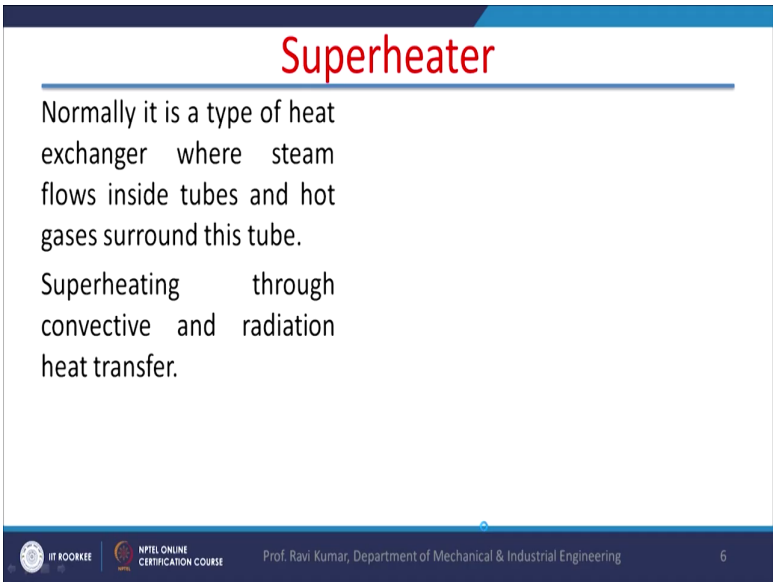
Now, after the mountings now this is the last one the man hole. Man hole is nothing, but a simple hole of the diameter of the 1 meter or 2 feets or the 1 meter depending upon the size of the boiler and the purpose of the manhole is to uh now a worker enters through this hole to the wall inside the wall because the boiler size is quite large. So, the boilers the size of the quite large and manually some somebody has to enter through a hole, through a hole somebody has to enter the boiler for the cleaning and the maintenance purpose, right.

Otherwise, cleaning of the and the maintenance, it is how the boiler doors are also provided, is it look at the Cochrane boilers, it is how the Cochrane boilers doors are provided, and

Babcock's and Wilcox's boiler doors are provided for inspection and the maintenance. Manuals are also provided in the boilers for mainly for the purpose of inspection and maintenance.

Now, we will come to the accessories. Now, function of the accessory is different from the function of the mountings. Mountings are mandatory, without mountings we cannot I mean operate the boiler, but accessories are to further either I mean they are further to improve the performance of the boiler. So, if you are using accessories we can we can improve the performance of the boiler.

(Refer Slide Time: 07:49)



Normally, if you look at the boiler has in old days, if you look at the old boilers they had efficiency of 60 percent, 65 percent some of the boiler had efficiency of 50 percent, now the boilers have efficiency more than 90 percent. Now, if you talk about the efficiencies, I mean if

boiler is 90 percent is a good efficiency or bad efficiency as a mechanical engineer or if I say there is a IC engine, petrol engine if I say efficiency is 50 percent or boiler efficiency is 70 percent, so efficiency of the boiler is better than the efficiency of IC engine. No, it is not like that.

Because in IC engine, what we are doing? What we are converting heat into the useful work, so a low grade energy is being converted into high grade energy and that to with a efficiency, 50 percent, no IC engine has efficiency of 50 percent, maximum is maximum is 40 percent, it is around 35 percent. An IC engine there is a thumb rule that one-third of energy of fuel will be converted in to the useful work, one-third of energy will go with the exhaust gases, one-third of energy will go with the cooling water.

So, normally in an IC engine the efficiency is 35 percent. It is very good efficiency. But for a boiler if I say 70 efficiency nowadays it is very poor efficiency. So, boiler efficiency has to be more than 90 percent, right. If I talk about the transformers, now after I mean let us go into the electrical also. Let us, if I talk about the transformer in a in a power plant, so transformer efficiency if I say 90 percent is a very poor efficiency for transformer. Because in transformer what we are doing? We are just sending energy in through induction from one coil to another coil, in that course we are losing 10 percent this is quite high 90 percent is very poor efficiency.

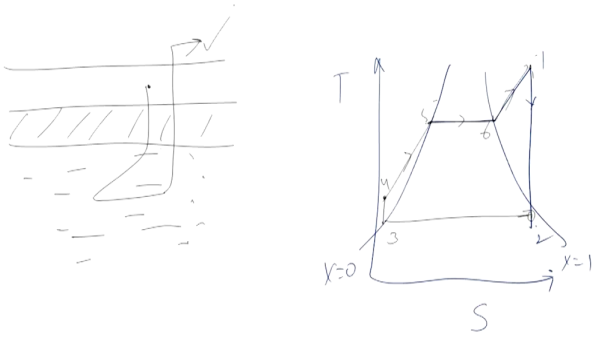
So, transformers have 99 percent efficiency, 98 percent efficiency, right. And for that 1 percent let us say, 1 percent suppose there is a 1000 kVA transformer, so 1 percent loss is 10 kilowatt, it means 10 kilowatt is being is heat is being lost, 10 kilowatt is quite high. So, that is why cooling arrangements are made in the transformers, so that this heat is dissipated.

Now, in the boilers the efficiency is normally it has to be more than more than 90 percent. If we talk about the compressors, compressors also it cannot be 90 percent, because in boilers what we are doing? Low grade energy is remaining low grade energy. So, low grade to low grade we are losing 10 percent. So, for compressors, for compressors also it is it has it is I

mean if I say compressor the efficiency is 50 percent it is not good efficiency, it should be around say 70-75 percent.

So, as a mechanical engineer one should have fairly good idea about the efficiencies of different devices which is I mean acceptable efficiency which is not acceptable efficiency. So, in nowadays in modern day's boilers efficiency has to be more than 90 percent, right. Even if you make one change, now, this things have designing has come to such a point even 1 percent improvement in the efficiency of the boiler will save a lot of energy, ok. So, the first thing is super-heater. Now, this super-heater is required for super-heating of a steam.

(Refer Slide Time: 10:57)



If you look at again Rankine cycle, right, and a temperature and trophy diagram X is equal to 0, X is equal to 1. So, this process 1 to 2 takes place in a turbine and not this is not like that

this is 1, 2, 3, 4, 5. So, boiler the pressures water enters the boiler at state 4; 4, 5 sensibility in 5 to 6 is change in the phase change and 6 to 1 is super-heating.

And super-heating is the nowadays in all power plants, super-heated steam is required. We do not use saturated steam in the power plant because such, so if you use saturated stream, there are many issues. So, all the turbines are designed for the super-heated steams, super-heated and if the temperature of a steam is quite high at the entry of the turbine. So, so boiler has to provide super-heated steam.

Now, how the superheated arrangement has to be made in a boiler? If you remember the Babcock's and Wilcox's boiler, the steam is stored in a shell in a horizontal shell and shell is partially filled with the water, right. Saturated steam is taken from here there is a super-heating arrangement in the Babcock's and Wilcox's boiler, super-heated steam is taken from here, it is past pass through a pin u pin and again it is supplied to the supply point of the turbine or any supply point.

So, this steam again because this side is fire, it is a water tube boiler, so this side is fire. So, this saturated steam again takes heat from the hot flue gases and it gets super-heated. So, this type of super-heating arrangement is made in almost all the boilers.

First the saturated steam is generated then saturated steam is again pass through the flue gases I mean through a u pin or a different type of pins and then again it is supplied because steam get. If you look at the Lamont boiler or any other boiler the super-heating arrangement is same. First of sensibility and then after sensible heating, so not sensible heating this saturation, the saturated steam generation then saturation steam is again pass through the flue gases for the generation of superheated stream.

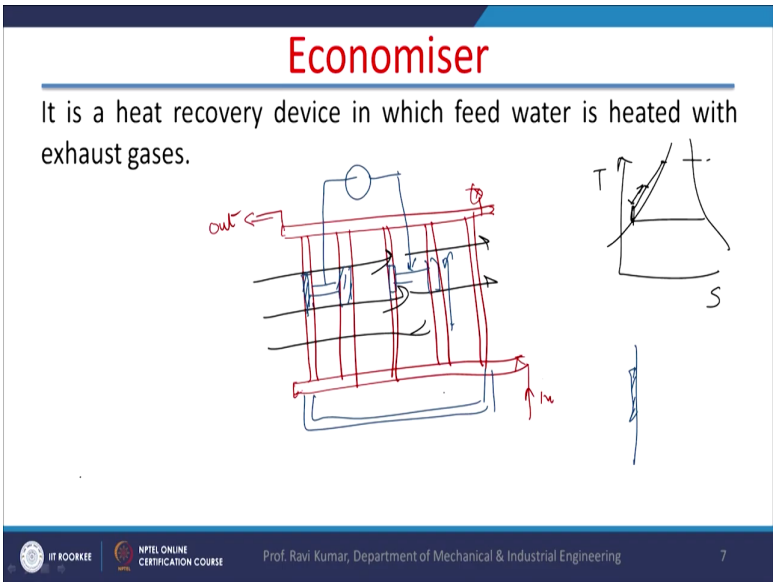
So, because it is very difficult to I mean generates super-heated steam in one single go. First, in normally what is done? First the saturated steam is generated is collected if it is a shell type of boiler and then again saturated steam is passed through the flue gases, again it takes heat from flue gases and super-heating is done.

There is several benefits of the super-heating. First of all it increases the thermal efficiency of the Rankine cycle, second is at the exit of the turbine the quality of a steam is high, so the blades are not. This we will discuss in subsequent lectures. But here for the purpose of super-heating, super-heater is provided and this super-heated, this super-heater improves the performance of the boiler or performance of the cycle.

So, after the super-heater we will discuss the economizer because in a boiler when the steam is generated and in the flue gases a lot of heat remains, even after the generation of a steam a lot of heat remains. And the ideal thing is we should have 100 percent efficiency of the boiler, 100 percent means whatever heat is generated it is being used for the generation of, it is a hypothetical situation, it is not possible, it is a hypothetical situation, and it will violate the law of thermodynamics also.

But we should try to extract maximum amount of heat from the from the flue gases for the purposes of generation of a steam. So, different necessities are provided. This is how the performance of the boiler is improved. So, economizer is one of such accessory which is used for uh which is used for improving the uh performance of the boiler.

(Refer Slide Time: 15:31)



So, in economiser there are two pipes headers, they are known as headers, so there is one header and there is another header, right. And this header there is a wall which supplies water in water in and there all herders are filled this is a blind ended. So, and this side there is a supply for water out. So, water entering from this side and leaving from that side. This side some safety wall is provided for a safety of economiser and this economiser is connected this header is connected with a number of tubes, it is connected with a number of tubes.

So, water entering from this side shall pass through this tubes and we leave from this. So, the flue gas is they move from this direction to this direction, the flue gases they move in this direction. So, normally there is a convective heat transfer. Hot flue gases they impart heat to the water and this water is feed water. Feed water means the water which is going for to the boiler for the generation of a steam. So, in a condenser the steam is gas condense, after

expansion in a turbine in a condenser the steam get condensed, the temperature of condense it is around 25 or 30 degree centigrade, right or 35 degree centigrade in that range only.

Now, this condensate is if is pumped to the boiler that is normal Rankine cycle, but before pumping to the boiler it is it takes heat from the flue gases. So, it is sort of economiser is a sort of heat exchanger. So, here the water, the condensing coming from the condenser it takes heat form the flue gases and the temperature of this condensate rises. So, the benefit of this is can be shown if you look at the temperature entropy diagram again.

So, when the this condensate this heating takes place, so after pressurization, sorry it is not before pressurization, after pressurization the heating takes place, so boiler it will enter at this point, not at this point. So, this heat will come from the flue gases, right and this much amount of energy will be saving. So, when we will calculate the efficiency of the cycle, efficiency of the cycle will definitely proof, right.

So, and it sometimes is go to the extent where there economiser in the heating in the economiser can be very close to the saturation temperature, this is also possible, right. So, in that case we will be going very close to the Carnot cycle. So, here these flue gases they pass over these tubes and impart the energy to the water which is flowing inside these tubes. But there is an issue here, the issue is these flue gases I mean they are not simply hot gases, they have unburned carbon particles, they have suit unburned carbon particles and different type of impurities, right and they stick on the tubes because these tube surfaces are cold. So, tendency is to stick on these tube surfaces.

When these tube surfaces are coated with the suit definitely it will hamper the heat transfer and that is a very serious problem. So, we are putting economizer, so initially for an hour or two it will work, ok, but later on the performance of the economiser will reduce drastically. So, for this purpose scrappers are provided. So, scrappers are provided on the surface, these are the scrappers. They move, they do two inflow motion on the surface in order to remove the suit on the surface or any deposition on the surface.

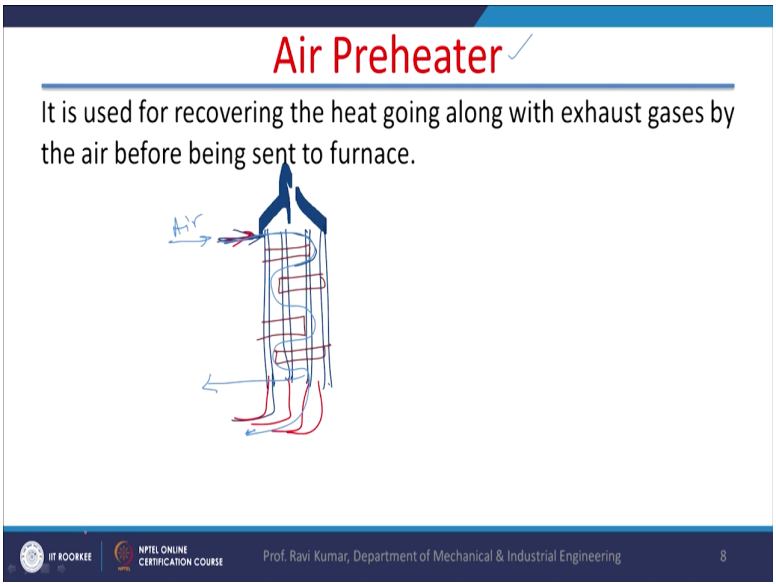
And for this purpose there is a pulley, pulley here and suppose here also, the all in all the tubes the scrappers are provided on all the tubes they are connected with the pulley, right. And two end, this two end for motion the removal of any deposit on the surface takes place. There was, this arrangement is necessary, it is mandatory. If this arrangement is not there, the performance of economiser will reduce drastically.

So, this two end flow motion, this two end flow motion of this scraper on the surface removes the suit from the tubes and it is collected in a suit chamber at the bottom of the economiser, right. But the function of the economiser is to take heat from the flue gases which are leaving the boiler and these flue gases they do heat the feed water and this saves energy that is why they are called economiser, right.

Now, after economiser we can take air preheater. Now, air preheater means the air which is used for burning the fuel, right. So, if you look at the heat balance if we increase the temperature of this air, right indirectly we are adding heat to the flue gases, right. So, normally the atmospheric air is used for the burning of the fuel, but instead of that if we use high temperature air, the high temperature air if it burns the fuel that heat will also go with the flue gases, right.

So, air preheaters, they are also heat exchangers air preheater. So, economiser is gas to liquid is the exchanger and the air preheater is air to air heat exchanger. So, air to air heat exchangers have lower efficiency, right.

(Refer Slide Time: 21:16)



So, a typical arrangement of this the vertical tubes, bunch of vertical tubes and where the hot gases are flowing in this tubes, hot gases are flowing through these tubes, right. So, they are vertical tubes hot gases are and they are leaving here from the top, right. And cold gases are entering from this side.

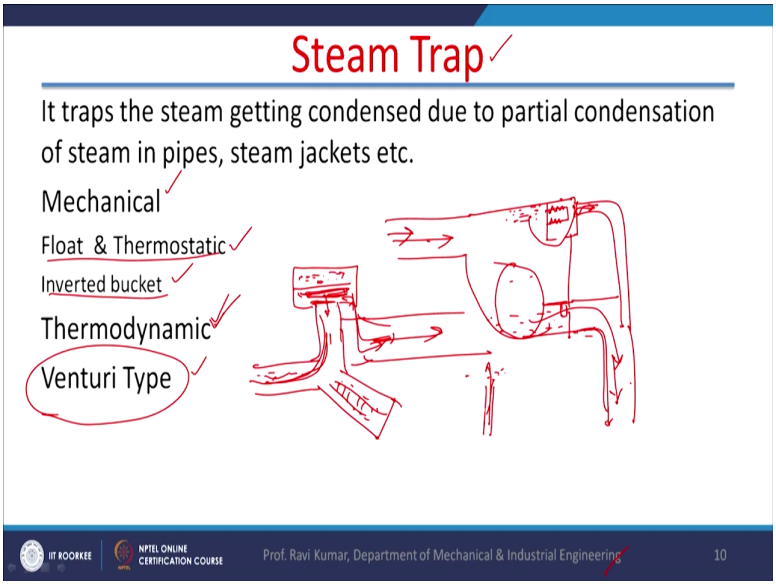
One thing is they just flow over these tubes, if they simply flow over these tubes some heat exchange will take place. But in such a situation when we have to increase the heat transfer baffles are used, if you remember baffles are used and for this baffles are placed like this. In boilers also baffles are that used in the in the water tube boilers the baffles are used, so that the maximum time is provided for the contact between the gases and the water tube.

Here also baffles are used, so that when the water enters water enters from this side it goes like this. So, when air enters from this side, air enters from this side and it passes over the

baffles, so maximum time is provided or it leaves from here. So, maximum time is provided for the contact between the cold air and the hot air or the hot tubes.

So, tubes the temperature of the tubes is high because it is high because the flue gases are flowing inside the tube. So, the vertical tubes flue gases are flowing inside the tube. They have web baffles and the cold air is entering for the top and leaving from the bottom, right. And it goes to the great combustion chamber we have burning of fuel is taking place and this heat is automatically added to the fuel gases. So, the air preheater the function of air preheater, is to preheat the air is preheat the air which is used for the burning of the fuel and this will this also enhances the efficiency of the boiler.

(Refer Slide Time: 23:36)



The feed pumps, the feed pumps the function of the feed pump is to feed water into the boiler there can be a reciprocating pump and then the uh centrifugal pumps, right. Reciprocating

pumps they do not have constant water supply, there is a intermediate water supply. So, such tanks are provided and reciprocating pump, so that they can have. Still, even after providing such tanks the supply is not uniform, but in the reciprocating pumps we can generate very high pressure where highly high pressure generation is required, only reciprocating type of pumps are recommended.

And there is a very interesting device that is known as steam trap, steam trap. The function of the steam trap is to separate a steam from condensate and non-condensables, right. So, this is also an accessory because what happens when the steam flows in the pipes in that course the condensation because those pipe is a 100 percent insulation insulated, some of the steam get condensate, right and it also it is also carried with the saturated steam.

The condensate is also carried with the saturated stream and they have to be separated out for any obligation. So, steam traps are provided, it is steam traps are provided in the boilers, to remove the steam and to separate the steam non-condensables and this condensate. So, they are mainly they are two type, then number of steam traps, mainly they are two types of steam traps mechanical type, and mechanical and thermodynamics.

So, mechanical steam trap there is a float and thermostatic type of steam trap. So, in a float and thermostatic type of steam trap there is a body of a steam trap, the steam is coming from this side, the steam water mixture. And there is a thermostatic expansion system here, there is an opening, here also there is an opening and there is a expansion system, thermostatic expansion system and it is coming here,. And there is a float wall, float wall is also closing this opening there is an opening and both of them are coming here, right. It is like this.

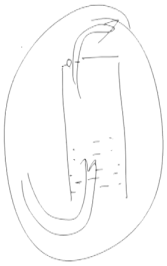
So, you must have seen in the flush system in a system, system of his flush system there is a float wall. So, when this float wall at the bottom post position the wall is closed, it is hinged here. Now, mixture of a steam is entering a steam and water, non-condensables like here are entering here, the moment they enter here this side will start filling up with condensate, right, and hot steam because temperature is high this expansion valve closes this also, right. And a

during certain interval of time the non-condensables are accumulated here at the top portion, ok

When non-condensables are accumulated here because non-condensables will not condense, steam will condense, but non-condensable will not condense. So, non-condensables are accumulated here and this reduces temperature in this zone, but the temperature is reduced this wall is opened and all the non-condensables they leave from here. Some of the steam will also go with them, and it is not an ideal system, some of the steam will also go with the non-condensables, but non-condensables will leave from here.

The water level is raising. Now, water level is raising. Now, water level is raising, after certain level of the water level the water will be drained off from this side, right. So, this is a very popular arrangement, this is known as the float and the thermostatic type of arrangement and another mechanical arrangement is inverted bucket type of arrangement.

(Refer Slide Time: 27:51)



Now, in inverted a bucket type of arrangement there is a bucket and bucket has a hole. It works on the heuristic principle, right. Bucket has an hole to remove the non-condensables, right and the steam is this is a mixture is supplied from the bottom, right with the condensate when this bucket, inverted bucket is filled with the condensate it is lifted up. When it is lifted up the wall is open and the non-condensables and the steam are removed. So, this is another type of arrangement, this is known as inverted bucket type of arrangement for the stream trap.

Another arrangement is thermodynamic. Here the energy difference is used energy difference is used for the drainage of for the separation of this non-condensables or steam and the and the water, and this type of in this arrangement there is a pipe, this is strainer here, right and above this there is a disc, there is a chamber. And now here, from here the steam is entering to this

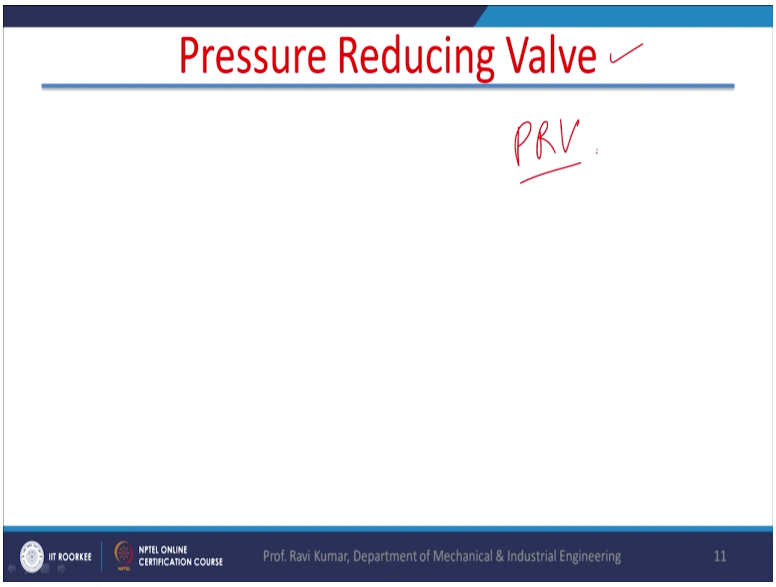
thermodynamic type of arrangement and this steam will lift this disc and it will occupy the hole space and it will leave from here to another pipe. It will leave from here to another pipe, right.

When this disc is lifted, in due course of time the condensation of this steam which is here takes place and this the pipe which is lifted it comes down and it will again closes this opening. So, this opening and closing keeps on going, right. And subsequently the steam which is entering from here is I mean the condensate and what it is called condensate and the steam they get separated and steam leaves from this side, ok. So, that is a another type of.

And the last one is Venturi type, this is the latest one the Venturi type of a steam trap. In Venturi type of a steam trap what happens in the same arrangement in narrow opening is provided. In this narrow opening what happens? Throttling of the steam takes place, and due to throttling the white particles are converted into the stream, right. That is the that is the difference this Venturi type is a new type of stream trap here a small opening is provided in the steam trap, when the steam enter, the wet steam enters the this small opening that throttling of the steam takes place and due to throttling the that water droplets are converted into the steam.

And back pressure is also generated, back pressure is also generated which prevents the enter entering of the I mean entering of the liquid into this close opening there is a narrow opening. So, these are the steam traps. But, in the stream traps are very important because what happens in any with the boiler line is very long very lengthy, pipeline is very lengthy in that case the substation amount of condensate is accumulated and it has to be separated out. And, the water has also has some dissolved non-condensable gases mostly air and that has to be separated out and they are all separated out in stream trap.

(Refer Slide Time: 31:28)



Pressure reducing wall, that is known as PRV. Now, pressure reducing wall is I mean, suppose this is the boiler the pressure is 100 bar and you have PRV. So, what PRV will do? It will first reduce it to 10 bar and then it will supply. So, it will supply it to the. Same thing happens when you take the high pressure gas cylinders also the PRV pressure reducing wall. So, from inlet say, inlet maybe 100 bar it is reduced to the 20 or 30 bar, only then it is supplied to the line. So, pressure reducing wall also an a very important accessories to a boiler. That is all for today.

Thank you very much.