Steam and Gas Power Systems
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Module No # 02
Lecture No # 06
Steam Generators

Hello I welcome you all in this course on steam and gas power systems today we will discuss on steam generators. Now steam generators are used as it implies from the name of itself they are used for generating the steam.

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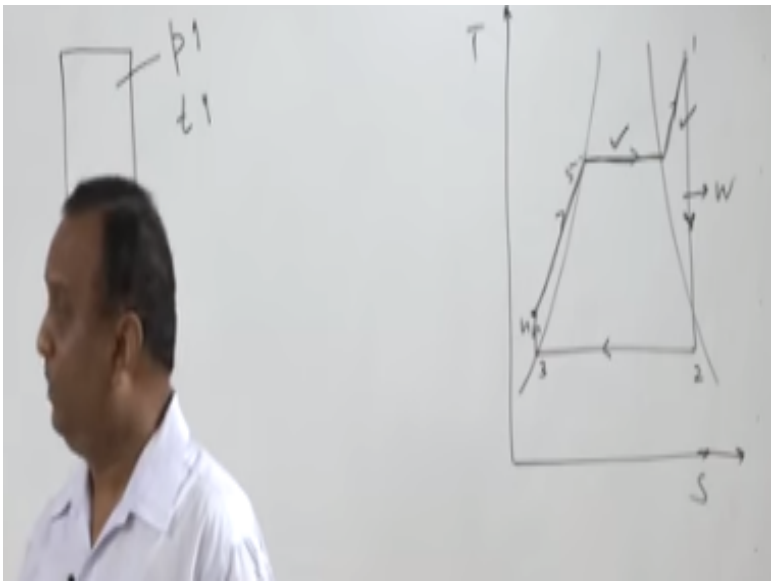

And in a rankine cycle if you remember temperature of entropy diagram state 1, state 2, state 3, 4, 5 and 1. So process state 1 from process state 2 to state sorry from process state 4 to state 1 takes place inside the boiler after pumping when the pressure is increased through a pump the fluid or the liquid or feed water goes to the boiler and this heat addition in heat water takes place inside the boiler.

So basically boiler in a in a thermal power plant or in a rankine cycle is used for steam generation and this steam is subsequently expanded in a turbine and that is how the output is attained from the cycle. Now in this course we will be covering the boilers there is steam generators.

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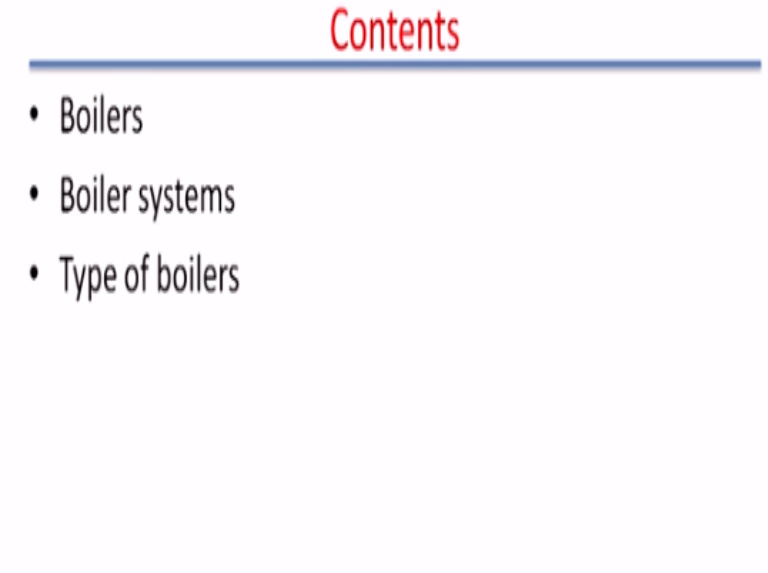

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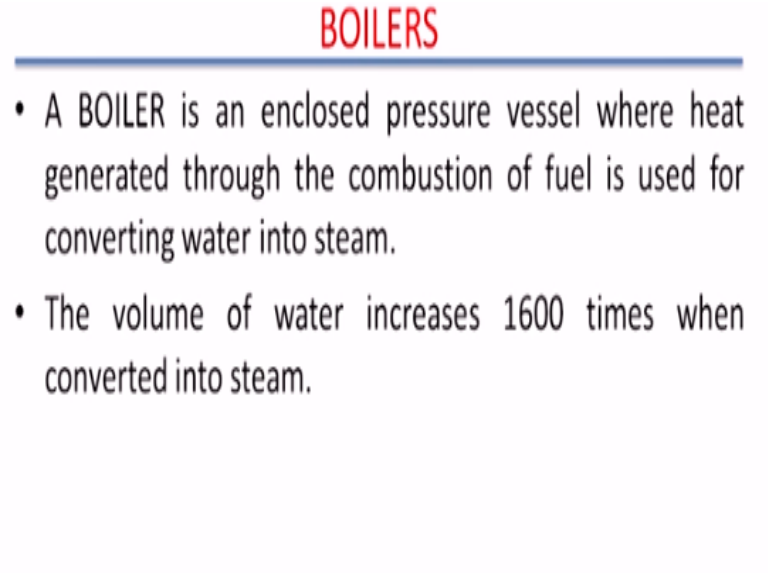

Boiler system and type of boiler by definition a boiler is an enclosed pressure vessel were heat generated to the combustion of the fluid is used for converting water into the steam because here the feed water is going to the boiler and subsequently it is converted into the steam. But when the water is converted to the steam there is enormous increment in the specific volume of the water it is approximately 60 it may go up to 2000 also.

So it is approximately 1600 times but the boiler has some confined space it is a I mean almost constant volume that is why instead of increasing the volume the pressure is increased. So the

steam available from the boiler is at high pressure and high temperature. Now regarding the requirement of the good boiler because before we design a think we study any equipment we first we understand what are the requirement of that equipment.

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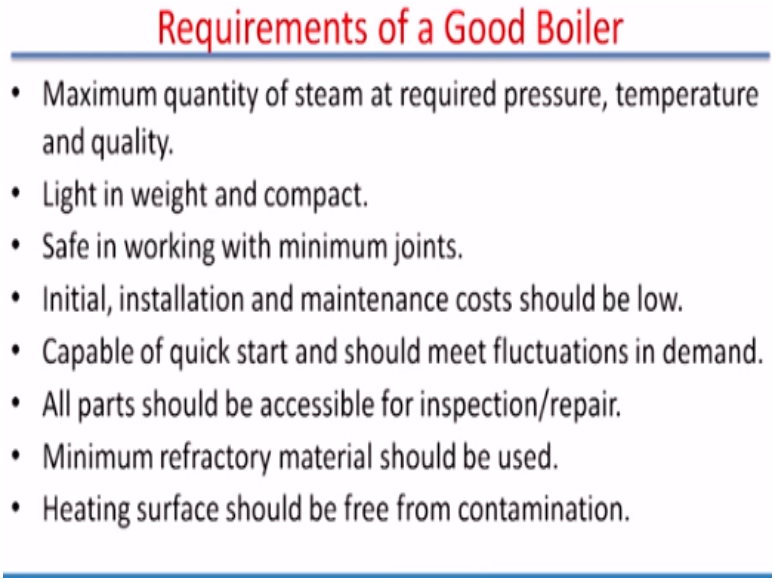

The requirement of the good boiler is maximum quality of the required pressure temperature and quality it is obvious when we are installing or purchase a boiler it should give maximum quantity of the steam and required pressure temperature and quality. There three things which are important not only pressure and temperature but of the steam whether it is a wet steam or superheated steam that is also equally important.

Lighted weight and compact boiler has to the light in weight so transportation is easier it has to be compact it should occupy minimum floor area. Safe in working with minimum joints boiler should have because it is a high pressure vessel. So if it has minimum number of joints the changes of leakages will also be minimized. Initial installation and maintenance cost should be low.

So anything we purchase it has to be low cost and high quality so same is the same is the case here so initial installation and maintenance cost should be low. Capable of quick start and it should be the fluctuation in the demands say demand of a steam in any prime mover is not

constant it may vary and it may depend upon the load. So the boiler should be able to or boiler should be capable of meeting this fluctuation in demand.

All parts should be accessible for inspection and repair because boilers are always under inspection right. So the all the parts should be accessible for the inspector for the inspection and of course for repair as well, There must be respective material used for the boiler because later on in subsequent lectures I will explain you in details the working of the boiler then you will find that the refectory (())(04:58) work is also an integral part of a boiler that we will discuss later on.

Heating surface should be free from contamination because if contaminations are there the heat transfer will not be very effective so the heating surface will be free from contamination. Now regarding the boiler systems every boiler or every machine as certain systems.

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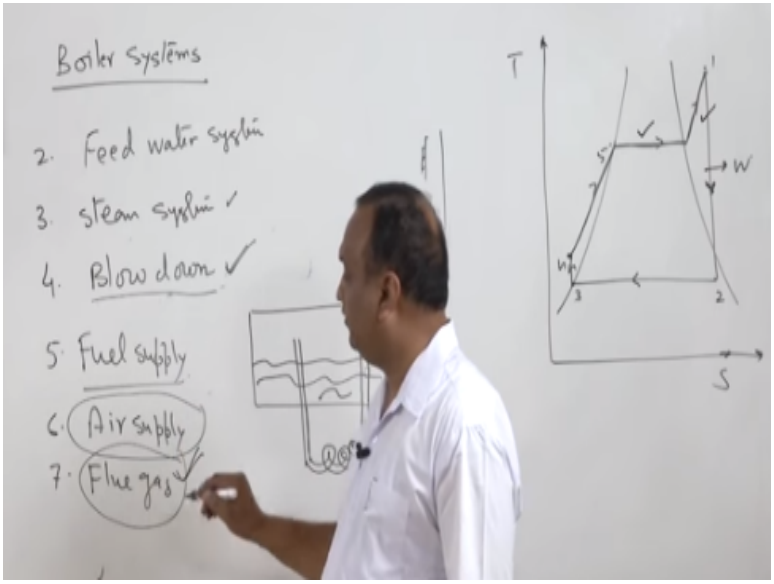

So regarding the boiler systems number one is water treatment system. Now water treatment system is we cannot use deaf water in the boiler because two TDS of deaf is water is quite high and it is not permissible to be used it is not permitted to be used in a boiler because when the water heating takes place in a boiler the solubility of salts in water reduces drastically.

When temperature exceeds 44 or 45 degree centigrade and these materials they get reciprocated on the surface and scaling is formed and this is scaling works as a insulators. Suppose there is a

boiler tube if scaling is done on the surface of the boiler tube this will hamper the heat transfer right. So in order to avoid this scaling the water treatment is done ideally we should use distilled water in a boiler.

But distillation is very energy intensive process so instead of a distillation demineralization of water is done and the water is less than conductivity of less than 5.0 micro siemens per meter is used for feed water in the boiler now this sorry this for is this is micro siemens. No siemens is inverse of ohm if you remember your electrical engineering then resistance of any conductor is proportional to length of the conductor and the area of the conductor and resistance is a constant.

If a constant in specific resistance L by A now specific resistance row is RA by L and the unit of his specific resistance is ohm meters. Now conductivity is opposite of this one by row so it turns out to be 1 by ohm meter and this 1 by ohm is known as siemens S it is denoted by S. So the conductivity of the water is expressed in terms of siemens per meter conductivity of water as to be less than 5.0 micro siemens per meter.

That reflects the purity of water now portable water can have conductivity of 250 micro siemens per meter. Now sea water if you look at sea water can never be used for boiler but if you look at the connectivity of sea water it turns out to be 5 into 10 to power 6 micro siemens per meter or 5 siemens per meter. So it is quite high I am just giving you values to compare the quality of water.

So in ideally in a boiler were water has to be distilled water but we cannot use distilled water so we use the water with a thermal conductivity of sorry electrical conductivity of less than 5.0 micro siemens per meter now there is a in addition to the this water treatment system. There is another system which is known as feed water system feed water is the water which goes to the boiler but it does not go by its own.

So there to be system is place now feed water system includes hmm a feed pump and feed check wall. Now feed check wall is a sort of non-return wall because when the water enters the boiler the pressure of this fruit will rise and that flow may takes place though the feed check wall is sort

of a non- return wall which is used in the boiler and which does not allow water to flow from boiler to pump.

So there is only unidirectional flow of the feed water and in addition to this there is steam system also. Now steam system means the steam is generated in the boiler in almost all the boiler it is stored in a drum right. It is stored in a drum the steam from a drum is taken if we want to do the super heating of the steam. Now when the steam is stored in a drum part of the drum is filled by the saturated water and part of the drum will be filled with the steam.

So you will never get a super-heated steam so here in this case what we do we provide a pipe which takes saturated steam to the boiler or the fluid gases and then we get a super-heated steam from this outlet right in addition to this there is a steam check wall and there number of safety walls right. It includes there in steam system now forth is blow down system right.

Now blow down system is it is a blow down wall okay and it is provided at the bottom of the wall. Suppose you have switched of the boiler when you have switched off the boiler it means you are not supplying heat or it disconnected from the from the or you are not providing any fuel to the boiler subsequently the boiler will switch off and whatever water is available in the boiler it will blow down through this system so there if boiler as to be a boiler must have a blow down system also.

Fifth is fuel supply system right a boiler may use solid fuel it may use liquid fuel so if it is liquid fuel there has to be liquid fuel pump which will pump the liquid fuel into the furnace if solid fuel has to be supplied the several arrangement for supplying the solid fuel. So this is also a part of the steam generation system air supply system and seven is flew gas system because air available in air combustion system is often no sufficient.

So air as to be circulated in the combustion chamber there are two ways of circulating the air eight we use natural draft or we use induce draft or force draft or the induce draft and force draft or attained by a providing sense. So there I a separate system for air circulation in the boiler flue

gases also because flue gas because the heat exchange takes place between the flue gas and the water.

So for the circulation of the flue gases also there is a system in the boiler and the chimney or baffles are provided in order to manage of flue gases in the boiler. Then different type of boilers and they can be classified on different type of parameters first is orientation.

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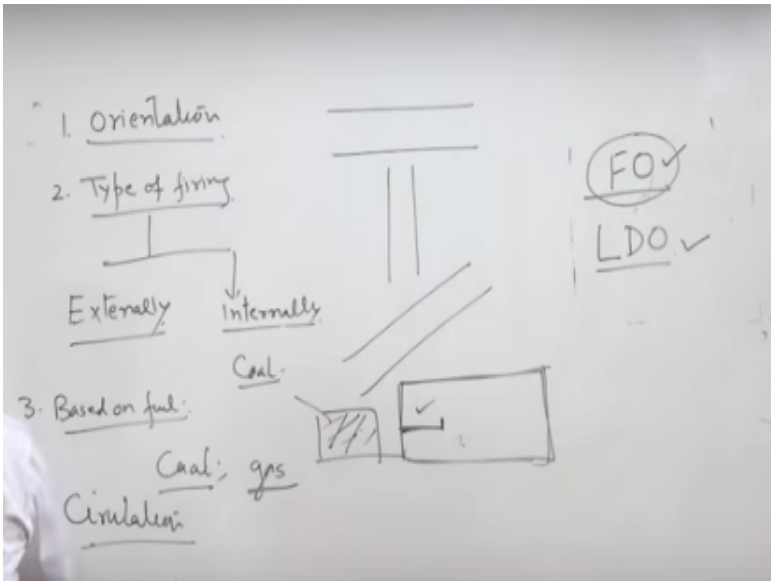

Orientation of vessel of the boiler right if it is if the vessel is horizontal it is over the horizontal boiler. If vessel is vertical it is vertical boiler if the vessel is inclined if it inclined boiler right. Type of firing it is firing of the flue. Now how the fuel is fired in some of the boiler or initially when the boiler were manufactured the firing was provided within the boiler some a great was provided now great the new term great.

Great is a place or a platform it is perforated or it has having a several rods and this buffer I will show you the plan of the grate it is going to be something like this a number of solid rods right. And few lies over this rods air is circulated. Suppose this grate air is circulated to the grate which facilitates the burning of the fuel. Now each form in the grate suppose this is the grate H form is the grate is collected in ash pit.

Ash pit is just below the grate so the type of firing most of the boilers in the earlier stage were internally fired right the grate walls inside the boiler body like I will not the boilers otherwise you will get confused some of the boilers this combustion takes place outside the boiler. I will give you example like steam locomotive if you have seen there is a steam locomotive the combustion of fuel takes place outside the boiler.

There is a big furnace inside the furnace normally pole or wood stock is used boilers the fuel in was used. Now a days steam engines are used in public transportation of goods transportations but that time because in India in think in nineties early nineties around 93 or 94 all the steam engines were discarded and now we are using these are locomotives or electrical locomotive electrical locomotives.

So coal was burned outside and the flue gases were circulated inside the boiler in order to generate steam right. So they are externally fired boiler and internally fired boiler so old boiler you will find in in in new boilers also many of them I mean majority of boilers are internally fired by these. Now based upon now third is based on fuel which fuel you are using the most popular for the boiler is coal right.

Coal is used then gases are also used even for this package type of boilers furnace oil is used. Furnace oil is a petroleum product that is used in small capacity boilers LDO is used then LDO is light diesel oil the normal diesel which is available on the petrol pump. So LDO is used can be used say for any fuel furnace oil is can be used as a fuel it is for the boiler coal, gas but gas can be used only for a stationary boiler for moving boiler gas cannot be used right.

And Woodstock can also be used if it is available in plenty forth is based on the circulation of air this I have already told you circulation of air it is a natural circulation of air in the boilers or the air is circulated using a blower or a induced draft is created or air is that there are two types of air circulation.

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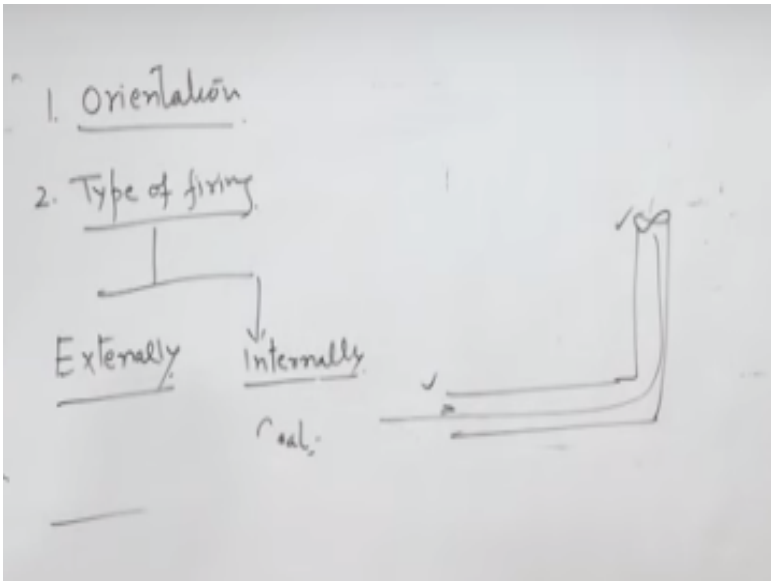

Suppose in a passage I have to circulate a air one method is I put a blower here and circulate the air in the passage that is known as force draft. Another way is I put a fan here or blower here which sucks the air through this passage it is known as induce draft. So either you go for induced draft in the boiler or force draft in the boiler or it can be a natural circulation.

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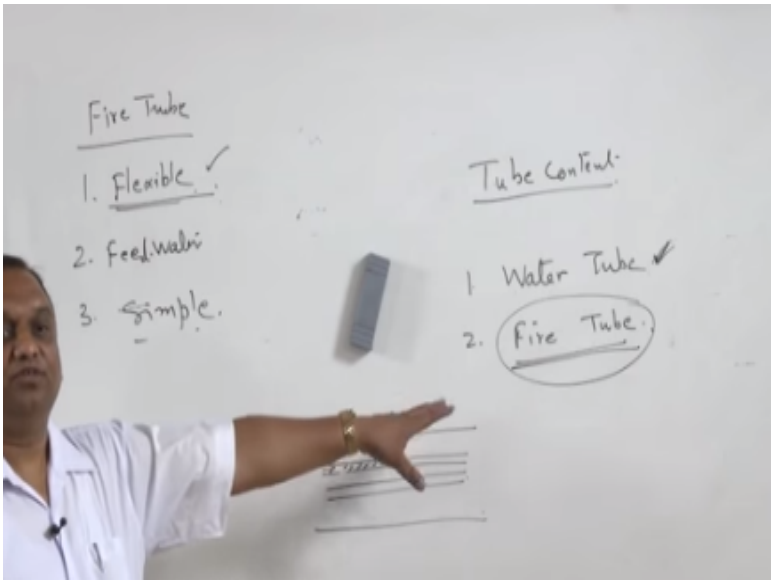

Now another type of classification is extent of fire extent of fire means it is a fired boiler or it is unfired boiler because in some of the boiler the firing does not takes place hot cases or circulated sometimes waste hot gases are available. So these gases are circulated in the boiler in order to generate the steam. Another classification of the boiler is tube content this is a very popular

classification of the boilers for according to the tube content classification are the number one is water tube boiler.

Number two is fired tube boiler right in a typical arrangement of the boiler will be shared and there are number of cubes may be in single tube or N number of tube. Now a days most of the I mean high pressure boilers are they are water tube boilers where water is circulated inside the tubes and the shell is filled with flue gases. There can be two arrangement right few gases they flow in the tubes and shell is filled with the gases or share is filled with the flue gases and water flows inside the tube.

So the water flows inside the tube and shell is filled with the flue gas or the boiler housing it may not be shell that is also true that in a boiler housing when the boiler housing is filled with the flue gases and water flows inside the tube then it is called as water tube boiler. So most of the modern high pressure boilers and earlier also number of boilers they were water tube boilers another type of boiler is fire tube boilers in fire tube boilers there is a necessarily there as to be shell and this shell is filled with partially filled.

It is not filled fully filled but it is partially filled with the water and fire flows inside the tubes and number of tubes are also less fired tube boiler there may be one fire tube or two fire tubes now these two classes of fire boilers will be separately discussing in in in two subsequent lectures. Next lecture will be on fire tube boiler and another one on the water tube boiler.

So with this two boilers number of these two boilers the number of fire tube boilers and number of water tube boilers we will be discussing in those lectures. Now what are the advantage because there are two types of boilers so this may have certain advantages over this or this may have certain advantage over this now the advantage of fire tube boiler over water tube boiler sorry the advantage of water tube boiler over fired tube boiler.

The biggest advantage is that the safety suppose because the steam is a steam is take from the boiler with high pressure as you have seen in the previous lecture the steam was supplied at 40 bar. So if the steam is filled with the shell right by accident suppose this shell burst it is going to

cause enormous damage. Now instead of that the high pressure steam flows inside the tube and it is how in the shell damage will be less I do not I do not say that there will not be any damage.

Damage will be there but damage will be less here right that is why most of the high pressure boilers right they are water tube boilers but definitely fire tube boilers have certain advantages. So advantages of fire tube boilers wills start with. First of all they are very flexible I mean fire tube boilers fire tube boiler they are flexible in operation what is the meaning of flexibility operation because the entire shell is filled with the boiler.

Suppose there is a sudden demand of more demand this steam or there is a sudden drop in the steam it can be accommodated in fired tube boiler it can be done in water tube boiler also but immediately it can be done in fire tube boiler. That is one advantage second is if there is feed water failure say failure can take place anywhere are any stage in water tube boiler right if feed water failure supply system fails overheating of tubes will takes place.

In case of fired tube boiler because shall is filled with the water so if there is a failure in the supply of feed water the damage will not be that series. So that is another advantage of fired tube boiler and the third one is maintenance is low simple and maintenance is low their maintenance is less why maintenance is less? Just simply saying maintenance is less will not become very less it is less because in water tuber boiler scaling takes place.

So if there is a bundle of tubes so each individual each of the tube as to be clean now a days they are clean with the help of chemicals. So the maintenance cost of water tube boilers is higher in comparison to the fired tube boiler right.

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Now again we will discuss the advantages of water tube boiler first of all safety okay if accident takes place in water tube boiler is less severe. Steam generation rate is large steam generation rate is large further we can operate on higher pressure why we can operate on higher pressure on water tube boilers. Because pressure is the pressure of its steam and in any cylinder stresses are hoop stresses can be expressed by two T right.

Now here for a same thickness if the diameter is increased or in order to maintain same level of stress if we increase diameter thickness of the place as to be increase. Now in five D boiler is fill in the shell diameter may be 2 meter or 3 meters right. Accordingly thickness has to be taken for shell thickness to be taken.

However in the case of water tube boiler the diameter of the water tube may be 1 inch or 2 inch 2 centimeter or 3 centimeter or 4 centimeters. So we can go for the same thickness we can go for very high pressure. So normally high pressure boilers are therefore water tube boilers so in water tube boilers maximum pressure can go up to 200 bar 150 bar.

In fire tube bar the pressure is restricted to approximately twenty bar normally we do not go beyond 20 bar and second thing is the water tube boiler are easy to fabricate because shell is not under pressure right. So the main part which is under pressure is the tube of the boiler so they are easy to fabricate and install and assemble at the sight right. So if we compare fire tube boiler

with the water tube boiler so pressure is fire tube boiler approximately 20 bar here it can go to we can go to up to 300 bar pressure right.

Because in super critical thermal plants this water tube boilers are used so it is so the pressure in fact the pressure in the water tube boiler is decided by the metallurgical limits of the material to what temperature the material can sustain.

Efficiency of this is 85 it is slightly more 85 to 90 % and sometimes in some of the fire tube boilers it is 70 % in old if you look at the old efficiency of the old fire tube boiler it is 65 or 70 % efficiency is also high for what water tube boiler inspection is fire tube boiler inspection is easier in fire do boiler in water in boiler inspection I mean there were some number of tubes.

So inspection has to be frequent and I mean for inspection has to be done in water tube boiler and basically because the scaling the problem is scaling that has to be taken care of so frequently first of all we have ensure that the feed water is in both the cases if that is true for both the cases the feed water it does not have this tedious is low for the feed water the conductivity is less than 5 micro siemens per meter and the frequent cleaning of the tube has to be carried out in water tube boiler right.

That is not the case in the fire tube boilers right so in the next two classes first we will start with the fire tube boiler in the next two lectures first we will start with the fire tube boilers and then in subsequent lectures we will take up water tube boilers and we will be taking certain examples right of fire tube boilers and water tube boilers that is all for today thank you very much