Power Plant Engineering

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

Lecture – 11
Burning of Fuel

Hello, I welcome you all in this course on Power Plant Engineering. Today, we will discuss about the Burning of Fuel. Any thermal power plant, any thermal power plant which works on Rankine cycle or the Joule cycle require heat input and in the thermal power plants the heat is converted into the useful work heat energy is converted into the useful work.

So, burning a fuel becomes very important in related to any thermal power plant. Because by burning a fuel the heat is generated which is subsequently converted into the useful work and the topic to be covered in the in this course is the burning of solid liquid and gases fuel.

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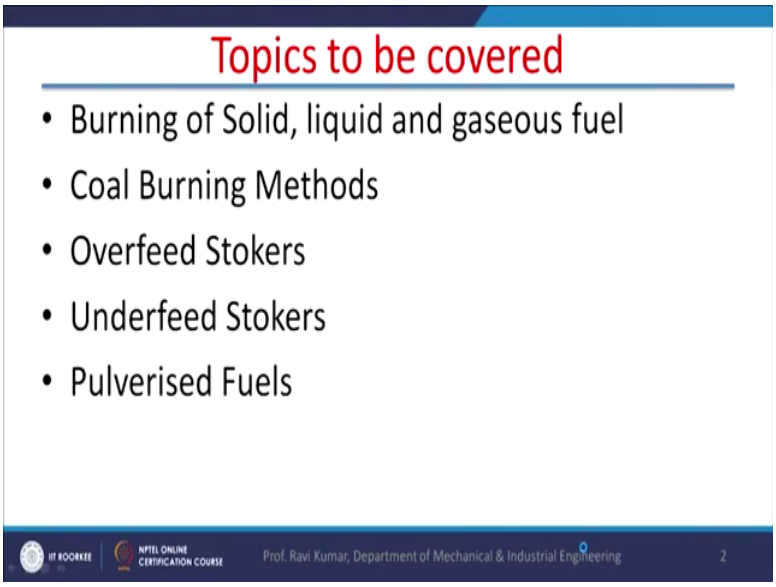

Coal burning methods overfeed and underfeed stokers and we will discuss about the pulverised fuel as well.

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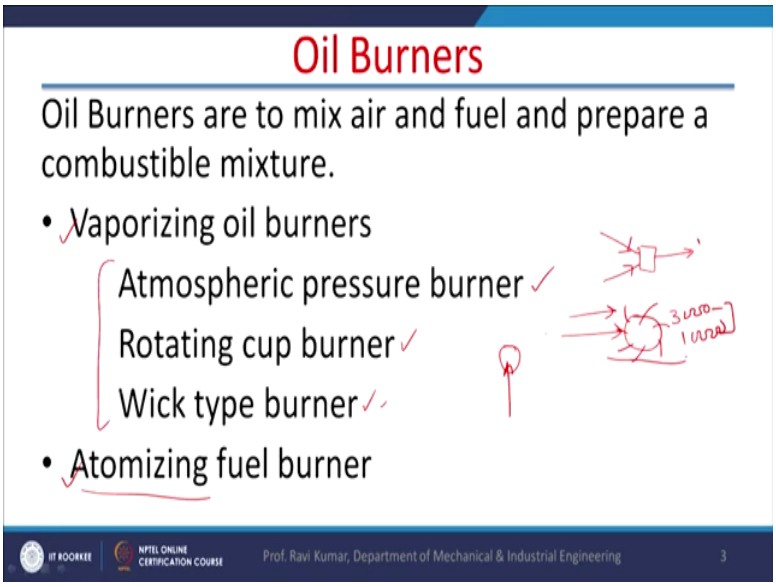

To start with, we will start with the oil burners; we will start with the oil, gas and then we will come to the solid. So, we will find some of the thermal plants which work using oil as the working fluid or the burning fluid; the working fluid maybe air or the steam. Now, for burning of the liquid fuel or the oil burners are required; burners are required and in the burners either fuel is vaporized or the atomization of fuel is done, either vaporization or atomization of fuel is done.

I will give you a reference, for example; in petrol engine in old petrol engines the carburetors were used. So, in the carburetors the vaporization of the petrol was done because in internal combustion engine the heat energy is converted into the useful work, I mean; the high grade of energy that is work. So, vaporization takes place used to take place in carburetors and atomization of fuel used to take place in diesel engine where fuel was injected in the air.

So, for vaporizing burner there are different type of vaporizing burners: one is atmospheric pressure burner, other is rotating cup burner, third one is wick type of burner. In atmospheric pressure burner, the there are two streams: one for fuel, another for air both are mixed in a chamber and the after the chamber the burning takes place.

So, these are very simple type of arrangement. Rotating cup type of burner in this burner there is a cup and the oil is fed into the cup and the cup rotates in a very high RPM; the RPM may vary from 3000 to 10000. At this RPM what happens due to centripetal force, the fuel is ejected outside and this ejected fuel is mixed with the air stream and this is how the mixing takes place because the mixing is very important in a for the burning of oil type of fuels.

So, this is the arrangement, this is a schematic arrangement for rotating cup burners where wick type of burners also, in wick type burners the wick maybe or the cotton or asbestos and due to capillary action; capillary action as happens in case of sorry due to capillary action; due to capillary action the fluid or the oil moves in upward direction and after that the burning of fuel takes place. So, these are the mechanism for the vaporizing oil type of burners.

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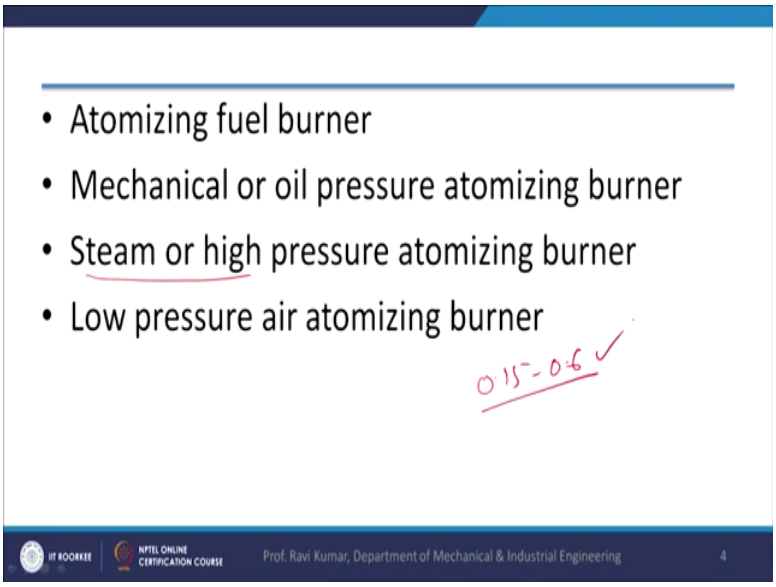

Now, there are atomic fuel burners also, in atomic atomizing fuel burners they are mechanical oil pressure atomizing burner where the fuel is injected in the pool of air with a very high pressure. So, atomization of fuel takes place and thus mixture is sent for the burning.

A steam is mixed with the fuel, there the mixed steam is a high pressure, a high pressure a steam is mixed with a fuel and then the mixture is injected for the burning. There are low pressure air atomizing burner also for a special application and the pressure may be around 0.15 to 0.6 bar pressure and low pressure air atomizing burner are also used in some of the specific applications.

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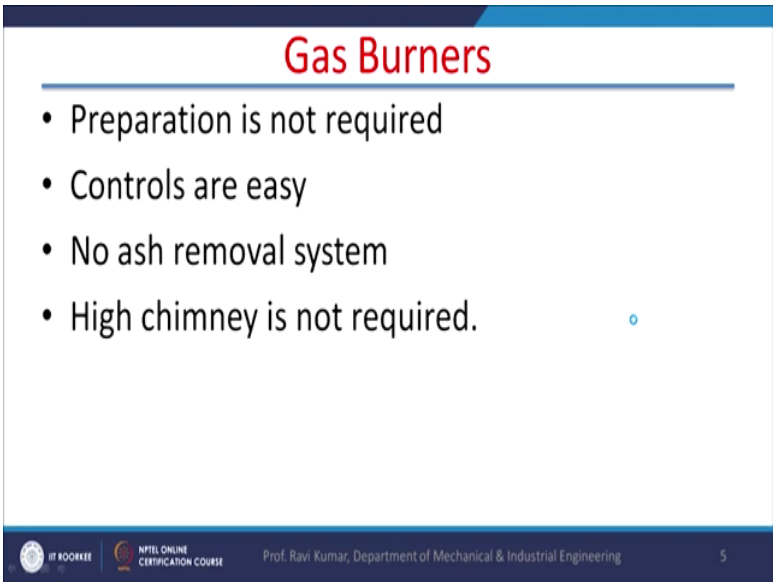

Now, after oil burners there are gas burners their application is limited, but in the gas burner the benefit is that the preparation is not required because gas itself is a volatile fluid and which is available in the gaseous form so preparation is not required. Control is easy we can easily control the flow of the gas. So, when the heat requirement is less we can turn the control wall and we can control the heat release rate of the fuel.

Ash removal system because gases fuel there is no ash. So, ash removal system is not because a removal of ash is a big job in thermal power plant. So, that system is not required for the gas burners and chimneys are also of course, chimneys are also not required. So, these are the benefits of the gas burners. But, in most of the thermal power plants or high capacity thermal power plants coal type of sorry coal is used as the fuel. Coal is abundance in India.

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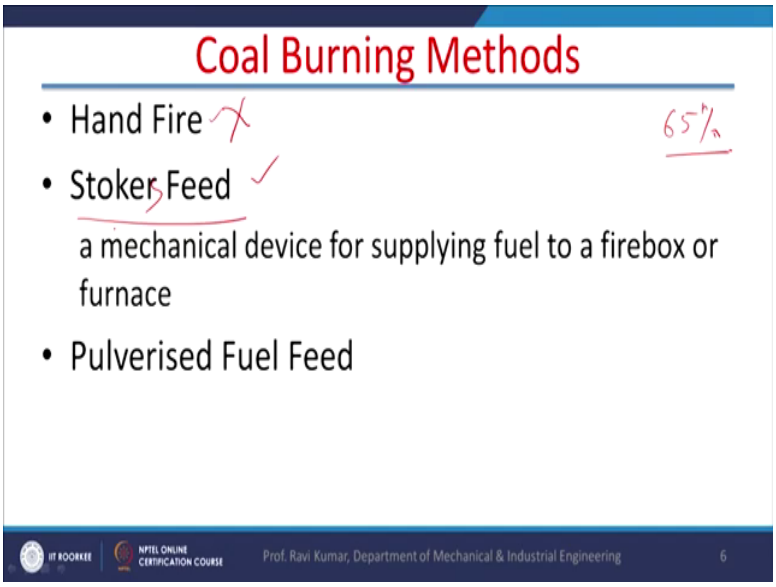

And a two-third of the coal production, goes to the thermal power plant around 65 percent of the fuel of the coal is used in the thermal power plant is a low cost high bulk item and you must have seen the transportation of coal takes place through the rail road in India. The burning of coal there are several methods of the burning of coal: first is hand fire system.

Now the, in the hand fire system simply coal is thrown into the a grate and it burns but it is a very crude type of system it is not normally used in nowadays in thermal power plants. And in the hand fire system, in the hand fire system the control is not that easy. So, this type of system is normally now not used in the thermal power plant. A stoker feed system; a stokers feed system is used it is a mechanical device for supplying fuel to a firebox or the furnace and pulverised fuel also used for nowadays for thermal power plants.

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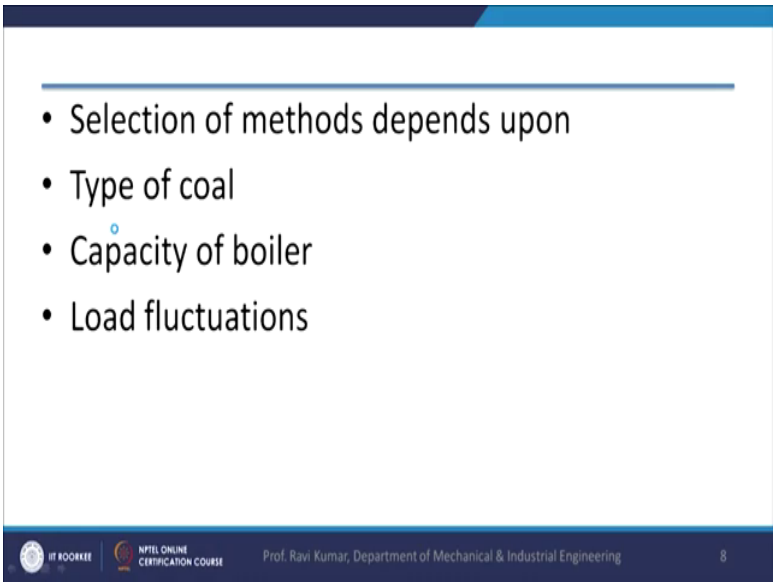

Now, selection method for which method you should be used for feeding the coal in the furnace it depends upon the type of coal and capacity of the boiler and fluctuation, load fluctuations. Because suppose we want to use hand feed, hand feed cannot be used for the case when load fluctuations is there.

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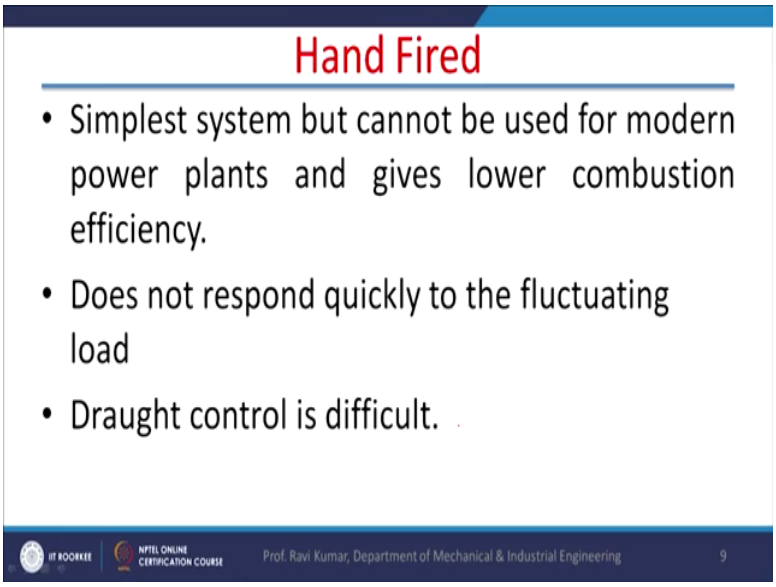

It is a simplest, as I said hand fire is the simplest method, but cannot be used in the modern power plants; power plants and gives lower combustion efficiency. It does not respond quickly to the fluctuation load, draught control is also difficult. So, it is totally discarded nowadays in the power plants.

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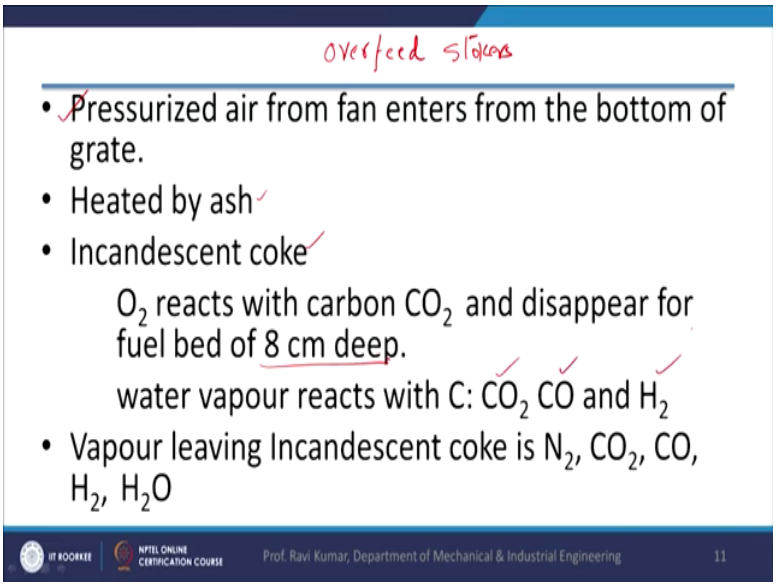

Now, after the hand fire there is a system which is known as overfeed stoker, overfeed stokers. Now, in overfeed stoker system I will give you a schematic arrangement for the overfeed stoker system.

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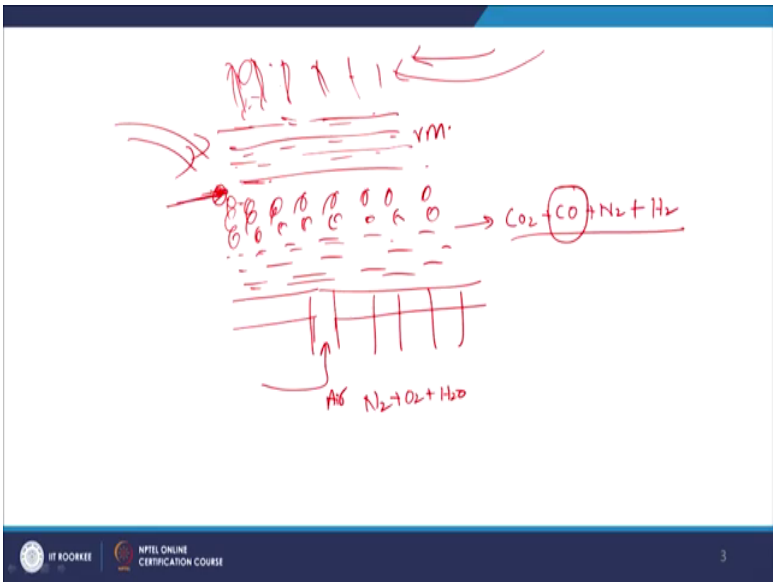

The air is supplied for the bottom, air is supplied from the bottom. So, in the bottom of the grate they are several openings from through which air is supplied and air is covered with the ash, there is a layer of ash; over the ash there is incandescent coke, it is a mixture of burned coal and the ash; above it is green coal and after that there is there are flames of the I mean; the where the burning of the coal takes place. So, air is supplied from the bottom.

So, air consist of nitrogen, oxygen and some water vapor. Now, this water vapor when it comes into the contact with the high temperature ash right and the coke, here the and the oxygen, when oxygen reacts with oxygen reacts with the carbonate forms carbon dioxide plus carbon mono oxide plus nitrogen, nitrogen is there. It does not take part into the reaction and then hydrogen is also formed because at high temperature this hydrogen oxide is also decomposed in hydrogen and oxygen and this and the volatile matter.

Now, this gas it moves through the green coal, this is the main coal and feeding of green coal is continuous to the grate right. And, when it goes to the green coal it pushes the or it helps in driving the volatile material from here also from green coal and burning of coal over the green coal where the burning of coal takes place.

In fact, the coal ignites somewhere between the green coal and this incandescent coal here somewhere here ignition takes place here, but you can take the flame at the top right. And secondary air is provided from here for the proper burning of the coal proper burning of the gases because there is a sort of incomplete combustion also there. So, this carbon monoxide is also in presence of secondary air, it is also converted into the carbon dioxide. So, this is the arrangement for the overfeed type of burning.

So, here as I mentioned pressurized air for the fan enters for the bottom of the grate, it is air is heated by ash there is incandescent coke over the layer over the layer of the ash. So, oxygen reacts with the carbon; reacts with carbon, carbon dioxide and disappear for disappear for fuel bed of 8 centimeter deep. Water vapor also react with the carbon and they form carbon dioxide, carbon monoxide and hydrogen is also liberated.

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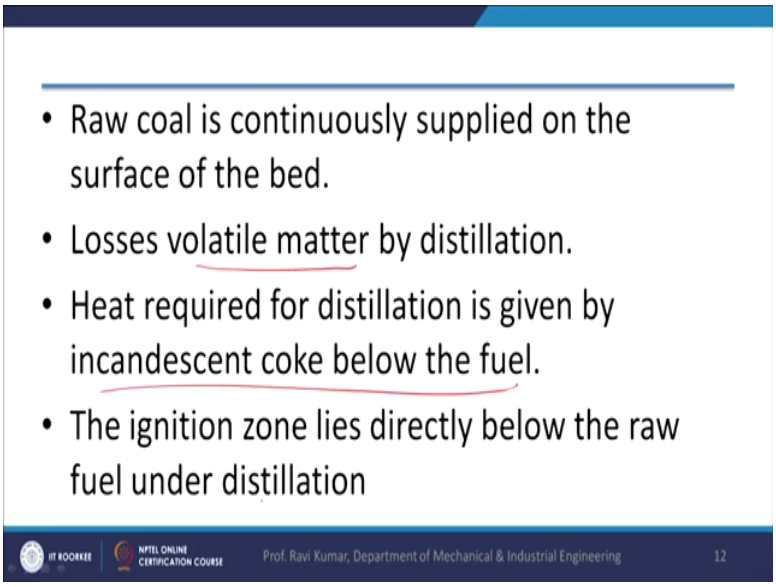

Raw coal, as I mentioned earlier the raw coal is continuously supplied on the surface of the bed, volatile matter by distillation. Distillation takes place when the when the hot air enters from the bottom, the distillation of the volatile matter takes place in the green coal bed. The heat required for distillation is given by the incandescent coke below the fuel. The ignition zone lies directly below the raw fuel under the distillation, as I mentioned earlier here somewhere, here the ignition of the fuel takes place.

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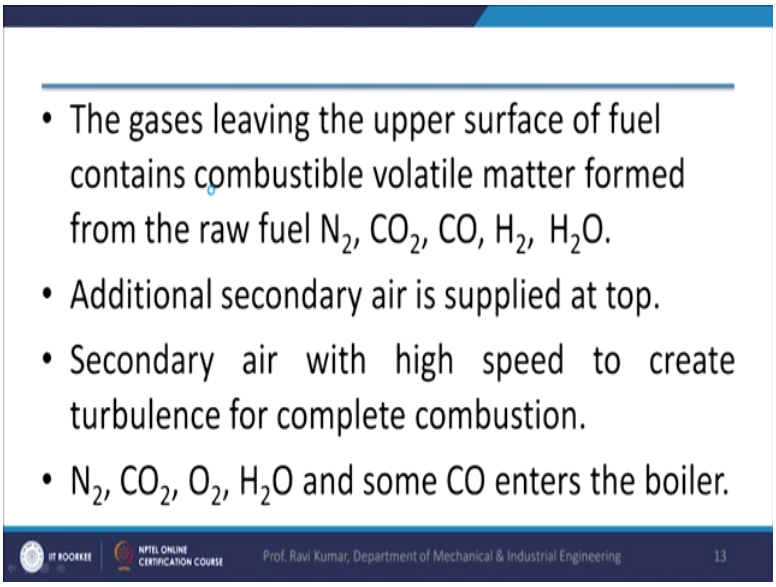

The gasses leaving the upper surface of the fuel contains combustible volatile matter formed from the raw fuel this is also I have mentioned. Secondary air is supplied for the top and this is how the combustion is taking place in the overfeed type of system.

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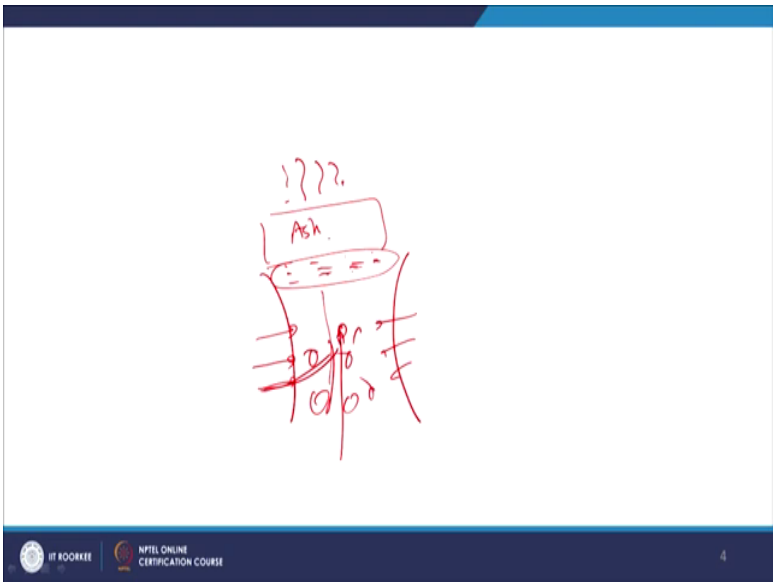

Now, we will go for the under feed type of system, in under feed type of system the arrangement is like this. The air comes from the sides and coal is fed from the bottom right. When the coal is feed from the bottom the above this there is incandescent layer of incandescent coal and below above it there is ash and here the burning of fuel takes place.

So, in this case this is under feeding of coal, when the coal is fed for the bottom the mixing of air and the coal takes place and the remaining reactions remain same, remaining reactions remain same. But, here the disposition of volatile material is slower in comparison to the over fed system because here air is not hot because that it is coming into the contact with coal the air is not hot, in the previous case when the air was coming into the contact with the coal it was hot.

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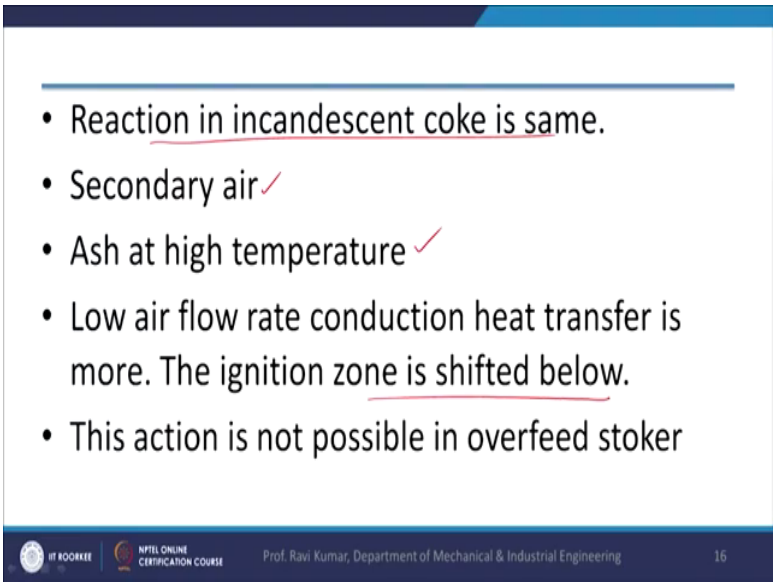

So, reaction in the incandescent coke is same secondary air is also required in this case, ash is at high temperature, ash is at high temperature because just below the flame there is ash. In the previous case, the ash was at the bottom of the system, here ash is at top of the system. So, at ash temperature is high low air flow rate conduction heat transfer is more because in this case the air flow rate is slightly less.

So, heat transfer through the conduction from the incandescent coal or from the surrounding is more. So, the ignition zone which was earlier between the incandescent coal and the green coal, it shifted a little low maybe I mean it should it shifts low. So, this action is not possible in overfeed type of stoker.

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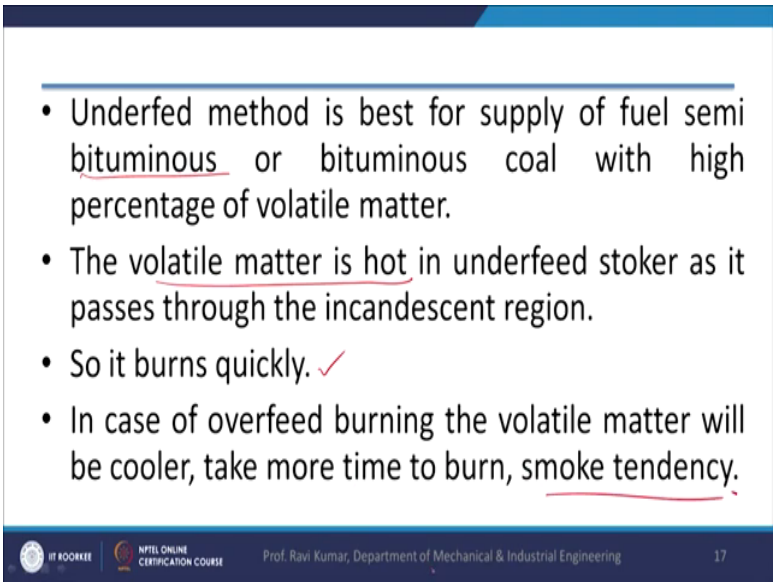

So, underfed is good is very good system for bituminous coal; bituminous coal is the highest grade of coal which has minimum amount of ash and the volatile matter is hot is underfed stoke as it passes through the incandescent region. The volatile matter is hot in this case, in previous case it was not hot. So, the volatile matter it burns quickly in case of overfeed burning the volatile matter will be cooler take more time to burn and there is a tendency for smoke.

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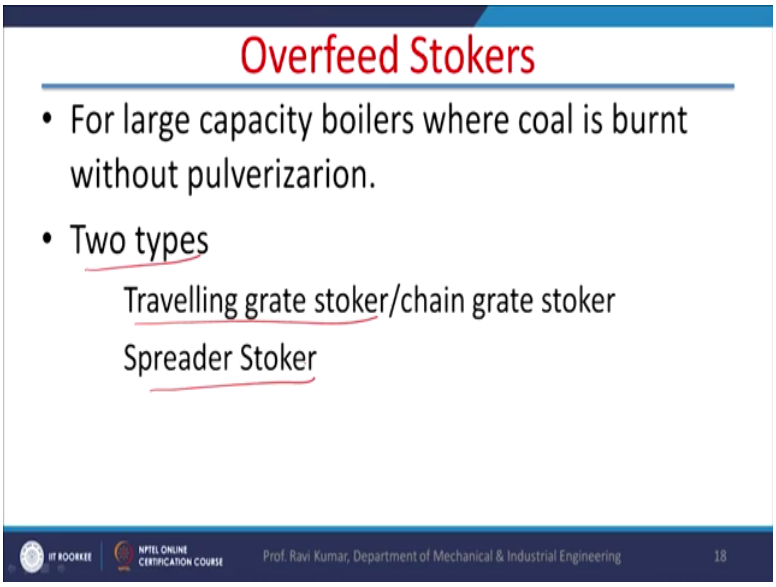

So, overfeed stoker is for the large capacity of the boiler, where the coal is burned without polarization. Now, for feeding the coal in the grate or the burning place; so, there are two types of methods: one is the travelling greater stoker, another is spreader stoker.

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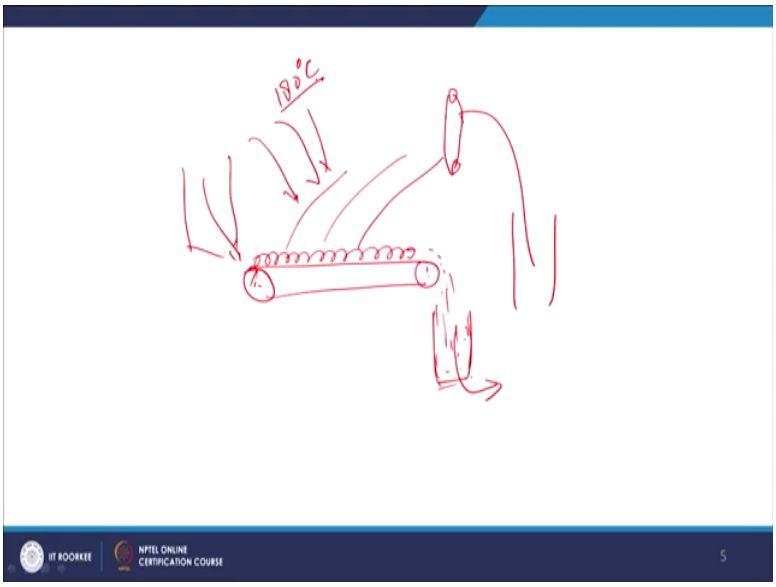

Now, in travelling grate stoker there is a sprocket there are two sprockets and the sprockets a there is a chain which is just fixed with those to this sprockets and on this bed the coal is fed, the suppose the coal is fed from this side to this bed. And, this coal moves on this bed, it burns here and the these I mean hot gases or the fuel gases they go to the boiler and where the steam is generated and they leave somewhere here.

And this coal after burning it is sent to the ash pit or some bunker or for further transportation because the ash which remains after burning the coal the ash handling is a difficult job. So, this coal the ash which at this ash may construe up to 5 to 20 percent of the mass or the coal. So, bulk is quite substantial and this ash when it is collected in a bunker it has to be transported to somewhere some other place for a disposition.

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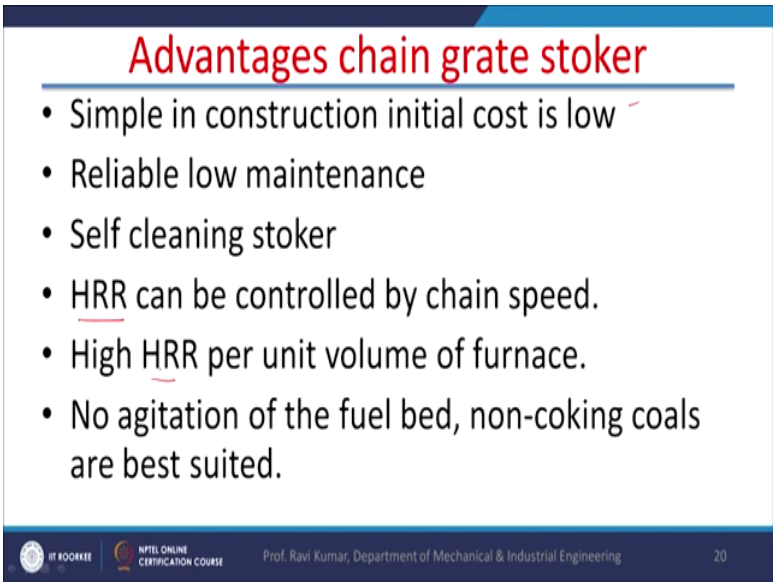

So, the advantage the advantage of chain grate stoker is; it is simple in construction the cost is low, it is a reliable maintenance is low, it is a self cleaning stoker, heat release rate can be controlled by chain speed, high heat release rate per unit volume of the furnace is possible, no agitation of fuel bed, no coking coals, no agitation of the fuel bed, non-coking coals are best suited for this purpose.

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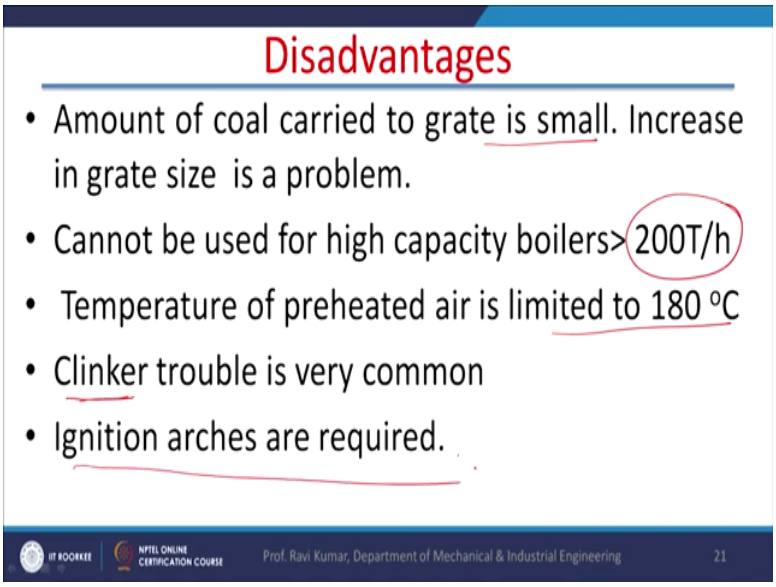

Now, there are certain disadvantages also for the system. Amount of coal which can be carried is quite small in the quantity and if there is a increase in grate size; I mean size of the coal its sorry increase in the grate size is problem we cannot increase grate size beyond a certain value. Because in that case, there will be issues regarding the design of the coal carrying system. It cannot be used for the high capacity boilers, if the boiler has the capacity of coal consumption of 200 tons per hour. So, it is not this type of system is not advisable.

Temperature of pre heated air which is supplied for the burning of coal because pre heated air is also supplied, preheated air is also supplied from this side; it is temperature is approximately 180 degree centigrade 180 degree centigrade, if you want to have idea if you touch the hot plate which is used for making the chapatti. Normally, the hot plate temperature is 180 degree centigrade to that temperature at that temperature the air is supplied for burning of this coal.

The clinker trouble is very common in such type of arrangement and ignition arches are required. So, these are certain disadvantages of this type of system.

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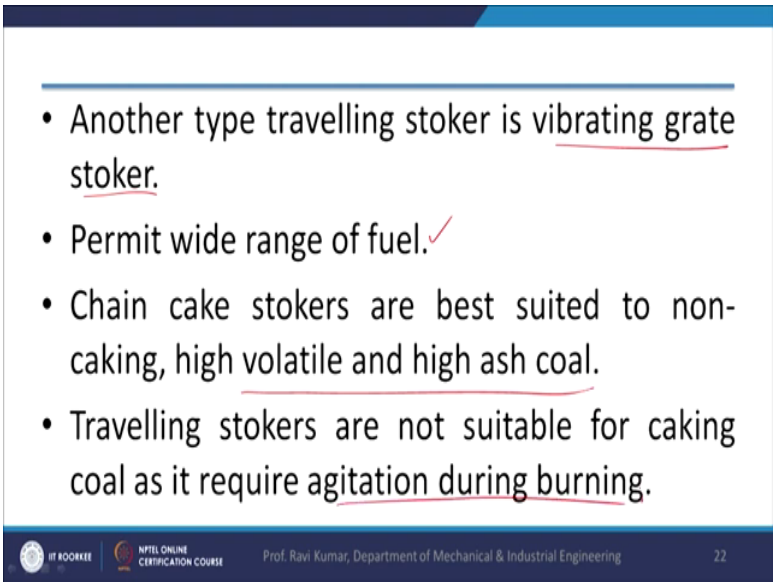

Another is vibrating grate stoke, the periodically the coal is fed through the gravity by vibrating the beds. So, this is another method of feeding the coal, permit wide range of fuel here the if the size of the coal is varying; I mean there is a is varying then this type of arrangement can be used, the chain cake stokers are best used to non-caking high volatile and high ash coal, travelling stokers are not suitable for cake coals for caking coal as it requires agitation during burning. So, these are the limitations for this type of arrangement.

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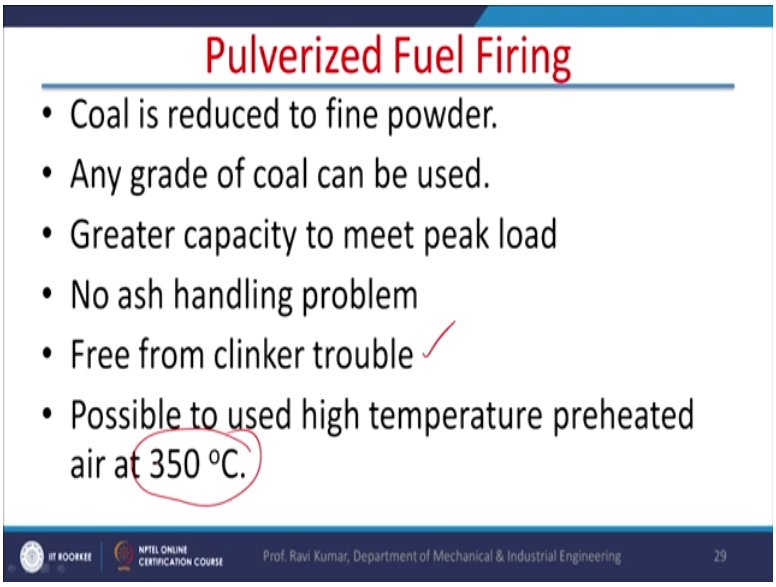

Now, I will discuss the pulverized fuel firing. Now, what is pulverized fuel? The pulverized fuel is; the coal is converted into the fine powder, coal is converted into the fine powder and this fine powder is mixed with the air. Now, this mixture of fine powder and air is burned and the heat is liberated.

So, any grade of coal can be used for the purpose of pulverization, it has greater capacity to meet the peak load and in such cases because there are fine particles of the coal ash handling is not a problem. But, at the same time the useful carbon also goes out with the fuel gases in such type of system and ash has to be recovered after the chimney, it has because anywhere ash will go so ash will be recovered after the chimney.

But this type of arrangement is free from clinker trouble and it is possible to use high temperature pre heated air at 350 degree. So, this is the best because, if we use the pre heated

air on higher temperature effective burning of coal will take place so this is the benefit of pulverized fuel firing.

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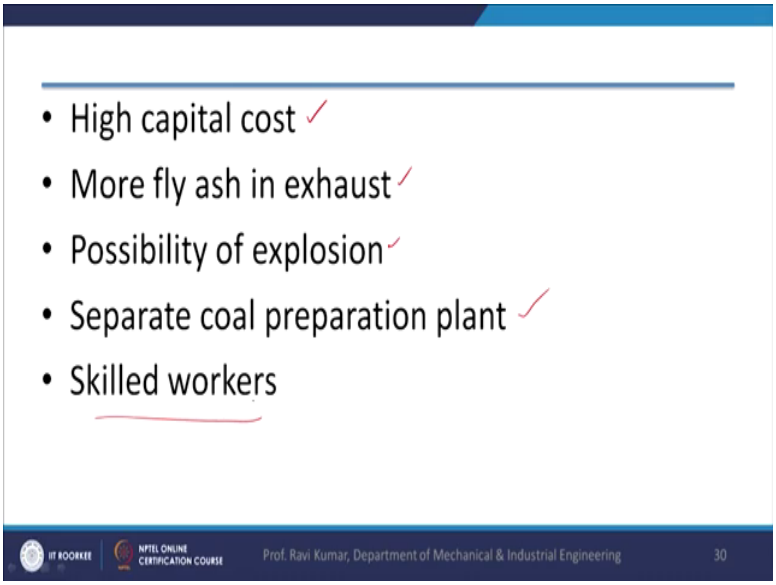

And, but the capital cost for sustainable system is high pulverized fuel firing the capital cost is high. More fly ash is exhausted and because it is it makes a volatile mixture and there is a possibility of explosion also. So, the care has to be taken while using the pulverized coal system then the possibility, there is a possibility of explosion and which has to be taken care of.

Then a separate coal preparation plant is required ,in pulverized coal system separate coal preparation plant is required that is the additional requirement for this type of system. And we need skilled worker, worker have to be properly trained because possibility or probability of accident is relatively high in such type of systems.

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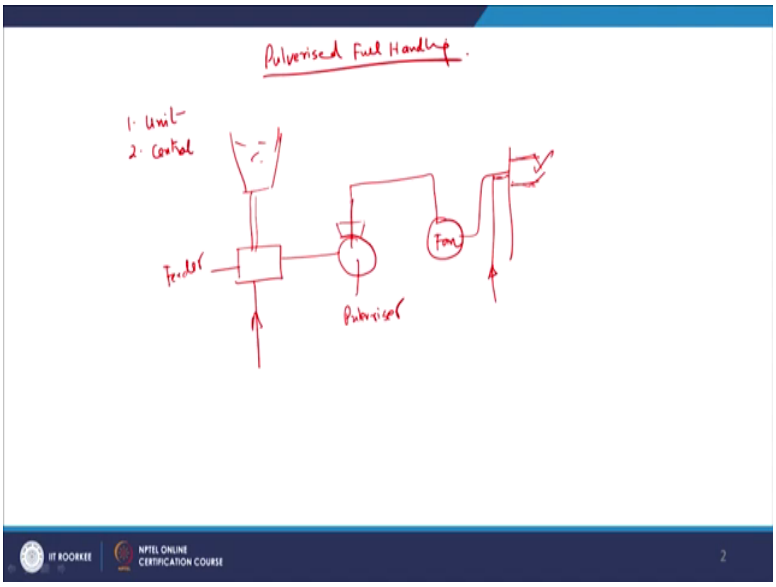

The pulverized fuel handling is also important in the power plants. So, pulverizing, pulverised fuel handling. So, there are two type of system for pulverize fuel handling: one is unit system, another is central system. In unit system, there is one pulveriser and one pulveriser can be connected to a number of burners.

So, main components are pulveriser and a burner, right. So, in unit system there can be one number of burners connected to one pulveriser, but in the central system they are big central system of course, is used for the big power plants. So, in the central system there are number of pulverizes and the pulverize coal is collected in the bin, from the bin it is distributed to different furnaces.

So, we will start with a, single unit type of system. So, unit type of system there is a raw coal, the raw coal is sent to the feeder, this is feeder, from feeder it goes through the pulveriser, where pulverization of the coal takes place and a separator is also connected to the pulveriser.

So, the mixture of fine particles of the coal or the coal dust and the air it goes to an external fan; this is a fan, this is pulveriser ok. From fan, it goes to the burner and we are the burning of pulverize coal takes place. Now, to get two types of air which is supplied to the coal: one is the primary air though this is primary air is supplied from here it is normally hot. So, primary air mixes it is it get mixed with the fine dust particles of the coal and this is how the movement of the fine dust particle of the coal takes place in the system and there is a secondary air ore.

So, normally secondary air is 20 percent of the total air requirement. So, this is preheated secondary air which is supplied here and the total air and the fine dust particles they move to the burner where burning off pulverised coal takes place.

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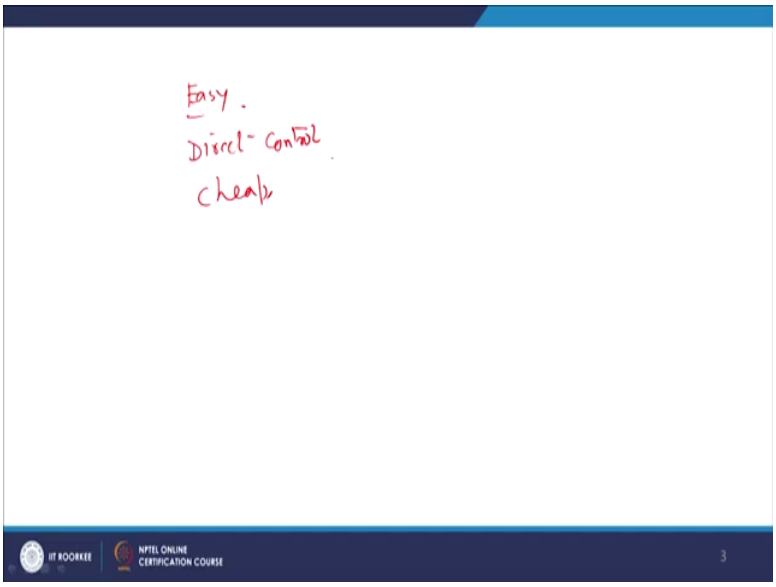

Now, for this type of system the advantage is that easy for operation; operation is easy because there is only one pulveriser and it is connected with a different number of burners. And, we can directly control the combustion, the direct control over combustion because there is only one pulverizer with the help of that pulveriser we can directly control the combustion process. And, in addition to that this is the system is unitary system is cheap, maintenance is low and it is less expensive.

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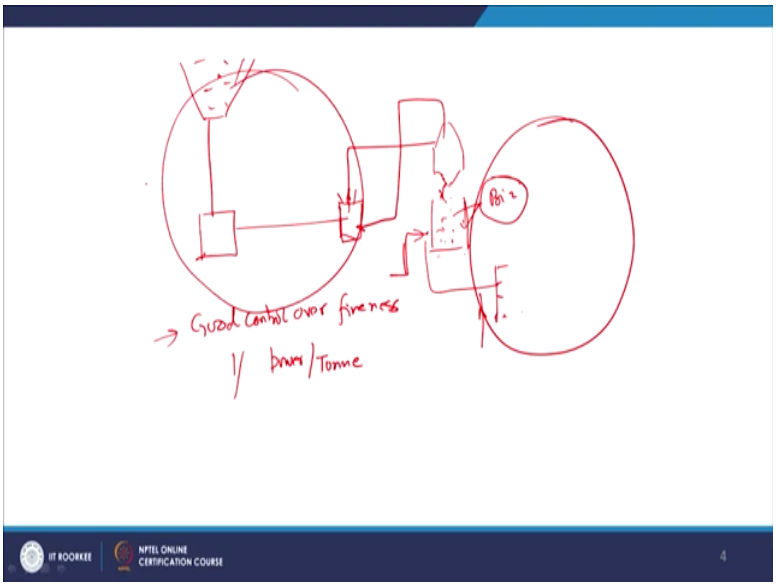

In addition to this, it is less flexible also this system is less flexible if you compare with the central type system. In central type of system, the feeder is same say I mean the coal raw coal comes from here let us say this is a feeder, there is only one feeder. It goes to the pulveriser and there can be a number of pulverisers and from these pulverisers, all I mean I am showing only one there can be 3 or 4 large size of pulverisers, the outlet of the pulveriser is connected to a cyclone separator.

After the cyclone separator the pulverised coal is separated out and if there is a bin in which it is collected and in this bin a separate air supply arrangement is made, that is known as primary air. This air takes pulverised coal from the bin and it is supplied to the burner right, this is a little different from the previous arrangement. So, here a separate primary air, here in that arrangement the primary secondary air was naturally here also secondary air will be supplying near the burner, but the pulverised air is supplied when the fine particles of the coal are collected in the bin, right.

And this system has a very good flexibility, it has good control over fineness; fineness over the particle over fineness, which was not earlier because it has feedback system also. Feedback means this like this the particles are again sent back to the pulverizing mill the big sized particles are sent back to the pulverizing mill, again they are pulverized and they are sent back to the cyclone, right.

So, we can maintain or we can control the fineness of the particles and further the boiler oil is not obstructed in the unit system the pulveriser has to be placed next to the boiler. So, oil side of the boiler will be obstructed by the unitary system; this is a central system. In central system, the oil side is of the boiler is not obstructed that is one of the major advantage.

Power consumption per tonne of per tonne of power, per tonne of coal is less in case of a central type of system and burner, the operation of the burner because; the operation of the burner because the pulverised coal is supplied for the bin. So, operation of the burner on this side is independent of the operation on this side, so these are the advantages of this system. Now, we will further discuss on the burners which are used for burning the pulverised coal.

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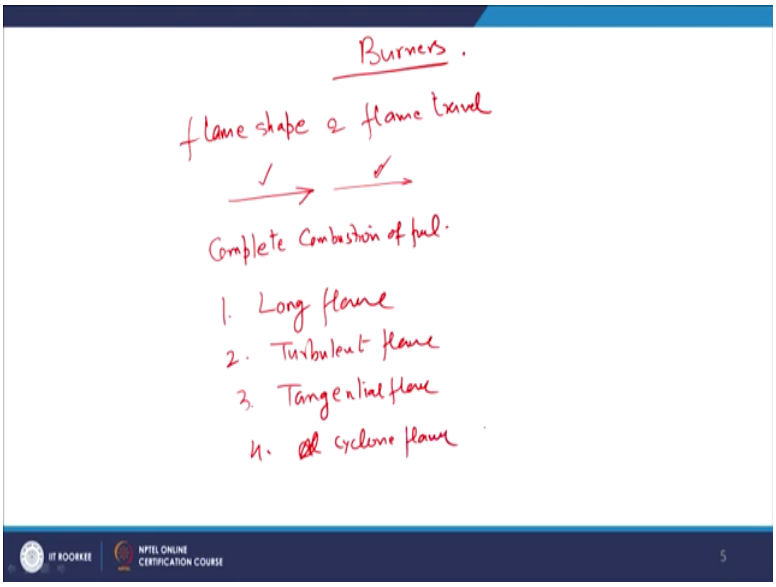

So burners, so as I said earlier primary air, the burner main function of the burner is; the main function of the burner is to burn the fuel and good design of burner indicates that the proper flame shape is maintained, shape and flame travel is maintained and ignition is stable. So, ignition remain stable inside the burner and there should not be any flashback.

So, in order to prevent flashback the forward movement of pulverised coal, this speed of this should be equal to the flame front speed, if these two speeds are matching there will not be any flash back. If the speed of the feeding of the coal is less than the speed of the flame front in that case flashback will take place and that should be avoided. And, further requirement of the burner is that it should provide complete combustion of the fuel that is very important. Because, if the combustion is incomplete it means there is a wastage of resources.

So, complete combustion of the fuel that is a requirement and secondly there should be uniform generation of heat there should not be any hot spot in the burner because those hot sports they will erode the burner wall and they will reduce this life of the burner. Now, there is a classification of burners there is a long flame; there is a long flame burner, there is a turbulent flame burner, tangential flame and the last one is cyclone flame. Now, we will start with the long flame burner.

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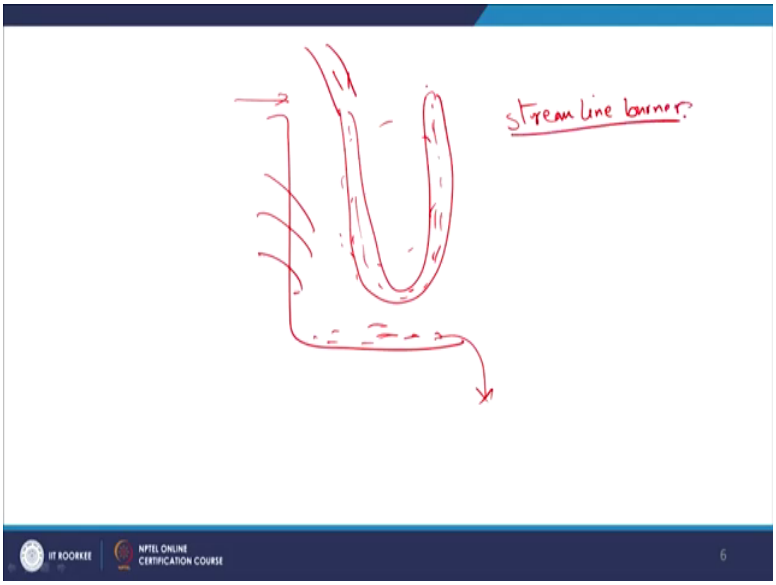

In the long flame burner, suppose it is something like this and your primary air is coming from this side and there is a tertiary air also, because air secondary air is coming from this side and combustion is taking place here right and the flame of the burner is very, it is sometimes it is called U flame burner also. This happens when the coal has no volatile material, no volatile coal when the low volatile coal is there this type of burner is recommended.

Here, the formation of ash takes place and subsequently ash can be drained off or else can be removed from the system. So, this is the long flame type of or U flame type it is also called streamline burner also stream line burner right. After this there is another burner, which is known as short flame burner or turbulent burner.

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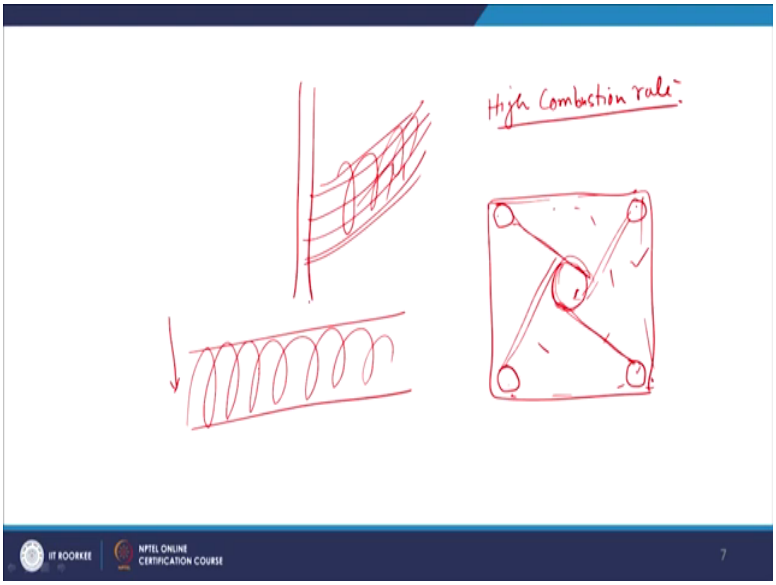

In this case the flame is short, but very high turbulence level of turbulence is very high. So, level of turbulence is very high that is why it is known as short flame burner, but in this burner the heat rate of combustion is rate of combustion is very high, it has high combustion rate, this type of burner.

Now, another burner which is very interesting that is tangential burner, in this burner in a rectangle or in a square on four corners it is a combination of burners, four inlets are provided in fact there are four burners, in this burner there are four inlets right. And, at the center

suppose there is a circle, the outlet of the burner is tangential to this circle; outlet of this burner is tangential to this circle. This is imaginary circle, outlet of this burner is tangential to this circle and outlet of this burner is tangential to this circle.

So, it a very good turbulence is generated here which ensures the complete combustion of entire combustible material in this space. So, tangential burners are very very efficient burners, another type of efficient burner is cyclone burner where spiral motion of the flow of pulverized coal is provided by tangentially injecting the air and coal mixture. In this case also complete combustion of coal takes place. So, there a few examples of the type of burners which are used for burning especially, the pulverised coal, that is all for today.

Thank you very much.