Waste to energy conversion
Dr. Prasenjit Mondal
Department of Chemical Engineering
Indian Institute of Technology, Roorkee

Lecture – 08
Incineration – 2

Hi friends. Now let us start the second part of the module Incineration.

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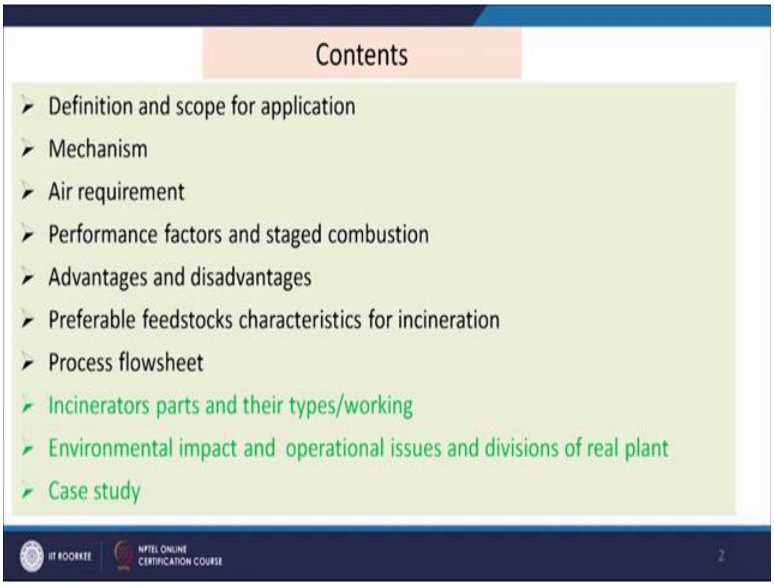

In the first part we have discussed on the definition of incineration, mechanism of heat its advantage disadvantages, its flow sheet for the incineration of solid waste, and in this part we will discuss on incinerators and their parts and types and the working; environmental impact and operational issues and divisions of real plant and will provide some case study.

On the basis of the discussion we had in the first part of this module, we have come to know that particle size time temperature turbulence play significant role for the combustion of solid waste. So, when we will be thinking about the design of reactors or incinerator then obviously, we have to keep in our mind about all those parameters.

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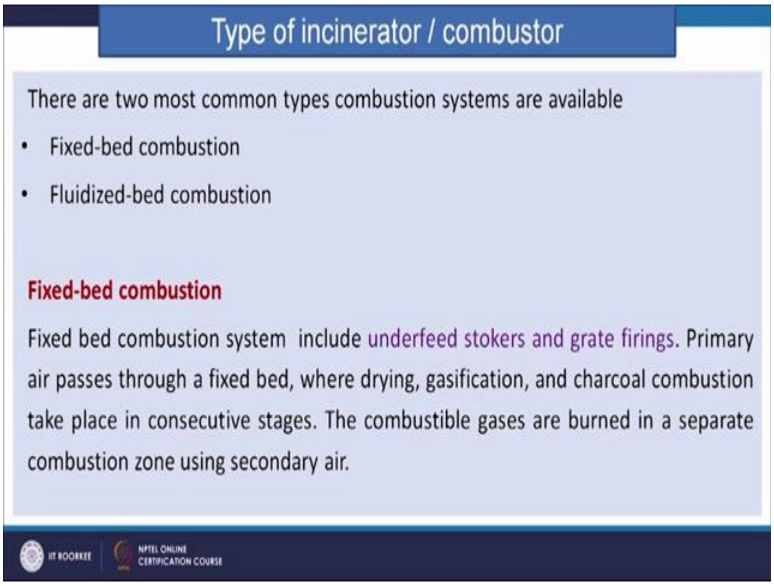

And considering all those facts the people tried basically two types of incinerators one is fixed bed and another is fluidized bed.

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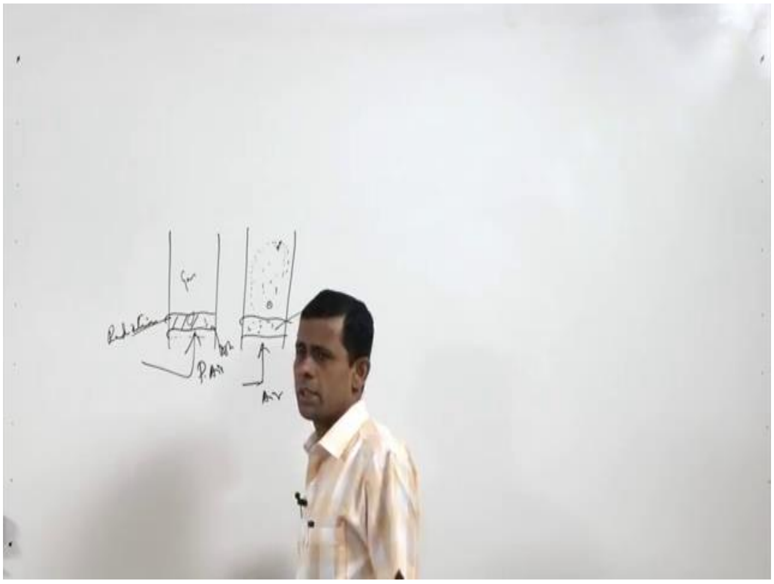

Fixed bed means the material here the solid waste or biomass, the bed will be fixed. So, this is a bed fixed bed this bed may lift shift from one place to another, but in fluidized bed there is no fixed bed this bed all particles are in fluidized phase.

So, in this case; obviously, the size of the particles will be lesser than the size of the particles present in the fixed bed, and in fixed bed we are providing primary air here also we are providing air, this air will help different methods like say drying, gasifications and combustion in consecutive way and we will form the gas ash we will collected here. So, mode of heat transfer here is basically radiation, here we need to provide some media basically sand. So, the sand media is used here and it is heated off that sand media and solid particles are incombus in fluidized phase and this hot sand media sand particle transfer heats to the solid biomass or solid waste.

So, mechanistically the transfer of heat is different in these two incinerators. So, efficiency is also different temperature requirement is also different, and both the systems have some advantage and disadvantage. So, basically this fixed bed is suitable for any type of size the size may be bigger larger size, but now how the fixed bed incinerator works. Obviously, we have to put the heat inside the incinerator. So, one fitting arrangement will be there, and we have to hold the material inside this combustion zone for say 30 to 45 minutes or say 60 minutes like this, the larger time we have to put the material.

So, we have to make certain arrangement so that the particles retain in the combustion zone for a longer time that is why one grate is required. So, one grate is required. So, grate helps to retain the materials on the combustion zone and helps the contact of the materials with the primary air.

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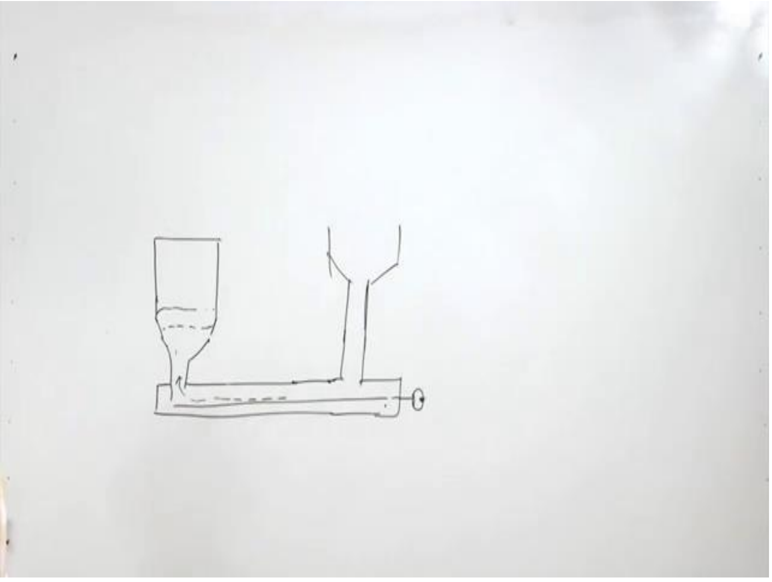

Now, depending upon the nature of grates or the fixed beds or basically divided into two types that is underfeed stokers and grate firing; underfeed stokers means see if we have one combustion zone, from the bottom part the material will come, it will goes up and here is the hopper we have. So, here we are having hopper the material is coming down and some screw arrangement is there some screw arrangement is there. So, that screw arrangement is shifting this material from here to that way, and it is pushing it inside this combustion zone, that is called underfeed stokes. So, underfeed stoker. So, underfeed stoker in this way. So, material comes from this and enters the combustion zone and then combusted and ash is collected from it.

So, this is your underfeed stokers. So feedstock here: feedstock comes through this like this and then it will go to your fire box.

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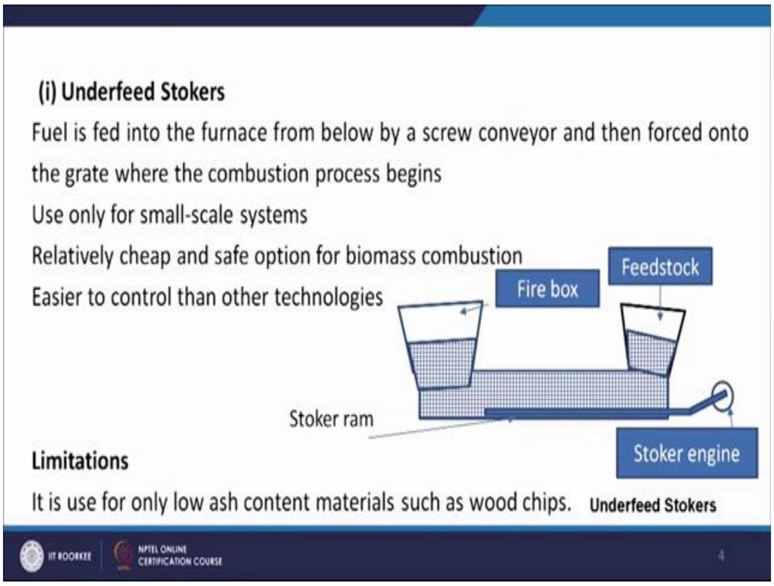

This is not very attractive and it has not very large applications it is limited applications and it is used for only low ash content materials such as wood chips, this is relatively cheap and safe option for biomass combustion and easier to control than other technologies.

Now, let us see the grate firings; in grate firing wastes are spread evenly over the grates, here is distributed uniformly throughout the bed and thus combustion is kept homogeneous and stable, it can use materials with high moisture and ash content as well as with varying particle size. So, that is the beauty of this process that bigger particle size can also be used here easily.

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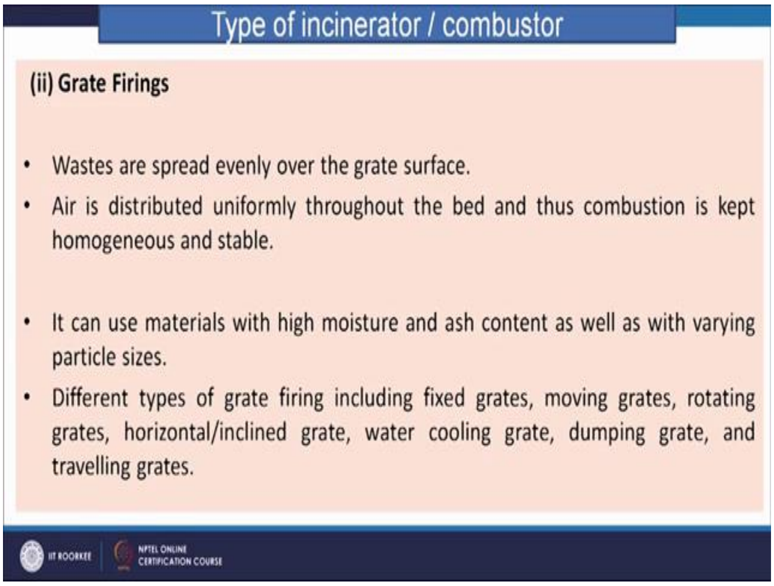

And different types of grates can be used like say it can be fixed grates, moving grates, rotating grates, horizontal or incline grate or water cooling grate, dumping grate and travelling grates. So, different types of grates can be used some of the important grates types are mentioned here that is reciprocating grate.

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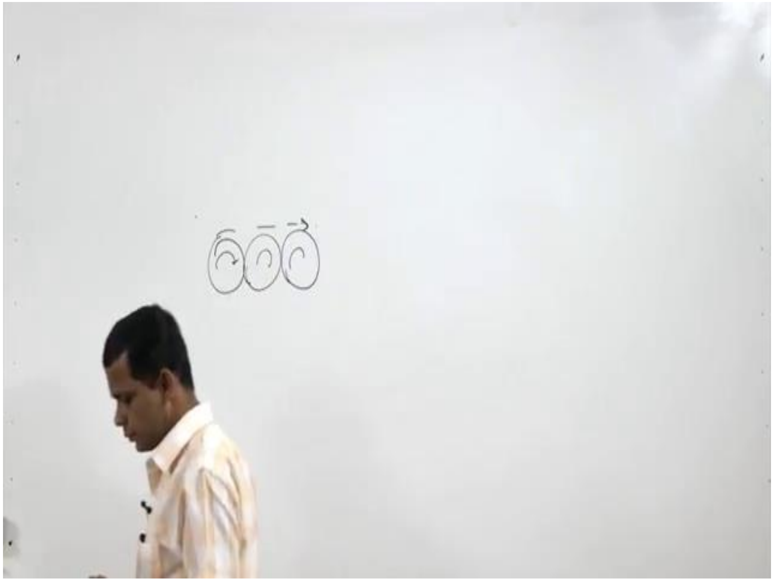

So, reciprocating grates means this grates have resemble stairs with alternating and fixed or moving. So, this is also stairs another is stars is there. So, this is alternating. So, this is fixed this is alternating. So, this can be moved this part can move here and again this can go there. So, materials which are putting here that can carried forward. So, that is reciprocating movement one stairs is fixed another is having movable, and rocking grate system that is pivoted or rocked grate type. This grate section produce in a upward or downward motion advancing the waste down the grate and roller grate. Roller grate is also that is made of rollers. So, one roller is there say, this material this is moving that way another roller is moving that way. So, material is advancing.

So, material will advance the solid materials will advance with this from this to this and this way it will be moving that is roller grate and rotary kiln. So, sometime rotary kilns are used and widely used in commercial scale and that is as an inclined cylinder which rotates.

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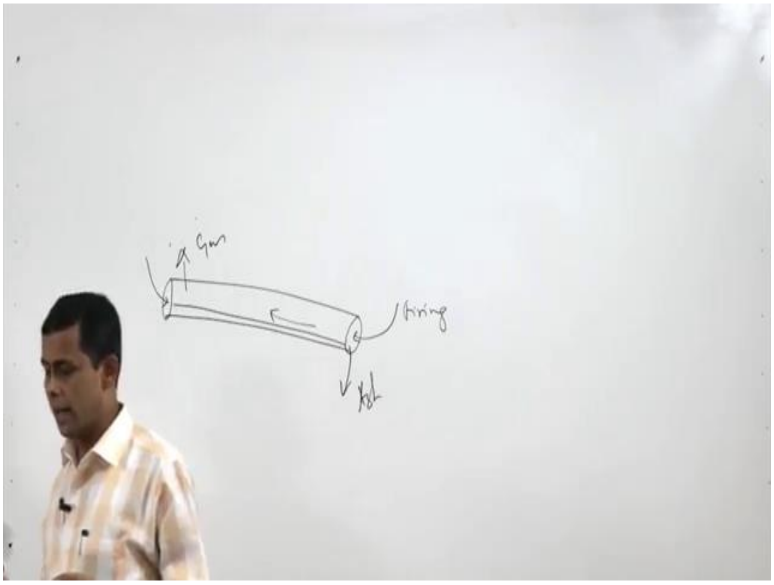

So, inclined cylinders which rotate; so once it is rotates on one end will put feed it is having some inclination and it is rotating. So, material will move downwards the material will move downward and from other end we will give firing. So, once initial firing is there. So, high temperature is going on. So, combustion taking place gradually the combustion will goes on. So, gas will go upward and it will get escape from this. So, from this it will get gas and from here we will get ash. So, this is rotary kiln, and rotary kiln has wide applications for solid waste incineration.

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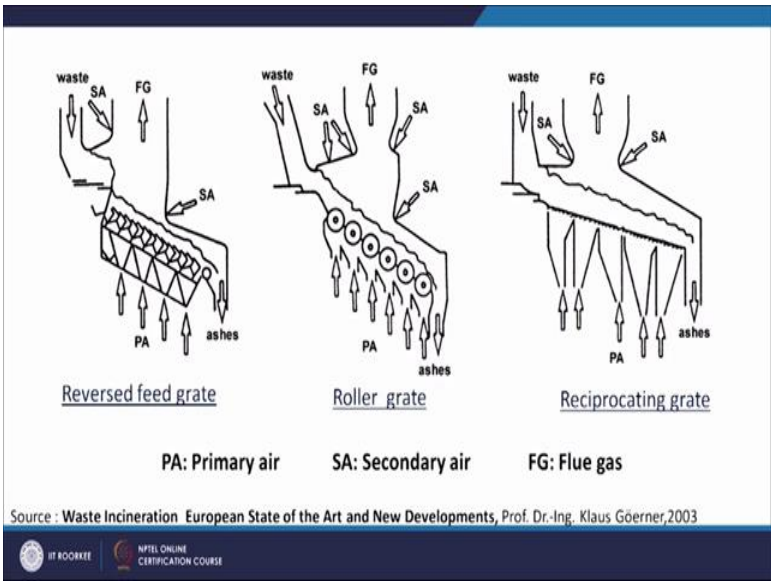

Here some example or some working of roller grates reciprocating grates and reversed feed grates are shown; we have already discussed on it.

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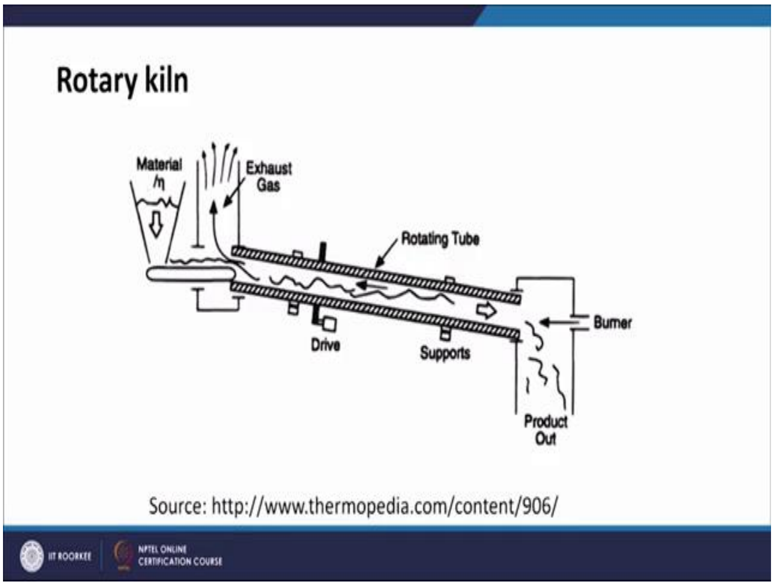

Now, this is the rotary kiln the operations we have already discussed and mechanism of waste burning and grates. We will see the grates provide sufficient time grates hold the material in the combustion chamber and helps for the contact of oxygen and waste materials in the combustion chamber that is very interesting. By changing the design of this grate section we can monitor the quality of the gas, how it is we can create different situations in one situation the air and solid waste travel parallelly in the combustion zone, in another case the solid waste and the air travels in a counter flow mode, and in other cases center flow is also possible.

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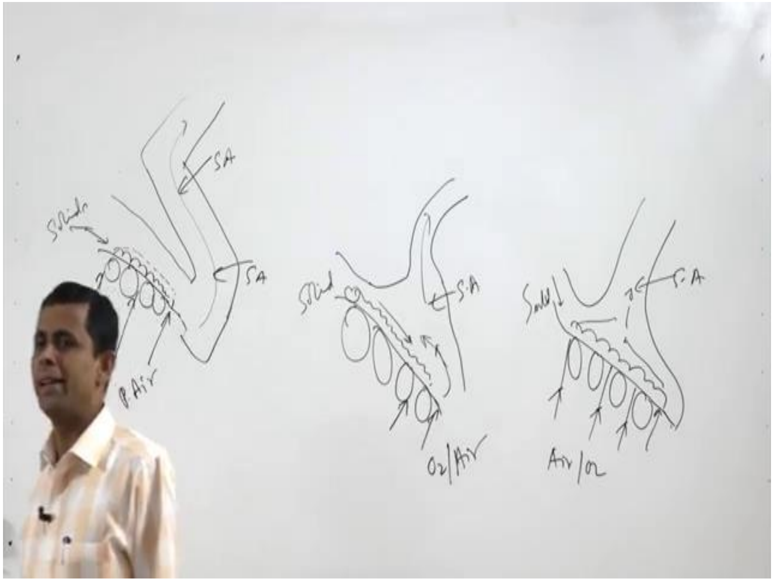

So, here we are putting the solids. So, roller grate is used to bring in down say, now we have to put oxygen, we have to put oxygen equally we have putting oxygen and here entry it is going this way and this is the outlet of the gas. So, solid is coming here we are putting here. So, solid is moving in this direction air is also moving in this direction. So, parallel mode it is moving and then when the combustion is being completed the gas is going up. So, you can put here secondary air we can add here primary air. So, secondary air we are putting the air or somewhere any place secondary air may be. So, this is the parallel flow of the solids and air in the combustion zone particularly on the grate that is parallel flow.

In other case we may have this is our solid, solid is going in that way we have rollers, we are putting oxygen here and here only we are not putting oxygen there and here this is the situation, air is going that way solid is coming that way. So, counter flow counter flow of solids and counter flow of oxygen. So, this is oxygen or air this is solid counter flow. So, it is going on we have putting here secondary air and another situation we can generate through center flow. So, center flow means we are putting oxygen or air oxygen. So, solid is going in that way solid is going that way. So, this is this will move that will also move and this will go in that way. So, here it is going. So, this is secondary air we have putting, this is primary air this is solid. So, this is your center flow this is your counter flow and this is your parallel flow.

Now, these three different designs will be having different characteristics and different influence on the properties of the produced gas. Fine we will prefer which one; say the material is having low (Refer Time: 15:26) that means, carbon content is less. So, that will be requiring more heating so; obviously, the parallel flow mode will help for the handling of those types of materials, but if we have some materials some solid waste having high heating value; that means more volatiles and more carbons. So, those will be not requiring that much of extensive heating. So, we can use say counter flow pattern and mixed and your center flow will be in between counter flow; and parallel flow parallel counter and center.

Now, the parallel flow pyrolysis gases pass through hottest area providing high gas burned out. So, hottest high gas burned out and this is this is intermediate and low gas burned out.

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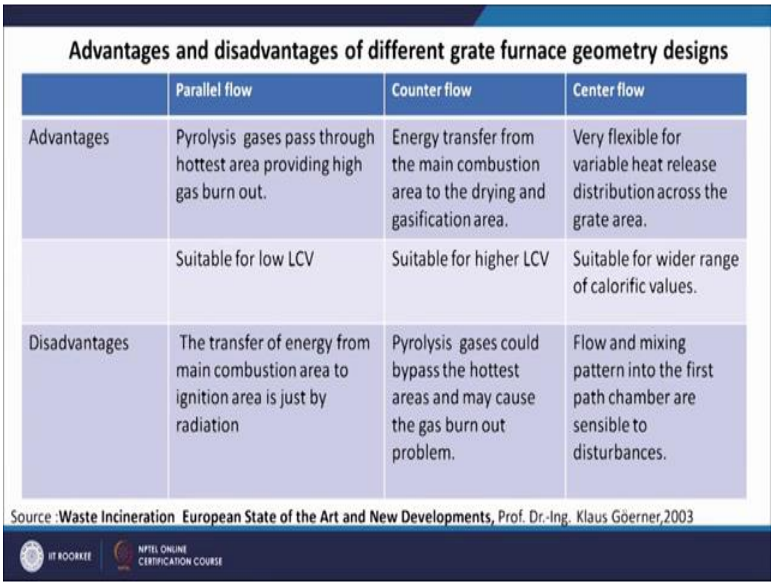
Advantages and disadvantages of different grate furnace geometry designs

	Parallel flow	Counter flow	Center flow
Advantages	Pyrolysis gases pass through hottest area providing high gas burn out.	Energy transfer from the main combustion area to the drying and gasification area.	Very flexible for variable heat release distribution across the grate area.
	Suitable for low LCV	Suitable for higher LCV	Suitable for wider range of calorific values.
Disadvantages	The transfer of energy from main combustion area to ignition area is just by radiation	Pyrolysis gases could bypass the hottest areas and may cause the gas burn out problem.	Flow and mixing pattern into the first path chamber are sensible to disturbances.

Source :Waste Incineration European State of the Art and New Developments, Prof. Dr.-Ing. Klaus Göerner,2003

The parallel flow has disadvantage the transfer of energy from main combustion area to ignition area is just by radiation. So, this is by radiation and counter flow disadvantage is pyrolysis gases could bypass the hottest areas and may cause the gas burned out problem, and a center flow that is flow and mixing pattern into the first path chamber are sensible to disturbances. So, these are the advantage and disadvantage of these different types of grates design which can be used for the fixed bed incinerator.

Now, we will be discussing on fluidized bed incinerator. So, in fluidized bed incinerator sand media is used, sand media is fluidized along with the biomass or waste in incinerator then heat is transferred from the solid hot sand to the solid particles.

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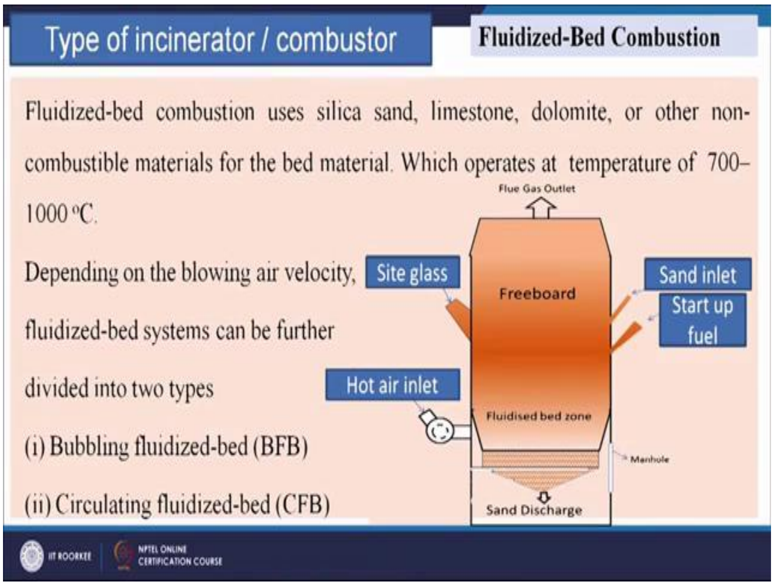

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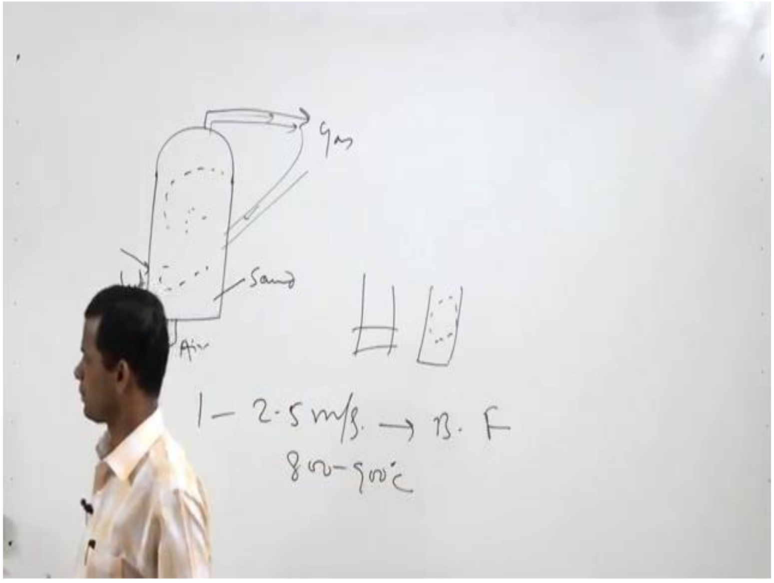

So, here time requirement is less, temperature is also relatively lesser see in this case which we need we need to put some sand we have air, we need some feed also and sand. So, this is fluidized gas. So, particles are in fluidized phase, now the question is a fixed bed can be converted to fluidized bed if we increase the air velocity, if we increase the air velocity a fixed bed can be converted to fluidized bed a fixed bed can be converted to fluidized bed, and minimum fluid fluidization velocity for (Refer Time: 19:17) fluidization that is able to separate particles of the fixed bed enough from each other. So, that they are cohesive in force is counteracted, and after increasing further air velocity the fluidization will take place.

Now, if we increase this air velocity further. So, fluidization is taking place with bubbling bubble formations, further increase in air velocity the solid waste as well as sand particles part of it will be carried over. So, we will be getting two types fluidized bed one is bubbling fluidized bed, another circulating fluidized bed.

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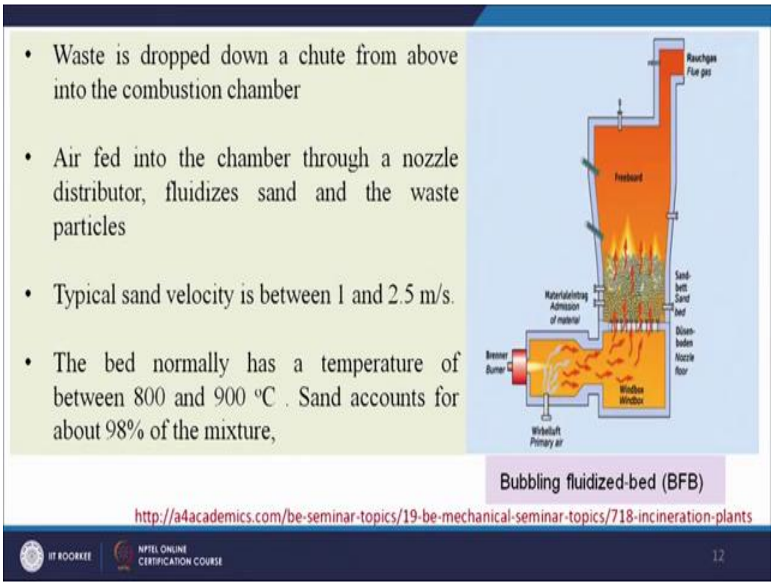

So, circulating fluidized bed use is more air velocity, and in that case part of solids has to be recycle back. So, this is bubbling fluidized bed. So, in case of bubbling fluidized bed we use intermediate velocity more than packed bed and lesser than circulating fluidized bed, and typical sand velocity for bubbling fluidized bed is 1 to 2.5 meter per second, 1 to 2.5 meter per second for bubbling fluidization. The bed normally had a temperature of

800 to 900 degree centigrade, this will interesting that sand contains around 98 percent of the mixture.

So, these are the characteristics of the bubbling fluidized bed incinerator. So, here it is dumped waste is dumped from the chute and air is first from the bottom (Refer Time: 21:27), in case of circulating fluidized bed here velocity is relatively more and part of sand and unburnt waste are recycled to the combustor after their separation from the flue gas in a cyclone.

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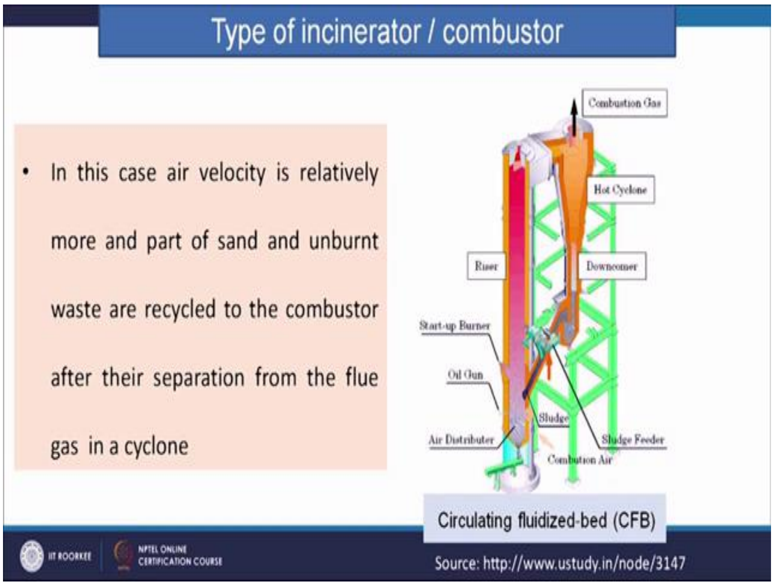

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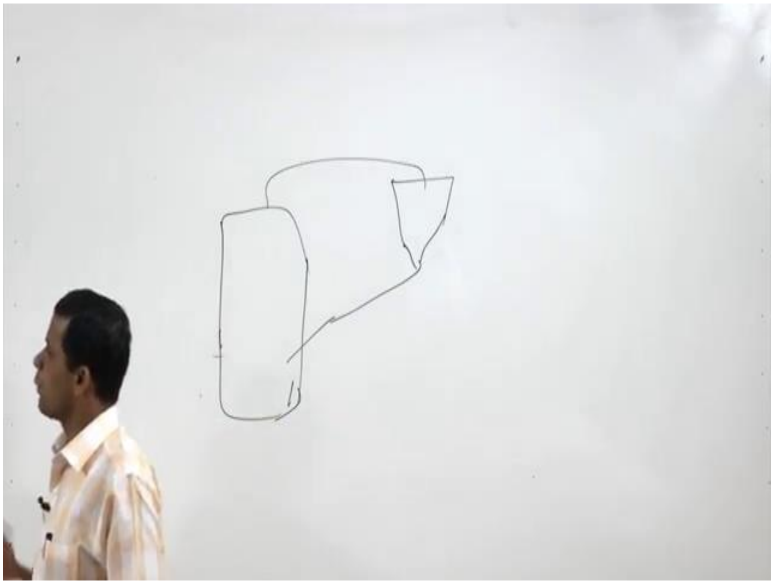

So, that will be separated in a cyclone and it will be recycled back, it will be recycled back to this. In this system we have some riser part like this as shown here and this is a close system operation is required for this, fluidized bed incinerator has some advantages as such it is suitable for high moisture fuel or low grade fuel, the typical operating temperature are lower than that of fixed bed higher combustion efficiency and more suitable for large scale operations.

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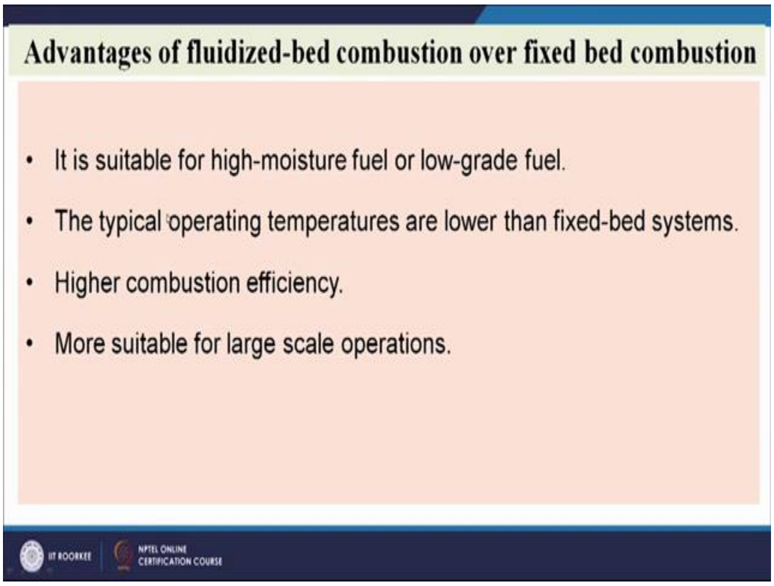

So, these are the different types of incinerator which can be used. Now whatever may be the type of incinerator if we see the flow sheet after incineration the hot gas is going for heat recovery.

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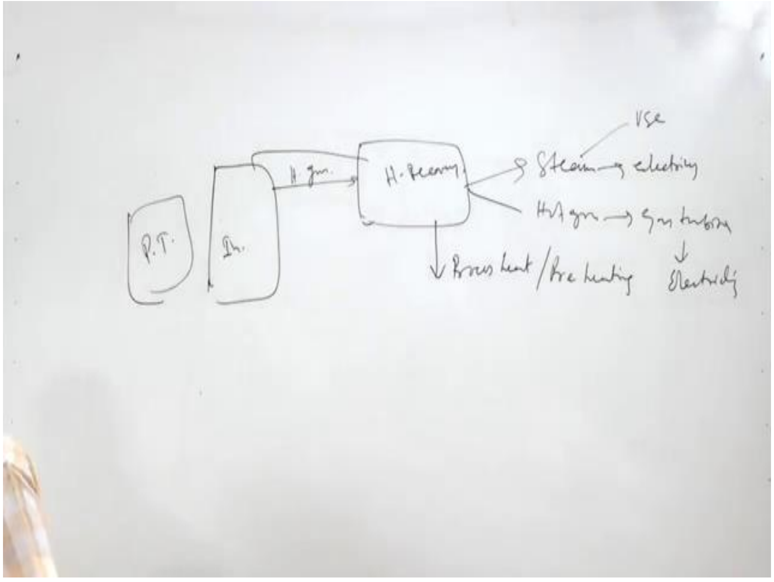

So, heat recovery is the second or third part of this, so pretreatment incineration and heat recovery. So, heat recovery is the third part of this and important part of this incineration process or flow sheets, hot gas when it comes in the boiler we may get steam we may get hot gas, gas turbine tow electricity steam to electricity, steam to any use or process heat to pre heating etcetera. So, we have number of options to use this hot gas.

Now, the recovery and over efficiency of this alternative (Refer Time: 24:00) are not same as for example, if we use this hot gas only for heat applications we can get 80 percent recovery, if we use steam only then you can get 80 percent again recovery we can get power only; only 35 percent recovery.

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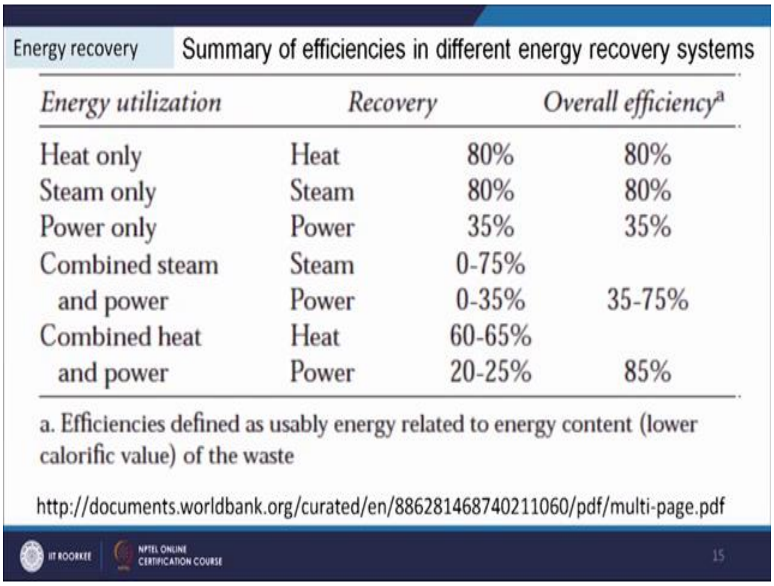

Energy utilization	*Recovery*		*Overall efficiency*[a]
Heat only	Heat	80%	80%
Steam only	Steam	80%	80%
Power only	Power	35%	35%
Combined steam	Steam	0-75%	
and power	Power	0-35%	35-75%
Combined heat	Heat	60-65%	
and power	Power	20-25%	85%

a. Efficiencies defined as usably energy related to energy content (lower calorific value) of the waste

http://documents.worldbank.org/curated/en/886281468740211060/pdf/multi-page.pdf

So, this electricity and this heat which is available here only 35 percent can be converted to electricity; combined steam and power we can produce both team steam and power in that case we can get steam recovery 0 to 75 percent, and power recovery 0 to 35 percent and overall efficiency is 35 to 75 percent; and if you use combined heat and power then we can get 60 to 65 percent recovery for heat, and 20 to 25 percent for power and overall efficiency is 85 percent. So, here maximum efficiency or overall efficiency is 85 percent and we can go for heat and power application, this is taken from some reference as given here.

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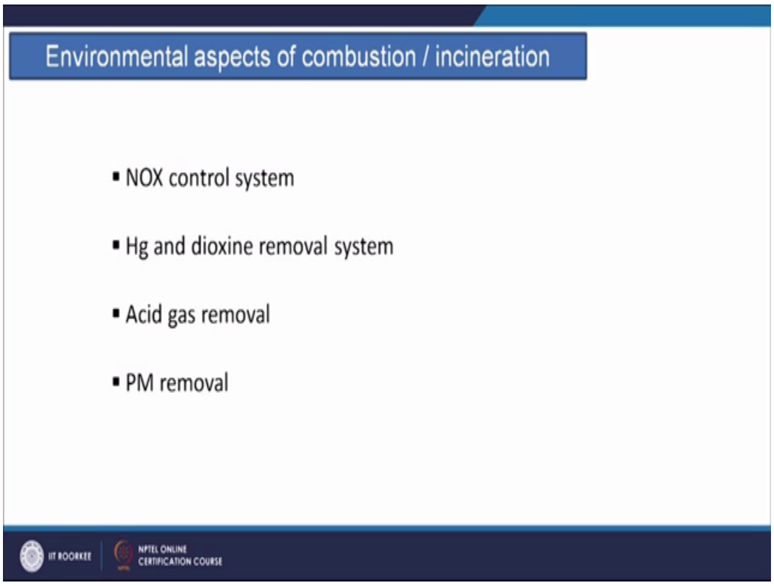

So, as per the flow sheet after boiler we have few gas clean up sections NOX, mercury removal dioxin removal, and acid removal and particulate metal removals are required and we will discuss this things in another chapter another module, we will now discuss some operational problems which is experienced during the operation of this incinerators; two important problems one is your slagging.

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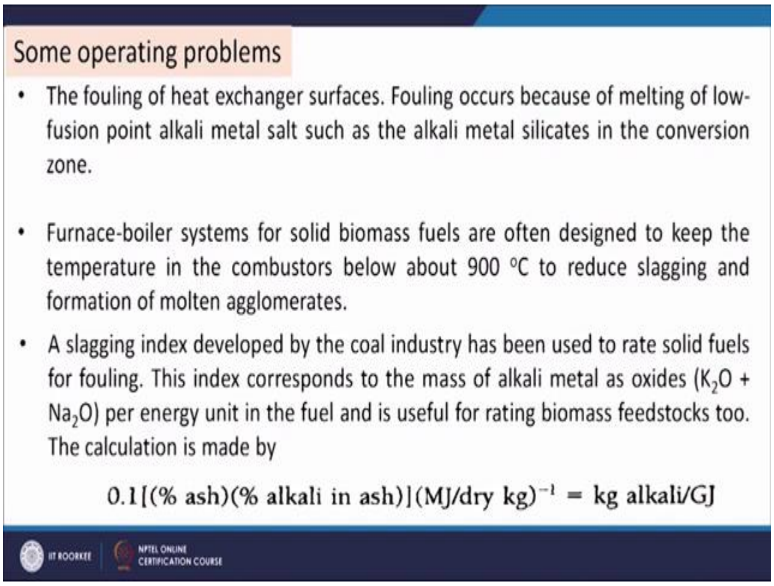

So, slagging will appear when the sodium potassium oxides alkali metal oxides which are low melting are available in the waste in higher extent, and quantify this problem slagging index has been developed by coal industry that is 0.1, that is defined by 0.1 that is ash percent into percentage alkali in ash.

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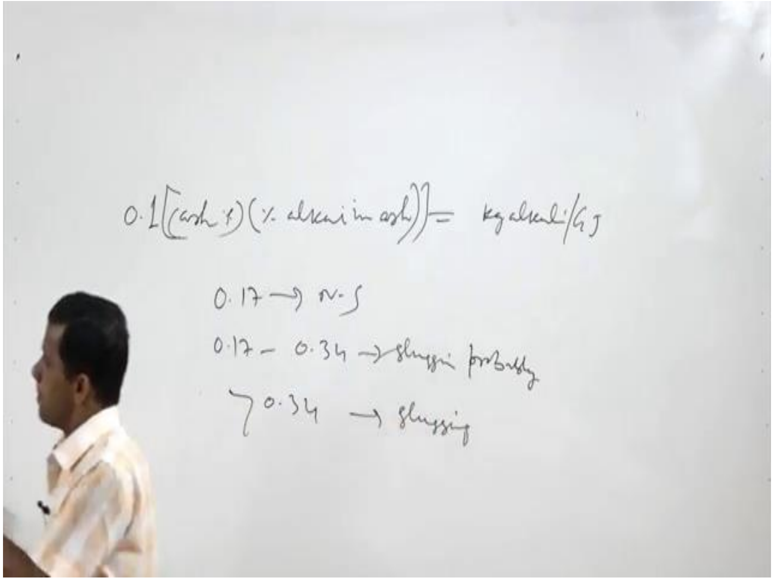

So, that is expressed in terms of mega joule per this is expressed in terms of kg alkali per gigajoule kg alkali per gigajoule.

This is initially applied for the coal only, but now it is extended for the application for biomass and waste also, and index range 0 to 1.7 kg per gigajoule indicates that the material is not slagging at all.

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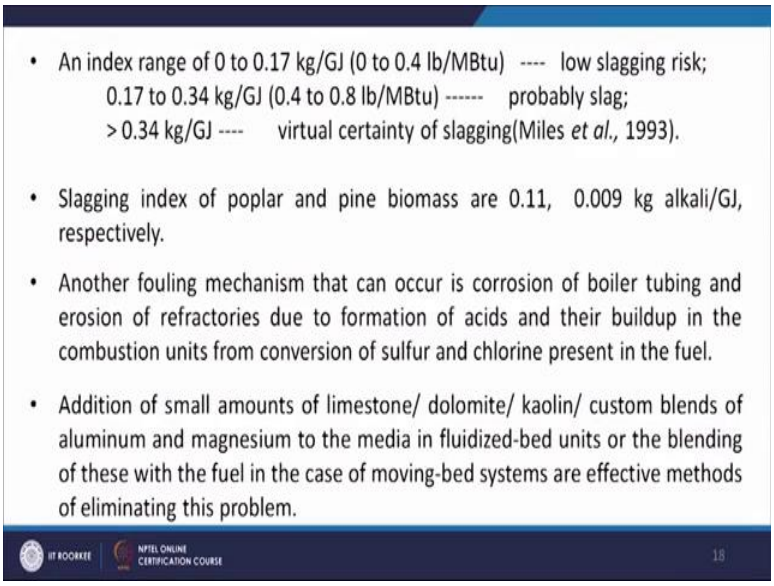

So, 0.17 to 0.34; 0.17 non slagging 0.17 to 0.34 slagging probably, but if it is greater than 0.34 slagging; the slagging index of popular and pine biomass are 0.11 and 0.009 kg alkali per gigajoule; that means, these are not slagging. Another operating problem which arises that is the fouling of the incinerator due to the formation of acids. So, if sulphur and nitrogen is present.

So, in that case nitric acid and sulphuric acid can be formed and that can the effect the furnish; should to reduce this effect some materials that will dolomite, kaolin, limestone, custom blends of alumina and magnesia can be used in fluidized bed. Different divisions or the parts of an incineration plant are waste receipt and handling, then combustion system, then heat recovery then air pollution control and the ash management solid residue handling system.

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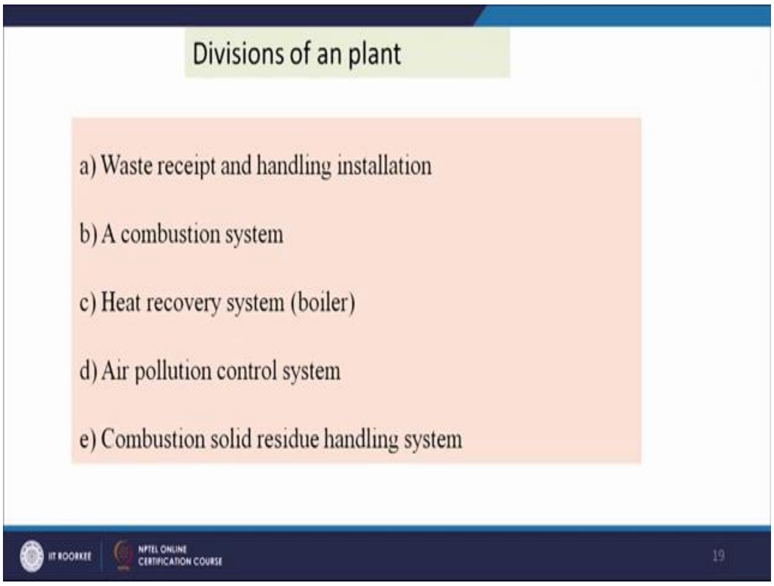

Here we will see some incineration plants; plants are built in India.

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Case study: Some **waste** incineration plants planned or built in India

Location	Company	Size
Narela, Delhi	Ramky	24 MW
Ghazipur, Delhi	Infrastructure Leasing & Financial Services	10 MW
Jabalpur, Madhya Pradesh	Essel infrastructure	11 MW
Pallavapuram, Tamil Nadu	Essel infrastructure	5 MW
Surat, Gujarat	Rochem	12 MW
Jawaharnagar, Hyderabad	Ramky	20 MW

http://articles.economictimes.indiatimes.com/2015-04-28/news/61616161_1_waste-incineration-waste-land-municipal-solid-waste

Narela Delhi that is 24 megawatt Capacity Company is Ramky; Ghazipur, Delhi- Infrastructure Leasing and Financial Services is 10 megawatt; Jabalpur, Madhya Pradesh- Essel Infrastructure, 11 megawatt; Pallavapuram, Tamil Nadu- Essel Infrastructure, 5 megawatt; Surat, Gujarat- Rochem, 12 megawatt; and Jawaharnagar Hyderabad- Ramky 20 megawatt. This is one informations on (Refer Time: 29:17) incinerator plant that is Robbins resource recovery facility that handles MSW and reduces landfill waste volume on 95 percent, and produces 50 megawatt (Refer Time: 29:31) two foster wheeler foster wheeler circulatory fluidized bed and refuse derived fuel are used in this plant.

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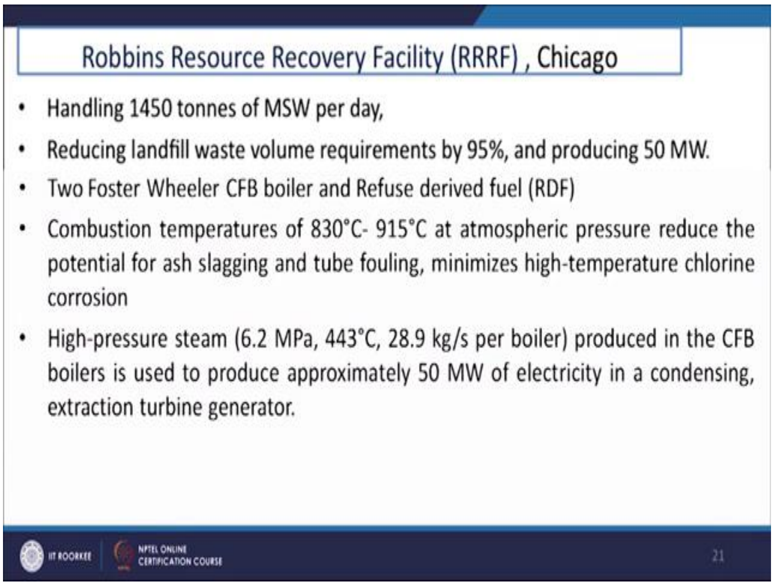

And combustion temperature is 830 to 915 degree centigrade, and high pressure steam is produced 6.2 mega Pascal and 443 degree centigrade, and that is produced in a circulatory fluidized bed boilers is used to produce approximately 50 megawatt of electricity up to this on this module.

Thank you very much for your patience.