Urban Services Planning
Professor Debarpratim Pandit
Department of Architecture and Regional Planning
Indian Institute of Technology Kharagpur
Lecture 38
Waste to Energy Part III: Incineration

Welcome back in lecture 38, we will talk about incineration. This is waste to energy part 3.

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The different concepts that we will cover are on incineration, the process the incineration in in the Indian context, incineration plant design and operation and finally stack emission standards.

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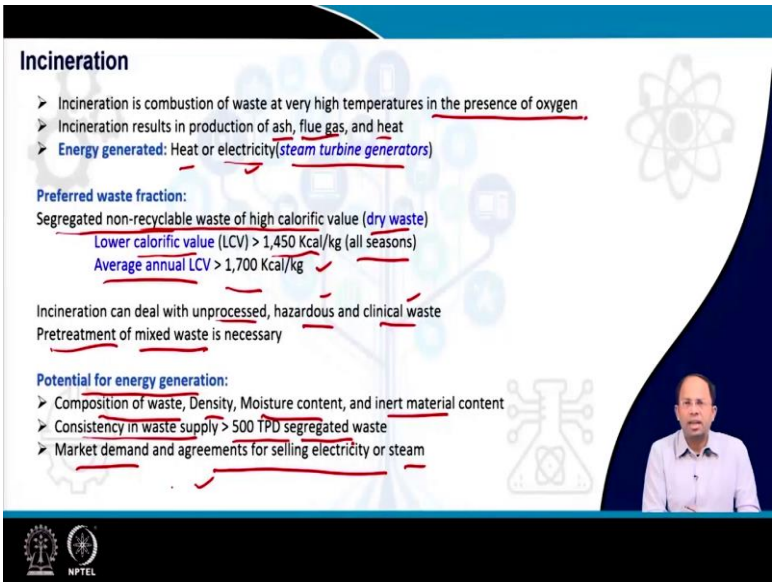

So, in the last lecture we were talking about RDF could be directly incinerated. So, in incineration plants we can use RDF as a feedstock, but in general, incineration can deal with any many kinds of waste. So, incineration the process, it is combustion of waste, but at very high temperature in the presence of oxygen, this is very, very important. So, that means we are burning waste using in the presence of oxygen.

So, this results the process of incineration of municipal solid waste resulting production of ash, flue gases and heat. So, these are the three primary output of the incineration process and the energy that is generated this heat that is generated were either it could be used directly. So, that means, we can use the heat for heating purposes or we can use it in steam turbine generators, and then we can produce electricity using those generators.

So, that is how this entire incineration process we can produce energy from the incineration process. Now, usually for incineration, we want segregated, non-recyclable waste of high calorific value segregated and also non-recyclable waste and of course, this should be the dry waste not the organic waste, organic waste should go for composting or biomethanation and so on. But still we what I can say that in incineration process is more what to say incineration processes allows a little bit poor quality of waste compared to other processes compared to RDF so on.

So, the lower calorific value that is minimum value is something around 1450 kilocalories per kg, which is allowed. And this is considering all seasons in some seasons, it is high some season it is slow, but lowest value is around 1450, which is like almost same as 1500 kilocalories which the software management rules specify, whereas the average annual LCV is should be greater than 1700 kilocalories per kg.

So, sometimes it is high or low, but the average should be something around 1700 kilocalories per kilogrammes. Now, insulation can deal with not only deal with normal segregated waste, but it can also deal with unprocessed waste, hazardous waste and clinical waste. So that is why many clinical waste is actually burned by in incinerators.

So, pre-treatment of if you are used going for mixed waste, definitely we have to go for pre-treatment or pre-sorting and all and then only we can realise the waste for incinerator. They are specialised incinerators for clinical waste or hazardous waste and so on, but directly and even though we are saying that incineration can deal with an unprocessed waste, but idea is to make the waste more than this calorific value, we have to do some amount of pre-treatment.

Now, the potential for energy generation, how much energy we can finally generate, via the incineration process depends on the waste composition, what is the content of the waste, the density, the moisture content of the waste and the amount of inert material that is inside waste. So, usually, the quantity also needs to be consistent over time same as RDF plant or any plant for that matters to operate a plant, smoothly, the volume of waste that has to be supplied to the plant should be consistent.

At least it should be greater than 500 tons per day of segregated waste. So, that means segregated waste should be supplied to the plant. And in today's context, many plants have their own pre-treatment systems and sorting systems shredding systems and so on. So, but the total quantity of segregated waste received by the plant should be greater than 500 tons per day. Finally, the products that comes out of the incineration process that also should have a market so market demand and agreements for selling electricity or steam.

So, if I am selling steam directly that has to be done in a very local area, so thereafter some agreements with the ULB or with the resident association over there so that I can sell steam directly for heating purposes and all. Or have to have agreements with the distribution company so that I can upload or sell this electricity directly to them and it could be put into the grid.

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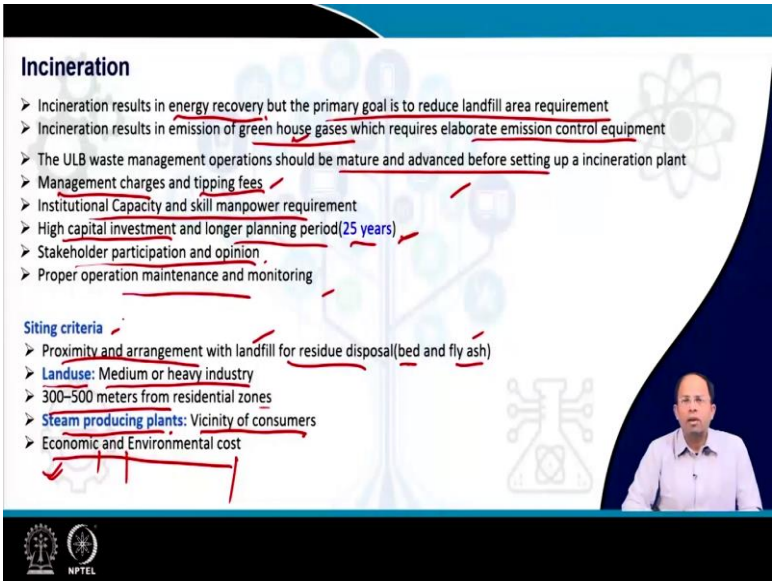

So, incineration results in energy recovery. But as you understand along with energy it results in lot of emissions. So, we have to be very careful and the entire process is also very very costly. So, the primary goal is to reduce landfill area requirement. So, usually we will take up incineration or similar process when the land area is very, very costly and there is no land

area available for suitable available for landfill or landfill sites and all. So that is where we will consider incineration.

So incineration results in greenhouse gases, which require elaborate emission control equipment. So, that means if you are not putting adequate equipment or your potential to not only increase the greenhouse gases, but also it lot of air pollutions in the local area and also a lot of contamination can happen. The ULB waste management operations should be mature and advance.

So, that means before you even set up a or suggest incineration plant for an ULB the overall waste management has to reach a certain level otherwise, what happens it is this is a very sophisticated procedure, it requires a lot of expertise, it also request certain amount of segregation and also the waste which is neither composted neither biomethanated bio methanation is done neither recycled that has to go for this incineration.

So, all these steps has to be done before the actual setting above this sort of waste to energy plants. Then management charges for this waste, who will pay for this particular plant and so, on tipping fees, if you somebody supply waste to this particular plant, who will pay the money for that waste, how the entire agreements would be walked upon.

So, these are things which we have to be considered about, then institutional capacity and skill manpower requirement, institutional capacity at ULB level so that they can deal with this kind of companies or the product that is being produced and eventually sold or the skill manpower requirement by the company itself to run this kind of operations.

So, again, setting up this kind of plants require high investment and the planning period also should be long like around 25 years, because I cannot just set up the plant and then forget about it. So, it has to be kept on operating for a long period. And we have seen examples where plants have started and after starting operation initially it has stopped because of the quality and the quantity of the waste it is received and maybe some other factors such as waste characteristic moisture, content and so on.

So, we have to be very careful regarding planning of the plant for the period as well as what type of plant what technology we are going to utilise and how much capital will be require. Then stakeholder participation and opinion is also very, very important. In many cases there has been a protest against incineration plants, because incineration plants reached a lot of

emission people can see visually that even though it is clean smoke that means you are putting the gases that are coming out through electrostatic precipitators.

And then there are scrubbing systems and so on. But still the way you can visually see that that smoke is coming out from the stacks. So that creates a bad impression. And so it is people have to be really explained what is happening, what are the emission standards and so on. Otherwise, stakeholder your opinion and participation. If you are not going to take that you may result in a lot of protest and eventually have to shut operations.

So, and then finally, it is a plant it is a industry you can see so it requires proper operation and maintenance and monitoring all throughout its lifetime. Now, where would I set up a plant? Now, the fundamentals are similar to setting up our landfill site. Of course, we have to find areas which is suitable and so on. So, but primarily, we will set up in areas where already medium and heavy industries are allowed. So, this is particularly comes under industry a polluting industry.

So, it has to be set up in land uses with support medium or heavy industry. And it also has to be near a landfill site where all the residue after you burn the waste lot of bed ash and fly ash is produced this has to be taken to the landfill site. Again, bed ash fly ash, these are two different qualities of ash that you generate. And one of them fly ash is very, very contaminated and so they have to be also given separate locations in the landfill site where we can put them.

So that means proximity to landfill site is very very important otherwise the transportation cost will increase. Then it should be at least some distance away from the residential zones maybe 300 to 500 metres if it is a land uses like for medium and heavy industries automatically it is far away from residential zones, then steam producing plants in particular in case where the steam produced in these plants is utilised for district heating or some local heating of those areas in cold countries usually this kind of systems exist, There the plant has to be in vicinity of consumers.

Otherwise, the steam will lose its heat during transfer over long distances. The economic overall the most important thing is the economic cost or the price of setting this plant and also the environmental cost of this particular plant. So, this is what we are going to eventually consider while deciding the staring criteria for this kind of incineration plants.

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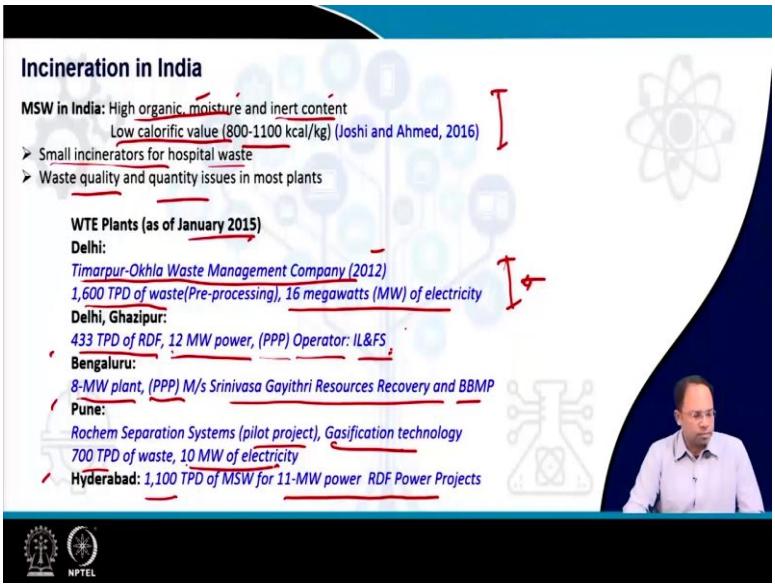

Now, coming to incineration in India, usually, the waste that we generate in India is a very very low calorific value around 800 to 1100 kilocalories. So, we cannot use it directly it has to go through many many processes and sorting, drying and all this. Usually, the waste is also high organic and moisture content and also inert content is very high. Recycled levels are also sometimes taken care of by the residences by selling them directly and all but still the waste contains lot of organic matter moisture and inert content. So, the actual quantity of waste required for Incineration is very low. So, that sometimes becomes an issue.

So, in so in many cases, we have seen the plants have stopped operation because of absence of the we have not thought of that what the proper quality of waste of adequate quantity is not there. But small incinerators are set up in many parts of the country usually this deal with hospital waste, because this is a specialised waste that has to be dealt with. So, incinerators has to be there as per the rules.

So, but in most plants waste quality as well as quantity is the issue that we are facing in India. Some of the plants the data is from 2015 some changes obviously, has happened after this. For example, in Delhi the plant that was set up initially the Timarpur Okla waste management company has set up a plant in 2012. It processes 1600 tonnes per day of waste after pre-processing it generated it pre-process that and then 16 megawatts of electricity was produced, but recently not recently, this plant has closed because of some issues. Because a particularly this waste quantity issues.

Then in another plant is set up in Delhi Ghazipur it takes in 433 tonnes per day of RDF and it generates 12 pp 12 megawatt of power and this is setup using PPP in PPP mode, public

private partnership mode and the operator of the private company is IlFS, infrastructure leasing and financial services that this is a company which is engaged in a lot of waste management projects.

Then Bengaluru you we have 8 megawatt plant again in setup in PPP mode and the operator is MS Srinivasa Gayitri resources recovery and of course, they are partnered with the Bangalore Municipal Corporation. Then in Pune Rochem separation systems has set up a pilot project but this is not incineration directly this is gasification.

This is one form of insulation you can say and they have they are generating 10 megawatt of electricity from around 700 tonnes per day of waste. And in Hyderabad 11-megawatt power RDF power project is created is setup and this is using around 1100 tonnes per day of municipal solid waste. So, these are some of the examples of RDF facilities sorry waste to energy facilities that has been developed, some of them are using RDF some of them are pure incineration plants. So, as per some of these are operating still now some of this has closed.

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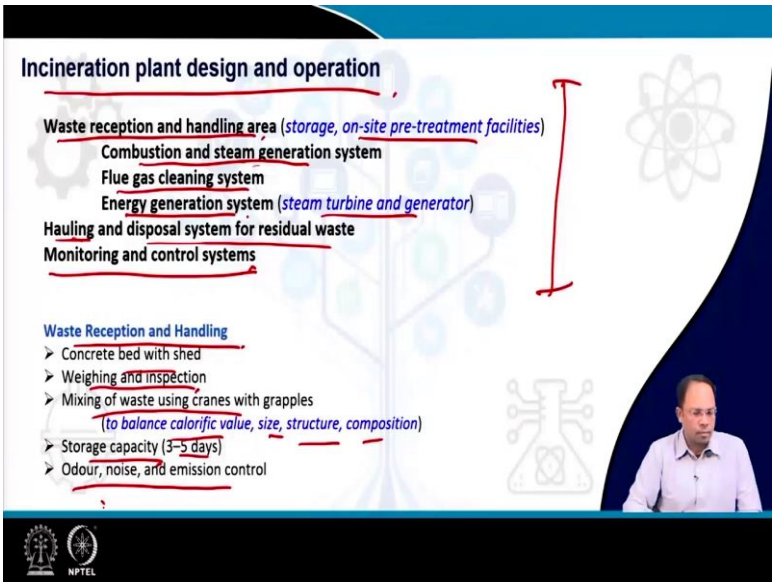

So, coming to incineration plant design and operation. So, again this the plant system design and all this is very, very important, why because the system design has to be aligned with what kind of waste we are getting. And not only that, based on the final emission standard that we have to reach and all there has to be certain criteria using which we have to design our system and each of the systems that we will design is of has got many processes. The processes vary and each process is takes in different inputs and different outputs that result in different environmental issues. So, that means every plant is different.

So, it is a technical engineering problem where you know, the plant has to be set up by specialised operator, but at the end of the day, we have to evaluate what is the environmental impact coming out of that plant and for every plant based on whatever process they utilise, each of these processes are different.

So, the plant has got a waste reception and handling area and that is the first step where the once the waste comes in it has to be stored there and some amount of on-site pre-treatment can be done over here, then combustion and then coming to the actual processes the combustion and steam generation system is there, where we actually burn the waste and we generate steam.

Then flue gas cleaning system, the gas that is comes out of this particular burning incineration process that is used for the steam generation in the boilers, but this gas itself needs to be clean. So, that is the flue gas cleaning system. Then the energy generation system is the steam is utilised to drive steam turbines or generators and using that we can generate energy and finally, whatever remains we have to the emissions that comes out or the solid matter like ash that comes out that has to be dealt with. So, we have to also take it to the municipal solid waste management landfill site.

So, hauling and disposal system for residual waste. Finally, monitoring and control systems for the plants. So, these are different aspects that you have to be concerned with when you are setting up a incineration plant. So, the waste reception and handling area usually has got a concrete bed with a shed, so, that it is not affected by rain and all weighing and inspection of the waste is done.

The waste is then mixed using cranes with grapples So, that the waste mix is uniformly and all and this balances the calorific values size of the particles the structure and the composition of the entire waste because waste may come from different areas of the city and also we make it uniform in composition. The storage capacity that we designed this particular concrete bed is for 3 to 5 days what a waste and order noise emission control different technologies different methods can be adapted, so, that these are less.

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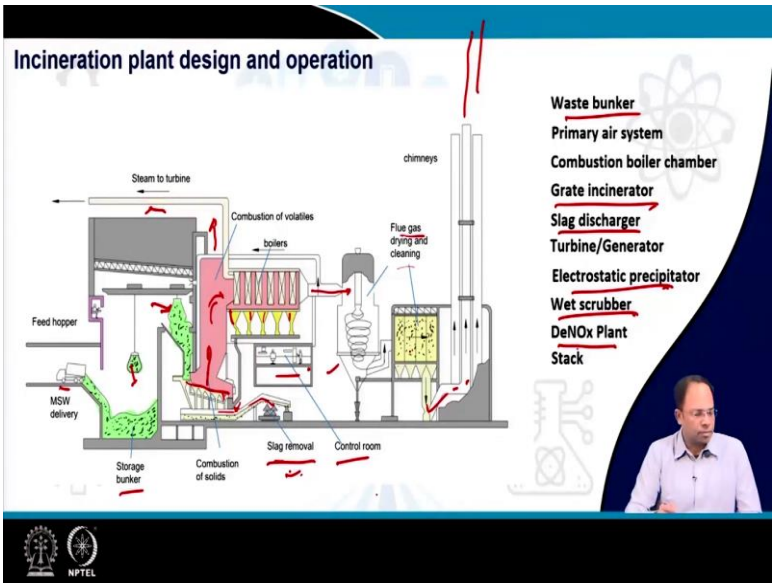

So, this is how incineration plant looks like. So, here you can see the delivery of solid waste is happening the waste is stored in a storage bunker we also call it waste bunker. Now, this waste is lifted up by this grapples, it is used to make the waste as well and it can lift the waste and then put it over here. So, this could be a conveyor belt or it could be a garbage chute and through this a waste chute so through this the waste goes into the grid.

So, this is the grid or the surface where the waste is actually burned. So, these are known as great incinerators, the waste after burning you can see that this is where the ash is falling and the waste the ash comes to this slag removal system. So, we call it slag discharger. And this is where the combustion is taking place, this is the combustion chamber and these are the boilers, this is a combustion boiler chamber and this flue gas that comes out comes in contact with this particular boilers, this is very very heated and this actually boils, it generates steams, the steam is taken out via this and then it is goes to the turbines.

Now, over here you can see the controlling operations of the plant where we have plant operators who can control it and whatever way this flue gas contains a lot of dust particles ash particles and all those are captured these are precipitated over here and this again goes back over here from where it is removed.

So, this gas is more or less this fly ash that is generated over here is relatively better we can utilise it in future for some amount of construction material in for creating certain kinds of bricks and other things. Whereas, the gas which goes out through this to the electrostatic precipitators that has to be cleaned over here and here the particle size is less.

So, this is the flue gas drying and cleaning system. This could be the electrostatic precipitator then these are the wet scrubbers, where the gas goes to different processes and it gets clean. Finally, there is a DeNOx plant where the nitrous oxides are taken out and finally, this is the stack where or the chimney through which the gases are laid out into the atmosphere. So, this is how the overall system looks like.

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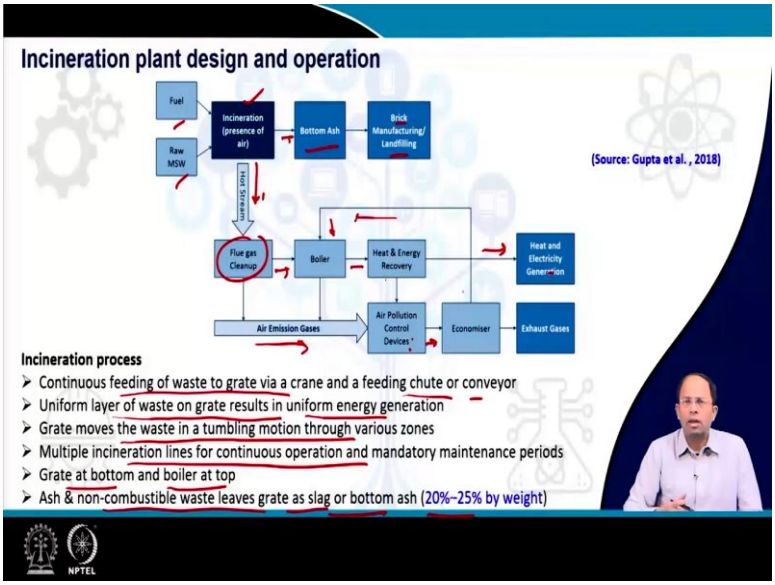

So, just to summarise fuel and raw MSW is put inside the incinerator in presence of air. It generates ash which is known as bottom ash. This could be used in brick manufacturing and also will be taken to the landfill site whereas the hot flue gas is first cleaned. And after a little bit of cleaning automatically precipitation happens it is used for in the boilers, so, that it can generate steam and this some amount of gases remaining gases after precipitation and all after clean-up is goes into the air pollution control devices then it is cleaned using electrostatic precipitators and all.

And finally, this goes into a economizer where some amount of gas is recirculated back into the boiler this is known as second tertiary care and I will come to that and this heat and energy recovery happens at the boiler because we are generating steam and eventually that could be used for electricity generation.

So, coming to the incineration process**,** we continuously feed waste to the grate via the crane and a feeding chute or conveyor we have shown that in the image a uniform layer of waste on the grate results in uniform energy generation. So, that means, we lay down on the grate is a surface over below which there are banners and then all sometimes we also use air flow inside the this as well.

And we and different this there are different designs of this incinerators of course, but the idea is to spread the waste over this particular surface and the waste gets spread, the grate moves the waste in a tumbling motion through various zones.

So, eventually it passes through the entire grate and then the waste converts into ash, multiple incineration lines can be set up and because that will result in continuous operation when one line can be maintained the others would keep on operating and at the grate. The grate is usually at the lower at the bottom, whereas the boiler is at kept at the top and ash a non-combustible waste leaves grate as slag or bottom ash and it is something around 20 to 25 percent of the overall weight of waste that goes into the incinerator.

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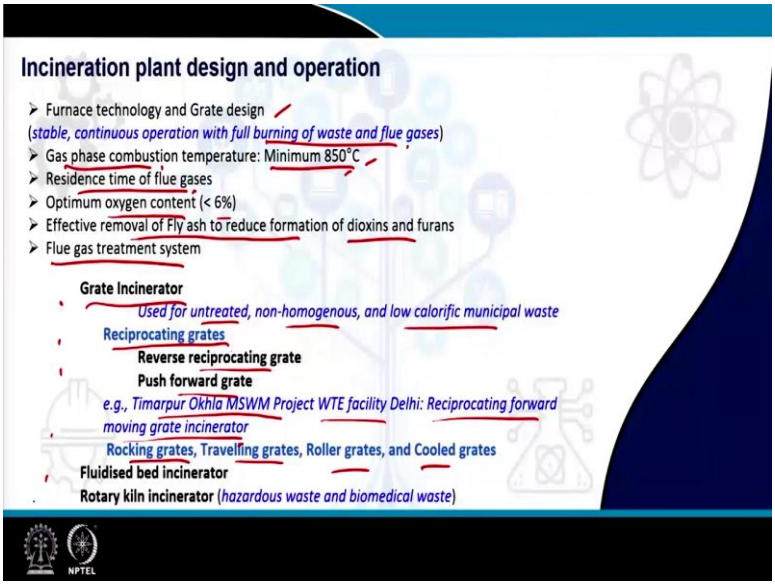

So, the furnace technology and the great design is very very important it results in stable continuous operation with full burning of waste flue gases. So, the choice of my great design or furnace technology depends on what sort of waste is coming in. And so, we have to make sure that the burns uniformly accordingly we will select the proper technologies for this. The temperature of burning is around 850 degrees centigrade. So, this you can say this is a gas phase combustion temperature.

And we have to also control the residence time of flue gases because we have to keep it at high temperature, but we cannot keep it for long because eventually that will result in other problems and optimum oxygen content should be more less than 6 percent. And we have to remove fly ash before it cools down otherwise, it will result in formation of dioxins and furans which are very very, problematic or this contaminates the surrounding area. The flue gas has to be treated.

So, we have to design a flue gas treatment system as well. There are different kinds of incinerators, you can see are great incinerators, rocking grates, travelling grate solar grate cooled grates, these are different designs, these are used for untreated non homogeneous and low calorific municipal waste.

So, as we have told earlier that incineration can happen with low quality waste as well. Then there are reciprocating rate is one specialised design of great incinerator where reverse reciprocating grates and push forward grate these are two types of grate. Reciprocating grates means one track there are arranged in a reciprocating order so that when one tray comes out, the other tray goes out and then this the second tray comes in.

So, it keeps on moving like that. So, one of the plants set up in Timarpur Okla MSWM municipal solid waste management project in Delhi this they use the reciprocating forward moving grate incinerator. So anyway, so these are very, very technical processes. So the selection of this depends on experts and all as we do not require it in the planning process.

But the problem is if you do not know this kind of technologies that are being utilised, then it would be difficult for you to evaluate what kind of environmental impact will result from the processes which goes inside or that is undertaken in this particular systems. So that is why we need to know a details about the technical processes or technical systems that are utilised in incineration plants.

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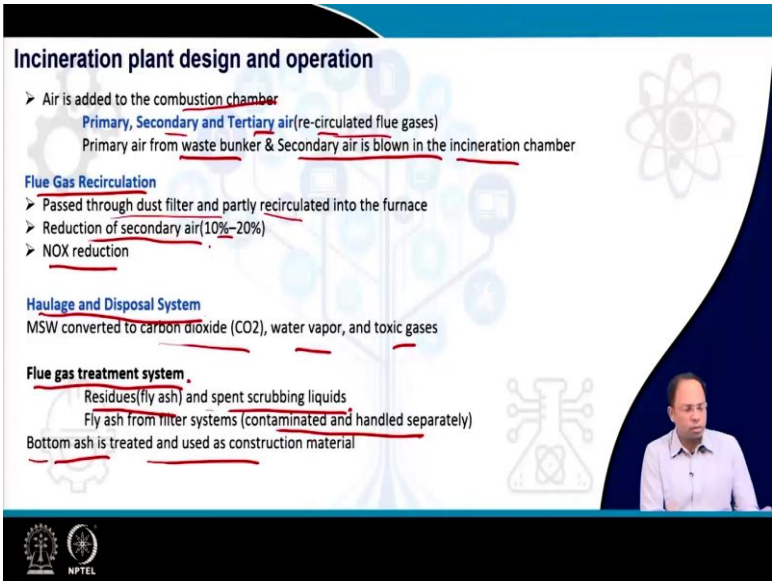

So air is added to the combustion chamber or without air we cannot have combustion here. So, primary air secondary air and tertiary air tertiary air is the recirculated flue gas whereas

primary air is comes from the waste bunker. This is just draw in air from the waste bunker and secondary air is blown in the incineration chamber directly.

That means we using some sort of lenses and all this air is centred in locations where it is required. The flue gas recirculation system is where after the flue gas is passed to dust filters and it could be partially recirculated back into the furnace which is access the re-circulated or the tertiary air and this reduces the need for secondary air by 10 to 20 percent.

And also, this reduces the overall NOX formation. Finally, the waste has to be hauled and we have to design a disposal system for this emission that is coming out from this plant and municipal solid waste is converted into ash and also to carbon dioxide, water vapour and toxic gases.

So, obviously, we have to have a flue gas detail flue gas treatment system. Now, the residues or the fly ash and are and spent scrubbing liquids that is after from the flue gas treatment system once we clean this flue gas, whatever remains this is very, very contaminated. So, this has to be handled separately and this has to be kept in separate position locations in the landfill site.

Whereas, the bottom ash that we were getting at the grates at or at different stages that can be treated and used as a construction material. So, we get ash at different stages. So, the ash which we are getting from the electrostatic precipitators the scrubbers that is very, very contaminated and it is better not to be utilised for other purposes.

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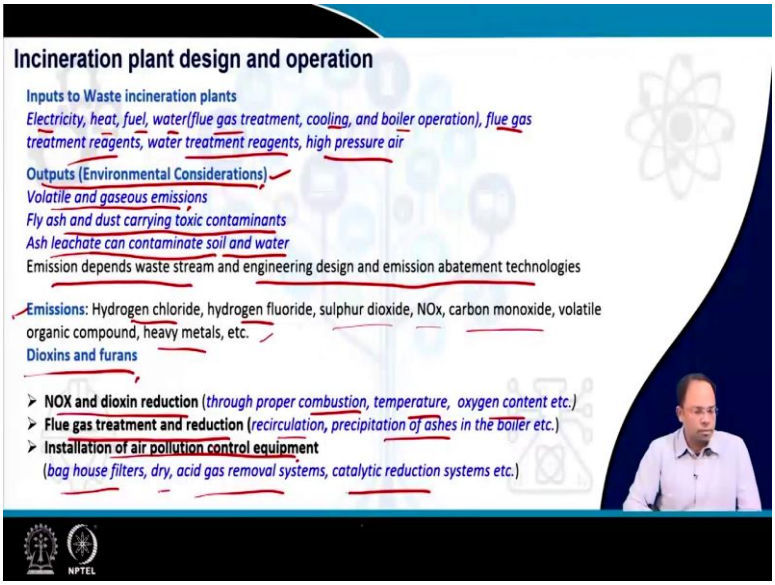

So, what are the input that goes into the plant? Electricity heat fuel water, water is used for flue gas treatment cooling and boiler operations. Flue gas treatment reagents water treatment reagents, high pressure air these are all inputs to the system. Why I am talking about inputs and outputs? Because this is how you evaluate the different processes and see which one is better.

So, suppose I have got incineration or I have got some other technique of like pyrolysis or we take certain other technical gasification or we take like, aerobic digestion like bio methanation. So, how do we compare this. So, it will be based on whatever inputs goes into the process as well as whatever outputs also come out of that particular process.

So, outputs are environmental considerations and this include consideration for volatile and gaseous emissions, fly ash and dust carrying toxic contaminants, ash leachate, that can be generated in the landfill sites which will contaminate soil and water. So, all these things are important and all this emission depends upon the initial waste stream that we are using and the engineering design and emission abatement technologies that we are using in the plant.

So, the more we invest in the plant, more better would be the final this stack emission that will come out of that particular plant. So, what do we this kind of plant emit? Hydrogen chloride, hydrogen fluoride, sulphur dioxide, NOX, carbon monoxide, volatile organic compounds, heavy metals and so on. So, this is not good at all.

So, it has to be within certain standards. So, we will talk about the standards after this, but along with emission it also create dioxins and furans which are very, very critical and we have to be very careful about this. So, one of the primary purpose is to reduce NOX and dioxin, this could be done via proper combustion at proper temperature and oxygen content.

And so, we have to select the right technology for combustion for the kind of waste that we are getting. Then flue gas treatment and reduction which is where we recirculation precipitation of ashes in the boiler, all these things happen. Then installation of air pollution control equipment this reduces the final quality of emission that comes out of this. So, for this we have baghouse predators, dry acid gas removal systems, catalytic reduction systems and so on.

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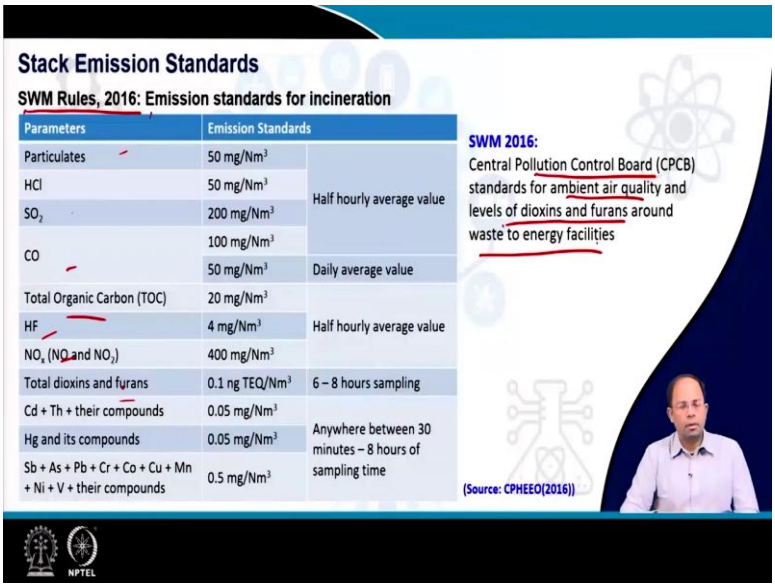

So, coming to the final emission standards from as given in the solid waste management rules you can see that we have got emission standards for particulate matter, which is 50 milligrams per normal cubic metre, HCl hydrogen chloride, 50 milligrams, sulphur dioxide, carbon monoxide, total organic carbon, hydrogen fluoride, NOX, total dioxins and furans and so on.

But these standards are given by in the software management rules, but we need standards, the software of management rules also specify that central pollution control board should set ambient air quality and levels of dioxin and furan standards around waste to energy facilities.

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So, these are some of the references that you can use.

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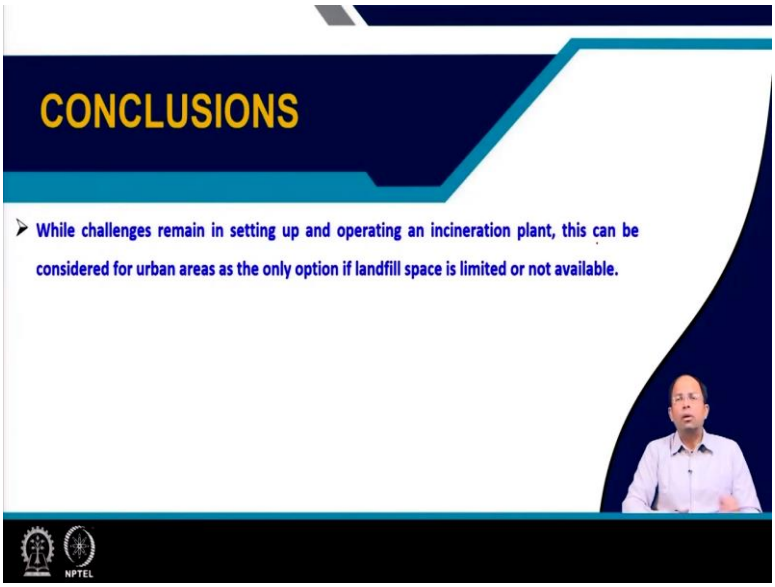

And to conclude while challenges remain in setting up and operating an incineration plant this can be considered for urban areas is the only option if landfill space is limited or not available. Thank you.