Course on Integrated Waste Management for a Smart City
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Module No 08
Lecture 36: Thermal Treatment (Contd.)

Okay so let us continue our discussion on thermal treatment which we have been talking about in the last 2 videos and so if you look at like what we were talking about in terms of the different technologies, incineration, combustion being the most popular technology which is being used, we talked about the concept the kind of how the waste to energy is being developed within the Indian context and some of the issues that we should be careful when we are trying to go for waste-to-energy plant.

It can work but again, needs a proper home work for that. So continuing that discussion, let us look at in terms of when we talk about this combustion, as I said, it is an oxidation process.

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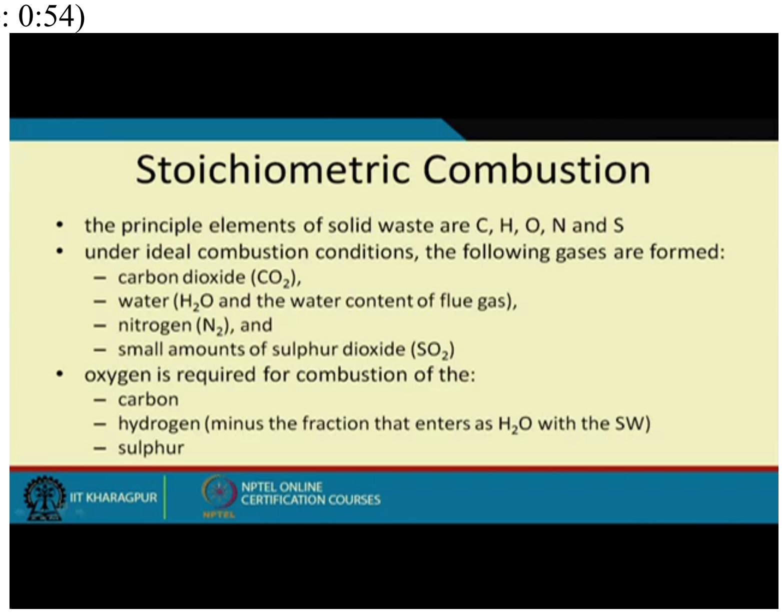

So combustion is an oxidation process and the amount the fraction of the garbage which will actually go through the combustion is the volatile solid fraction. So the volatile solid fraction, when we look at the volatile solid, we are looking at it is essentially the stoichiometric combustion is there. So we are looking at this stoichiometric combustion were the volatile solid fraction we have essentially carbon, hydrogen, oxygen, nitrogen and sulphur.

So that is what will be in the volatile solid part. So under ideal conditions, what will happen? Under ideal conditions, we will have all these reactions taking place, so carbon will get converted to CO2, your hydrogen will get converted to water vapour, and water content of the flue gas, it will be part of that, oxygen of course oxygen will actually help in the combustion process.

Nitrogen will be there, usually at the temperature at which we work, we do not have this NO NOX being formed and then sulphur will get converted to SO2. So these are the ones you see that what will happen. So it is a small amount of sulphur dioxide, mostly carbon dioxide, some water vapour, so oxygen is required. So we need oxygen for producing for the burning the carbon, we need an for the burning of hydrogen and minus the fraction that enters is H2O.

So there is some hydrogen already there, there are some oxygen already there. Then also for sulphur, we need the oxygen. So oxygen is needed for this combustion process. So when we say stoichiometric, we are basically trying to say from the very 1^{st} principle as you may remember from earlier chemistry and other classes that you had that if you have if you like one mole of oxygen will react with if you look at one mole of carbon will react with one mole of oxygen and then of course, there is something it is and then you get the CO2 produced.

Similarly hydrogen, 2 mole of hydrogen reacts with one mole. One mole of sulphur reacts with one mole. So again these are, these are very simple. We are just going to very basics that you had in some sort of high school chemistry. So if you know the formula, the bottom question is to know the formula, know the formula of this volatile solid part, we can calculate how much oxygen will be required going by this stoichiometric based on how much carbon is there, how much hydrogen is there, how much oxygen is there, how much nitrogen and sulphur is present.

So based on that, we can calculate how much total oxygen will be required. So that is it is in terms of the school that is what is known as the stoichiometric combustion where you go by kind of the basic principle.

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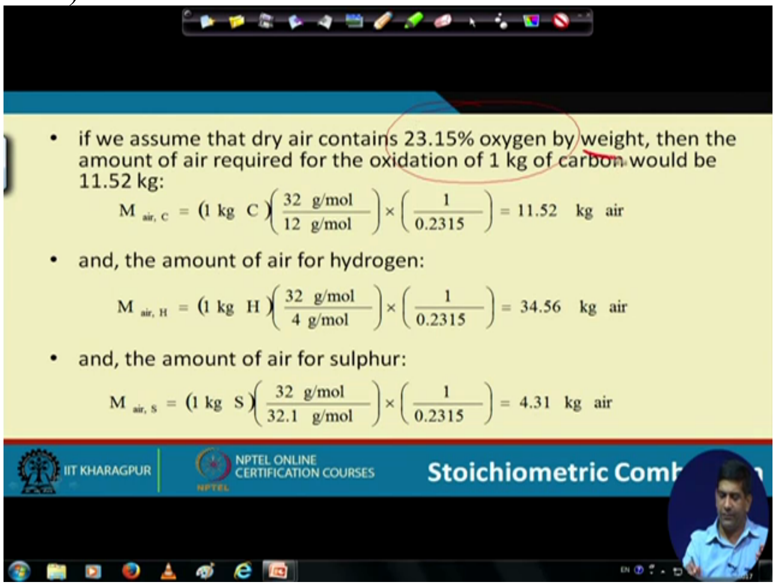

So if you so if you take one example, so if you assume that dry air contains 23.15 percent of oxygen, so we have those dry air, 23.15 percent of oxygen by weight and then the amount of air required, so if you think about that amount of air required for completion of 1 kg of carbon, so you can do that maths, 1 kg of carbon, so that means we can convert that into moles. So you divide it by 12 and then you get this much moles of carbon.

So one mole of carbon will require one mole of oxygen C plus O2 is CO2 and that oxygen is O2. So we are looking at 32 grams per mole. So that is your, since both are in grams, it is okay, although this is in kilogram since it will cancel out, so we we are okay, otherwise we can convert that to 10 to kilogram we can convert this also to kilogram and that factor will cancel out anyway as well. So with this we can find out how much oxygen will be required and from how much 23.15 % of oxygen is, oxygen is there in the air.

So we can find out how much air will be required, so we get the value of 11.52 kg of air. So it is similarly you can do it for hydrogen, you can do it for sulphur and you can find out how much kg of air you require for 1 kg of carbon, 1 kg of hydrogen, 1 kg of sulphur. So if you so if 1 kg of carbon require 11.52 kg of air, so it is actually, for each one of them, the number is higher on the air side so because so that is we can get we can do those calculations using the basic stoichiometric combustion equation.

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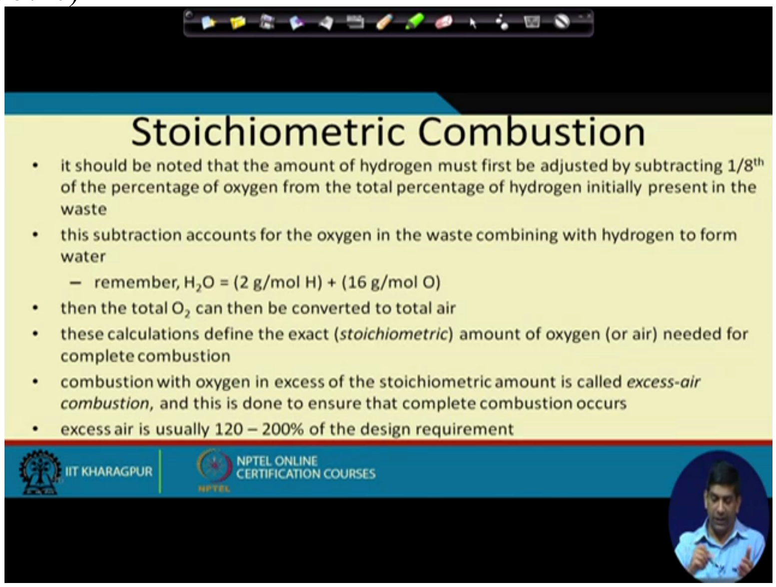

Now stoichiometric combustion is the amount of hydrogen 1^{st} we have to adjust the amount of hydrogen by because $1/8^{th}$ of the percent of oxygen will be initially from the total percentage because of the water, that whatever is the oxygen is present. So we can subtract $1/8^{th}$ of the percentage of oxygen hydrogen for the hydrogen 1^{st} we adjusted by subtracting $1/8^{th}$ of the percentage of oxygen from the total percentage of hydrogen initially present.

That is to, this subtraction accounts for the oxygen in the waste combining with hydrogen to form water because this is there because water is what? 2 grams per mole of hydrogen, 16 grams per mole. So that is why it is 1 upon 8. So that is why it is say 1 upon 8^{th} is over there. So since $1/8^{th}$ of the percentage of hydrogen sorry for oxygen is part of the hydrogen which is there as the form of water, so we need to take into account that part.

Total oxygen, then the total oxygen can be then be converted to total air. We can do that. This calculation, we are looking at the exact stoichiometric amount of oxygen or air needed. Many times we apply some excess air because when we supply the air here again, we have to supply the like in the in the compost process, we have been supplying the air for aerobic degradation. Similarly here in the combustion process, we are supplying air for the burning.

So it is again a combustion is an oxidation process. So we have to supply the air to it. So when we supply the air, there may be some leakages, your things may not work up to 100 percent efficiency. So you always have some excess air. So that is what here we are talking about that we supply some air as an excess of the stoichiometric amount, that is called the excess air. And why we do it?

This is to make sure the combustion occurs because then incomplete combustion leads to PAH, leads to carbon monoxide, even particle it matters if it is if it is a combustion happens very nicely, if it burns really well, the pollution is less. So as you can see that initially also, like if you are even burning coal, or you are doing anything, you are burning anything, once the fire really catches nicely, you do not see any much smoke coming out even from your if you burn some coal or even if you burn some stuff like campfire or anything, once the initially you will get all those smoke and then you get your eyes itchy and all that because of all that smoke coming out.

But once the it burns really well, once the really nice fire has set up, the smoke goes away. So because now the complete combustion is happening the combustion, so the smoke is gone. But the smoke is there but at a very low level. But initially when you have the incomplete combustion, you have a lot of air pollution happening. So excess air is usually we produce 120 to 200 percent. We do not want too much of an excess air because earlier I said that you when you work this incinerator, you work at a certain temperature.

If you add too much of excess air, air has a cooling effect. So temperature will try to go down. And the temperature goes down, you have problem in terms of in terms of creating more air pollutants because air again you have to for commission of less air pollutants, you need to keep the temperature at a high level. So that is that is also is needed.

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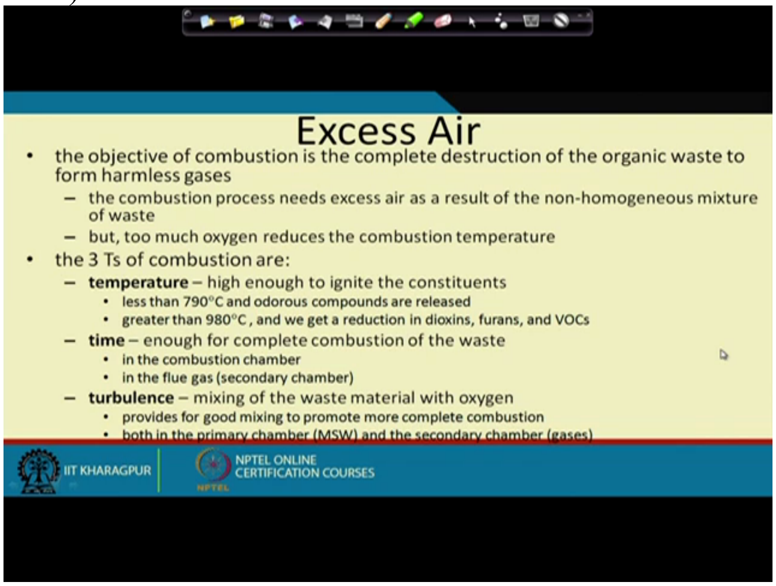

So excess air it is the objective of combustion is to complete destruction so we want complete destruction. So to avoid like air pollutant issue, so for the complete destruction of the organic waste into harmless gases. So combustion process needs excess air. Why? Because we have a non-homogeneous mixture. Had it been a very nice homogeneous mix, the excess air requirement may be less but here, think about the garbage.

One piece could be this small, the other piece could be this big. And then this may have, this will burn really well, this may not burn that well, it may be more complex, reaction will take longer time. So for all those things to happen, you need to make sure that you have enough amount of oxygen and of course we do a lot of tumbling and turning and we will talk about that. And but there is, those things are required because of the non-homogeneous. But as I said, too much oxygen, we do not want too much oxygen because that will reduce the combustion temperature and that will lead to air pollution issues.

So we do not want that. So in terms that is in terms of the excess air, then this term is very very important in terms of air thermal combustion specially, there are 3 Ts of combustion. Like that is designed of the very basic of a based combustor. You need to design it for 3 Ts. Now what are those 3Ts? Number 1, temperature. We kind of talked about that a little bit already. Now why temperature?

High enough to ignite, you have to burn it. Less than 790 if I just take it off, less than 790 will cause odorous compounds are released. You do not want less than 790 degrees. Greater than 980 and we get reduction in dioxins, furanes, and VOCs. So that is why I said, most of the incinerator will try to work it around 1100 to 1200 degrees centigrade. Definitely above 1000 because they want a reduction in dioxins, furanes and VOCs. You do not want these to be released into the atmosphere.

So they try to work at around 1100 to 1200 degrees centigrade, definitely above 1000. You will not see an incinerator working under 1000. If it works under 1000, that means it will have air, it may have bigger air pollution problem and then it will have a bigger load on the air pollution control system. Now that is the temperature, one of the most important pickers, temperature at high temperature, good enough for burning to take place and good enough for keeping the air pollutant low.

So that is the reason why we look at the temperature. The 2^{nd} part is time because it is a reaction. You have you have done this chemical kinetics as part of your high school or also maybe 1^{st} year of engineering, 1^{st} year of whatever discipline you were there when you talked about this chemistry, you talked about this chemical kinetic. Now what is this chemical kinetics? It basically tells you the reaction rate. Some reaction is slow, some reaction is fast and effectively, it takes time for reaction to take place.

Reaction does not happen instantaneously. Some does, like if you drop a drop in if you have a water and drop in acid, then the acid really dissolves and then you measure the pH at any point of there it is ok you will find the same pH. But if you have, if it is a lake was much bigger, probably not but if I am talking about a small beaker, yes. But same thing, but that is a liquid media. Things does dissolve and mix. That is reaction is relatively faster.

But when we talk about waste incineration, we have the combustion going on, things has to burn, so it takes time. So we have to know the time that it takes for reaction to take place because when you will see the combustion chamber and you will see some sketches, the waste actually goes through the combustion chamber, so it gets dropped and goes through the grades and then at the bottom, it comes out as the ash.

So the time it takes to travel here, it should be, it should be more than the time it requires for the reaction to take place for the complete combustion to take place. Otherwise, you will have the incomplete combustion. Your bottom ash quantity, residual quantity will go up and you will be actually you will be losing the energy that you could potentially get out of that. So that is why, enough for complete combustion, that is very important. We need to have a complete combustion in the combustion chamber.

And then also we do it in the flue gas in the secondary chamber, for the flue gas is also burnt in the secondary chamber. So that is in terms of the temperature, time. So two Ts the cupboard. Now for the 3rd T, is for is what is known as turbulence. Now what is this turbulence? It is basically you are mixing, you are trying to mix the waste together. So you are trying to make the waste together so that it where the air comes in, it gets mixed, all the different areas get exposed nicely so that it burns really well.

So why it is needed again, it is for the heterogeneity of the material. It is otherwise it provides good mixing to promote more complete combustion. And we do it for both the primary chamber and for the MSW and then the flue gas which is released which is burned in the secondary chamber, you will see some sketches that there also we try to mix them. So mixing helps in reaction, is basically we are trying to make the reaction as complete as possible.

So 3 Ts remember that, temperature, time, turbulence. So these are very very important in terms of in terms of work combustion process in terms of the waste incineration process. And in fact, this is also important for coal when you do this coal based thermal power plant but the some of this like for specially for turbulence, maybe less in coal than in here because that is a more homogeneous material.

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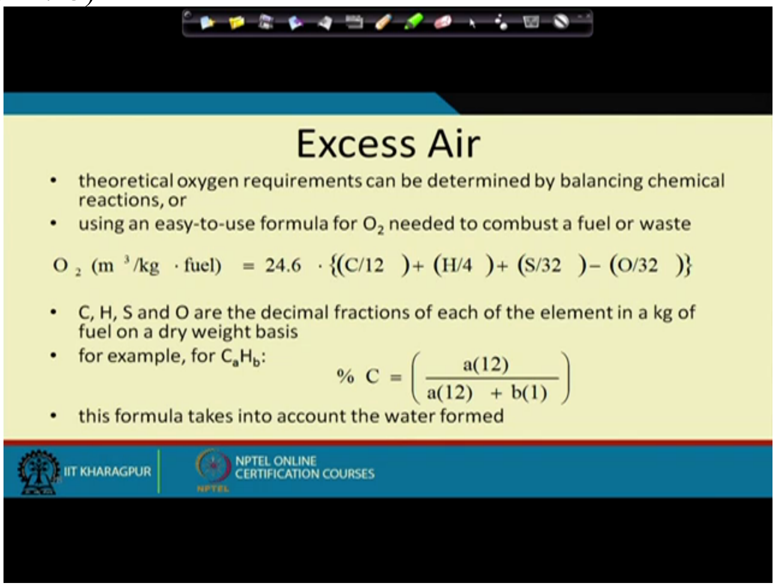

So we can do this excuse me we can do this excess air calculation, there is a theoretical oxygen requirement can be determined by balancing the chemical equation. So if you know the chemical equation, you can just balance the equation. There is a if you do this, if you take any any like a chemical formula for the volatile solids, you if you know the carbon, hydrogen, sulphur, oxygen, you can also use this relationship which has been which has been developed using the stoichiometric calculation.

So if you are you can do it from basic as I showed you in few slides back, and now you can use this equation as well which is in oxygen in metre cube per kg can be calculated based on 24.6 times carbon by 12, hydrogen by 4, sulphur by 32 and oxygen by 32. Why oxygen is negative? Others are positive but oxygen is negative. I you should always, whenever you see something like that, the thing should come in your head, why it is this?

Of course it is very simple because oxygen, the amount of oxygen present in the garbage, in the volatile solid fraction will also contribute to combustion. They will actually acts as a source which is needed for combustion. So that oxygen we are subtracting because we do not need. That oxygen is already there. We do not have to supply this much amount of oxygen which is already present in the garbage.

We will supply only the oxygen need, we will subtract this (())(16:16) because that oxygen is already present there. So we do not have to supply that much. And whatever is additionally needed which would substantially what this would be much less, that is what we need to supply. So you need to be again, anything like this when it comes, you should think, you should not just take things as a face value. You should always try to understand why it is the way it is. So these are the here, carbon, hydrogen, sulphur, oxygen, they are the decimal fractions of each of the elements in a kg or fuel on a dry weight basis.

So if we can know, we can, I was telling you that we can do this CHONS analyser. Many labs has it where you can analyse your garbage sample and then you can find out this carbon hydrogen, oxygen, nitrogen, sulphur per kg of the fuel and then based on that you can plug in those numbers here and then you can get how much oxygen will be required. So for example, for CAHB, percentage carbon is you can calculate based on what is the A value, B value, we can calculate this.

This formula does take into account the water form. So that is why water has already been accounted for. So we do not have to worry about that part. In the stoichiometry we have to account it for separately. So we will we will use this equation in subsequently when we do some maths problem and we will see that again over there.

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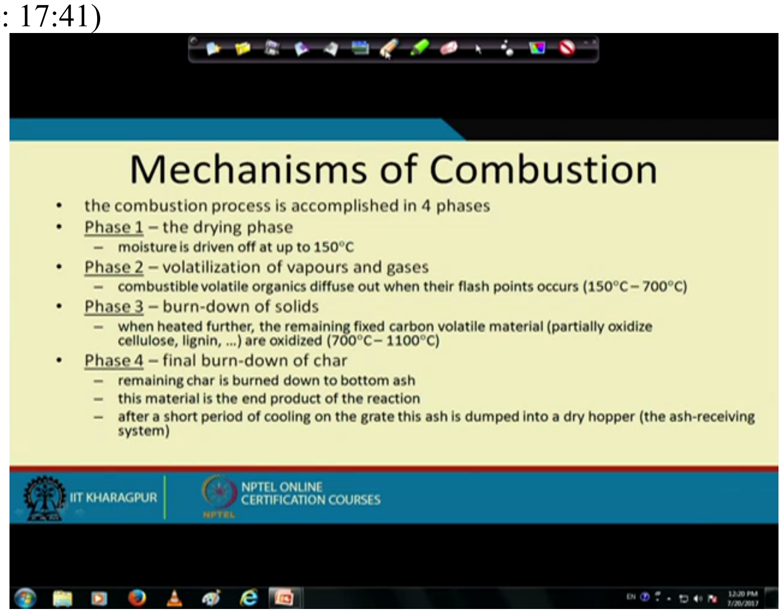

So in terms of how this combustion process works, there are 4 phases, we try to define them in 4 phase. Phase 1 is 1st it is a drying phase, you are trying to dry it, you are making the moisture go away. So moisture go away, what we will do? Moisture will go away at what temperature? Slightly above 100 degrees centigrade. So that is why, the drying phase goes to around 150 just to have a like around we have to definitely go above 100 so it goes above 150.

So moisture is driven is off, so in the 1st phase, we are just getting rid of the moisture. In the 2nd phase, we are volatilizing vapour and gases. So we are taking the temperature to around 700 degrees centigrade and then we are volatilizing all those vapours and gases. Whatever the vapours and gases that is formed, so the volatile components, volatile solids we measure at what? 550 degrees centigrade.

So we take it up to 700 so that all those things which could be volatile, will get volatile, things may get converted to flue gas, get to some of the gaseous component. And then next will be when we heat further, we try to heat it further, so the remaining fixed carbon volatile material, they will partially oxidise cellulose, lignin, those things will be there. So they will get oxidised further at 700 degrees to 1100 degrees centigrade. So that is why I said, above 1000 you will see most of the time is working.

So that is where you have even further burning down of the solid. Then you will have some char so those char, remaining char is burned down to bottom ash. So from the char, you get the bottom ash. And this material is our end a product of the reaction. And then once it cools down a little bit, this ash is dumped in a dry hopper, the ash receiving system and then it gets taken away from the main plant and then it goes to the ash handling system, ash handling part of the plant where ash will be handled.

It could be, ash could be right now most of the places actually other than Western European countries, this ash is being dumped in the landfill but there are lot of work even I did a project long back where we used this waste to energy ash as a partial we recovered some of the aggregates, some of the material from this waste to energy ash and we used it as a partial substitute for aggregate in road construction and we did a pilot, we did a lab and pilot and we saw that it does work up to a certain proportion.

We were looking at differentat what proportion you can mix it so that their pollution, so that the leaching is not a problem in terms of the surface water contamination and all. And we found out that it could potentially work. And there are many places in Europe and other where they are actually using that as a partial substitute for road construction. Our work was done almost 12 years ago. So at that time, it was just in a very beginning stage.

So we had all, we had a paper on that published in a journal. So it is so this is so this is what how, then if otherwise if we do not use it, we have to send it to a landfill. But part of that ash could be used specially from Indian context if you think about we are thinking, we have to have housing for all. Is not it? People are talking, we need to have housing for all by 2020 or 2050 whatever.

I think it is 2020. So for housing, so we did lot of raw material. Even to build all this infrastructure, highways, roads, and other stuff, we need a lot of construction material. And we know that we have, we do not have that much construction material. We have lot of problem in sand and all that. We have lots of fly ash from the coal thermal power plant, we have a lot of residual from the coal thermal from the coal thermal power plant and we have, we can build this waste-to-energy plants and we will have this residuals from here.

And if we separate this different, if we separate the different fractions, remove the heavy metals, some specially the ferrous ones can be taken out by using this magnet and all and then do some environmental risk assessment. That is again essential. Many times we, we take a waste and we just try to use it for road, we try to use it for certain other applications and we say oh, the problem is solved. Problem is solved but not, we do not know.

It may become a problem in some other area. That is why, environmental risk assessment, what is what is known as in the Western world as a term called beneficial reuse risk assessment. So where we are trying to beneficial reuse this ash, whatever ash whether from waste to energy, from coal-based thermal power plant or any industrial waste, when we are trying to use the beneficial reuse of waste, you need to make sure that you do a beneficial reuse risk assessment.

What does that mean is basically you are looking at the leaching, you look at the total amount of any heavy metals, organics, other things present, whether it will be a problem to environment in terms of the surface water and all, could potentially have a groundwater problem, it is a soil contamination problem, so those things needs to be looked into. Otherwise what we are doing is, we are basically taking a problem at one point and distributing that problem in other areas.

So that is not really the environmental solution. Ultimately you will have to go back and fix those problems over time. So we have to, we should do this beneficial reuse risk assessment and that is very very critical. In Indian context, we do not see that much work going on in that area. Like there is, there needs to be work done in that area. I hope those work will be taken up in a in a big scale specially when we are trying to recycle, reuse most of this industrial waste.

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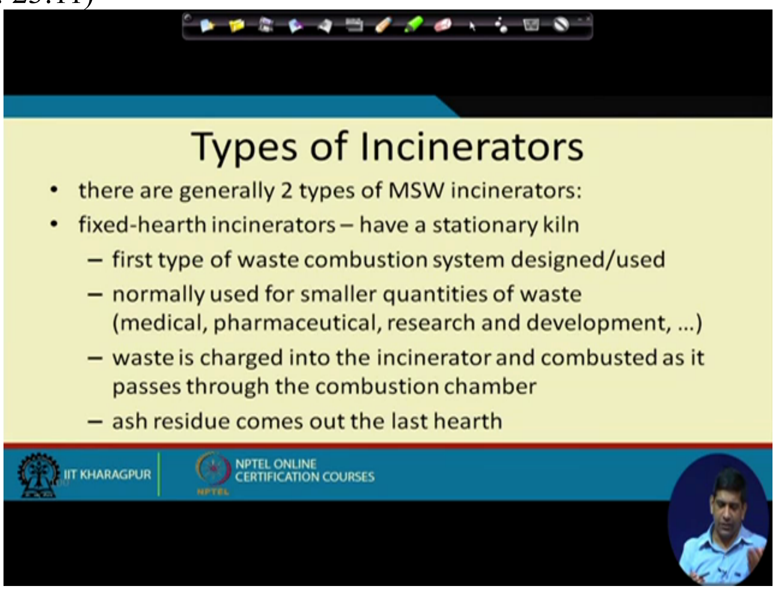

So let us see, and then we go to the next one. Then there are different types of incinerators. There are in terms of municipal solid wastes, you may essentially see 2 types where is we have 2 types of incinerator which is a stationary kiln. You see that. So municipal solid waste, you mostly see 2 types of incinerators, 2 types of MSW incinerators. We have a stationary kiln which is used. It is the 1st type of waste combustion system designed and used in terms of any in combustion system.

Normally we do it for small quantity. For the small quantity of waste, we can use this stationary kiln. Also used for medical waste, can use for pharmaceutical waste and for R&D purposes like research and development purposes if we used to have an incinerator, we use a, have a rotary, stationary kiln, stationary kiln incinerator. So what why what we do? Your waste is charged into the incinerator and combusted.

It passes through the combustion chamber, ash residue will come out at the last you will have the ash residue come out. So it is a basically a very simple system. Waste is inputted into the incineration, combusted, it passes through the combustion chamber, so there is a combustion chamber. So you think about as a, if you can draw it over here, we have this combustion chamber, so once this waste will travel through the combustion chamber, so combustion will take place along the length and so from here, and then finally we will have the ash coming out.

So that is your stationary kiln where ash will be taken out. So that is, the reaction will take place in this particular area. So that is one type and usually done for a small quantity of waste.

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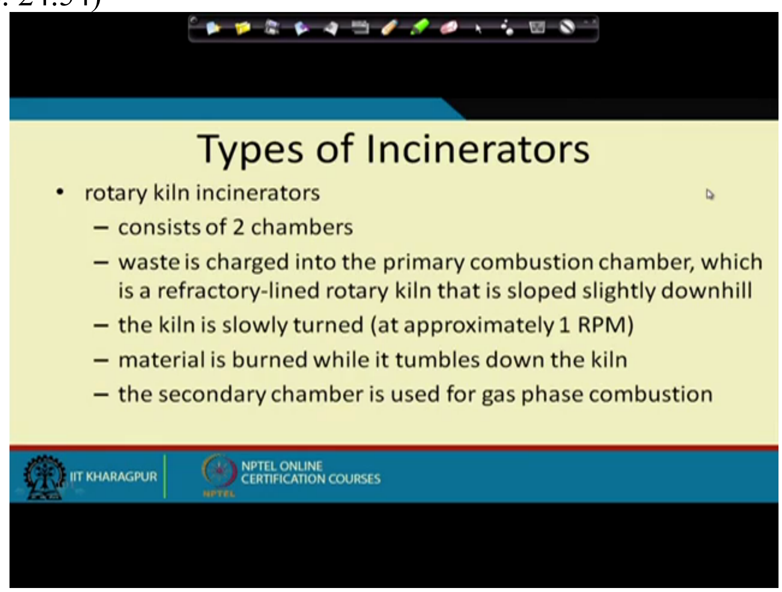

And then other one is the rotary kiln. Rotary kiln will have two chambers. So you see rotary kiln is used a lot in cement and other places you have this rotary kiln as well. It has consists of 2 chambers. So there is a primary combustion chamber and there is a secondary combustion chamber. In primary combustion chamber, its refractory lined so it is just go back, okay it is it has consists of 2 chambers. So we have is a primary chamber which is primary combustion chamber which is refractory lined rotary kiln, that is slope slightly downhill.

So you have a slightly downhill, so waste will travel down and then it also gets rotated as it moves, so things keeps rotated. And the kiln slowly turned at approximately 1 rpm. So it is only 1 revolution per minute. So it is a slow turn. At 1 revolution per minute it is turning and the things arethe kiln is turning, the same time the waste is travelling down. So I will I will show you some sketch, I think I have some sketch in next few slides.

So waste is turning, waste is also tumbling down and the kiln is rotating at the same time and it is getting burnt. So it is getting burnt and then you take the secondary chamber, we use for the gas phase combustion because all the gases that is formed in the primary chamber is taken to the secondary chamber and they are burned further at a high temperature. So it is a, here we can we can work with a lower temperature and then we can take it to the secondary chamber where we heat it at a high temperature.

From energy point of view also, it works out to be better because you you do you save some energy.

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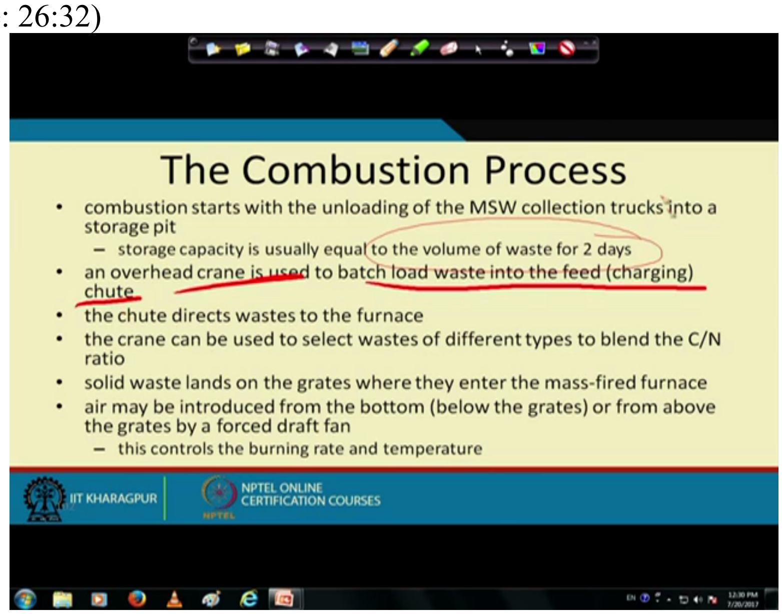

So the combustion process, the combustion will start at the unloading of MSW trucks into a storage pit. So you have a storage pit usually where the waste will get dumped in from these trucks and those storage pits will have enough volume to have volume of waste for 2 days because say if you have a down for some reason, the plant is not working for some reason, so you do not want to, the waste has to, has to be collected.

So you have a storage which can at least handle 2 days worth of waste. And then you have a overhead crane which is used to batch the load waste into the feed which is a charging chute. So it is basically you have this that if we can draw it here in a small, so that is think about that is your storage capacity. The waste is over here and then there is a crane will come down, get the little bit of waste from here and then it will take it and dump it into the waste incineration part where all this it will get passed through here where the air will be supplied and then the garbage will burn and that.

And I think I have lots of sketches to explain. And so the chute will direct the waste to the furnace, the crane can be used to select the different waste to mix the carbon nitrogen ratio if you have different types of waste to increase the calorific value. So you want to mix different types of waste. Then the solid waste will land on these grates. As they enter the mass fired furnace, the air will be introduced from the bottom. So that is where the air will be pumped in.

And then it is below the grates or from the above the grates by a draft fan. This controls the burning rate and the temperature. So the movement of the grates will control the like how the garbage will flow down. In terms of the air supply, we will control the burning rate and also the temperature you need to have a eye on the temperature as well.

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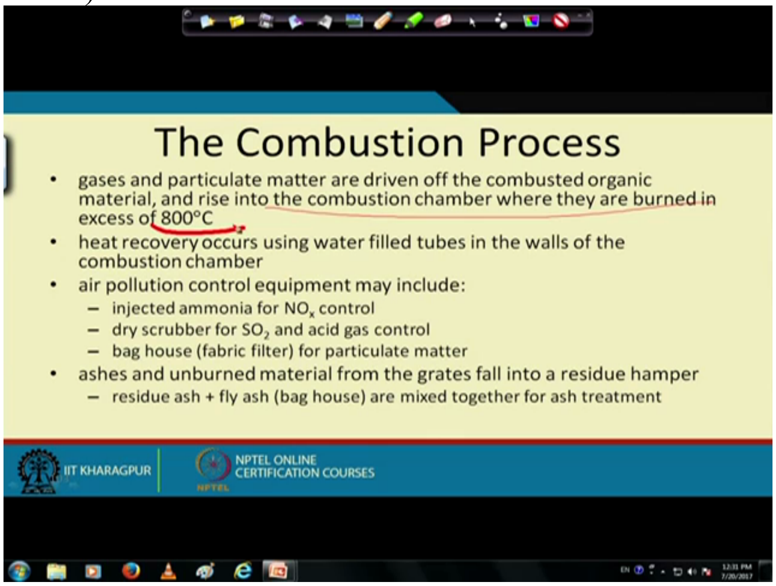

So once the, then the gases and the particulate matter, they will be combusted of the organic material and then they will rise on the combustion chamber where they are burned in excess of 800 degrees centigrade. So this is taken to in another combustion chamber where they will be heated up to 800 degrees centigrade. Then we will have a heat recovery system using the water filled tubes. So you will have the walls of the combustion chamber.

So that is the heat exchanger where the heat generated will be taken up by this water, water will get heated up. So that will become your basically produces steam and steam will lead to generator, run your turbine and all that. Air pollution control equipment will be there where you try to inject ammonia to control NOX, dry scrubber for SOX and acid gas removal, you have a bag house like a fabric filter for particulate matter, ESP is very popular.

You need to have ESP these days as well, electrostatic precipitator. Different categories are there, like 2 fan, 3 fan, different category of electrostatic precipitators are out there which you need to use. And then you will have some ash and unburned material, they will from the grate and finally it will dump into the residual hamper. So these are mixed together for the ash treatment. So that is those ash could be dumped in a landfill or could be recovered, things could be recovered as I was trying to explain earlier.

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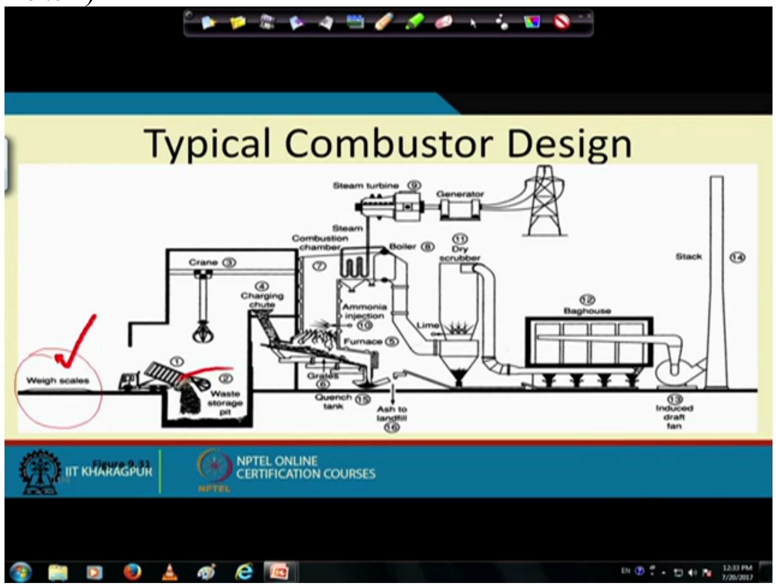

So that is the typical design. So let us look at this over all of this particular plant and then let us try to explain this. So typical combustor design so here let us go over one by one. So we have the weighing scale where the garbage will weighed in. Why we need this weighing scale? Because this we need to know how much waste is coming in because the collection company will also get paid based on the amount of garbage they are bringing in.

So the weighing scale will weigh the full truck and then they will weigh the empty truck on the way out so and then they will know the waste of amount of garbage coming in. So this, after it comes in, it will get dumped into the waste storage pit. So that is where it gets down here. Then you have this crane which will come down and then collect the waste and then take it and then drop it at this charging chute. So this charging chute is where the reaction starts.

So here the reaction is starting. You supply oxygen and then it basically it comes down and then this is your grates. So that is where from this point to this point is where you have the reaction taking place and that is where you are supplying oxygen from the bottom here. So this is where this is this is called the grates. So these are it is the grates (())(31:14) ceramic material which can withstand very high temperature.

So that is where this is burning. Then you have your secondary combustion chamber. So the gas that is going up, it is even heated up further so that you have less air pollution issues. Then here is your heat exchanger, these are the tubes which has water, it generates steam. From steam, it goes to the steam turbine, generates electricity. So that part is energy part. And from here, the ammonia scrubber, ammonia injection will control the yes the ammonia injection will control the NOX.

And then you will have here you add lime, you have the dry scrubber, you have the bad house and then you should have a electrostatic precipitator somewhere now it has to be there and then finally you the stuff, it is taken all the way to the up and then thinks kind of come off from the stack. So this is how a typical and this ash can go to a landfill for recycling or reuse recycling of ash. So this is typically how the waste to energy system works.

Only major one major thing which is not there on this sketch is the electrostatic precipitator which should be part of this air pollution control system which is a kind of a must these days in all the countries.

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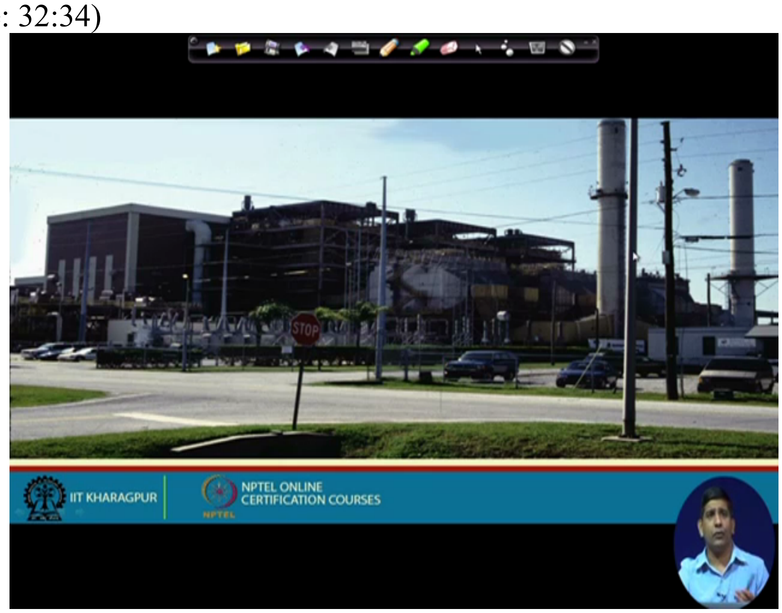

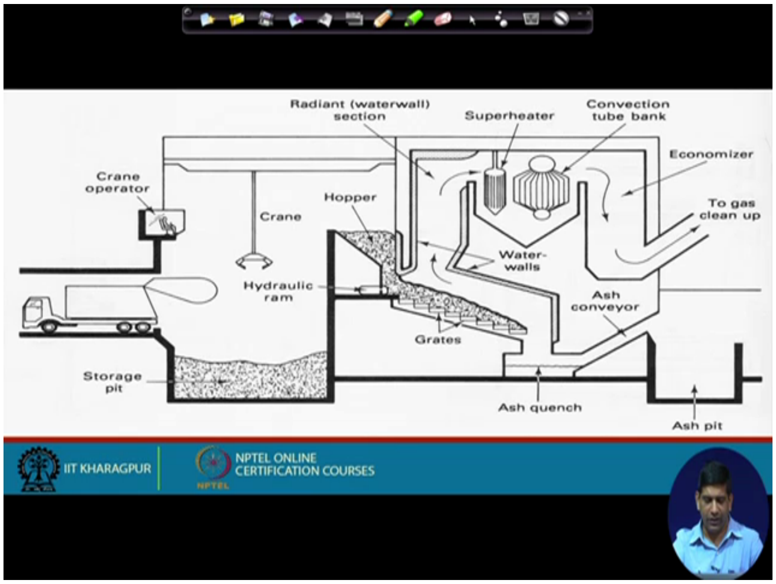

This one picture of how this waste to energy plant looks like, any typical factory kind of thing. Another image of showing you the same stuff where you have this waste coming in, it is a self-explanatory, little bit of more detail here. So crane coming out, the hopper going in, that is where the reaction taking place, then you have some water walls where that heat exchanger will work and then the ash, the secondary things are taken up for the ash cleanup over here. So little bit of different design but again, very similar concept as what you saw earlier.

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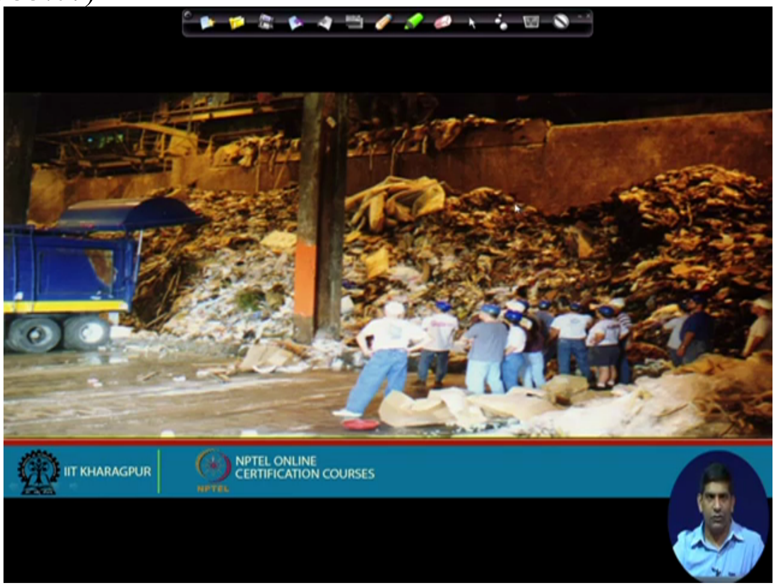

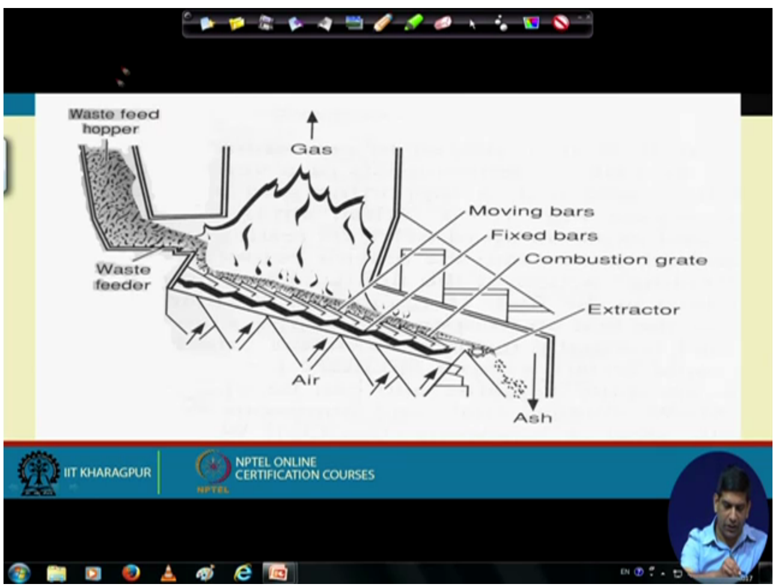

So then this is another picture of some pictures of the waste to energy plant. So here, waste coming in to see place and as you can see, the waste being dumped in. And that is your crane if you can see it see it on your screen, that is the crane which is lifting the garbage and then dumping it into those grates.

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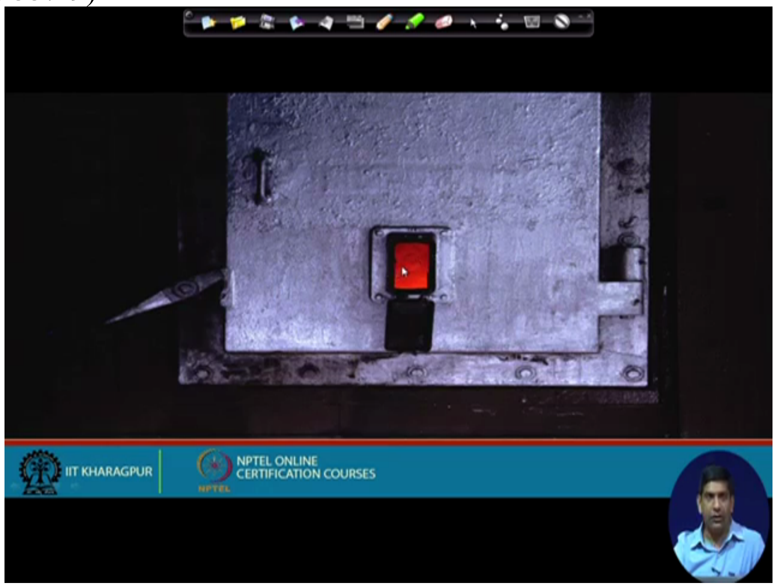

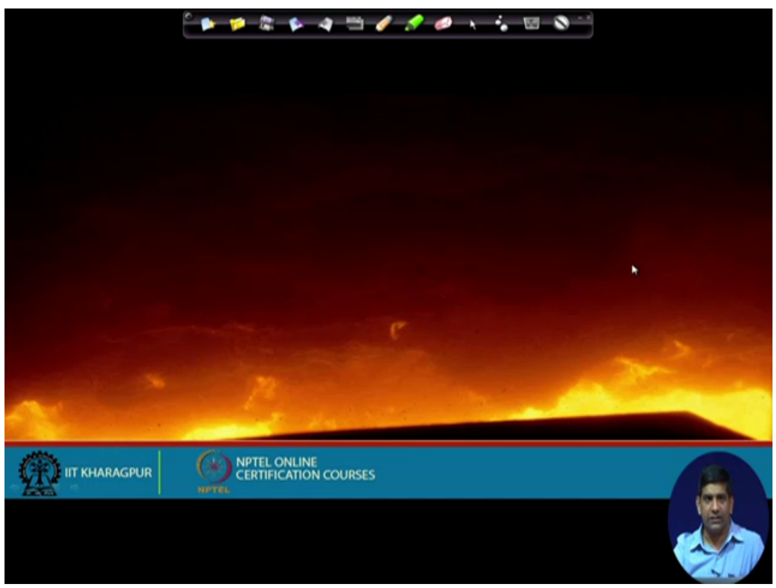

And then it gets dumped into here. You can, if you can take a closer look, that is where the garbage is burning and then it is producing the heat which would be used for steam.

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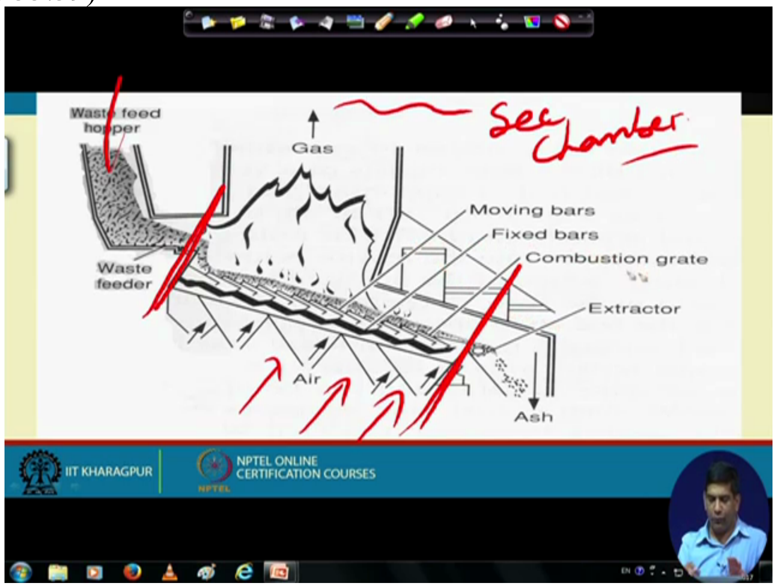

So this is how it looks like. You have as I said it will it will get input over here and then it is between this point and this point is when the reaction will take place, the air is added from this section, this and some of this gas, this gas would be taken into the secondary chamber, secondary chamber for further combustion so that air pollution is less. And then there are different moving bars, fixed bars, we will talk about that in more detail probably in the next next video, we will talk a little bit more about this grates in detail but this is how things really work in terms of the waste incinerator.

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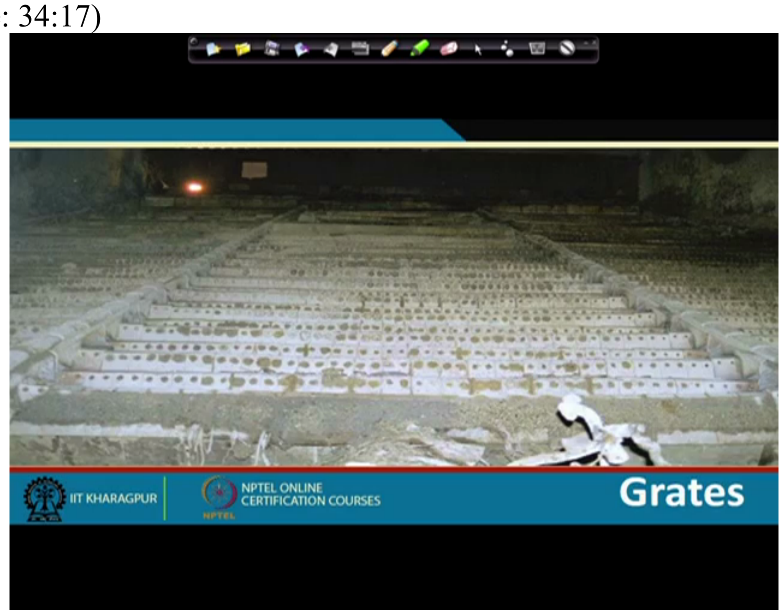

So bottom line in terms of and this is the grate when it is not working. So this is a ceramic grate, very costly. So this is under maintenance right now. Otherwise this is the place where you saw all those flames coming out. So this was the place where or those flames were coming out. If you have watched, I think I have told you in the very beginning, if you have watched this Toy story 3 movie, so at the end of the movie, when you see those all those toys taken to the waste to energy plant, that is actually a waste incinerator.

And of course, that is 2 toys comes in and then saves everyone like our Salman Khan will do it but similar stuff so that they can Toy story 4, otherwise if the toys are burned, how will they make Toy story 4? So but that is the waste, that was the waste incinerator.

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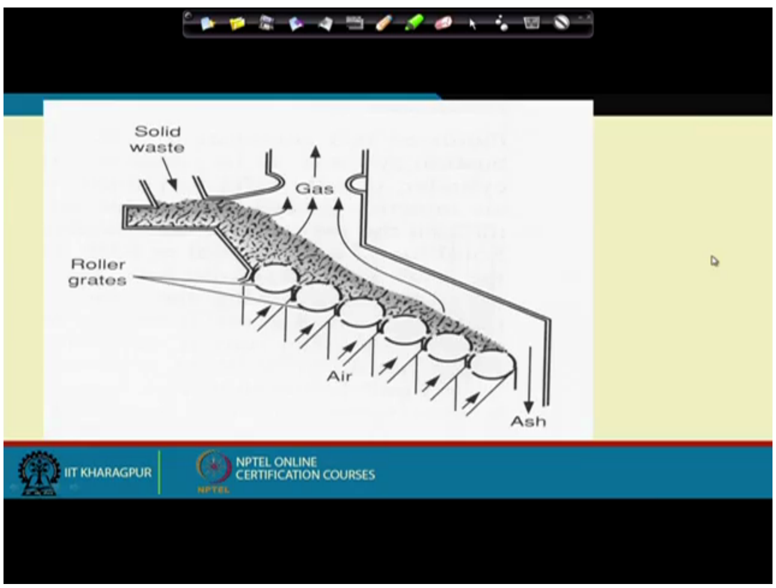

Okay and this is the other type of grate. 1st you saw like a steps, this is like a roller, again same thing. Here rather than using the steps, you can use the roller and that can be used as well. So different types of things are used.

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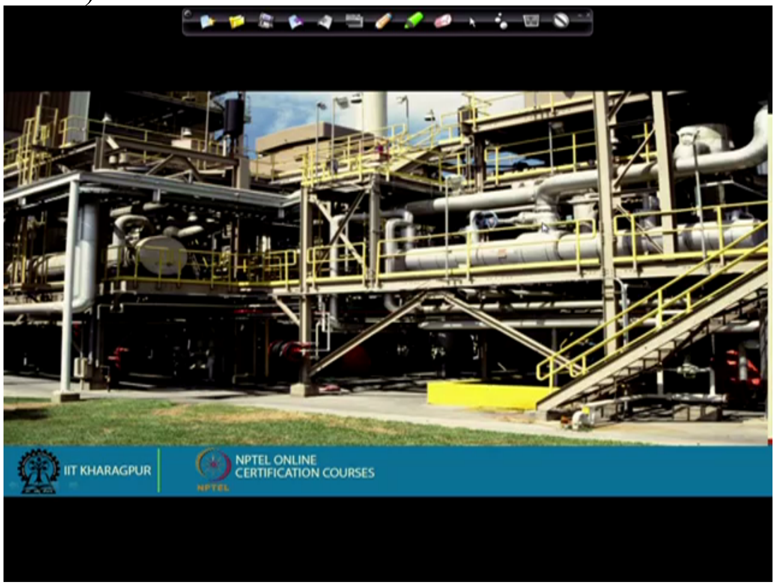

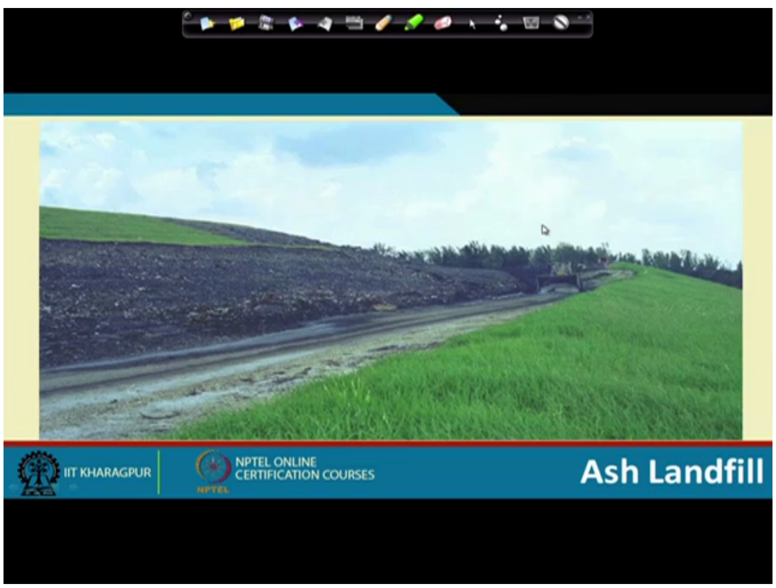

So again, some pictures of waste-to-energy plant a close picture and the ash has to go to a landfill or can be recovered and but as likely part of the ash does make to the landfill. So let us stop with this and then we will continue our discussion in the next video and that is I think you had a good understanding of how a typical waste to energy works, plant works and what are the different technologies, the 3 Ts are very important, the temperature, time, turbulence.

And that is just you should have a good idea about why those are important. That is even important for your exam and for the quizzes. So with this let us close this video here. And then we will see you again in the next video. Thank you.