Municipal Solid Waste Management
Prof. Ajay Kalamdhad
Department of Civil Engineering
Indian Institute of Technology, Guwahati

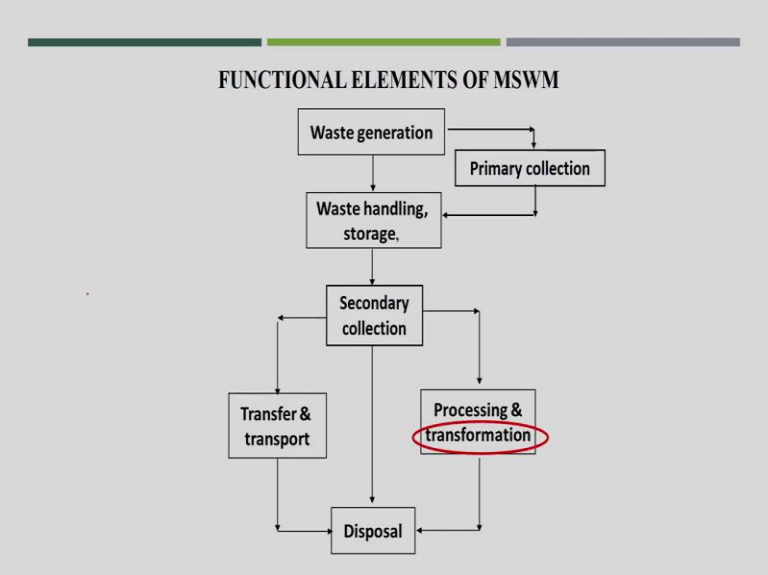
Lecture No - 23
Waste-to-Energy(WtE) plants (Case studies) Pyrolysis and Gasification

So hello students! today we are in last lecture of module, chemical transformations so until now we have discussed about the incineration process, their types and two major issues of incineration process. One was fly ash production and solid residue production. ok and also the treatment also I have discussed. Now, before finishing this module, I thought of highlighting some case studies.

Because in India also, you know Swachh Bharat Mission, there are a number of cities, that are coming up with waste to energy plant specially the incineration plants are getting installed. So I thought of some few case studies on that and also one more chemical transformation that is especially for the solid waste but also can be possible for organic waste maybe agriculture waste, special segregated waste even the plastic.

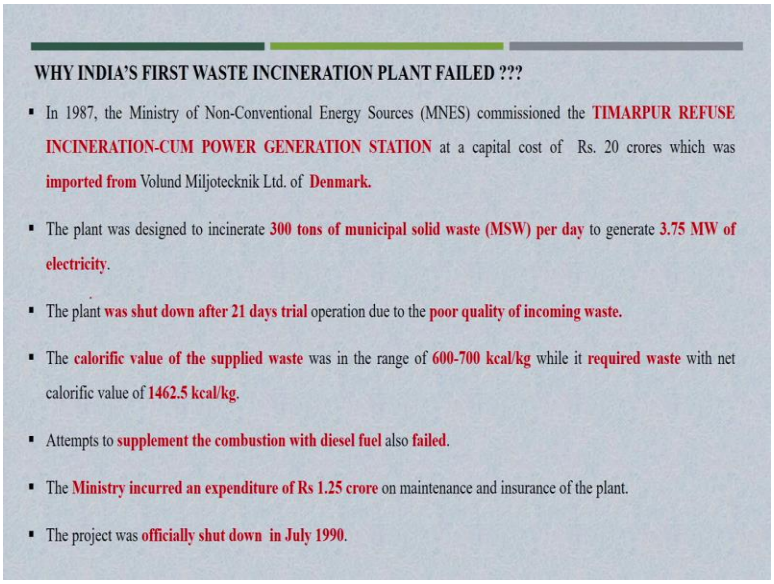
Suppose if you were able segregate, it is possible to go for such kind of chemical transformation process that normally is called as pyrolysis and gasification process which we are going to discuss today.

(Refer Slide Time: 01:53)



So we are in the 5th function element transformation, ok. Now with this lecture is a waste to energy plant some case studies and pyrolysis and gasification processes.

(Refer Slide Time: 02:04)



So the first question I would like to ask is why did India's first Waste Incineration plant fail? So in 1987, the first incineration plants came up in Delhi. Yeah, that is Timarpur disposal site, that had the capital cost of 20 crores. You can understand in 1987 the cost was very high and that major technology has come from Denmark, the plant was designed to use around 300 tons of MSW per day and the idea was to produce 3.75 megawatt of electricity from that.

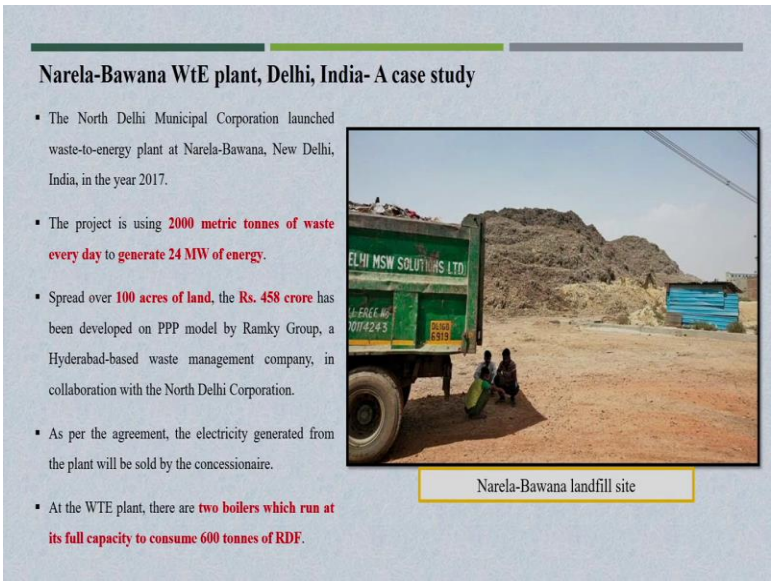
It was not only to reduce the waste or reduce the volume by combustion process, but also, the idea was to get some kind of energy out of that, that is in the form of electricity. So the plant was shut down after 21day trial operation, due to poor quality of incoming waste. So now you understand that in 1987, only that first rule was to come up with waste management rules. There was no proper segregation, your corporation also to just they started.

How best they will be able to collect the waste and the entire coming out waste mix waste, they put it into the incineration process. After 21day trial, I think they closed; shut down the plant. The calorific value because of commingled waste there always on mix waste, the calorific value of supply and waste was in the range of 600 to 700 kilo calorie per kg. And normally the plant was required to calorific value of 1462.5 kilo calorie per kg.

But the calorific value was very low because it was the mix waste and you know that in India those period almost 60 to 70% was the Kitchen waste or wet waste. And that was putting into the incineration plant. So there where attempt to supplement the combustion process with diesel fuel also tried that another fuel could use to produce the energy out of that but also it failed and then, finally the expenditure of 1.25 crore of maintenance and incineration of plant that was required to run for the 21 days' trial.

And finally, officially the plant was shut down in July 1990 after 2-3 years that has been completely shut down. So I think you got the answer of my question, why the major issue, see the technology was not the issue. The problem was waste, the poor quality of waste. See when you say the commingled waste or mix waste is a very poor quality of waste normally for the combustion process. Only the dry waste which is combustible if we were able to use as a refuse as an incoming waste that will be good for the combustion process.

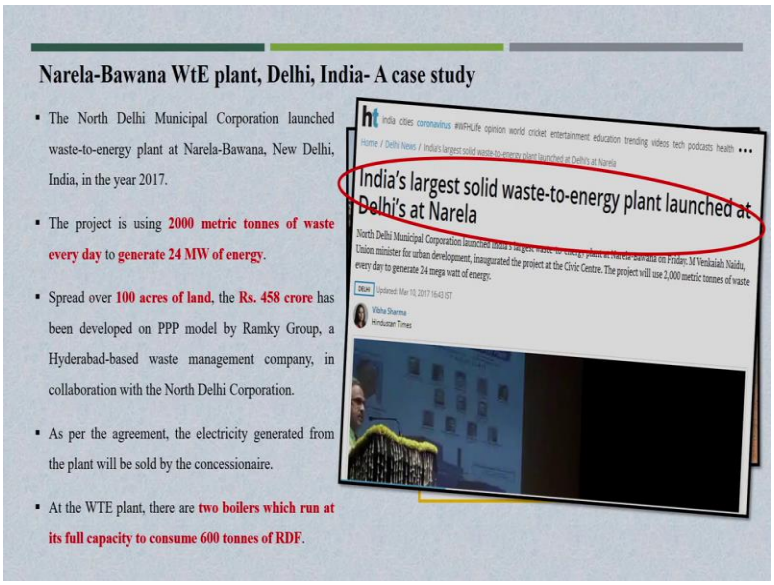
(Refer Slide Time: 05:45)



Then another plant come up in Narela. This was when North Delhi Corporation launched the waste to energy plant in 2017. So this was a landfill site, the Narela landfill site and the idea was to use 2000 metric tons of waste per day and generate 24 megawatt of energy. It was a good idea to spread over 100 acres of land and rupees 458 crore was required to develop PPP model. I will share one special module on the PPP also and that the private company was Ramkey, that Hyderabad based company with their collaboration the plant was started.

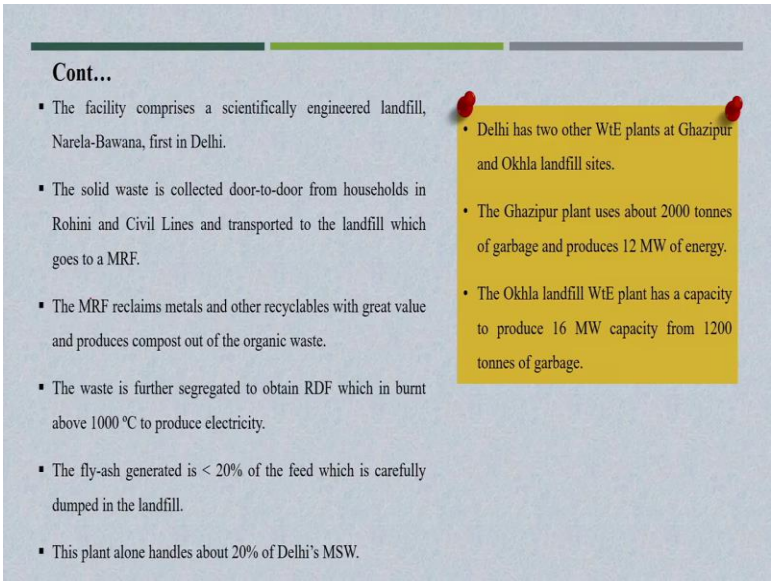
And the agreement also was that the electricity generated from the plant will be sold to the local area. There are 2 boilers which were running on full capacity, consumed a 600 tons of RDA. So, idea was that in this plant, the RDA plant will be there, the dry quantity will get separated and this dry quantity will only have to be used for combustion process. That was the idea not like the previous one like mixed waste.

(Refer Slide Time: 07:17)



This was some news. That was one of the largest solid waste to energy plant.

(Refer Slide Time: 07:29)

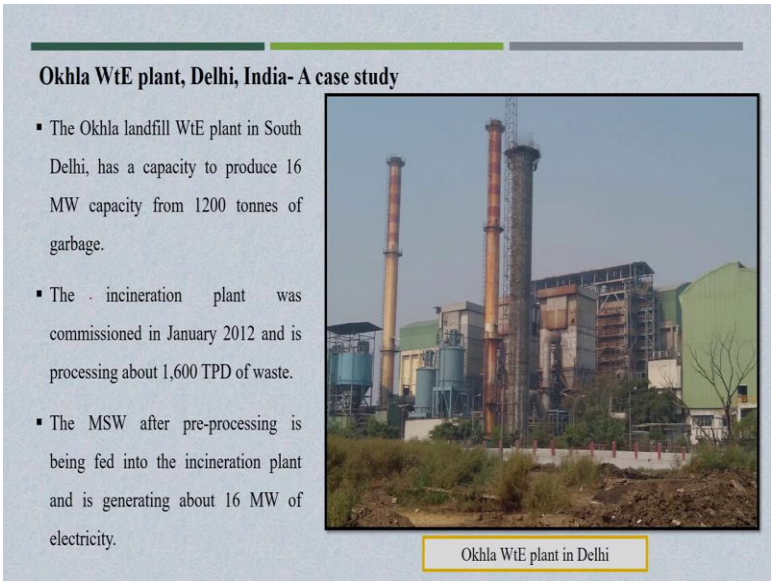


Under facility also comprise of engineering land fill. This was first in Delhi so you see here they had other MRF also. So to get the RDF, Refuse derived fuel also the whatever is possible to segregate for the recycling process like metal which is not combustible, used to get separate out of that and the basis for the segregated to RDF which is burnt above 1000°C to produce electricity.

The fly-ash generation was less than 20% of the feed, that was one very good technology and the plant alone handled about 20% of Delhi MSW I think 2000 per day. So these are two more

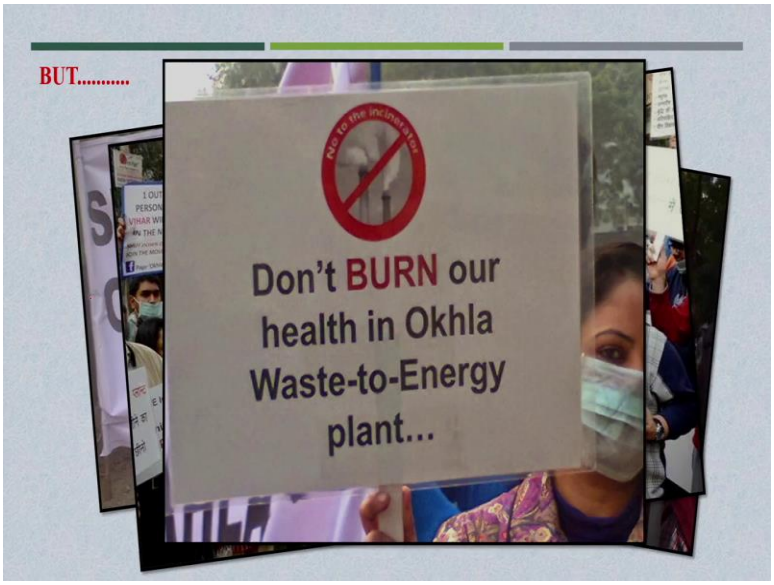
plants have come up in Gazhipur and Okhla landfill site and Gazipur was also used around 2010 to produce 12 megawatts of energy and Okhla Plant was the capacity of 1200 tons per day and to produce 16 megawatt energy electricity.

(Refer Slide Time: 08:53)



This is Okhla. I think that was another plant in Delhi so this plant is in South Delhi and has a capacity of 16 megawatt capacity of 1200 tons of garbage per day. So that was commissioned in January 2012 and to process about 600 tons per day of capacity. Earlier the capacity was 1200 but when it got commissioned, the capacity was increased to produce 16 megawatt of electricity.

(Refer Slide Time: 09:38)



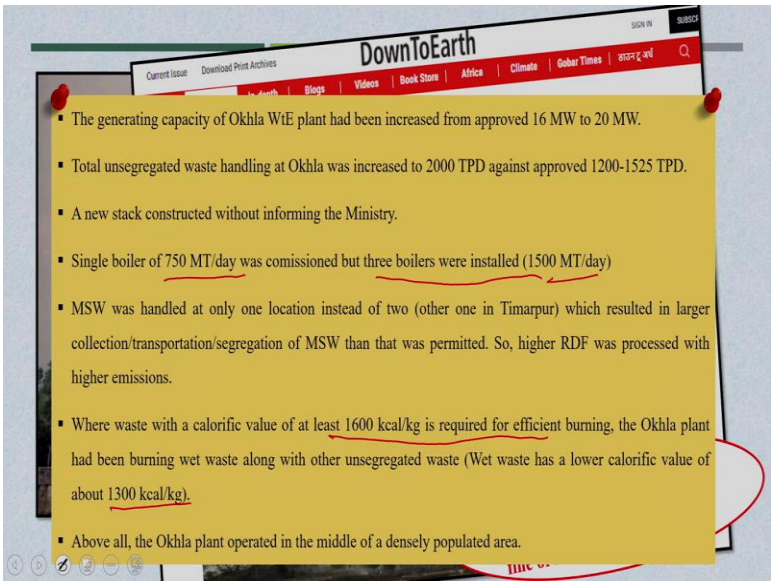
But I think these were some news in Delhi shutdown of Okhla plant as a lot of people were against this incineration plant. The real thing was that a lot of news have come up and the idea was: "DON'T BURN OUR HEALTH" in Okhla waste to energy plant. So, yes that was the reason why people were against this waste to energy plants and in general public issues against combustion plants.

The major problem was fly ash production because treatment already I shared some of the important points to you that treatment is very important and very difficult to handle 600-800°C of fly ash gas, also the solid received residue disposals were not able to have the proper sanitary landfill for the MSW is very easy to get land fill. But I think it is very difficult to handle such kind of waste.

(Refer Slide Time: 10:53)

This was another protest: "I do not want electricity at the cost of our lives". So, there was a lot of protest and that is my motive of showing you this

(Refer Slide Time: 11:08)

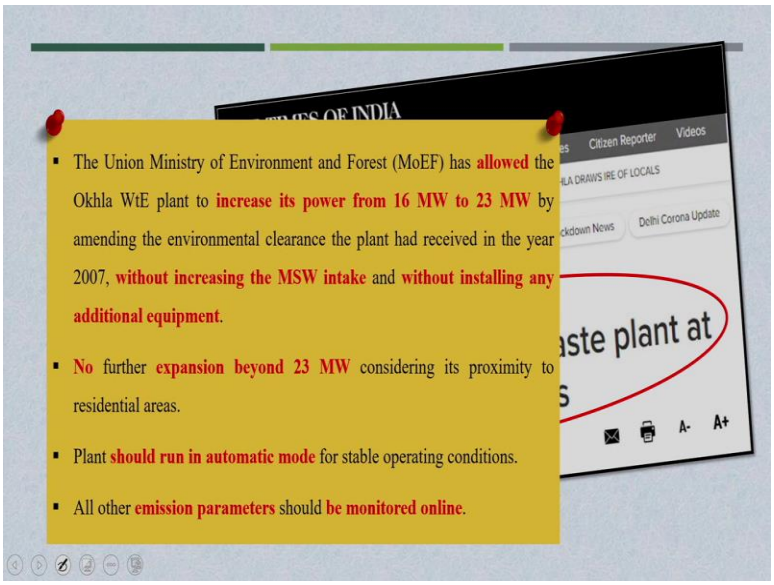


In Delhi, smoke emission was seen which became a major concern for the residents in the local areas so in 2016 the NGT National green tribunal, put a fine for Delhi Corporation around 25 lacs because of production of fly ash. So the problem was generating capacity of Okhla waste to energy plant was increased to approve 16 megawatts to 20 megawatts. The idea was 16 megawatts only but to increase the capacity to 20 megawatts, and the waste handling was approved to 1200 and maximum 1525 tons per day.

But they increased the handling about a 2000 tons per day and only the idea was there was one single boiler. Single boiler of 750 metric tons per day as commission but there were three boilers were installed each of 1500 metric tons per day. That was the problem and where the waste calorific value was required to be around 1600 kilos, but only they were getting 1300 kilo calorie per kg. So because of that proper combustion was not provided for the waste.

So because of that a lot of polluted gases used to be come out from the incineration facility. So now, currently also, this plant is not running.

(Refer Slide Time: 12:53)



Under this is board news. So now the MOEF been allowed the Okhla plant to increase the Power capacity increase its power from 16 megawatts to 23 megawatts by amending the environment clearance to plant have received in the year 2007 without increasing the MSW intake and without installing any additional equipment and no further expansion be on 23 megawatt considered its proximity to residential area.

Plant should run in automatic mode for stable operation condition and all the other revision parameter should be monitored on the online. So because of NGT has been come in between and has the fine around 25 lakhs rupees. Ok now I think you understand that in India still most of the corporation are trying to have the incineration facility because managing 4000-5000 tons of waste per day is very difficult and we cannot depend only on the biological treatment facilities like combustion, and biogas production would not be possible.

But for dry waste, I think we need such kind of treatment facility where not only the waste volume will get reduced, but also if you are able to produce some kind of electricity, some power is also highly beneficial and I personally believe that Technology was not the problem and for none of the plants ok. And now also some of the cities are coming up with waste to energy plants, like Jabalpur is already commissioned, and is running currently.

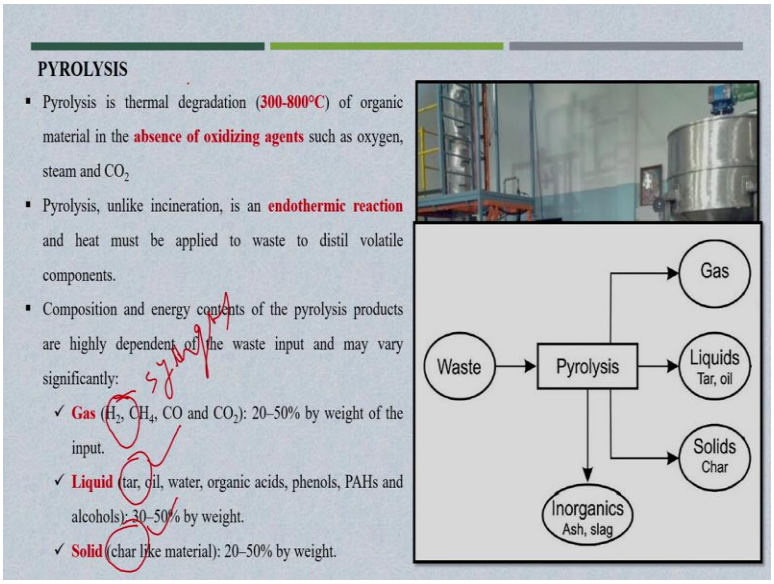
Indore is running one incineration plant; Hyderabad I think maybe it has got commissioned now. So many other cities are trying to have such kind of facilities, but technology wise there was no problem. The only problem is that how best we will be able to reduce the emission first, whatever the fly ash emission or polluted air emission and how best we will be able to treat that. we have MSW rules 2016.

We will discuss about that, what kind of treatment facilities are required we have special manual available with us, what kind of treatment facilities are possible? So, it is not that people in those private companies have to study this particular course, they can refer to the manual and get all the required specific information.

But the problem is that it requires a lot of funds to operate those treatment facilities. That is why I think maybe the local authorities and even those private parties were not able to run those particular treatment facilities. But let us see that in future we will have such kind of incineration plants. There we will see that they can run incineration facility followed by the emission treatment facility.

Now, I think I was sharing that there was another combustion facility like apart from incineration, pyrolysis and gasification ok. So, the first is pyrolysis.

(Refer Slide Time: 16:37)



Pyrolysis is also a thermal degradation, but the temperature is only around 300 to 800°C specially for the organic material in absence of oxidizing agent such as oxygen steam and CO_2. For incineration, you need a lot of air for combustion process, but this is without requirement of oxygen the thermal degradation could be possible with pyrolysis, unlike incineration, is an endothermic reaction.

So I think it is endothermic reaction means a lot of energy is required to run such kind of plants. So energy required is more than the energy that can be produced, using which you can run this type of technology. This is one small biomass pyrolyser in Mumbai. So, the composition energy content of the pyrolysis is highly dependent on the waste input and may vary significantly, ok.

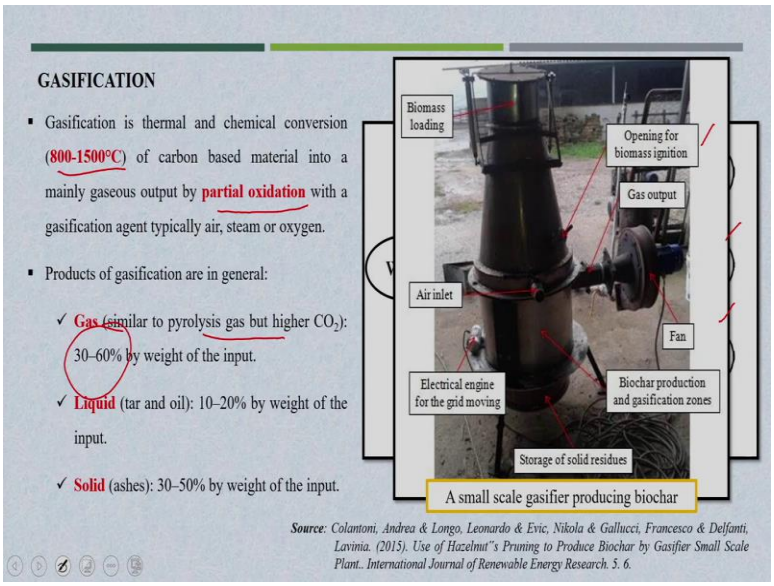
So here I won't say it is a problem, but the feed is very important here. Like for incineration process, I think there also I was talking about the need for segregated material. Obviously, whatever is the combustible, we can put it for incineration process, but in the combustible materials suppose, 5%, 10% and even 30% moisture also if you feed in the incineration plant there will not be any issue of that.

We can increase it to great length and we can dry them first and then we can go for combustion. But in this case for pyrolysis, even for the gasification, the composition of waste is very important and operation also we will change based on the daily feed. So there will be a three major products from the pyrolysis process first is the gas that majorly will be hydrogen, Methane, carbon monoxide, carbon dioxide and that will be 20 to 50% of weight of the input.

And liquid that is tar, oil, water that major composition is a tar. So here in the gas the major composition is hydrogen and liquid the major composition is tar, and for solid is a major composition is char. But I think we cannot say is exactly this gas also normally we called it as syn gas. Syn gas, synthetic gas is a highly combustible gas will be able to produce that. This liquid also can be used as in tar and solid also can be used for them in form of char.

But need some kind of treatment for that. So here by this you can see that there are only three major products.

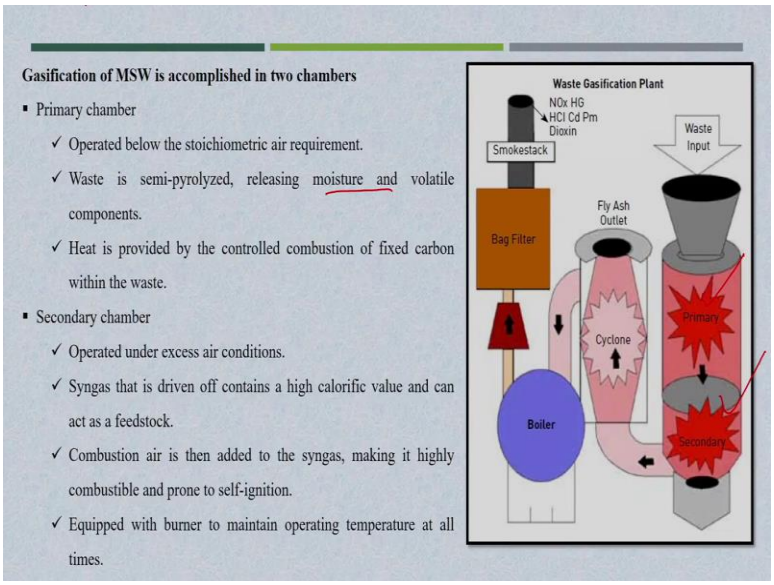
(Refer Slide Time: 20:01)



Now, the gasification: The gasification is also thermal and chemical conversion to hear temperature. is 800 to 1500°C and is a partial oxidation with a gasification agent typically air, steam or oxygen is a partial oxidation like now what will the difference between incineration and gasification. So incineration is a 100% oxidation? Complete oxidation is complete combustion of organic matter.

And what are the products also the same way like in pyrolysis process the gas liquid and solid service. So obviously, we were calling this as a gasification process to gas concentration is more like the quality will be the similar but the quantity is more 20-60%. Liquid that is also tar and oil. But I think the quality is somewhat good like pyrolysis process and solid also the ashes 30-50 percent of their weight of the plant.

(Refer Slide Time: 21:30)

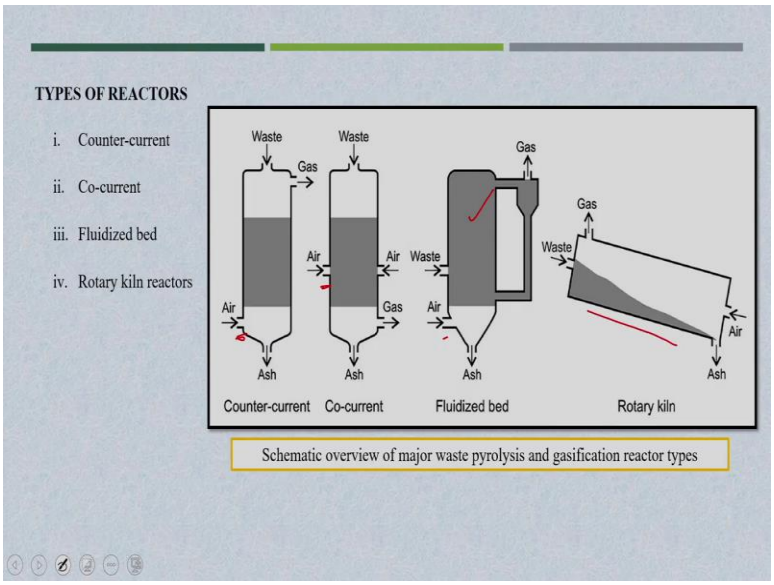


This is a small-scale gasifier that is why biochar. The gasification MSW is accomplished in the two chamber. So here you will see that there are two chambers. One is primary chamber and second is a secondary chamber. When the primary chamber is operated below the documentary requirement waste is semi pyrolysis release moisture and volatile components heat is provided by the control composition of fixed carbon within the waste.

So here is a primary chamber. The idea of this primary chamber is to release the moisture that was the major event where temperature also will be low and secondary chamber operator under excess air condition here. Here the small amount of air is getting put for the primary chamber for the combustion process. Syngas that is driven off containing high calorific value in can act as feedstock. ok

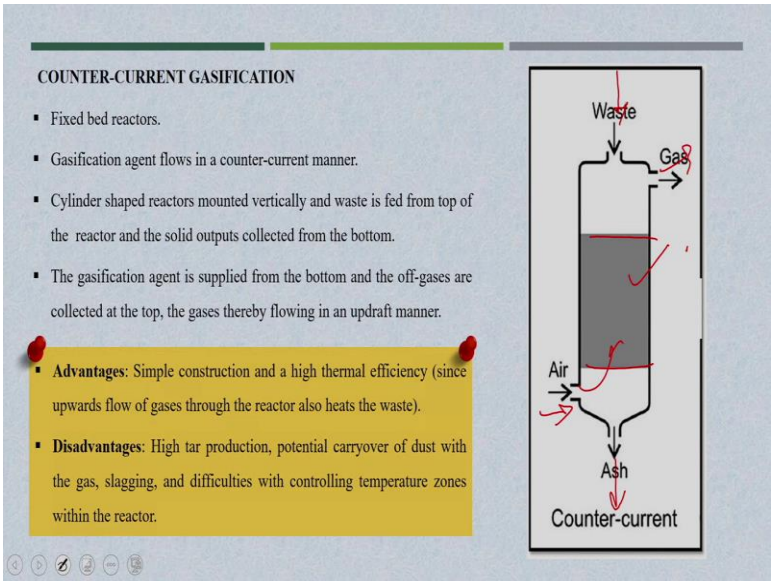
So again depend upon the design normally the gasification will have 2 chambers: primary chamber followed by secondary chamber. Now, type of reactors.

(Refer Slide Time: 22:38)



The gasifier, that is the countercurrent, co-current, fluidized bed and rotary kiln reactor. There are different Technology itself in the gasification. So and that is depend upon the how we are putting the air inside the reactor. So the first is the countercurrent you see here the second co-current, a fluidized bed where waste will be in the products condition and finally is a rotary kiln. So we will go one by one.

(Refer Slide Time: 23:10)

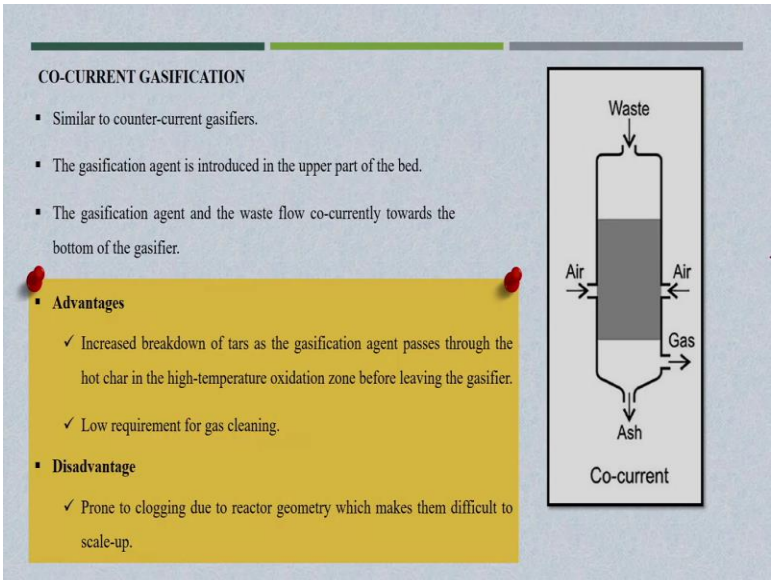


So first is the counter current gasification, so there also it is a fixed bed reactor. The bed is fixed, this is the waste that is the particular bed, and gasification flow into the counter current manner, it will go like this. Cylinder shape reactor mounted vertically and wastage feed from the top of the reactor in solid output collected from the water. So the waste is fitted from the top and ash

will come out. The gasification agent is supplied from the bottom and the off gases are collected the top.

what are the advantages of that? Simple construction and high thermal efficiency since upward flow of gases through the reactor also hit the waste. So, obviously the air is supplied upward and therefore proper combustion could be possible here. Now, the disadvantage high of tar production, potentially carrier of dust with the gas, slagging and their difficulties with control temperature zone within the reactor. These are few disadvantage of the counter current gasification.

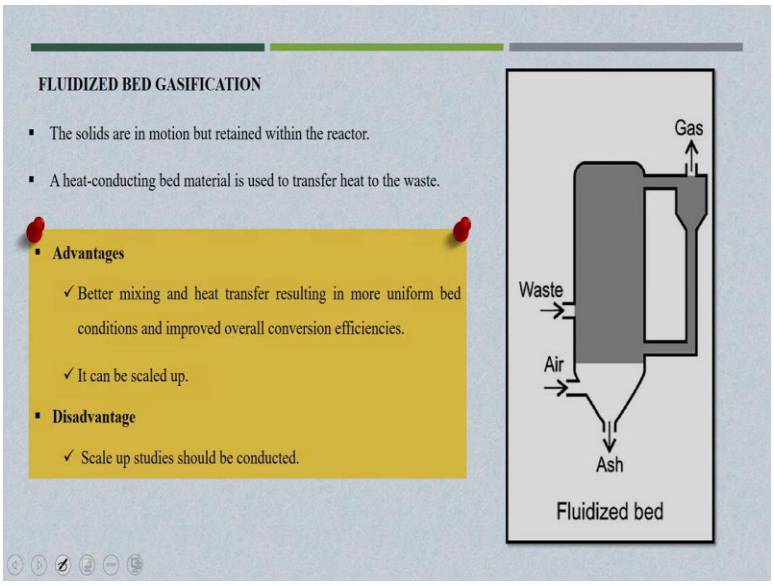
(Refer Slide Time: 24:40)



Now the current gasification air is directly entering into the waste material. Design of a similar gasification is introduced at the upper part of the bed, and gasification agent and waste flow co-currently toward the bottom of the gasifier. So what are the advantages of that increased breakdown of the tar as the gasification passes through the hot char in high-temperature oxidation zone before leaving the gasifier, low requirement for the gas cleaning,

and disadvantages, prone to clogging due to the active geometry which makes them difficult to scale up. So because here gasification agent is directly entering into the waste material so clogging could be the one problem here.

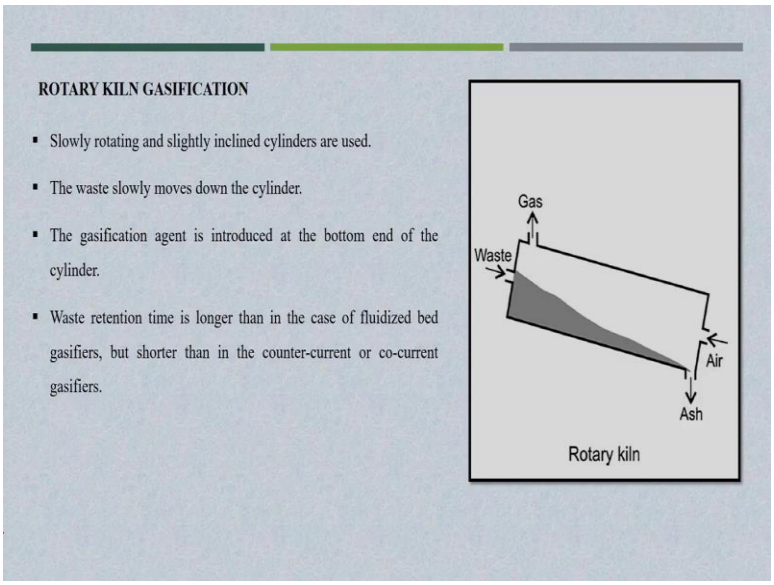
(Refer Slide Time: 25:33)



Next is the fluidized bed gasification. Now here see that entire waste is in the fluidized condition. The solids are in motion but are returned within the reactor. Heat conducting bed material used to transfer heat to the waste. So what are the advantages? the better mixing and heat transfer resulting in more uniform, bed condition and improved overall conversion efficiency. It can be scaled up ok and disadvantage: scale of study should be conducted. I think that is also important point.

In India, in special in the Academic Institutes, I think research on to the composition is very difficult. Maybe I think small unit we can design, we can fabricate, small unit, but scale up is again difficult task and specially this both, whether it is pyrolysis or gasification, they do not have much literature in India. The small one, small scale of facilities are available, I think specially the chemical engineer they use to work into pyrolysis and gasification, but I think scale-up studies are not available with us.

(Refer Slide Time: 26:58)



And now what is rotary kiln gasification? Slowly rotating and highly inclined cylinders are used, the waste slowly moves down to the cylinder. The gasification agency introduced at the bottom end of the cylinder, so the waste retention time is longer than in the case of fluidized bed gasifier, but shorter than in the countercurrent and co current gasifiers. ok. So these are the few gasifiers. I think in India we will not find the pyrolysis and gasification for the MSW principal solid waste

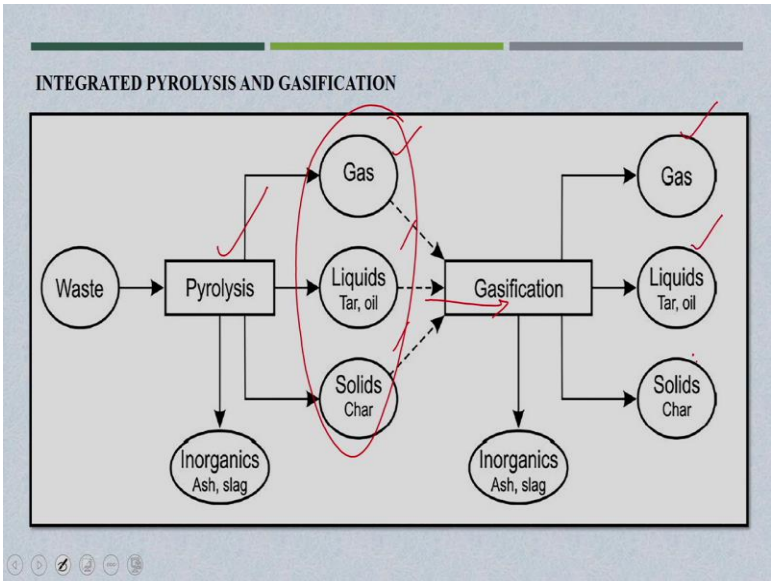
Because there is major problem in India, you know that segregation is the major problem and for that the feed should be highly segregated material. Not only segregated but also required very high calorific value based, but I think I personally believe that this both methods are highly beneficial if you compare it with incineration process, simple incineration process, Grate based incineration process.

See there always we have to talk about emission quality, fly ash, solid Residue and huge production of this pollutants. But here in the both the treatment facilities we never talked about the pollutants. Whatever the gas is being produced, we are calling agents in gas, highly combustible gas, can be easily utilized. The solid, liquid, Liquid is tar, oil, that is also very high calorific value.

Solid char that can be used as a highly combustible material easily can be used in road construction purposes after primary treatment or otherwise also we can use it for many other

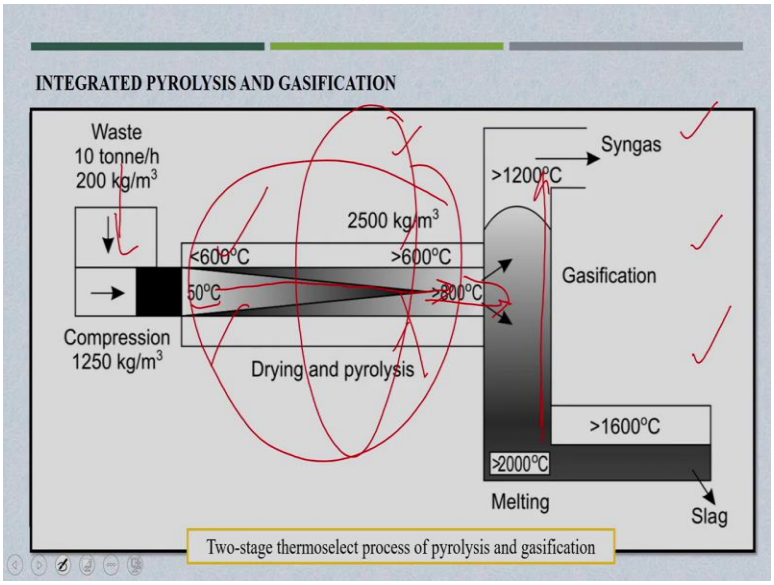
places. So I am also willing to see the pyrolysis and gasification plants for the MSW but I think we do not have much research on that. Specially to inform you IIT Guwahati also I started one project were specially looking into this integrated pyrolysis and gasification plant.

(Refer Slide Time: 29:12)



So here the thought is simple. Waste first it will go for pyrolysis that will produce gas, liquid, and solid, again these three products will be getting gasified and that whatever products will again come up. This will be highly beneficial products can possible to come up.

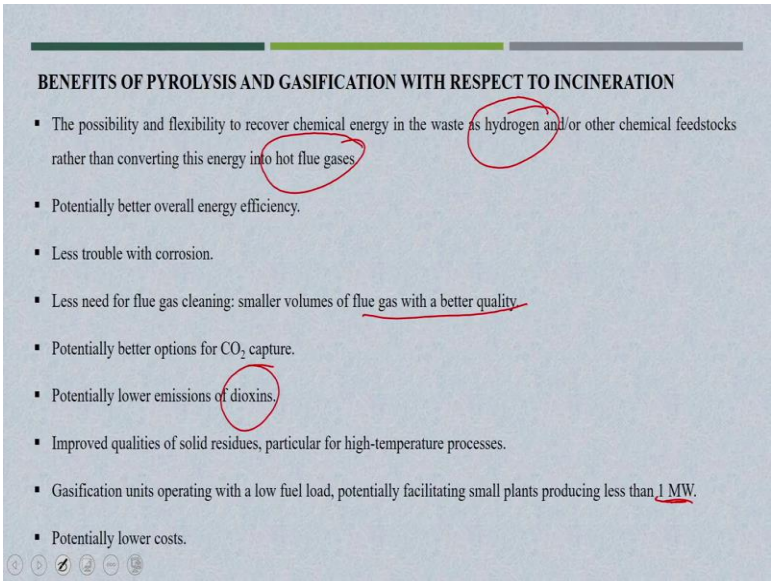
(Refer Slide Time: 29:36)



The thought is that the waste is getting filled it will start from the 50°C small temperature, it will go up to 800° C temperature, and now this is the pyrolysis process, where drying will start from

the drying and after combustion finally this entire one it will be added to the gasifier where temperature can go up to 1600 to 2000 °C., and again that entire product will get combusted. I think we will require research on that. The specially scale of units are small units and followed by the scale of units let us see.

(Refer Slide Time: 31:21)



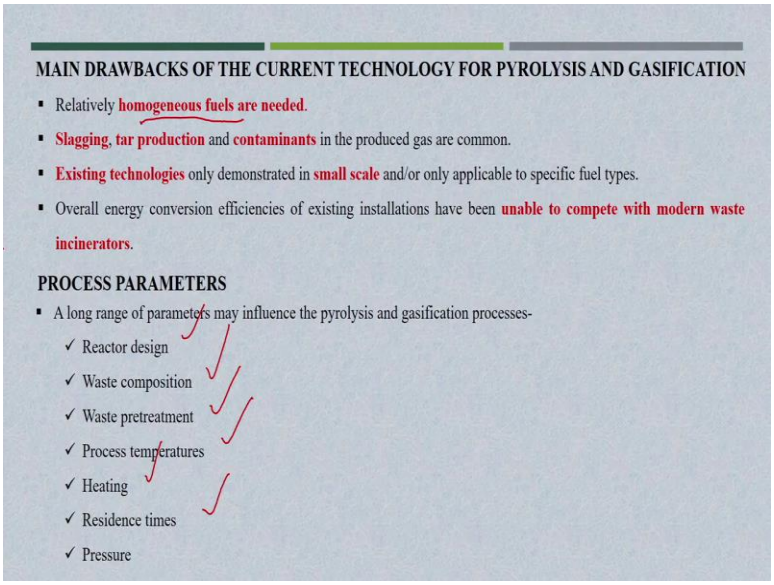
What are the benefits of pyrolysis and gasification with respect to the incineration process? The first benefit is that the possibilities and flexibility to recover chemical energy in the waste as hydrogen. That is the major production in gas. So otherwise in the incineration hot flue gas is getting produced that is why we called it as syn gas and here we are calling it as flue. Incineration is potentially better over energy efficiency, if you compare with the incineration facility.

Less trouble with corrosion. I think that highly corrosive gases are getting produced in the incineration process and you always have to check your equipment there. But here there will not be much corrosion because a lot of metals are getting volatile, metals are so being getting generated into flue gas because of that the corrosion is a major problem. Less need of flue gas cleaning and gasification pyrolysis process because the small volume of flue gas with a better quality.

Potentially better option for CO2 capture also, potentially lower emission of dioxins. This is also one of the important one. So when you talk about incineration and whenever we talked about flue gas production, I think dust, acids, metals and nitrogen, the oxides of Nitrogen that are possible to be removed, again we have to treat for the dioxins and furan gases also. So, here it is a low emission of dioxin and improved quality of waste solid residues particularly for high temperature process.

The gasification units operating with a low fuel load, potentially facilitating small plant producing less than 1 megawatt plant. Small units can be set up possibly and at a potentially lower cost. I think there the capital cost is very high and also followed by maintenance cost is very high in the incineration process compared to the gasification, Pyrolysis process.

(Refer Slide Time: 32:48)



The main drawback of current Technology for pyrolysis and gasification, few drawbacks also, I am sharing that. I think I do not know whether is a drawback or is a requirement for pyrolysis gasification process that highly homogeneous fuel is needed and that is the major problem with MSW. It is very difficult to get the homogeneous fuel. But see that in the corporation area also lot of agricultural waste gets generated and this agricultural waste is highly homogeneous nature.

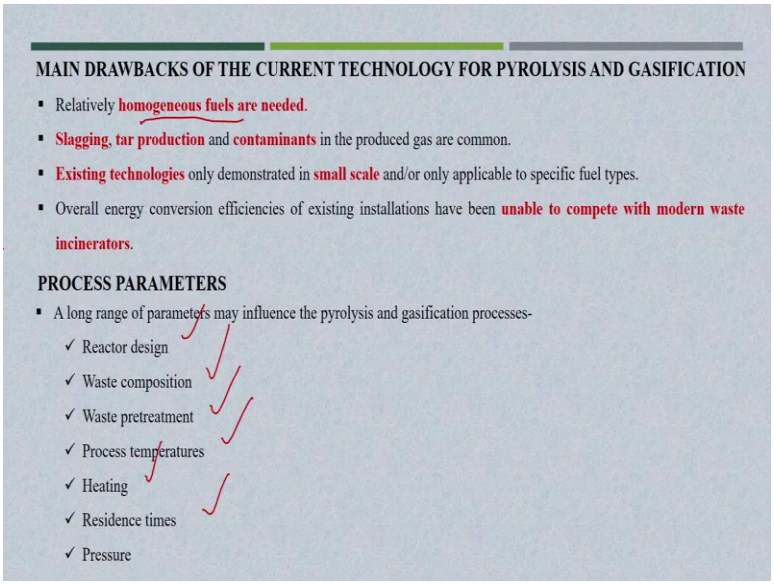
Even the small scale industry is also the waste is highly homogeneous nature. Particular industries also are producing particular kind of waste. If it is organic in nature, obviously we can

have the pyrolysis and gasification process, but for MSW, it is a major drawback. The slagging tar production, contaminants in the produced gases are common. So I think, I shared that gas is separate and solids are separate. But I think there are also, synthetic gas tar or solid that can be possibly there.

The existing technology is only demonstrated in small scale and is not applicable for specific fuel types. Overall energy conversion efficiency of existing incineration has been unable to compete with the modern way incinerators. That is also one of the drawback because I shared that we need a lot of literature for that, so that we can compete with the other incineration technologies, Now the process parameter to run the pyrolysis gasification process.

What are the range of parameter that may influence the pyrolysis and gasification process: for reactor design, waste composition based pretreatment, process temperature, heating, residence time and pressure combusting the material? So, there are a lot of parameters influencing the both the processes. So because of that also, I think I can say this is one of the drawback where lot of parameter has to be studied first before running the pyrolysis and gasification process.

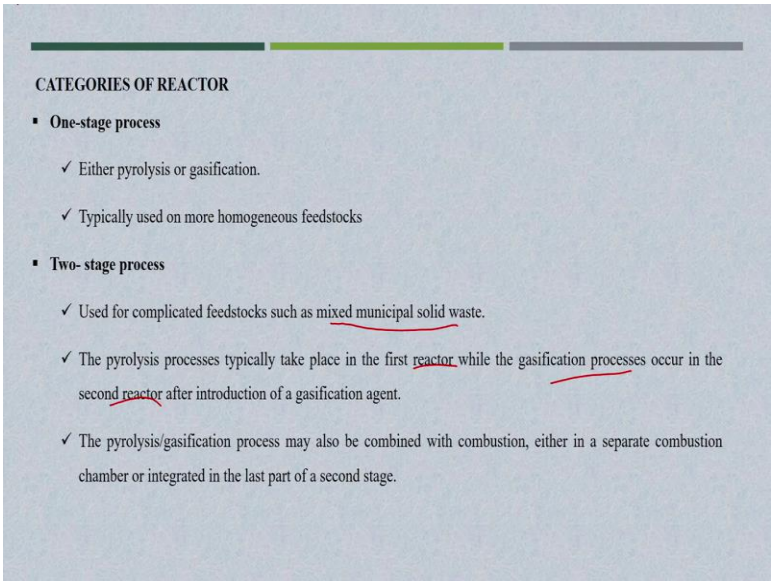
(Refer Slide Time: 35:20)



So technology wise long range of pyrolysis and gasification technology exist. From waste point of view two main aspects differentiate. One is Energy Recovery Technology, that is focused on generating the syn gas suitable for utilization in a gas motor, or gas turbine to produce electricity.

And second is material recovery focused on producing the stable solid residue so the first aspect is syn gas production and second is stable solid residue production could be used for construction work for other purpose. Material recovery often occurs on the expense of energy recovery obviously.

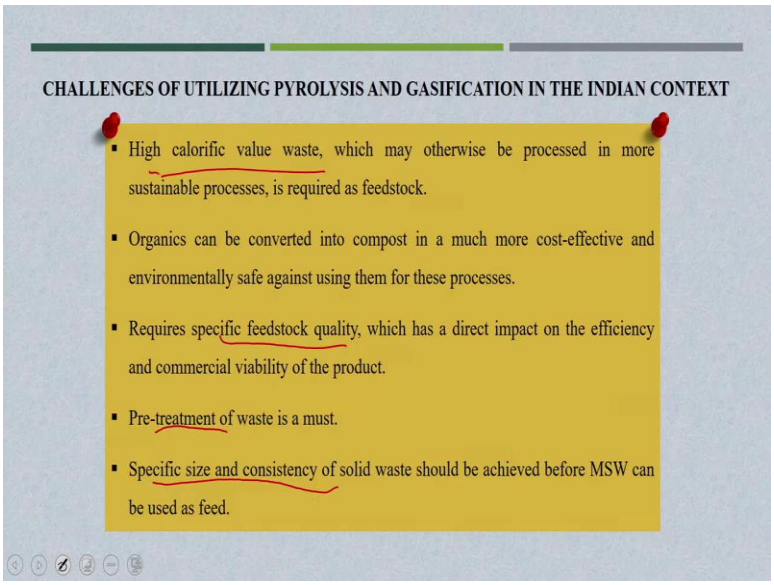
(Refer Slide Time: 36:10)



So now categories of reactor they are one stage process, either pyrolysis or gasification process typically used on more homogeneous free stock and two-stage process which I shared about two stage so used for complicated feeds of such as mixed municipal waste that is what I was sharing, if you are able to do the two-stage process means pyrolysis followed by gasification can be utilized for a mixed waste MSW.

So pyrolysis process typically takes place in the first reactor while the gasification passes in the second reactor ok, that is a two-stage process.

(Refer Slide Time: 37:00)



Ok, so challenges of utilizing pyrolysis and gasification in the Indian context. I think there are few point I had been noted out because what are the challenges before thinking or before trying to get incineration of gas pyrolysis here and gasification plants in India. First, the high calorific value waste which may otherwise be processed in more sustainable process is required as feedstock needed to be understood first.

We need high calorific value waste then only it is possible to run the pyrolysis and gasification process. Organics can be converted into compost in a much more cost effective and environmentally safe manner for this process. So here organics any organic can be utilized for pyrolysis in gasification process so waste reduction also can be possible to utilize. It is also possible that many countries are running, Pyrolysis Asian plant for sewage sludge.

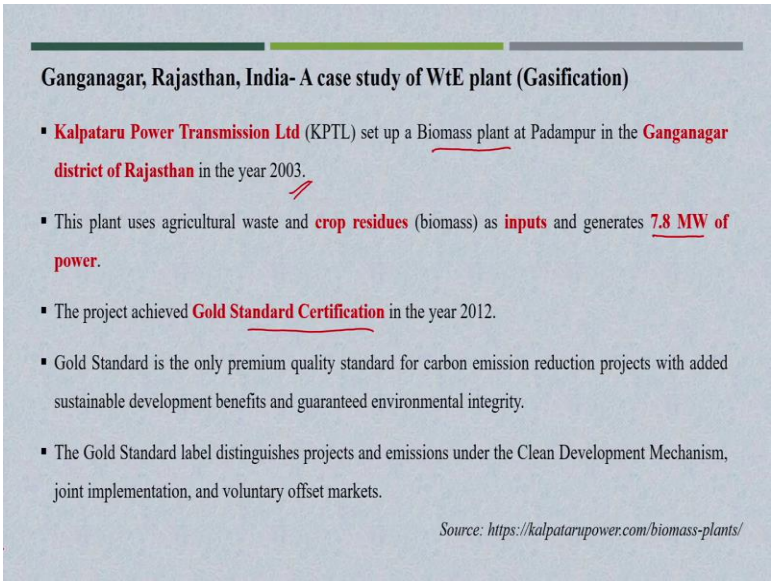
that are dry are having 30 to 40% moisture, also could be possibly utilized. But I think already biological treatment facility is combustion, and anaerobic digestion is already cost-effective processes. So why to use such kind of process that requires specific feedstock quality, which has a direct impact on the efficiency and commercial viability of the very specific feedstock quality is required.

Pretreatment of waste is a must ok means the cost is there if you say the pre-treatment and specific size and consistency of solid waste should be achieved before MSW can be used as feed.

This is a very important point specific size; means you need very special kind of pretreatment. Pretreatment means one special shredder is required and after shredding particular size of waste, that will come up for the pyrolysis and gasification process.

But still I believe that, whatever the challenges normally we will find in India or developing countries are possible to be solved. But for that we need to research especially in an academic Institute can come with the scaled up pyrolysis and gasification plant.

(Refer Slide Time: 39:40)

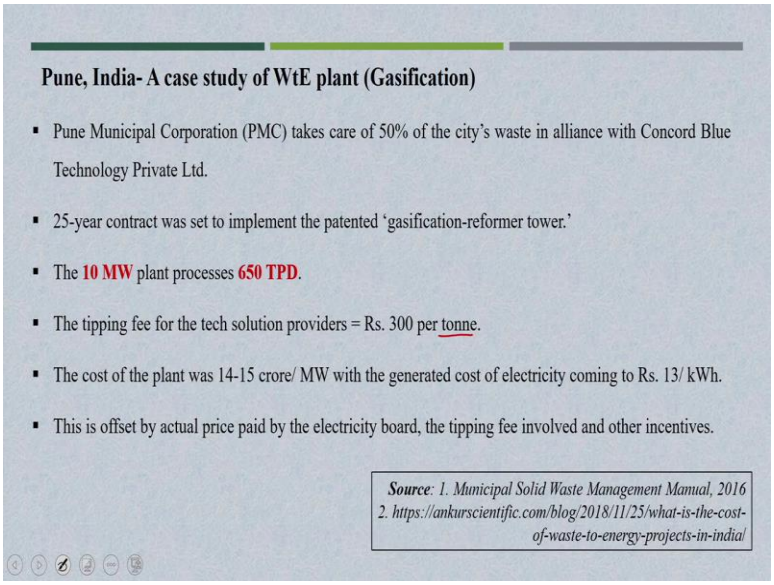


So I have one or two case studies, and I personally like them because they are very old. A treatment plant is available, near Ganganagar, Rajasthan that is gasification based waste to energy plant, it is the Kalpataru Power Transmission Limited set up a biomass plant, it is a biomass based, agriculture biomass based plant in Ganganagar district of Rajasthan near 2003 very old plant and still is running properly.

The plant uses agricultural wastes and crop residue as input and generates 7.8 megawatts of power which I was sharing that, I think still we do not have for the MSW but for agricultural residue highly beneficial because of homogeneous nature and organic nature of the waste. So the project also achieved Gold Standard Certification year 2012. Gold standard is the only premium quality standard for your carbon emission reducing projects with added Sustainable development benefits and guaranteed environmental integrity.

I think for my knowledge that this is the only plant which will have the Gold Standard Certification. Because that is specially for the special kind of products where carbon emission is very less and guaranteed to have environmental integrity.

(Refer Slide Time: 45:10)



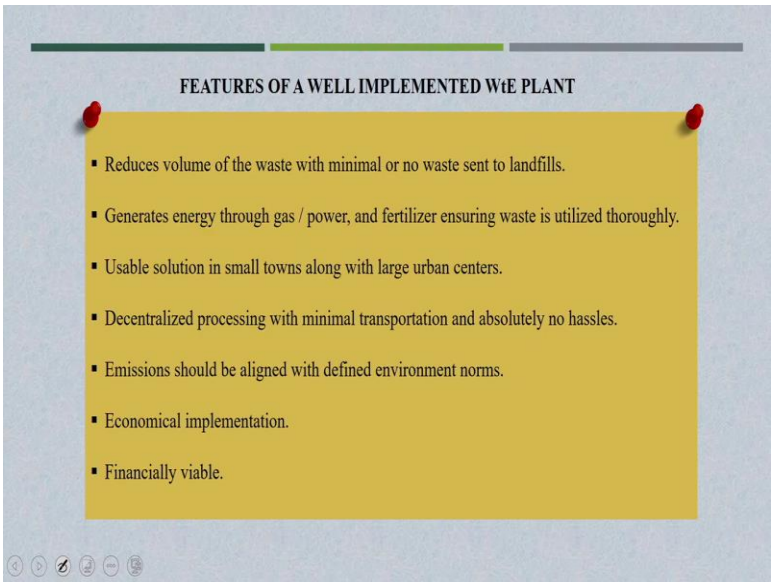
There is another plant in Pune, waste to energy plant, gasification based. So, Pune Municipal Corporation takes care of 50% of cities based in Alliance with the Concord blue Technology Private Limited is also under PPP mode, maybe and 25-year contact setup to implement the patented gasification reformer tower. The idea was to generate 10 megawatt energy to process 650 tons per day waste. The tipping fee for the Tech solution provided around 300 rupees per ton.

But then I think I have another module I think that will be your last module of financing and PPP. There I will talk about the tipping fee. Here is just one point. I want to share just for this lecture. The tipping fees is that any private company is collecting the waste and whatever treatment they are doing and whatever amount they are collecting; the local authority will give payment against that. So that is called the tipping fee.

So for 1 ton of waste it is 300 rupees per day so remember that for 650 transfer day is a huge amount of money has to be paid to the private authority. The cost of the plant was 14 to 15 crores

per megawatt with the generated cost of electricity coming to rupees 13 per kilowatt hour. So this is offset by actual price paid by the electricity board the tipping fee involved in other incentives.

(Refer Slide Time: 43:17)



So these features will be implemented in waste to energy plant. I think this last slide, what are the features should be there for well implemented waste to energy plants, the reduced volume of the waste with minimal or no waste sent to the landfill. That should be the thought and generate energy through Gas, Power and fertilizer ensuring waste is utilized for only usable solution in small towns along with the large urban centre.

Decentralized processing with minimal transportation absolutely, no hassle, say emission should be aligned with the defined environmental of economical implementation finally financially viable. So here we will finish this module. In total, we had 5 lectures and I believe that you people have completely understood the incineration properly, waste to energy plant incineration but finally the point I want to mention is, earlier also, I was also against the Incineration facility, because the same waste which is combustible also are recyclable.

Like paper, plastic, rubber, leather, even organics are recyclable, can be made recyclable or could be made combustible or biologically degradable. But I was thinking that having such kind of facilities also in India there are most of the cities of combusting facility, recycling facility, but

still we are not able to handle, mixed kind of wastes and everywhere the segregation is not possible. So I think I believe that we need to have the incineration facility in India.

and both kind of like incineration plants and also the pyrolysis gasification based units, you need different kind of wastes. And I believe that in next 15-20 years we will have more kind of incineration plants or combustion facility or waste to energy facility, and only the point has to be mentioned that we need to really work onto the treatment facilities. If you are able to treat the flue gas emissions or flue gas polluted gas, I think we can run the incineration facility.

So from next module, We will go for biological transformation, starting with combustion. Thank you.