Plastic Waste Management
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Lecture – 27
Plastic Waste Management Practices - Mechanical and Feedstock Recycling

So, hello and welcome back; so, we will be focusing on in this week as you know where we are; our focus is on plastic waste management options. So, we are looking at the different methods in which we can manage this plastic waste including recycling and we will be talking about other technologies which are used in India as present and also some of this stuff that is being used in abroad, so and that potentially can be used in India too.

So, in this particular video, in the next around 30 some minutes, we will be focusing on recycling part, which is the mechanical recycling as well as the feedstock recycling.

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We did start this part little bit in the previous module, as you may remember, you saw this slide, where we were looking at the waste is that plastic focused on plastic. How the mechanical recycling of plastic happens? So, since you already had it in the last video. So, I will not spend too much time on it, just very quickly a recap.

So, you have the waste cup plastics coming in. So, different types of plastics coming in, gets sorted into different plastic types, then it will be granulated, they will granulated,

plastic will be put through a wash to remove dirt and soil and other material, then it will be dried after washing, drying, then you extrude it. You make the strings or then strings will be water cold and then you cut the strings to make the pallets and these pallets are good, can be transported and can be used for different application for making the new products and all that.

So, we discussed this quite in detail in the last video. So, if you have to revisit the last video towards, then you can watch it again.

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So, that was the process and again if depending on from collection of the PET bottle up to the new products, this was the last slide. We saw in the previous video, where we looked at from the consumer, the municipality is getting the waste, waste is getting sorted out and then it is compressed, bailed and this bailed material goes into a plastic recycling plant, kind of the layout, that you just saw in the previous slide. And then when it is shredded, clean, pet flakes and then palettes, which can be used for different application and as you can, the applications have been listed over here.

You can use it for textile sheeting, in injection moulding as well as you can make bottles out of that. So, as you can see different products can be made out of a recycled plastic and it is already happening. It is not, it is there in place and it has been happening like plastic does get recycled and one of the biggest buyers of recycled plastic is in our country is Reliance it itself, where it takes these and use it for textile in a big way.

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So, what are the advantages of going for these kind of recycling? Its since we use high temperature. So, any pathogens or any toxic components or the pathogens and they are degraded by the use of high temperature. There is also a reduction in the water volume due to the high operating temperature. So, water by using the produced gases as fuel. So, you can use that whatever the gas is produced, if you can capture and use it in the fuel it, that limits the supply of external fuel as well. So, it can be recycled within the plant.

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So, that that helps disadvantage; when you recycle at there are certain organic contaminants are formed, organic air contaminants like V O Cs Volatile Organic Carbon. There is also carbon emissions to the atmosphere. So, these are harmful to the nearby plants and animal life. So, we have to be careful we have to collect these. So, the plant needs to have proper air pollution control system in place.

So, this is a I would say although we have listed it under disadvantage, if the plant is designed properly, these things can be taken care of, it is not that this cannot be taken care of. So, it is not it, as long as there is a good practice in place and so much of the recycle plastic finds it's new home is a less useful product, that is another it is a recycling, it is not what is known as up cycling, where you are making a better product than initial product. Usually, it ends up being slightly inferior product than the initial product and which is often referred to as down cycling.

So, plastic bottle might become plastic furniture and in turn there is a still, a demand for making a new plastic for plastic bottles. So, it does help, it does help in to, at least we do not need plastic for plastic furniture, but for since it is mostly down cycling, we do need to produce newer plastic for that kind of material from which this recyclable plastic was sourced from so, that is become say it is a kind of a, I would say it is an operational issue, it is a technological issue.

So, if we can come up with better technology, where we can up cycle, where we can this in their doing the recycling process we keep it the quality as good as the original, which is not easy. then of course, you have to look at economics and operational issues associated with that as well and products from recycled waste may not be durable, which is actually again it is a questionable.

We have put this bullets in this these slides, because this is how it has been reported and all those. and so, as a as whenever you take a course you should look at the different angle. So, here as an instructor of this course, I am just putting you the information, which is available there. I am trying to discuss that information and try to make sense out of it. It does not really mean that, like we may not agree with certain things, but it is still since, it is there in the literature, it is there in that like different reports out there. We should be aware of it.

So, it says that products from recycle waste may not be durable. the question might take on that is, has not if you do a good job, it will be durable. So, if it is not that it, but that there are concerns. So, because since the plastic quality is little bit inferior and many times it, these are the psychological issue as well, we feel like oh this is a recycled product. So, maybe it would be less like it is a less quality, is slightly inferior which may not be true in many times, if the quality may be at par, but it is still that thought thought does come in terms of in marketing of the product and all. And there of course, that there are issues of recycling it again and again.

After the plastic has been recycled once, it can it is usually it cannot be recycled many times for many to many types of plastic. There have been some studies in Europe, in Germany again we have looked at some of the plastic bottles that they use for Coca Cola or Pepsi in Germany, even plastic bottle I am talking about, not the glass one. They are taking those plastic bottle, they are cleaning it up and they are using it, again they are sealing the bottle and using it again.

So, that kind of plastic bottles also exist. Again, it the cleaning is required of course, it goes from say you have drink it once time and you do not want, somebody else will not like to drink from that bottle in which you drink so, but since the plastic quality is so good of course, that plastic will be costly and that it could be recycled, if I remember from that video correctly, around 11 to 12 times. So, 11 to 2 recycled means it can be not the new bottles, it is the same bottle can be washed and reused 11 to 12 times.

So, those kind of bottles are also available which does, but again those it comes with a price, but you do not have to, you can use it twelve times. So, that is as long as it is it is approved, may in many places, it may not be approved in many countries, but in Germany they do that.

So, increasing increases processing cost and low quality jobs again, these are there are these are debatable topics. You can debate on either side and it does not have to be a low quality job as long as you make good product and you sell their product and it increases processing cost again, but it does also, it also reduces the cost of the of the raw material. So, you do not have to source the raw material, you can use the recycle plastic as the raw material. So, you have to look at whole life cycle costing and that in terms of lifecycle analysis aspect.

So, as you know we we do have, there is another course on NPTEL on lifecycle analysis which already done twice and I hope probably, it will run in future too. So, it is there we kind of we you have to bring those concept in.

Those concepts are universal concept becoming these days of different types of application, where you really look at the pros and cons from an environmental point of view and economics point of view and of course, the social and as angle as well. So, that is where this sustainability concepts comes in.

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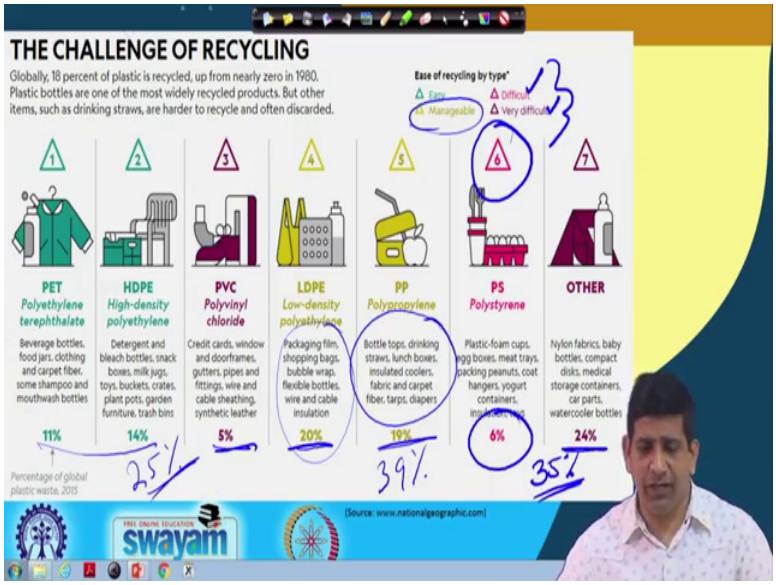

So, there are, there are some challenges of plastic recycling as well. So, this is 2015 data, which is again around slightly more than three years old, from National Geographic dot com and as I said earlier, National Geographic is one of organization, which has worked quite extensively on plastic waste, in plastic waste issues in the last few years.

And they are also going to look at, they will have an expedition actually, coming from these from Haridwar from Gangotri all the way down to Bay of Bengal, where they will be looking at and even they will go part of Padma river, which is in Bangladesh.

So, where they will look how, look at how mismanaged plastic waste from different cities along the river Ganga is leading to plastic getting into river Ganga. So, that is their whole plan. So, they will get on a boat and then they will go through this stretch and I am helping them for the part of the work and so, I will be on board for some time as well,

but not for the entire stretch. So, there National Geographic is doing a lot of work in plastic waste area for in globally. And so, they have come up with this kind of part of their report and as you can see, they have looked at all the different types of major categories of plastic here. So, globally 18 percent of plastic is recycled. So, in 1980 it was 0, 1980 we had 0 percent.

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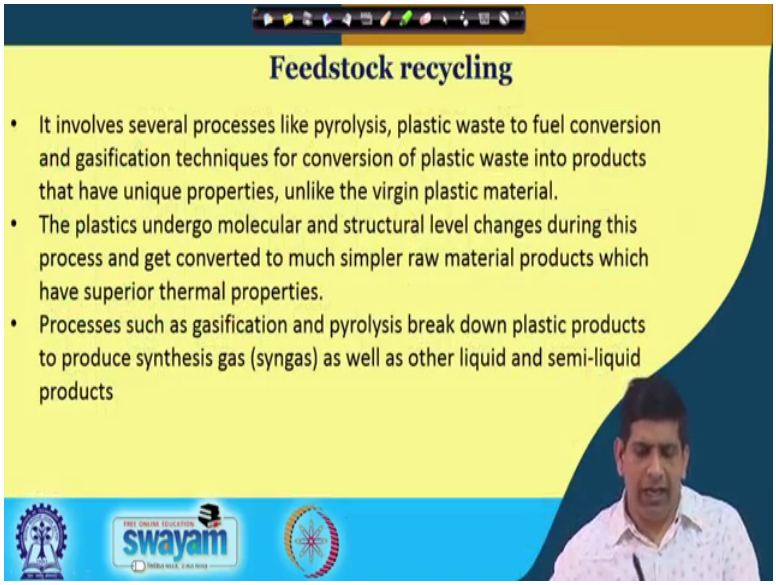

So, as you can see here in 1980 we had 0 nearly, 0 percent in 1980 now, globally around 18 percent. So, that is it still, but we should do much more, but around 18 percent is getting recycle and up from 1980 plastic bottles are one of the most widely recycle products, it is the bottles which is PET mostly.

So, this is what it is a most widely recycled, but other items are also there like a drinking straw, there they are like harder to recycle and often discarded. So, this other material drinking straws and other stuff is harder to discard and we will look at some other materials here as well.

So, here in terms of PET, which is around 11 percent. It is of the plastics PET, which is polyethylene terephthalate we use for beverage bottle, for the food jar, clothing and carpet fibre, some shampoo and mouthwash bottles as well. So, these are what the P E T is used for so, that is your number one, in terms of resin code, which we looked at in one of the slide, you know the one of the videos earlier as well. Number two is H D P E, which is High-Density Polyethylene detergents and beach bottles, bleach bottles, snack

boxes, milk jugs, toys, buckets, crates, plant pots, garden furniture, etcetera and trash cans so that is around 14 percent.

P V C for polyvinyl chloride, your credit card, windows, door frames, gutters pipes, fittings, wires, a cable wire and cable seating cover synthetic leather, that is P V C that is number three L D P E, which is number four, low density polyethylene 20 percent and then your P P, which is poly polystyrene polystyrene and others.

So, which is and if you look at here it this kind of talks about ease of recycling type. So, the green triangle which is the first one and two which you see, they are easily recycled. They are the recycling of these is much easier in terms of those green triangle in the this and there. So, it is an easy recyclable.

Then we have the purple one, which is right there, which is right here, this purple one is very difficult to recycle, because the technologies which out there, it is not really be able to recycle it much and same thing with many others, which has nylon fabrics, baby bottles, compact discs, medical storage containers, car parts and water cooler bottles. So, those are an on 24 percent. So, quarter 24 percent and 5 percent, so 29 percent. So, slightly less than one-third.

So, one-third of the plastic waste is actually cannot be really recycled. So, if you include that is it on 29 percent and then if you include this, the difficult part in there as well which is this pink triangle, pink or reddish triangle, which is 6 percent, so 6 plus 24 plus 5. So, we are looking at 29 plus 6 35 percent. So, 35 percent is either difficult or very difficult to recycle. So, more than one-third of the plastic actually, cannot be recycled. So, that really becomes a concern.

So, it is those plastic wastes, even if we have a fantastic, a plastic recycling collection and all that happening more than one third is really difficult to recycle, difficult and very difficult. There are places where they do recycle, those as well like Netherlands, Austria, you go you will find some recycling plants which do that, but again your overall like cost and all things just do add up. So, country like India, it will take time for them to kind of go to that level.

So, we need to have a very good plastic waste management system, on top of the recycling of plastic. So, because we have will have it at least one third of plastic will be

really difficult for us, to recycle. Then manageable ones, which is the yellowish green right, there L D P E and polypro and P P, which is packaging film, shopping bags, bubble wrap, flexible bottles. Those material then P P is the bottle, tops drinking straws, lunchboxes, insulated coolers, fabrics and carpets fibres and other stuff. So, that is around 19 percent.

So, this is 39 percent right here, which is a manageable, 25 percent is the one, which is easily recyclable. So, it is easy to recycle. So, one-fourth is easy to recycle, 40 percent, is can be recycled, 35 percent difficult and very difficult to recycle. So, that is kind of what we have in terms of challenges of recycling today and that is based on the technology, which is prevalently available globally. So, there will be pockets in the world, where even all the plastics, most of the plastics are being recycled, but that is not that much common.

Then the next, this is what, this was we were looking at mechanical recycling, where you have taken the product and try to recycle it as it is, you make a new pallets from there you make new and then you make pallets and based on those pallets different resins, you make newer products out of that. Now, we will talk about feedstock recycling, where we are essentially, we are trying to take the plastic and use it either through some pyrolysis or similar technology. So, we will talk about those issues.

So, here there are several processes are there like pyrolysis, plastic waste to fuel conversion and gasification techniques that is as and the goal here is to convert the plastic waste into some useful product so that we can do some sort of resource recovery from this plastic waste and that into product that have unique properties, whether you have you come up with a product, which are unique unlike the virgin plastic material.

So, you come up with plastic material which has slightly unique properties. So, what happens here, the plastic undergoes, plastic undergo molecular and structural level changes during the process and they gets converted to much simpler raw material products, which have superior thermal properties. So, that becomes simpler raw material product, which have you have like a better thermal properties.

So, process such as gasification and pyrolysis what they do? They break down plastic products to produce synthetic gas, which is also known as syngas as well as other liquid

and semi liquid product. So, that is it helps in terms of recovery from that particular waste stream.

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So, pyrolysis is which is again you will you must have heard about, it quite a bit, if you have not you will you will hear as you get more into this plastic waste management or in general even for several agricultural waste management and specific waste types.

So, pyrolysis it is, what you are doing, it is a thermal or thermo chemical process we can say. It is a thermo chemical process, it is endothermic, it is not not isothermic endothermic. So, endothermic means we have to supply energy and it is irreversible. You cannot change after it happens. So, you are doing a endothermic irreversible thermo chemical degradation and decomposition of complex long chain organic polymer molecules.

Because that is what you have in plastic, you have organic poly molecular sorry, organic polymer molecules and it is a long chain and then you convert that into units of simple sort chain compounds, at temperature greater than 300. So, you have to work at temperature greater than 300 in the absence of oxygen with and without application of pressure. So, that is what typically happens in a pyrolysis.

So, you are taking this polymer molecules, longer chain polymer molecules, converting them in units of simple chain compounds at temperature greater than 300, absence of

atmospheric oxygen either in presence or in absence of pressure. So, that is application of pressure. So, in plastic waste pyrolysis with it involves breaking down or plastic into products of all the three phases, you have some solid product, liquid product, gaseous product. Solid print product known as char with many, if you do it for from the wood waste from forest residue, many times you hear that term biochar.

Similar, here you have a char and when you do that it is made of carbon and has a minor proportion of other elements known there as well. Liquid product is oil like material, similar to diesel for as for isoplastic originally, petroleum-based product. gaseous phase product is known as syngas and the syngas also has a good calorific value. So, that can be used as I say fuel.

So, if you look at the solid product is essentially char, which is kind of biochar. So, you will have a many times we hear the term plastochar as well, can be used as an adsorption material for different remediation purposes, clean-up purposes. Liquid product is kind of similar to diesel can be used for a petroleum based product, it like it can be used as diesel, gaseous product, as syngas can be used as a fuel, because it has a good calorific value. So, this is what you are looking at when you are trying to do the pyrolysis of the plastic waste.

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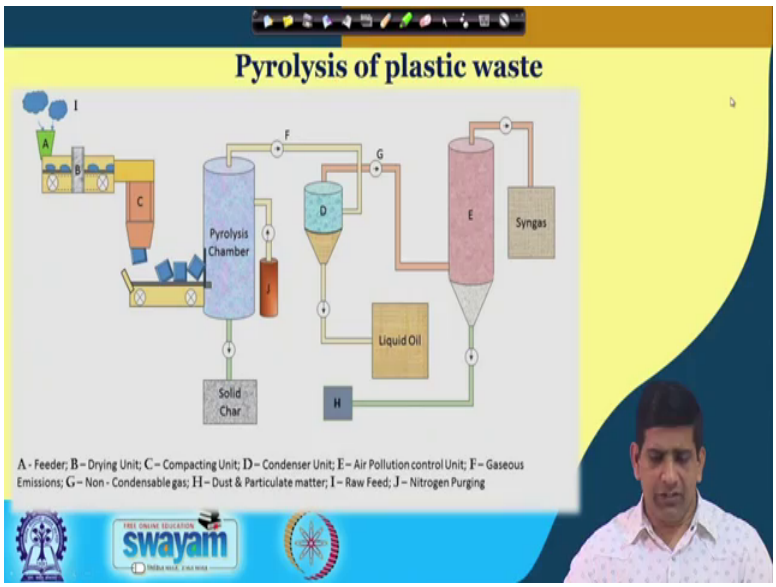

So, just a quick look at the schematics and then we will also walk you through a small video. So, here one is here the a the feeder unit, we have a feeder unit, then you have

dryer unit, things are being, this B is the dryer unit right there, then we have compaction happening, after compaction you have condenser, you have a condenser unit, you have air pollution system which is right there, air pollution system and then F is the gaseous emissions which is coming out from there.

This is our pyrolysis chamber where the pyrolysis is going to take place and non condensable gas goes to G which is over right there, and F we talked about that, H is the dust and particulate matter needs to be connected, I is the raw feed which is coming in into the system and also we have the nitrogen purging which is the system of J, which is right there. We just that is the J right there, which is a nitrogen purging in the pyrolysis chamber, because we have to do it in the absence of oxygen.

So, that is we purge it with nitrogen and try to make a condition with in absence of oxygen. So, this is how the system usually works. You have a solid product coming out in terms of solid char. So, you have a liquid product coming out in terms of liquid oil and we have the gas product coming out in terms of syngas. So, we can use all these three product for different applications as we just discussed.

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So, let us look at this is a plastic pyrolysis process, that same schematic which I explained to you in a minute just a few seconds back. the similar plant not a minute this will not be exact exactly 100 percent the same, but similar plant as you can see being in

how it operates, how it works. So, let us look at this video and then I will explain to you as we move through the video, the different steps.

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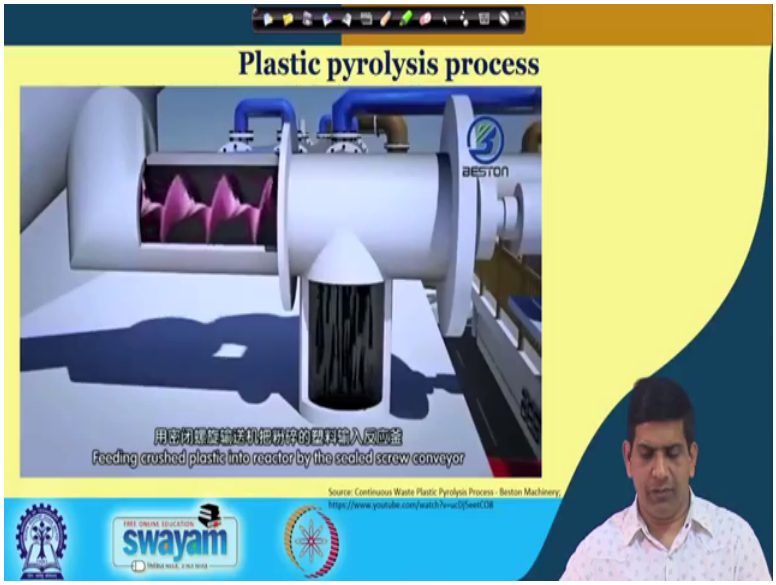

So, that is the narrative to feeding crushed plastic into the sealed screwed conveyor. So, it is coming through the conveyor and then it gets feeded into, the plastic is getting feeded.

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So, here the fire in the fuel in the burning room the fuel could be diesel, natural gas, or L P G.

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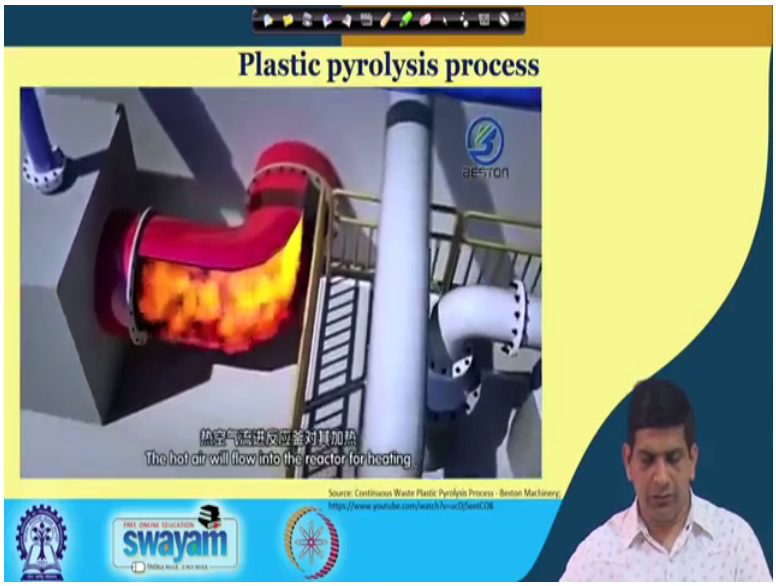

So, that is your burning, things will burn hot air will flow the reactor for heating.

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So, when the inner temperature of the reactor, if there is a change and then oil gas will be generated.

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Then it goes to the manifold. From the manifold heavy particles will be liquefied. Light gases will rise.

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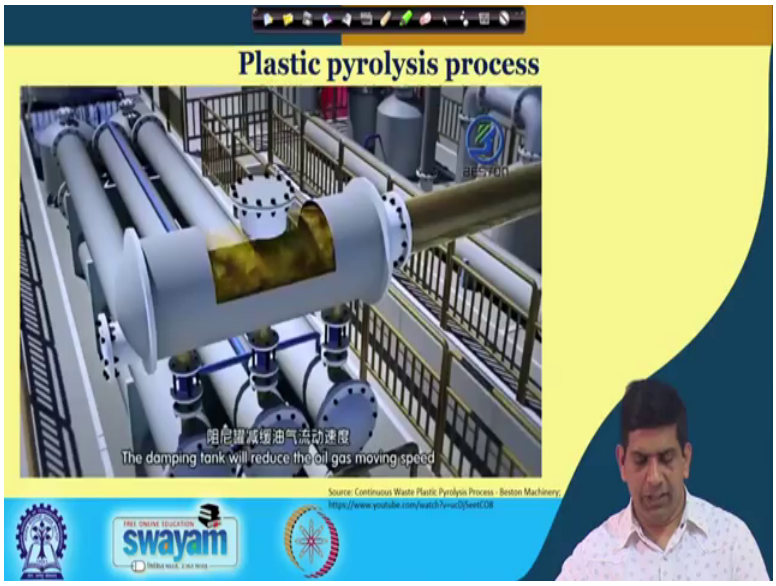

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So, here they have a damming truck will reduce the oil gas moving speed.

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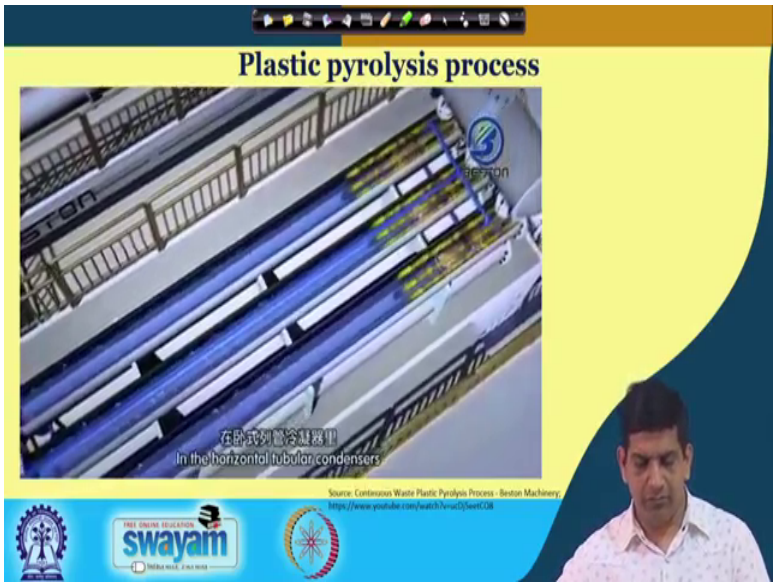

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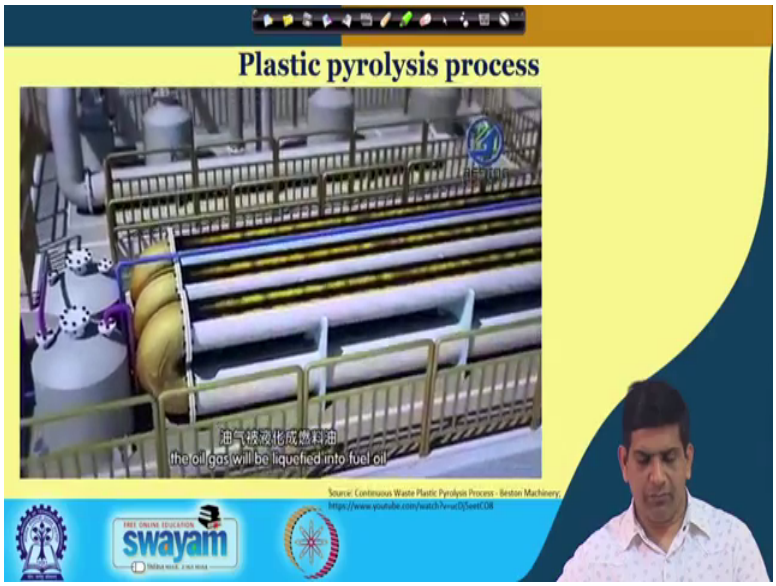

So, you have a then gas would be condensed in the horizontal tubular condenser. You have the condensation happening then they all gas will be liquefied into fuel oil.

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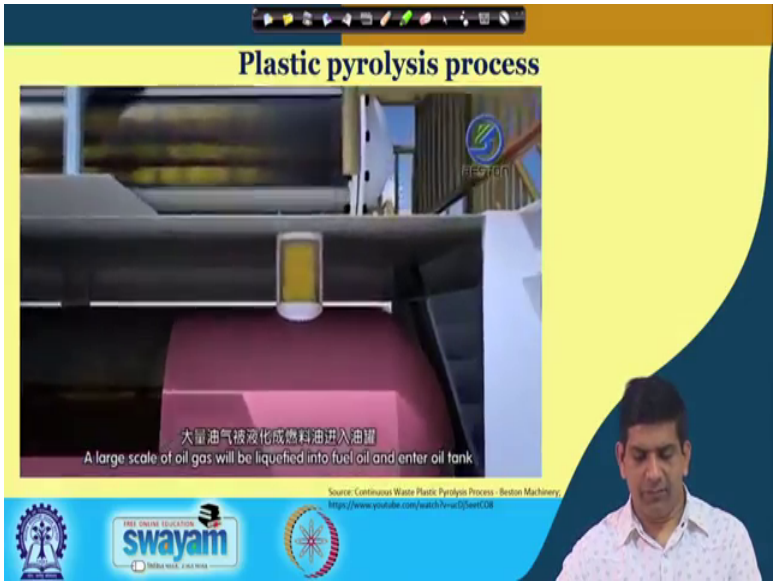

Large scale of oil gas will be liquefied and then those two oil tank.

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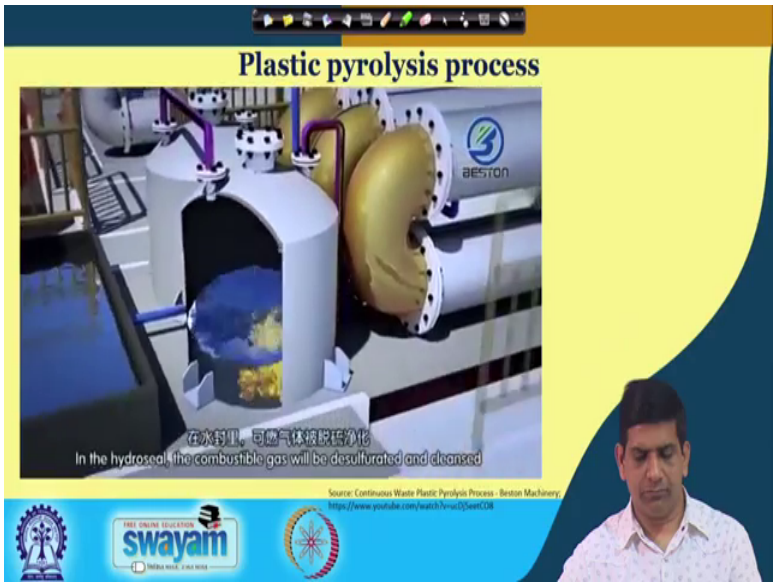

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So, as you can see then the recycle goes to the burning room and then we have to provide the heat saving a lot of fuel.

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So, that whole process that we just explained and the hot smoke goes out of the reactor through inner pipe to the heat exchange system.

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So, they are recovering the heat, they are recovering the then get the char product, they are also getting the syngas product. So, here it will get heated by the hot smoke.

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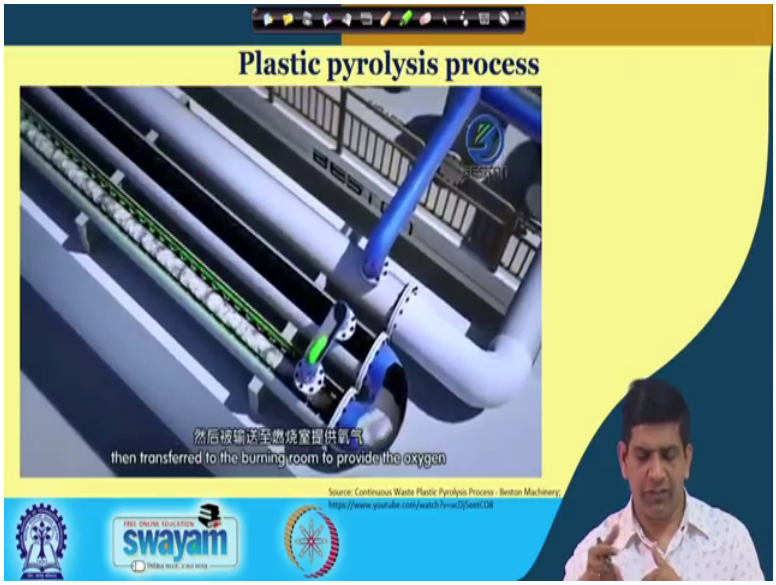

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And then that that can be used then transferred to the burning room, to provide oxygen. So, and you can generate from that syngas also you can if you want you can use it as a heat source and then you can also use it as a energy source and heat is of course, is energy too.

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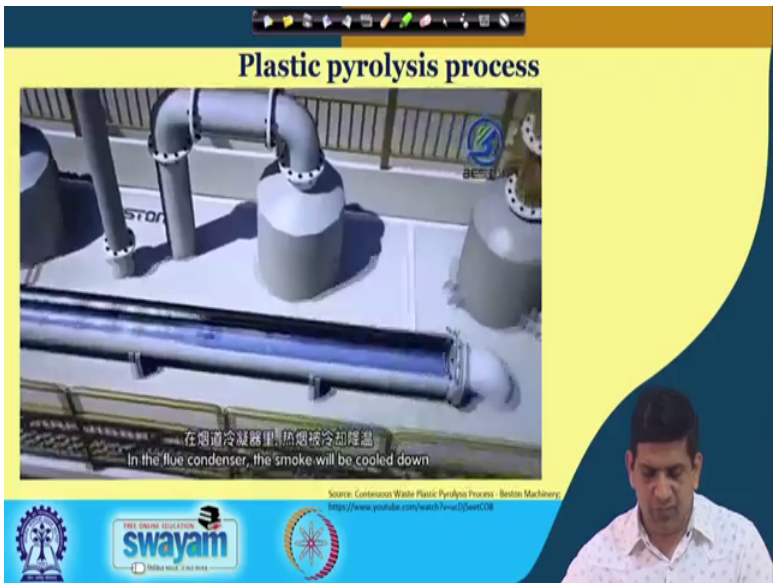

So, then this smoke will be cooling down in the condenser.

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So, all these different steps is explained in great detail, then it is spraying tower, this small will go through the water washing and water spray did remove the air pollutants.

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Ceramic ring adsorption and activated carbon; so, all these things happens in as a air pollution control system.

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And this not only happens for this plant this happens in may all the plants, where you have this is after four filters. It goes through a smoke, goes through the stack, which is and they meets European Union standard.

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So, similarly in India it has to meet the Indian standard. The carbon black, which is collected is discharged through auto screw discharge. So, carbon black is collected as well, which can be used as adsorption material.

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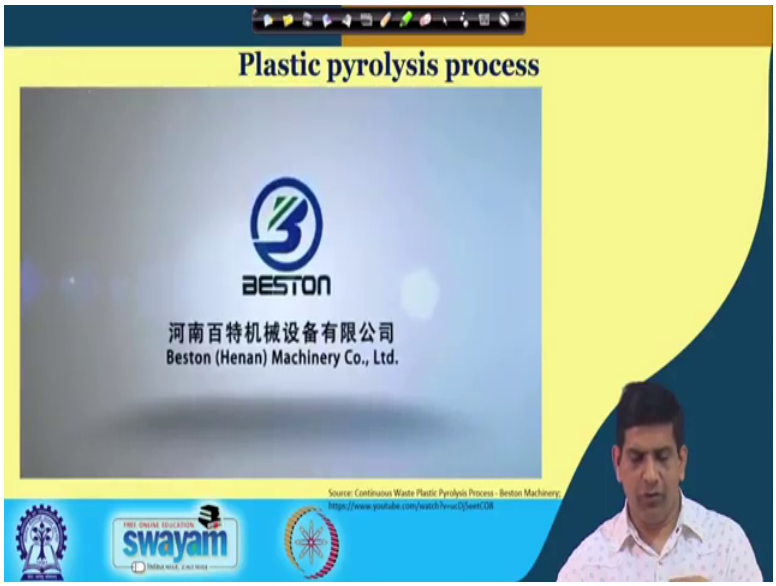

So, that is an overview of how the plant kind of works for plastic pyrolysis. So, this is how a typical plastic pyrolysis plant the process. So, kind of wanted to give you an overview of that, we looked at the schematic just before and then you saw this video, which gives you an idea of that.

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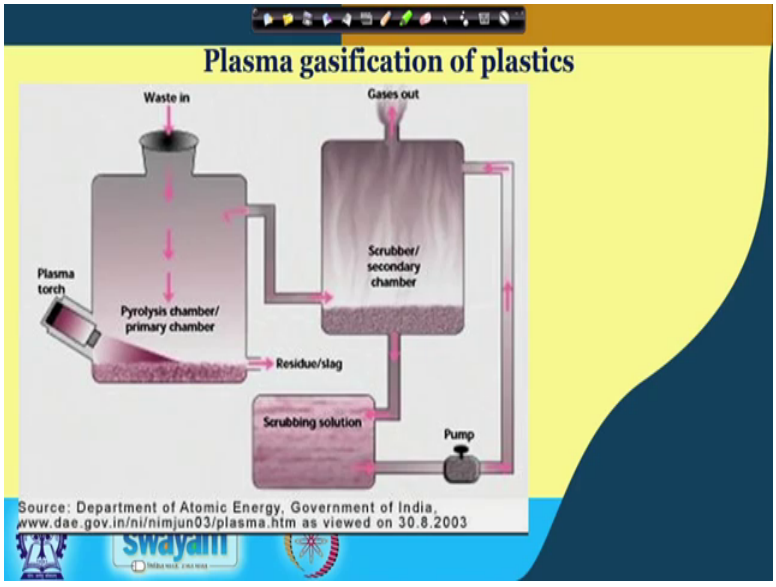

Next is plasma gasification of plastic, where plasma is used for treating the plastic waste. It is not very common actually to use the plasma gasification it is, because plasma use a lot of energy. So, pyrolysis is more popular than the plasma, because plasma usually we

are working at 5000 to 10000 degree centigrade, depending on different fuel, different waste types and it becomes costly to do that.

So, here the plasma torch is being used, the waste is coming in, it goes into the pyrolysis chamber, which is the primary chamber then from the primary chamber things are going into the secondary chamber, which is also known as the scrubber and there is a square gases will be collected out there is a scrubbing solution, which will come out and then things kind of goes back in here. So, in there is a plasma gasification developed by department of atomic energy government of India.

So, we will look at a little bit more detail about that plasma gasification technique and then we will stop this video right there. So, this is I want you to watch this video, we will have a just 1 or 2 minute discussion. There is a audio to this video. So, I will keep quiet and you watch go over this video and then after it we will be just have a quick discussion and close that video core close this particular module at that particular time.

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Plastics in its varied forms and structures, have deeply penetrated our daily life. No wonder, entire Indian landscape is struggling with menace of plastic wastes. Plastics do not decreed and decompose naturally, if set under earth could remain same in the soil for up to 300 years. Plastic wastes opposing many hazards to human life, flora and fauna including other natural resources.

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Disposal of plastic wastes in environmentally benign fashion is a formidable challenge welder where.

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Hence, petroleum conservation research association in collaboration with C S I R C M E R I developed an innovative technology for environmentally safe disposal of plastic waste along with energy recovery.

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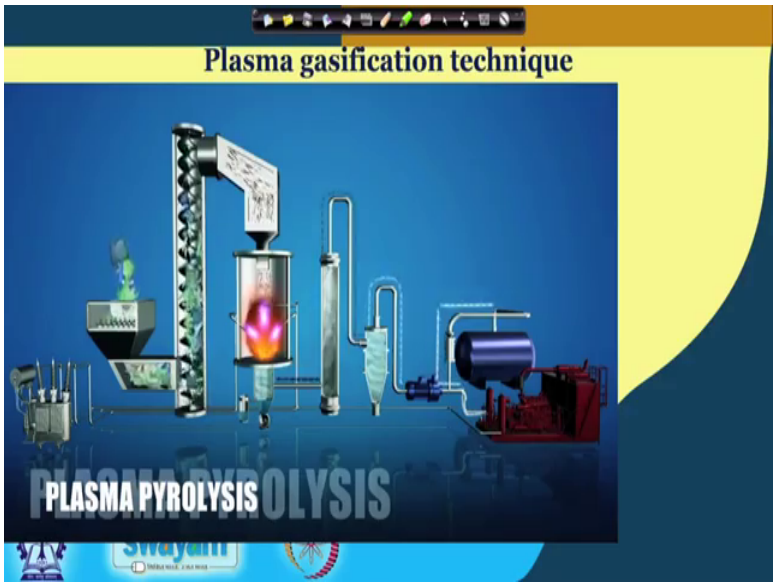

The technology plasma pyrolysis transforms high calorific thermal plastic wastes into a valuable synthetic gas, which can be applied well to gas turbines for power generation. It can also be used as a synthesis gas for hydrogen production.

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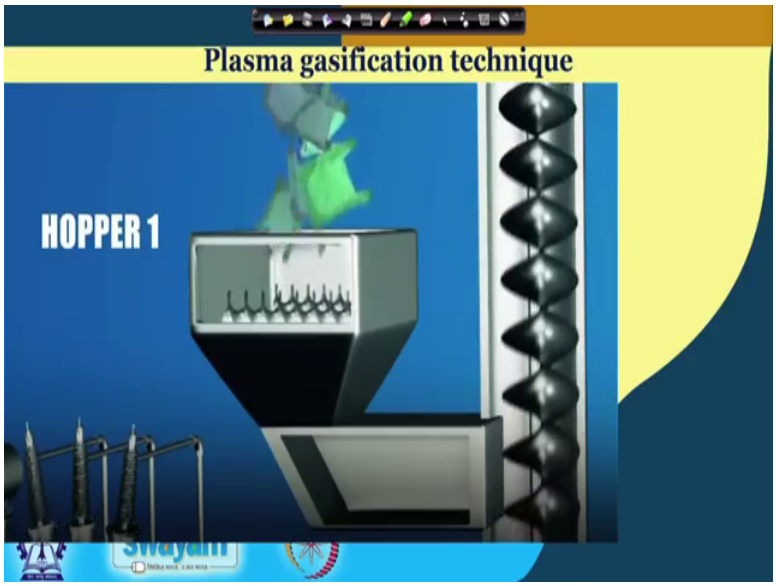

In the first step; the plastic waste is fed in the hopper 1 to provide an intermittent supply to the column of shredder.

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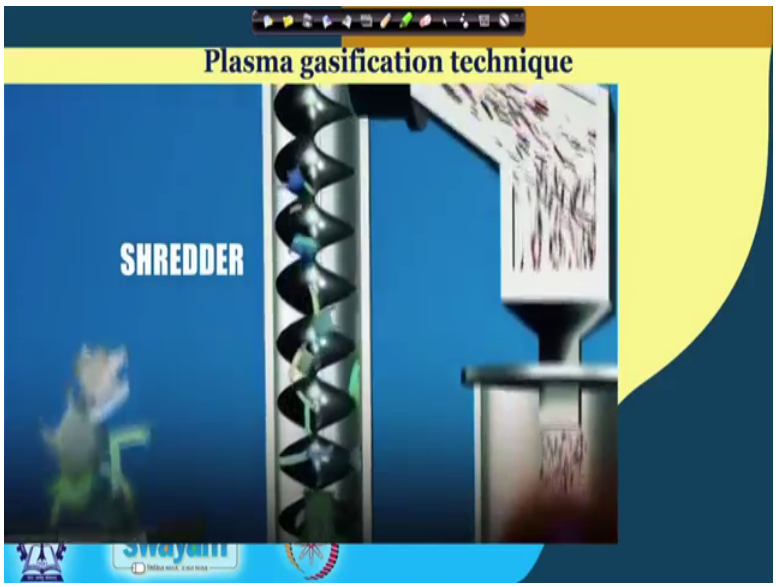

Shredder reduces plastic waste into smaller bits of suitable sites, which are fed to hopper 2.

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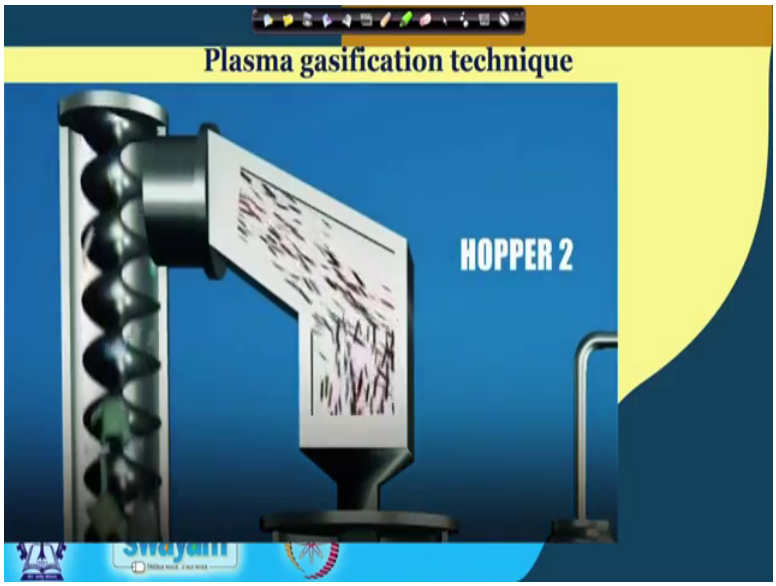

The second hopper connected to the gasifier supplies feed intermittently to the gasifier, but the feed read can be suitably adjusted by means of a control knob.

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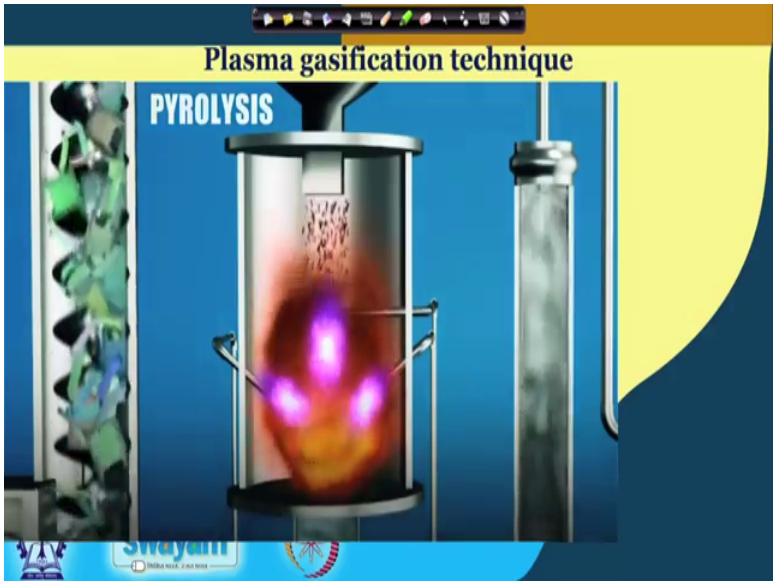

Pyrolysis or reactor is the heart of system, consisting a cylindrical chamber with a tapering bottom half. A transformer supplies necessary voltage to the graphite and carbon electrodes fixed inside the gasifier.

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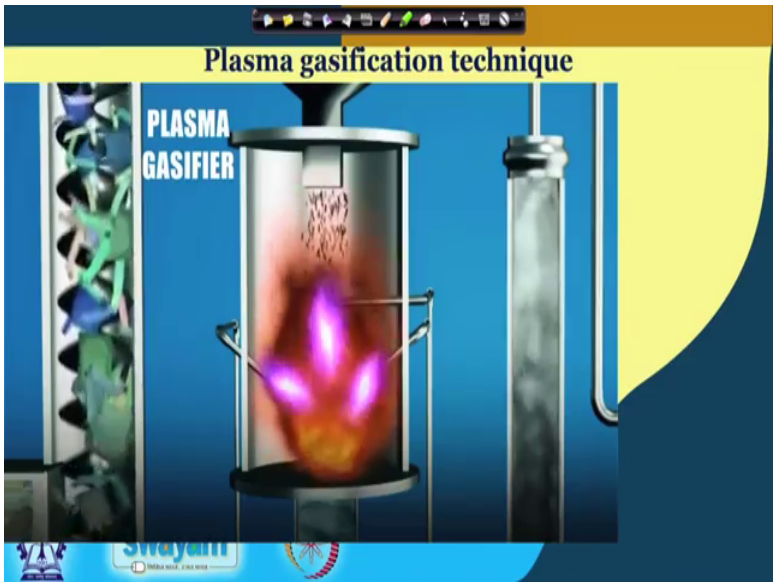

As a result a very high temperature over 3000 degrees Celsius is generated at the sparking zone.

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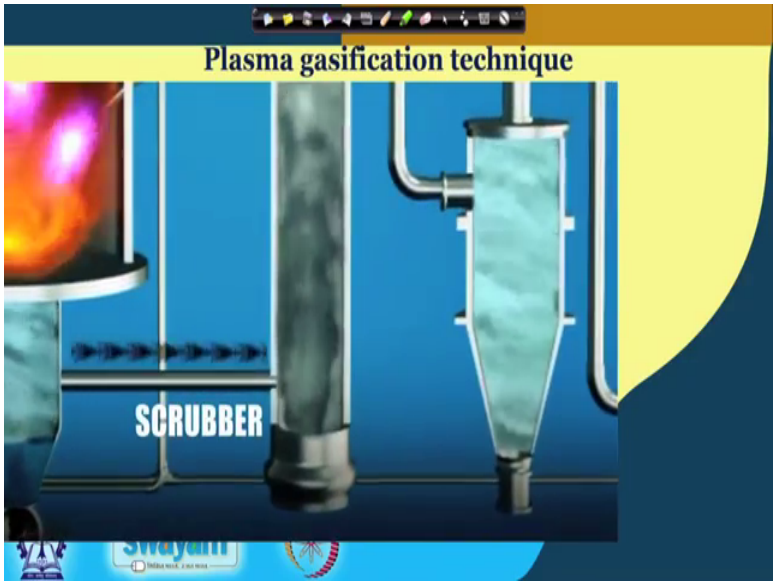

A slag removal system at the bottom of gasifier dreams, slag continuously in a water pot. High temperature in the gasifier generates syngas, which is passed through water scrubber for cleaning and quenching the hot gas. The con dude carrying the gas enters the scrubbing tower at the middle and water is sprayed from the top, the flow of gas is maintained by an i d fan which continuously sucks the gas.

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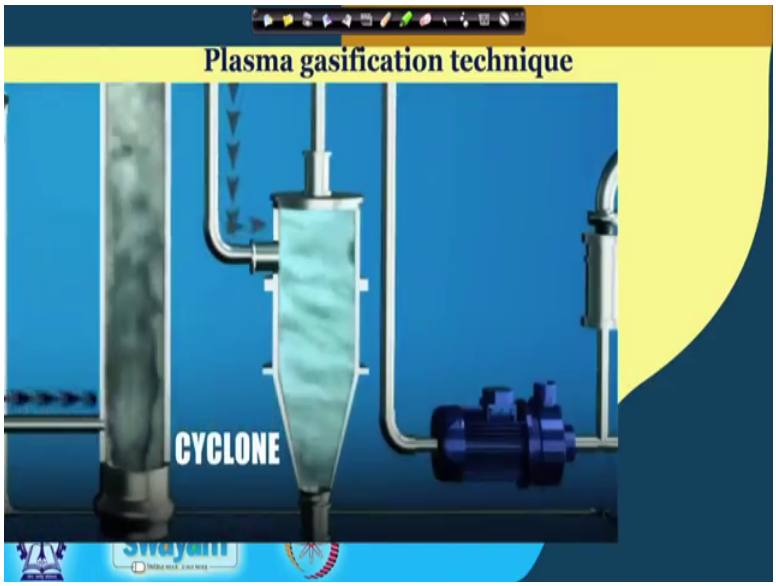

Cooled gas enters in a cyclone separator, which removes particulate impurities from the syngas through vortex separation. Rotational effects and gravity are used for separating impurities.

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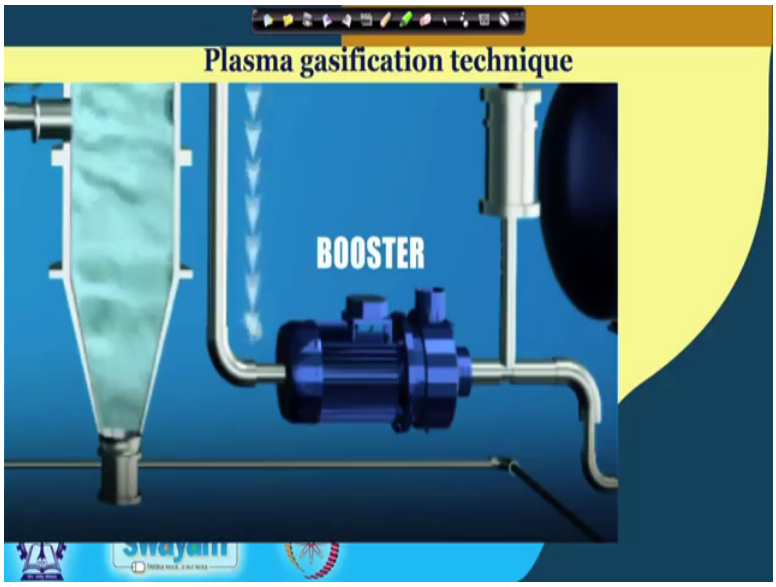

The cleaned and cooled combustion gas is passed through a booster for generating requisite pressure in the supply system. Now, the syngas is ready for supply to gas generators for power production. The syngas can also be used directly for various thermal applications in industrial units. Pyrolysis process can also run on the power

generated by syngas. The prototype has demonstrated the efficacy of technology for plastic waste disposal with energy recovery. The technology is poised to become a significant game changer in the field of energy economy.

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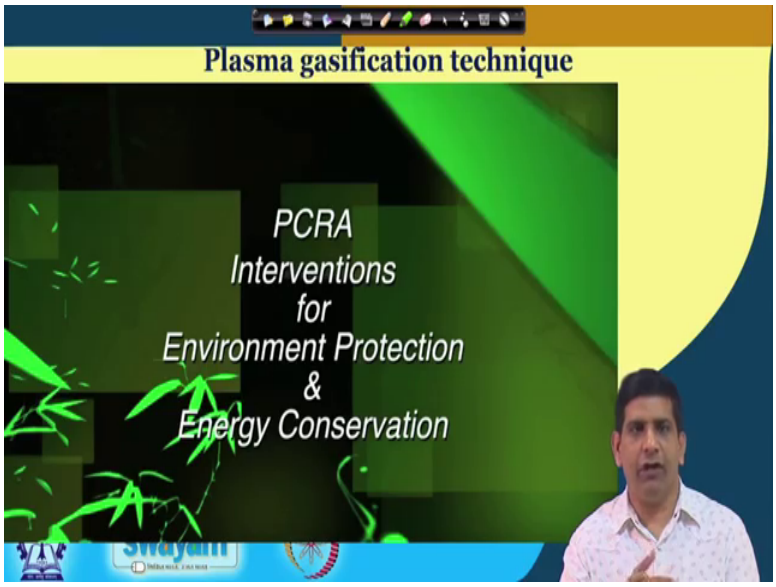

So, as you saw this video, which kind of goes over the entire process of that plasma gasification technique and it can be done for plastic, it can be done for some other waste stream as well. So, as you went through the entire process, one of the again its as a feeding system has the main plasma chamber, where the reaction is taking place. Then has a good air pollution control system, for taking care of the air pollution. So, this is kind of typical of different types of thermal based treatment that you will see, we will have these components in there.

So, that is kind of let us close this video at this particular point and then we will continue this discussion in our next video. So, thank you and keep watching, keep putting your questions on discussion board we will be happy to answer those questions there.

Thank you.