Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Bioenergy

Lecture – 25
Pyrolysis Process

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So welcome back to the lecture series on bio energy so in the last class we talked about the combustion process so now we are in the fragment of different conversion strategies from biomass to energy and in the combustion we ended up with how heat energy being used to generate electricity by generating sufficient amount of steam from water by boiling the water and that steam is fed to the generator and that is how the electricity using produce okay so today what we will do in that series it is coming back to the charts where we were.

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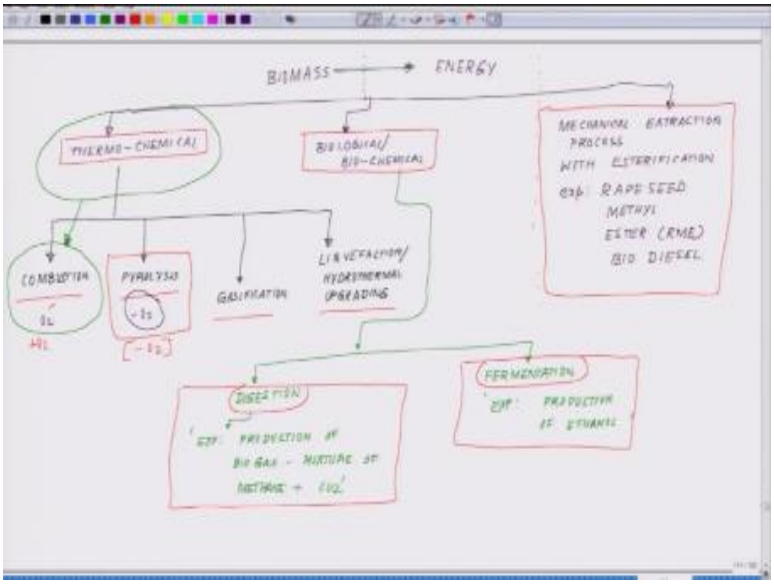

So we will be touching upon the process of pyrolysis so as compared to combustion where we are using in the presence of oxygen here it will be in the absence of oxygen okay.

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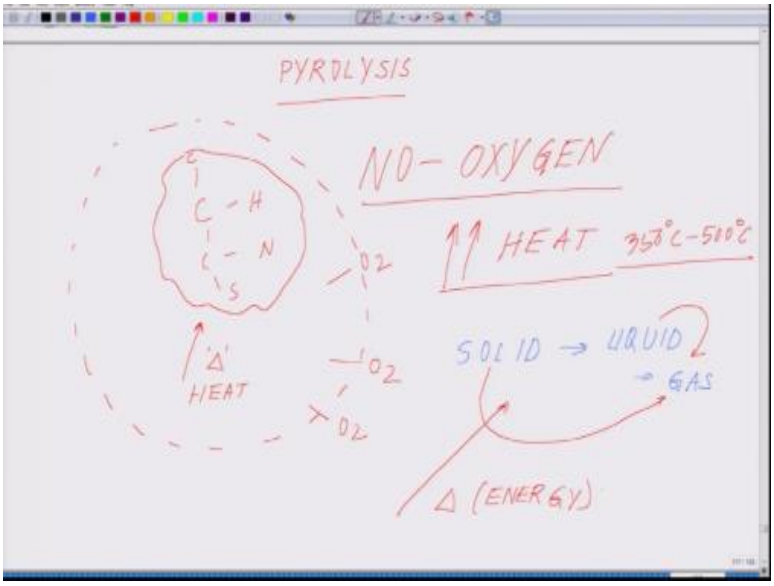

So much as we do in every class before we really get to the details of the process let us try to understand the whole process if you break this word pyrolysis into two part pyro plus lysis pyro means fire and lysis means you are breaking down something so in other words you are breaking down something in the presence of fire or heat you can also call it a thermolysis so say for example if you so you have a material like this which consists of carbon hydrogen carbon nitrogen sulfur whatever you know you can keep on adding all the different kind of elements.

Now you expose this you heat this up you provide heat energy and you maintain this to provide the heat energy in the- oxygen environment or no oxygen okay so this is the situation so you have no oxygen and you are giving heat to any form of biomass around say no 350 degree centigrade to 500ºC typically you can go up you can also go up to 800 or you can go up as much as you can but typically this is the range so think of a situation your material you are heating it in the absence of oxygen.

So generally whenever we heat something there are two three things which could happen of course in the presence of oxygen most of the carbon matter it becomes carbon dioxide and moves out and because of heat sometimes the matters transform into change its estate if you are in the solid it may go to the liquid state and some time it may even go to the gaseous state depending on itself at what temperature it changes the face you know like you have seen naphthalene balls they directly from solid they transform into gaseous state okay.

So you see that naphthalene balls are used inside to protect our woolen clothes and although kind of stuff okay similarly there are materials which from solid phase that goes into liquid phase okay similarly there are materials which from the liquid phase moves into the gaseous phase so there are always these transitions which take place in the form of from solid to liquid to gas or even this is not that strict it could be like this okay look like this so and so forth so all you need to have this kind of phase transition is some form of energy either in the form of heat light or whatever you know you just need certain amount of energy by virtue of which you can make this thing happen.

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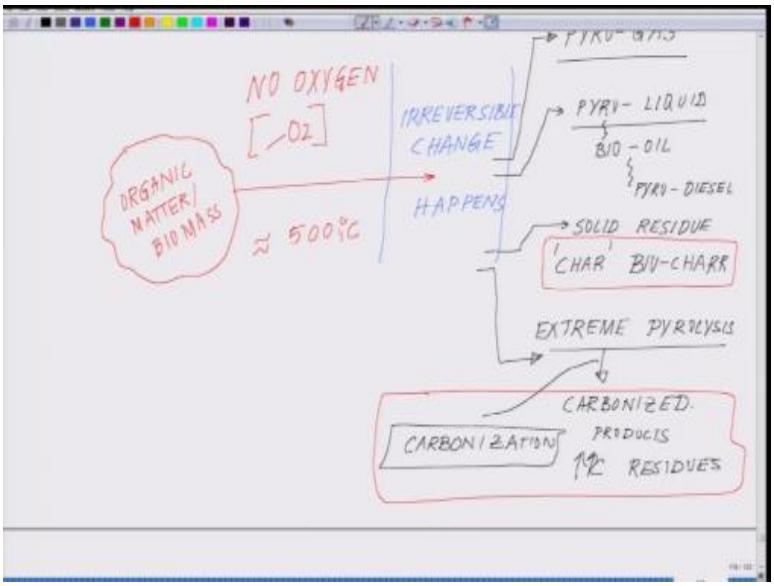

So now if you think of so you have the organic matter or biomass with you which is a solid material organic matter or biomass now what you do is in the absence of oxygen no oxygen you raise the temperature inside a chamber to 500 degree centigrade are irreversible change takes place so you cannot really go back irreversible change occurs in the phase of the matters happen and this irreversible change leads to generation of multiple products there is something called pyro gas okay this is the gas which is liberated out.

It generates something called pyro liquid the pyro is the word which is used because this is getting generated through pyrolysis process which is also called commonly as bio oil and you can call it even biodiesel but that is kind of a know the tricky way to achieve that feat then you have solid residues which are present which are called char solid residue and solid residues are termed as char or an intensity is coming from charred materials.

So you know charring has been the word you must have hurt it got charred because of fire or something so it is a charred material and since this charring is happening in a material which is a biological origin it is also called bio char okay and if you go really extremely increase the temperature further up and you go for a very heavy pyrolysis so what you would this is also called an extreme pyrolysis for a prolonged period of time what you will get is a carbonization carbonized product just left behind this.

The carbonized product and this process also pyrolysis process at times is also called a carbonization process the name itself is self-explanatory carbonization means the formation of carbon rich carbon residues which are left behind okay so the things overall what could be done and if you look at these products like chars or bio chars which are present there or extinct carbonization processes so this is not something out of the world you all have seen one thing you must have seen after harvesting of the crop in the fields especially in the northern part of this of our country you will see the farmers burn the field after harvesting especially to get rid of.

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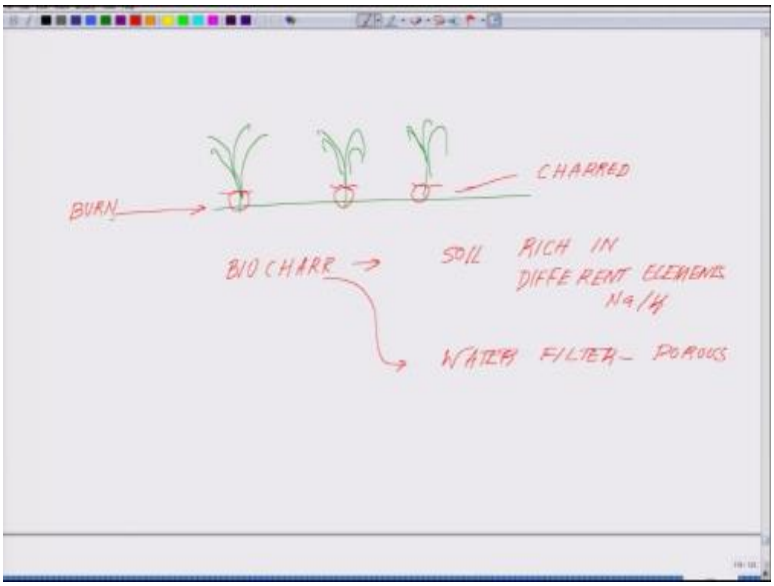

So when you are so what happens when you are like say for example you see appeal you see so the plants are or another crop is going like this okay in the soil okay now when the farmer cut the crop they cut it like this cut it here so still what is left behind is the part of the residue then the farmers burn the field which takes care of this part of the residue and kind of leaves behind a chars look of the fee this is nothing this is incomplete of course there is oxygen present but still incomplete burning.

Okay and these charring is very similar except the fact this kind of charring happens in the presence of oxygen but when one can do that kind of charring in the absence of oxygen you get this kind of things and because of that incomplete charring what you get those kind of bio char stuff what we get they are very good for the soil because they are rich in different elements or alkali metals like sodium potassium like okay and they are also some of these bio char materials are also used for water filters because these are very porous material and you must have heard about activated carbon and all these things which are used so these are produced through this so if you look at it if you go back a little bit in the previous slide.

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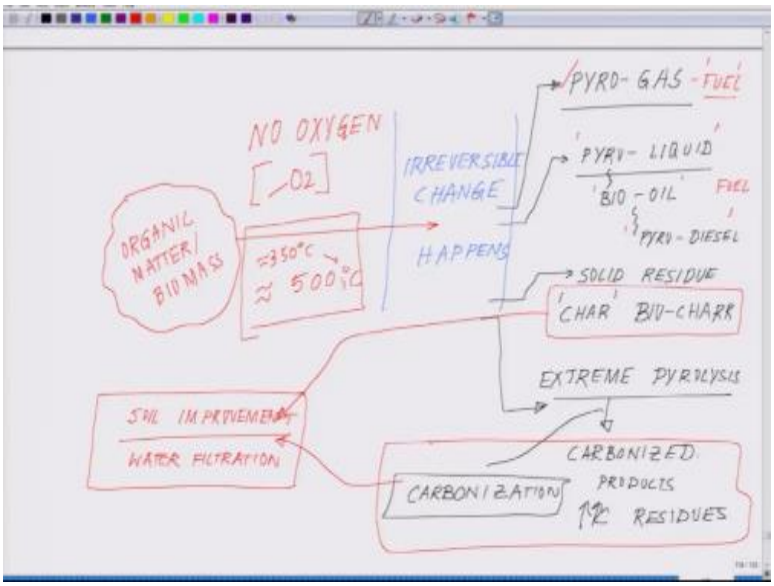

What we talked about so when a charring process or the pyrolysis process is being done what we get is a pyro gas which is a form of fuel and we will talk later now in this class in the next class what are the challenges in it then we get what is called pyro liquid or bio oil or even pyro diesel this is another form of fuel where as this solid residue which is left behind has implications or has significance or even customize product for soil improvement as well as water filtration and this bio charging or pyrolysis process is very extensively used in the chemical industry chemical engineering in order to produce myriad of different kind of products okay.

So the process what is significant here to realize this is one point which I did not talk so I showed you that you are raising the temperature around you know from 350 degree centigrade to 500 likewise okay now this parameter is controllable how you are raising the temperature what does that mean that means I can raise the temperature like this say I start with say typically a room temperature of 37 degree or you know 30 degree okay and I switch on the heater so before I get into this just I will give you an idea that how the by charring apparatus generally happens in the laboratory conditions where the big by Chars apparatus.

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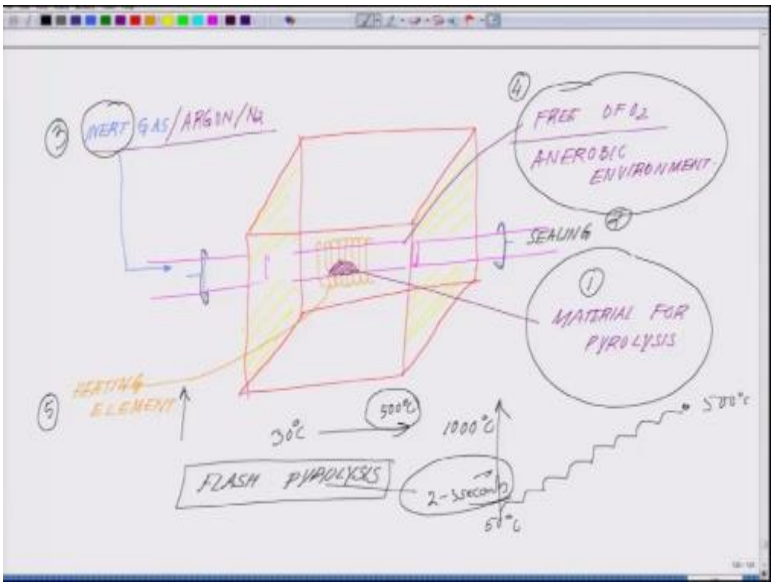

So it is something like this okay that will kind of help you to visualize how the structure looks like so the structure looks like this you have a box like this which is kind of the reactor so okay in that box you have a tube coming in from here it is actually runs through like this comes out so there is a tube inside from this wall like just shading the wall for an understanding from this wall 12 has gone okay now you have a source of inert gas which you purge it into the system and which ensures that this whole tube so you can seal the tube from both sides okay.

Now say for example you have a material which you need to pyrolyzed. So I am putting the material like this okay, so you left the material like this okay this is the material for pyrolysis okay and you have the inert gas in the form of argon or nitrogen you can use as inert gas so you are making this whole chamber free of oxygen so this is an anaerobic situation anaerobic environment okay.

So there is no oxygen out here and around this there is an heating element whose temperature you can control from outside so here is the heating element okay so what you do is you keep the sample step one so let me put this is the step one you get the material this is the material you want to biochar or carbonized or prior realized you seal the chamber from both sides this is step

two sealing the chamber point three you make the whole environment inert step 3 then once you are sure that this is this whole environment is free of oxygen then you switch on the heating element.

Now this heating element can take the temperature say all the way up two thousand from wherever you are starting for 30 degree or you know whatever be the temperature inside it now there are multiple ways you can raise the temperature you can do it in small step cycles 30, 40, 50, 60, 70, 80 likewise okay and whatever the temperature you set say for example you set a temperature that I want to reach 500 degree centigrade right yet that is called a slow pyrolysis you are raising the temperature slowly and you said that you once it reached the set temperature to stop there.

But there is another way you can raise the temperature from 30 to 500 you can reach like you know in few seconds two seconds look something like just imagine say for example all of a sudden there is a volcanic eruption and there are all the trees which are present there and the volcano the lava fallen in a fraction of a second the whole material the whole vegetation get converted into I mean charred millionth of a second.

So exactly similarly like that similar to that you can really jack up the temperature like shook instead of having the temperature curve like this say for example you are the stepwise temperature you are increasing okay you are reaching to this point say for example if this is a 50 degree centigrade this is 500 degree centigrade over period of multiple cycles you do it over say half an hour you go where you can actually reach it like this boom and say in two to three seconds okay.

Such processes where you are raising the temperature like soup like this is called slash pyrolysis and it has it is implications I will come so what if in control here is how the temperature so see for example slash hydrolysis you can understand or visualize it better if you think of all of a sudden there is a volcanic eruption and the molten magma or the lava falling and covering the vegetation in a fraction of a second and the whole vegetation because of that excruciating high temperature of the molten magma of the lava just get carbonized in like this.

So that is a flash photolysis sorry flash pyrolysis okay no flash pyrolysis has it is advantages so what is happening let us coming back out here as I was showing you this process.

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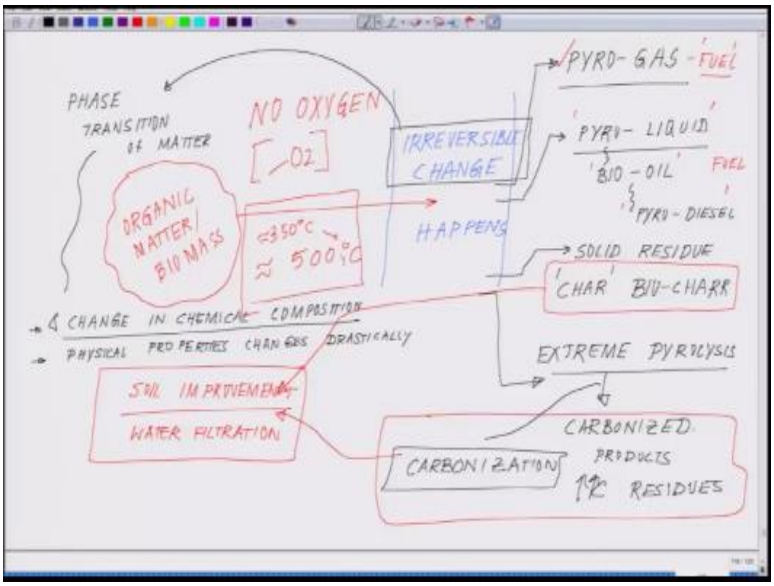

There is an irreversible change which is taking place I mentioned this right this irreversible change is nothing but a phase transition of matter okay phase transition of matter and not only to the phase transition there is a change or change in chemical composition okay there is an drastic change in chemical composition apart from it is physical properties also changes drastically or almost irreversibly changes drastically or almost irreversibly changes drastically.

Now this whole thing is a function of how you are raising the temperature it has been observed that several biomass when they undergo a flash pyrolysis like this they get transformed into liquid as well as gaseous will very fast without leaving behind much residues.

And these are some of the very interesting technique and even talking about pyrolysis itself if we talk about the whole pyrolysis process if you can think of how over the ages over centuries over million years and billion years, the coal and all other products are formed essentially what has happened if you think of it underneath the earth. So if we talk about through geological times.\

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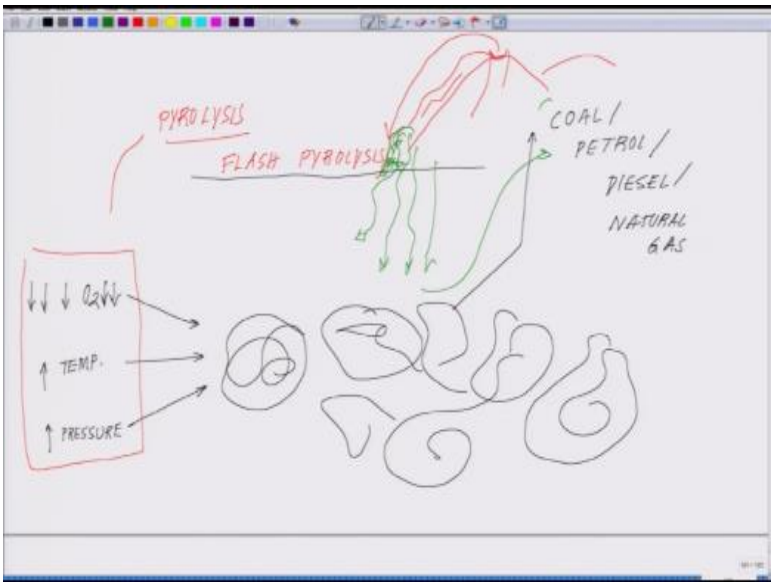

The trees so underneath the earth if this is the earth crust so over the years all the trees and vegetative matter has gone down you know through the ages and these biological organic matter in the absence of oxygen, because underneath the ground you will have very, very little oxygen or almost no oxygen and you will have higher temperature and you will have a higher pressure.

So under these conditions several of these things have got transformed over centuries to the products which we are enjoying today in the form of coal, in the form of patrol, in the form of diesel and even natural gas okay. Now try to draw a similarity within these conditions and what I just covered in pyrolysis it is pretty much the same or even more even flash pyrolysis okay why through the ages, you know I have these mountains and the magma is coming through you know through volcanic eruptions okay.

These have transformed the series of vegetations which are growing there and eventually all these things got went down through the geological leaders and get transformed into what we call these kind of products. Now as I was mentioning the last class so this is a big challenge, because now all these things have has happened over centuries and now we want to emulate that in a short span of time which is the real crux of the challenge.

So this is the basic fundamental pyrolysis what I wanted you people to understand. So we will follow up on pyrolysis after this about how the pyrolysis process leads to formation of liquid fills, gaseous well and what are the challenges, and what are the efficiency rate with which challenge but the take-home message is that visualize the pyrolysis process in a laboratory condition the way I explained you and try to visualize.

How the pyrolysis must have taken place through centuries underneath the earth crust we are in high pressure, high temperature and lack of oxygen many things have got transformed into the product which we are enjoying today. So in the next class will follow up on pyrolysis and we will move on to the other gasification liquefaction technique thank you.

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