Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Bioenergy

Lecture – 22
Factors Determining the Conversion Process- III

By
Prof. Mainak Das
Biological Sciences & Bioengineering &
Design Programme
IIT Kanpur

Welcome back to the lecture series and by energy. So in the last class we talked about the volatile matter and the fixed carbon so, today what we will do we will talk about the ash and the residue levels followed by the alkali metals which are present in it and what are their implications.

So again lets in the slide look at what are the points we have covered in terms of the material property so, we have talked about the moisture content, we have talked about the calorific value, we talked about the proportion of fixed carbons and the volatile and this is where we have talked about the van curb lane diagram and everything.

Now today what we will do, we will talk about this ash and the CU content and followed by the alkali metal content okay. So this is what we are going to do today, so before as we do in every class to start off with, I will try to explain what I am going to jot down as the notes so, when we talk about ash or the residue what we meant?

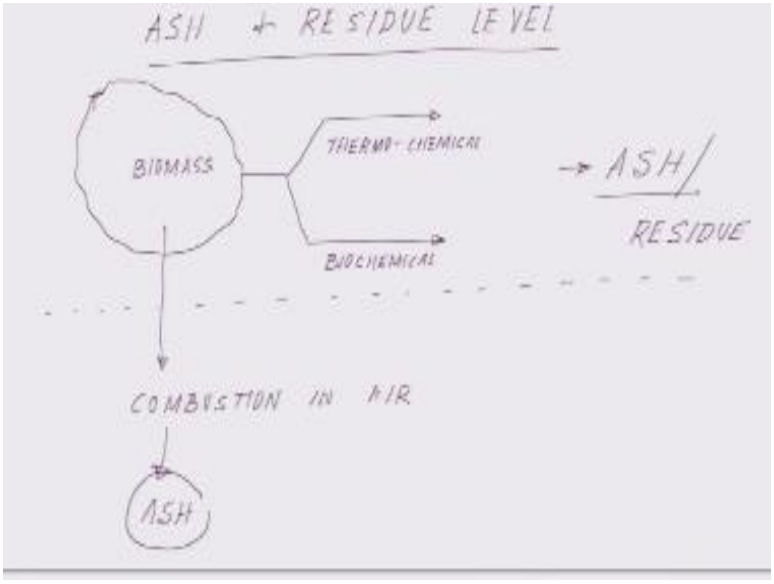
So say for example, you take a piece of paper, you take a piece of paper and you burn it so what you get is black colored ash kind of stuff okay. Now take the same piece of paper and treat it with the same nitric acid or put it in some water what you do get will be something else? So depending on how you are treating the biomass so here I am considering the paper of the biomass depending on how you are treating the biomass your end product will be different okay.

So there is a distinction between ash content or the residue what are that will be distinguished otherwise many a times what happen we kind of you know confuse between both of them but in this lecture we will clarify what is the ash content, and what is the residue content and where these two words have started okay.

So to start with so today lecture will be on ash flash residue leave okay. Now talking about ash basically the way it works is the chemical breakdown of bio fuels by either thermo chemical or biochemical processes produce on soil residue okay. So say for example, you have something like this is your biomass what has to be processed okay, now you have two routes either you convert it and we will be talking depth about all these things do not get worried either you have a thermo chemical route of conversion or you have biochemical route of conversion.

So based on that what we produce are after all this conversion, what we land up is we land up with a series of residual masses and these residual masses are the one which is termed as ash okay or residue. Now why it is called ash or residue this is where I am going to come, so if I say for example, when you are burning something in air. So this is one aspect if you have to so now if for example you take the biomass okay and the combustion in air here and this residue what you get because of the combustion is called ash okay.

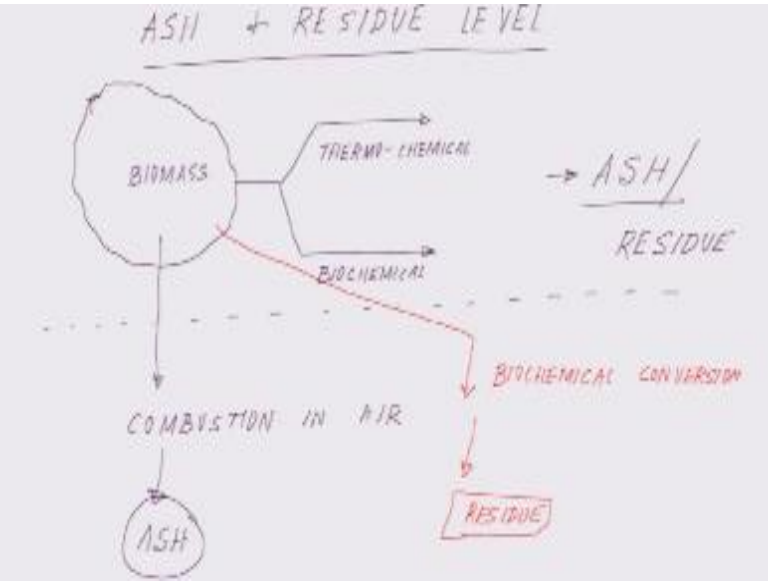
(Refer Slide Time: 04:51)



So this is exactly the same thing when I told you. You are a piece of paper and you burn it in the presence of air you get all that black cheering left behind that is your ash content okay, s o the next thing going back again to the slide. Now if you convert it instead of doing this route. When you convert in the biochemical routes okay.

During biochemical conversion, the biochemical conversation could be in several ways this biochemical conversion leads to the percentage of the solid residue which you get out of it falls under what we call our soliciting okay and generally.

(Refer Slide Time: 05:52)



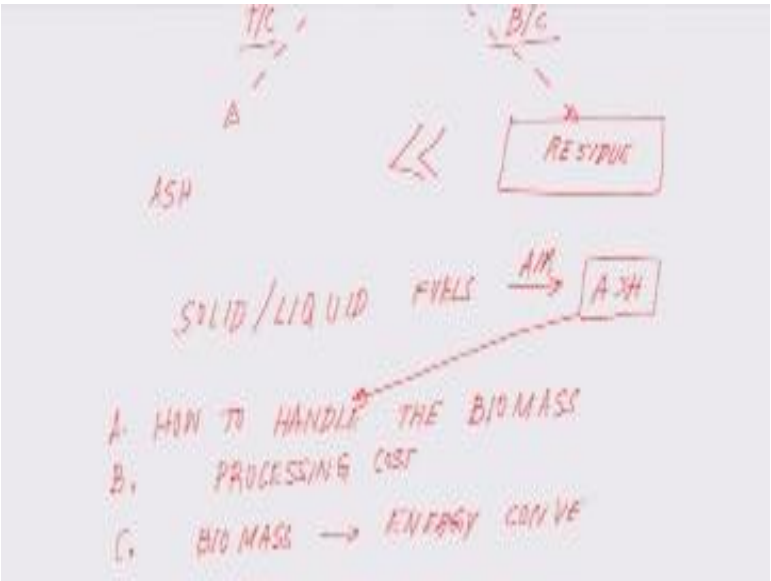
If you see for the same material say for example, if the same material and you follow one route to convert it into ash and you follow another route to convert it into residue, this is by the biochemical route and this is by the thermo chemical. TC represent thermo chemical route and this is the bio chemical route.

You will always see during biochemical conversion the percentage of solid waste or solid residue will be greater than the ash content, This is critical so, always remember this will be far greater the residue content ok. So when produced by combustion in air the solid residue is called ash and forms standard measurement parameters for solid and liquid fuels. So for any kind of solid or liquid fuels when these are burnt in air is called ash okay.

The ash content of the biomass affects both handling, this ash content decides how we are going to handle the biomass and its processing costs so, there are three parameters it besides one how to handle the biomass because if you have a lot of ash content which is not good so you may need to follow a different route, how to handle the biomass in terms of its conversion okay.

Step one the second parameter what it decides is what will be the processing costs, which will be involved in it and third an important parameter, what it will be decided is bio mass to energy conversion efficiency okay.

(Refer Slide Time: 08:11)

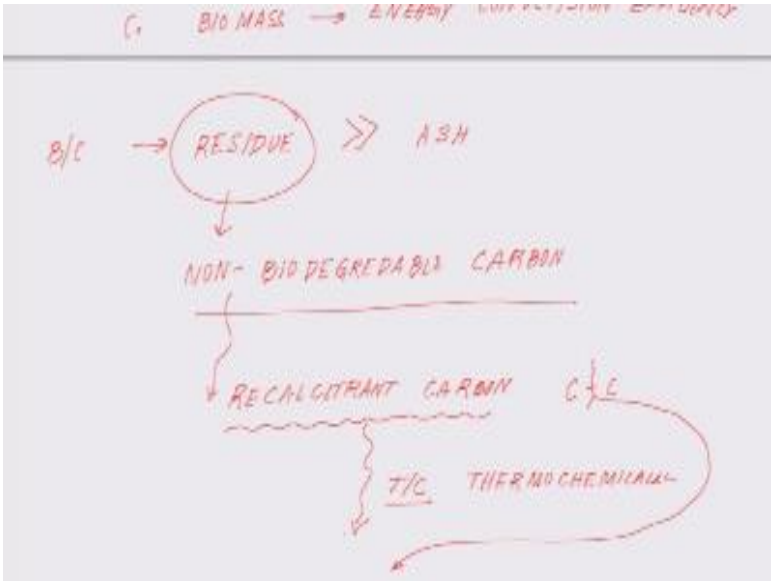


These are the three important things efficiently, which will be dictated by depending on the ash content okay. Now for a biochemical conversion process the solid residue represents our non biodegradable carbon present in the biomass, this residue will be always greater than ash content we have already talked about it okay.

So residue which is generated from the biochemical conversion is far greater than the ash content okay that we have already and this part the residue which is left behind is a non biodegradable product okay. This is the non biodegradable carbon which is present here, after whatever has been derived out of it okay. This residue will be greater than the ash content and because it represent essentially, what it is representing is the recalcitrant carbon which cannot be degraded further biologically but could we burn during thermo chemical conversion.

So whatever you are getting as the residue is basically called recalcitrant carbon and this could be further this material could be further thermo chemically. So TC just remembers that this is the thermo chemical conversion and talking about thermo chemically. You can derive so this is carbon, so that brings you to different kind of so you can again break this bond as I was trying to tell you through thermo chemical drought and you can use this energy.

(Refer Slide Time: 10:10)



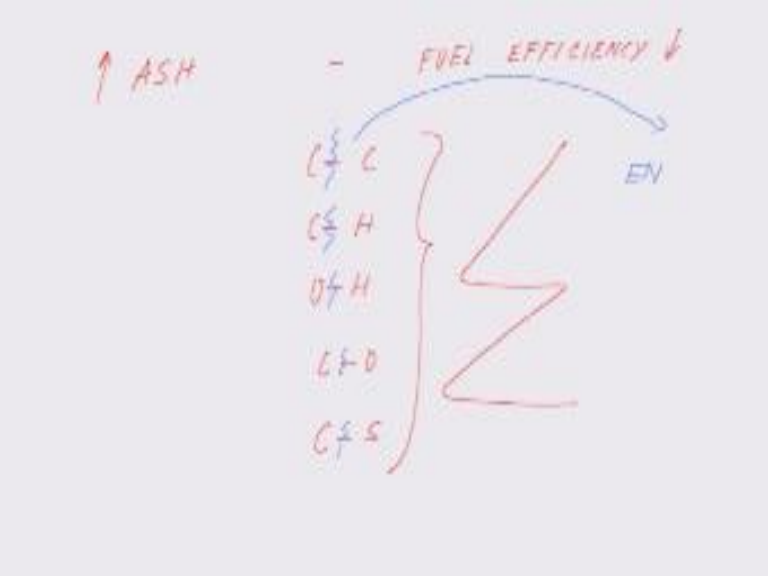
So if you look at the whole process, each one of them is complementing each other. There are certain things which are selected because of their water content. They are preferred that they should be by chemically converted because again let us take example of algae, when you bring the algae from water, it has lot of water content.

Now to remove the water content and that takes a lot of energy to evaporate the water instead if you do a biochemical conversion to that you derive the useful things till you are left with a huge amount of residue, that residue will be devoid of water right. So that particular residue can be further used for utilization for energy product by thermo chemical conversion.

So you are realizing that there are several ways were both these techniques to it complement each other okay. Now coming back what are the some of the challenges what you will face with the ash content and if the ash content is higher, what happens okay? So dependent on the magnitude of the ash content the available energy of the fuel is reduced proportionately, so say for example your ash content is up so to automatically your fuel efficiency will be low.

Why is it so think of it so if you go back the previous class I gave you a very interesting way to look into the matter you have carbon, carbon bond you have carbon hydrogen bond, you have oxygen carbon bond. So again try to go back to that diagram huh, so it is something like that you have carbon, carbon hydrogen, oxygen hydrogen yeah carbon oxygen yes carbon sulfur and liquid.

(Refer Slide Time: 12:20)



There are so many bonds so I told you it is basically the summation of all these bond energies which is being given out, so if you are breaking this bond, breaking this bond, breaking the bond, breaking this bond which using derived as your energy output okay. Now here is the catch, I told you the question what I posed in front of you was that if the ash content is higher the fuel efficiency will be lower? What does that mean actually?

It means there are several such bonds out here, out here, out here somewhere which is not broken and the bonds which are not broken either takes the form of ash or in the form of residue. So essentially in order to break those residual bonds you have to give more energy into the system okay. So it means you put more thermo chemical some energy into it then you break them down.

So if for a finite amount of matter your ash content is higher, the ash content is high okay that means the amount of energy which will be derived from it will be lower. In other word for per unit matter or say in terms of gram kilogram tons whatever you unit you use the amount of energy which should be coming out of would be lesser as compared to energy-efficient material where the energy will be higher and ash content will be less.

So overall if you have to think you just have to think of a material which is bound by atoms. Atoms are attached to each other by n number of bonds you are breaking the bond by providing energy. The energy could be provided in two three different ways; one way you put thermal energy, thermo chemical energy or you can do are mostly hydrolysis processes which are done in terms of fermentation or biochemical routes.

So what these are doing or you can do even an enzymatic digestion where you are enzymes are going in a chopping of the bonds between those atoms and the energy which is liberated out of it is being fed or stored or being used as a form of energy okay.

So if any of these processes fails to derive maximum energy out of it in other word that is left behind as ash or residue. So that is what I am trying to tell you if your ash percentage is higher it means the fuel efficiency of that particular material is lower. So one needs to go for ensuring the maximum amount of that material is either burnt out or dissolute in biochemical conversion process.

The more they dissolve the residue percentage is going to go down the more it burned the ash percentage is going to go down and the more energy will be liberated out of it okay. So putting this concept together dependent on the magnitude of the ash contained the available energy of the fuel reduce proportionately in thermo chemical conversion process.

The chemical composition of ash can present significant operational problems, so ash and its problem okay. So what happens is that mean especially, when you are doing some thermo chemical process thermo chemical conversion and if the ash content is fairly high think of a case study where the ash contained is fairly high? There are certain operational problem and what are the operational problems you are going to face operational problems.

So the operational problems are something like this. During the combustion ash can react and form something like a slag or a liquid phase reacts to form a slag and block the processes. So what happens when there is a thermo chemical processes, some of this ash combined together with other reactants and form something called a slag okay and these slag what is form the kind of in a reactor the kind of deposit and those depositions are not at all helpful, they block all this so whenever we talk about the mode the concentration of ash.

So takes its say for example, if you think of a situation car exhaust pipe so the residual you have seen the car exhaust or a scooter exhaust or something you see and that exhaust there are a lot of such carbon getting deposited okay. Which is basically an unburned process which is essentially what we call as ash or residue which is over way depending on if it is a fuel cell coming from fuel cell whatever okay.

So now those depositions will eventually choke that pipe okay so, that is exactly what happens what we talked about operational problems. So suppose you have a reactor where you are doing the thermo chemical conversion. Now there is a lot of ash which is formed so ash will be mixed up with other ingredients in that reactor and it will block the nozzle sauce that come a reactor okay.

So these are the kind of operational problems which are faced by people, when they are converting a material which produces a lot of ash. So that is very critical when you pick up the material you have already done your due diligence by going through its conversion process how much ash it will produce and you may have to realign the reactor, realign the thermo chemical converter. In such a way that it could handle this high ash concentration and it does not clog the

different orifices and different pipes and different outlets and different inlets of that whole reactor okay.

So this is very very critical, so next in the same line after we have talked about ash just put it together so ash is when you are doing air combustion. Residues are the ones which are formed because of bio chemical or fermentation reactor or basically you can call it a wet chemical process of converting a biomass into some form of energy okay.

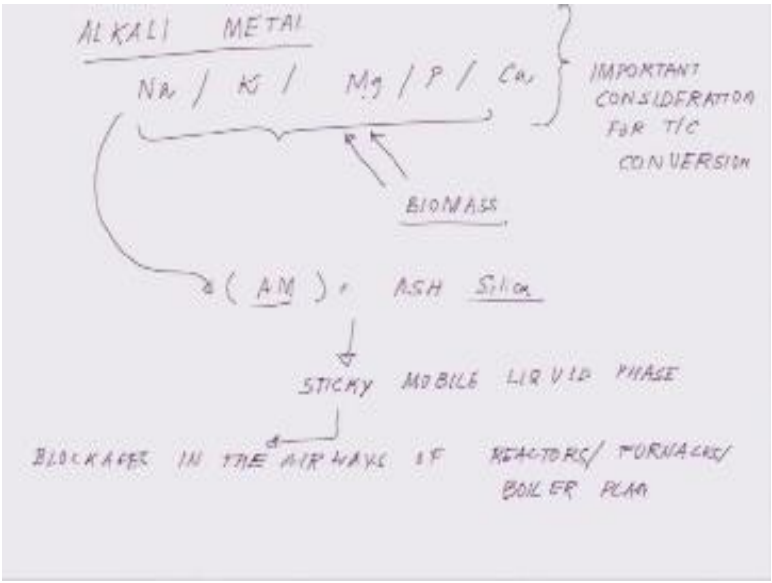
These are the two clear-cut distinction what we meant by residue and what we meant by ash?
Now what we will do from here we will come to ash content out here. So one percent, four percent likewise okay. So if you look at it though we just draw has lesser moisture with her but it has higher ash content okay as compared to the wood and if you go little up. So now what we will move on to is the alkali metal content okay.

So coming to the alkali metal content now so whenever we talk about the percentage of alkali metals, so biomass is coming from all different kind of biological sources so they have all sorts of elements present in them but the alkaline metals are of so major significance for operational reasons. So the most of the alkali metals what we are what are present in nature are sodium, potassium, magnesium, phosphorus, calcium, you have sulfurous residue likewise.

So these have very important consideration for thermo chemical conversion process okay. You have important consideration for thermo chemical conversion. Why is it so? So these are all kind of you know coming from different kind of biomass sources, because these mixed up with ash what we talked about just contains lot of silica or silicon ok. So these alkali metals AM and just putting am as alkali metals, alkali metals mixed with the silica present in the ash and they form something like a sticky mobile liquid phase okay.

Sticky mobile liquid phase and this sticky mobile liquid phase are other operational hazards because they created blockages in the airways of reactors furnaces and boilers reactors, furnaces and boiler plant okay.

(Refer Slide Time: 22:14)



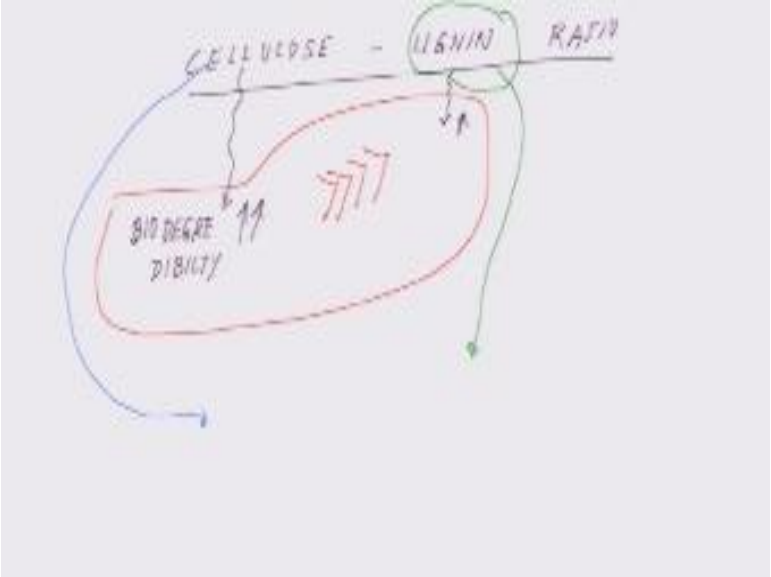
So talking about this silica this is another interesting thing which I did not cover in the ash pod until you silica is present intrinsically in most of the plants. There is an intrinsic level of silica it is a structural elements and it is present there along the carbohydrate chains somewhere and it kind of helps in the binding and gives it strength but at times that silica also come in heavy amount from the soil where the plants are being too right say for example, you are deriving an energy crop from a location where there is a huge concentration of silica in the soil.

So that silica is being coming as an extra, so intrinsic silica and you have an extrinsic silica okay. So that silica which is coming as an extra creates a lot of problem in terms of clogging the boiler plant because that silica which is coming extrinsically is mixing heavily with those alkali metals and create a lot of problems okay.

Now this is what is significant for us to know about the alkali metals problems. So now coming to the last of this point which we have already talked about we will just briefly touch upon Cellulose Lignin Ratio. Earlier we have talked about it but we will just the closing would. So if you look at it in terms of the biodegradability cellulose has a very high biodegradability okay.

Take the bullet you whereas this has a low by degrees ability as compared to if you compare these two. In terms of the biodegradability this one is much much higher than the lignin fraction okay. So cellulose could be directly converted into several kinds of products like you know, you can convert it in ethanol and several things but if we have really good technologies where you can convert the lignin, because lignin content represent a potentially large energy source. Why is it so think of it again?

(Refer Slide Time: 24:52)

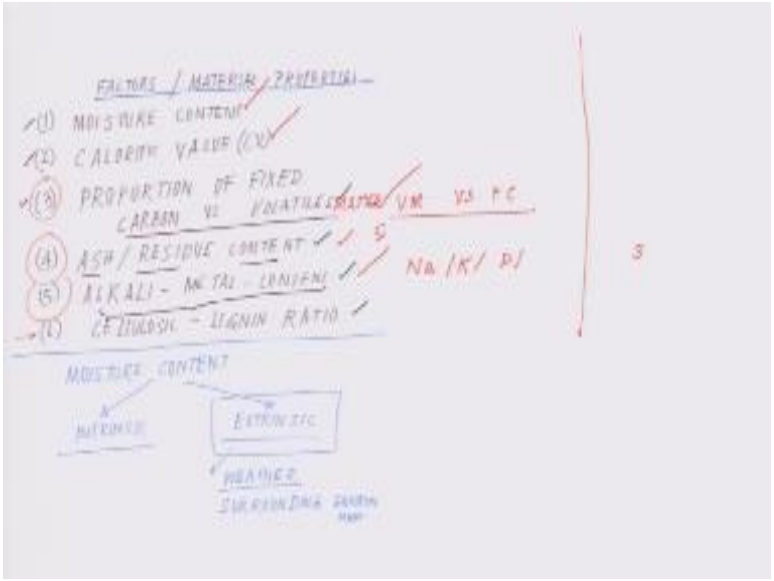


I told you that whenever we are converting something either the end product will be ash or residues so whenever we convert the plant or plant biomass we are left with a lot of lignin. So essentially we are unable to break the bonds in the lignin molecules right, so those born energies we fail to tap if somewhere or other but some technique we could tap those lignin molecules and break their bonding.

We can derive a huge amount of energy from it and as a matter of fact that is one of the big challenge how really to degrade because there is huge amount of lignin, which is there and it is really really high in energy content. It is just you have to find out a cheaper route by which your energy input here which should be loop E stands for the energy input.

Your energy input should be low and you should be able to derive the bond energy out of it okay. Derive energy out of it and lignin potentially represent a large energy source but challenges how to hydrolyze or hydrometic route to from lignin to zinc gas okay. We will talk later about the zinc gas and everything just tapping this energy in the form of zinc gas okay.

(Refer Slide Time: 27:18)



So that brings us to the list what we made in the beginning the basic parameters what are important? So the moisture content calorific value, proportion of fixed carbon versus volatile matters just added volatile matters VM versus fixed carbon FC, ash flash residue content, alkali metal content, sodium potassium, phosphorus yep sulfur content and you have here silica and everything and last the scissors to lignin ratio.

So whenever you get a material the first and foremost thing any bio material or any biomass is to evaluate these six parameters based on these six parameters one decides what kind of conversion strategy can be followed, which is our next class where we will be entering into all the conversion strategies depending on.

So this is the most fundamental just like as we did in photosynthesis the basic fundamental this is the move basic fundamental one has to understand these are simple parameters moisture content, calorific value proportion of fixed Cardinal versus volatile, ash residue, alkali metals, cellulose the lignin ratio but unless otherwise you have the knowledge of these and you optimize that which conversion efficiency or conversion procedure will be the best you will do mistake okay.

So read through this thoroughly and make a chart in your mind map or a kind of rain chart that these are the parameters which I always have to look any any material it could be bananas the peels of the banana too use of oranges, lemon it could be some debris but these parameters will remain constant okay. I will close in here and the next class will be starting with the conversion technologies which are based on these parameters. Thank you.

Acknowledgement

Ministry of Human Resource & Development

Prof. Satyaki Roy

Co-ordinator, NPTEL IIT Kanpur

NPTEL Team

Sanjay Pal

Ashish Singh

Badal Pradhan

Tapobrata Das

Ram Chandra

Dilip Tripathi

Manoj Shrivastava

Padam Shukla

Sanjay Mishra

Shubham Rawat

Shikha Gupta

K. K. Mishra

Aradhana Singh

Sweta

Ashutosh Gairola

Dilip Katiyar

Sharwan

Hari Ram

Bhadra Rao

Puneet Kumar Bajpai

Lalty Dutta

Ajay Kanaujia

Shivendra Kumar Tiwari

an IIT Kanpur Production