Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Bioenergy

Lecture -21
Factors Determining The Conversion Process-II

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Welcome back to the lecture series in bio energy, so in the last class we talked about the calorific value. So just to recollect coming back to the slide to remember the slide where we dealt with,

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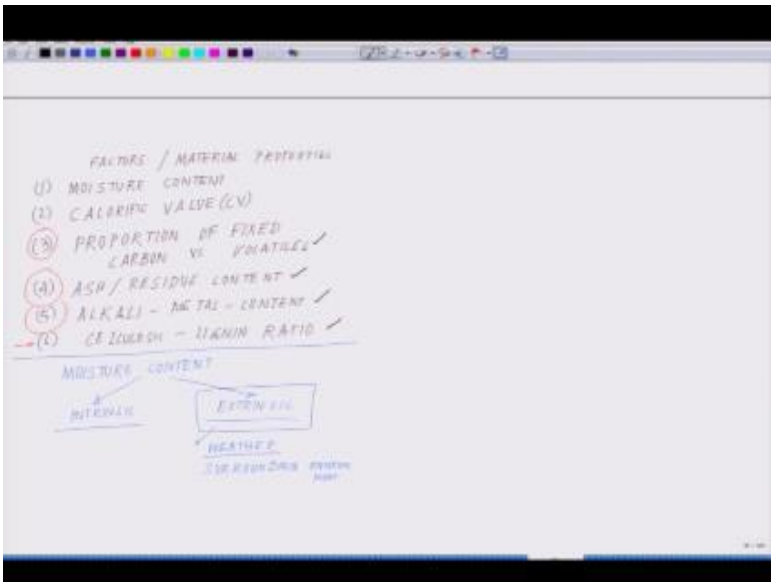

So we are supposed to talk about the moisture content so these are all the material properties what we will be dealing with calorific value which we have done. Then we are supposed to talk about the proportion of fixed carbon versus the volatiles point ash / residue content so there is something very interesting in that and then followed by the alkali metal content and last which will be partly a repetition of the cellulosic

and lignin ratio. So what we will do today is we will start with the proportion of six carbon and volatile okay.

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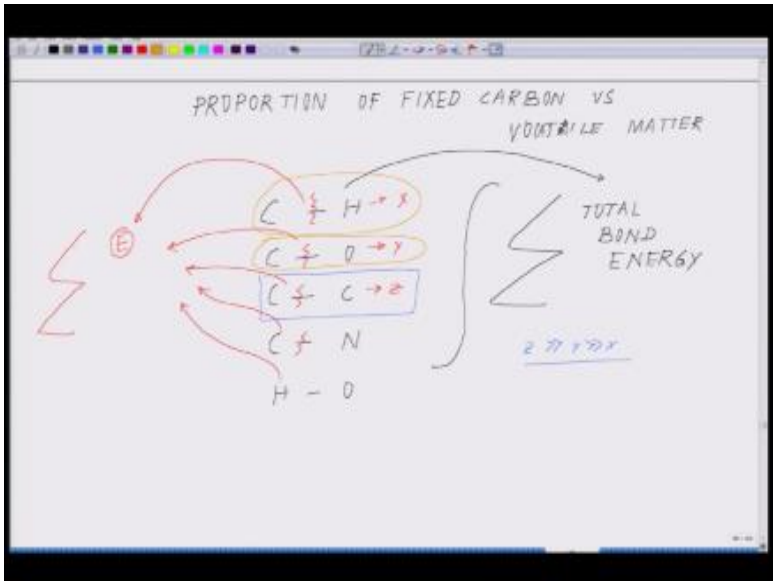

So this is what we are going to start of it proportion of fixed carbon versus whole lot once and volatile matters okay. So as we do in every class in the beginning I will put forward the concept for you and then we will kind of you know pulled out or the nodes which will help you. So talking about any matter of course here we are talking about the biomass or the material of biological origin they are mostly consists of from handful of elements the key ones are carbon, hydrogen, oxygen, and if it terms of proteins then you will have nitrogen, elaborate series of sulfur and bunch of alkali metals which include sodium calcium magnesium like this one and so forth okay.

Now each one of these form different kind of bonds with each other there will be carbon, carbon bond there will be carbon hydrogen bond really carbon oxygen bond there the oxygen hydrogen bond likewise there will be series of such bond. Similarly with all the different alkali metals and everything now what actually determines which material will get transformed into a good fuel it is determined by the summation of all the bond energies okay. So just for your understanding sake so if we talk about you have a bunch of carbons out here okay so carbon is forming bond with a hydrogen carbon is forming bond with oxygen carbon is forming born with carbon okay.

We carbon is forming bond with nitrogen and similarly hydrogen is forming board with oxygen so on and so forth. Now what we essentially do so we will have to integrate or we will have to submit these things in terms of the total bond energy okay. So those of you who remember during class standard 9th or 10th we used to do an experiment like bomb calorimeter where we use to measure these kinds of values. So very similar to that what you are actually measuring all these different bonds which are forming any kind of matter what is that total bond energy because what will happen is when you will be breaking these balls.

Say for example you are breaking their fault you are baking this ball you are breaking respond huh so these bonds will be generating a certain amount of energy and for in material the total energy is again it will be a summation of these different kind of energies which will be coming out from the bond breaking. So now if you can categorize all these things so say for example this has certain for energy value okay. Say some X joule okay, this one will affect y joule The Joule depending on which energy out here is maximum. So proportionately if say for example I say that this material has a lot of carbon-carbon bonds and if I say that carbon, carbon bond has the highest energy.

Say for example Z is the maximum has compared to Y or likewise huh x just for your understanding say so when I will be converting this by bio chemical, or thermo chemical route the amount of energy which will be liberated from that material will be higher as compared to if you compare again getting back to the chart. If you compare with say this one or this one so this kind of gives you an idea that why it is very important. That we understand what is the fixed carbon which is present there because the other forms of carbon may suppose you burn something in the presence of here what will happen carbon will form carbon dioxide.

Yet there will be certain carbons which will remain there intact and similarly the water will form vapor or there may be hydrogen, and oxygen they may vaporize out okay which are trapped in waiting and the hydrogen bond will beget broken down. So whenever we take matters we had to do an analysis where first of all you have to figure out what is the volatile matter present in it okay. After that what is left behind is the carbon material, and from the air one can estimate what will be the energy which will be derived out of it. So after giving you this brief kind of graphical outline now I will jot down the points which are critical for you people to understand.

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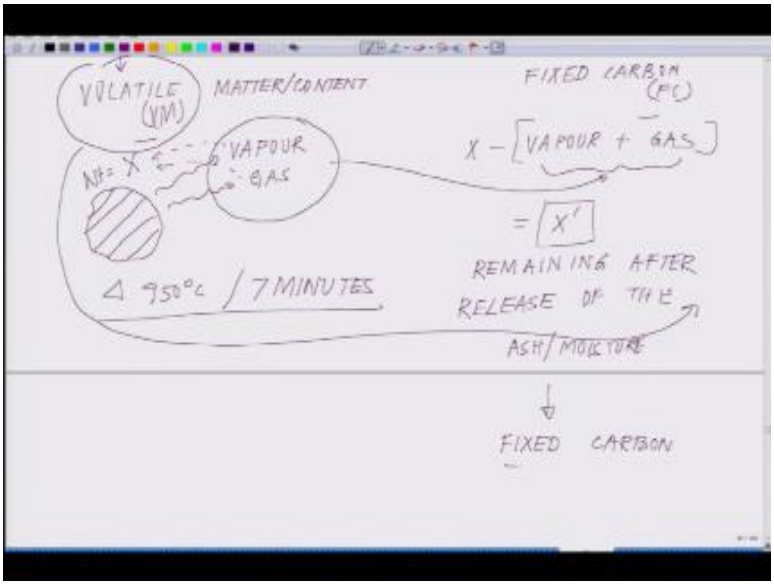

What does this mean okay, so in terms of if we go by the in terms of the full analysis if we talk about one second okay we talked about the full analysis have been developed based on solid soils okay has been have been developed based on solid fuels such as coal okay. Which consists of kinetic chemical energy in storing two forms okay so I have already talked to you about the chemical energy how they are stowed okay and now I will tell you what are the two forms okay so the two forms of chemical energy to form of chemical energy stored in such materials I am just putting E for the energy okay one is what we have discussed volatile matter or volatile content sometime it is also called as volatile content okay.

And other one is our sixth carbon which is denoted by f c SC whereas volatile matter is denoted by V M okay. So if you come across these things do not get confused okay so volatile content or matter of a solid fuel is the is that portion of, of the matter which portion which is driven off as gas including moisture okay. So suppose you take material like this and this material is you are burning it at 950°C for seven minutes okay. So this is kind of what has been said this is the material now after exposing it to that what is driven off out of it will be vapor and fill other gas or gas vapor whatever you know so. Whatever so say for example you take this raw material which has certain say for example certain weight is equal to say X.

So the volatile matter is these are the thing which has gone out of it okay. Now x includes when we talk about the weight x it improved the presence of the vapor material and the gas and all those things we get transformed okay. Now talking about the fixed carbon is after this so after X minus yep vapor weight of

the vapor minus foot of the gas okay. So this is all together what is coming out from here whatsoever is left behind this is the X prime this is the remaining after the release of the volatile this is the remaining after release of the volatile after of this volatile markers.

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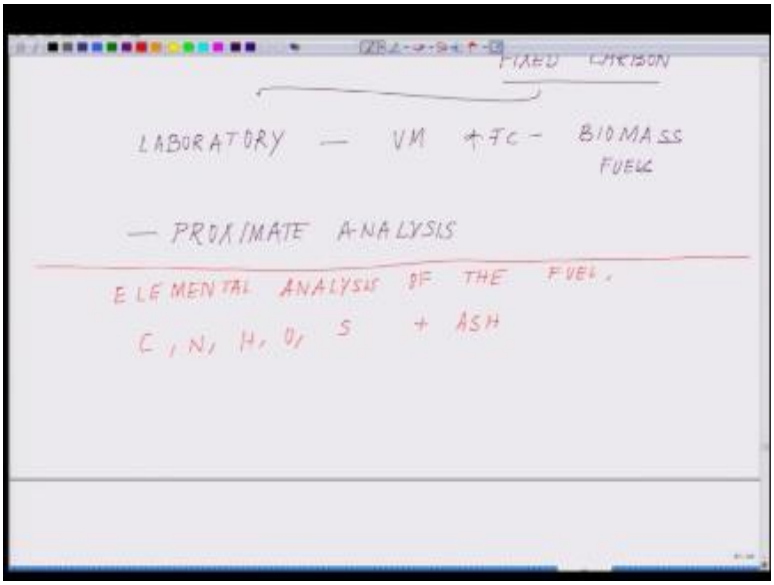

Which is which includes of course which includes ash / moisture okay this is these are the ones which are being evaporated out so whatever is left behind this is what we call as the fixed cargo and having said this I want to draw your attention to the first drawing. What I was doing where I showed you carbon-carbon bond carbon, hydrogen bond, carbon oxygen bond that six carbon what you see is the one which are left with carbon, carbon which is the real core that fixed carbon if you can break those bonds that will generate if you could the amount of energy will be fairly high so for any material your carbon, carbon is higher.

Then you can be rest assured it will be generating more energy provided you have the technology to break those bonds without spending a lot of energy okay. So to keep that in mind so coming back to the slide from this from here so this is the fixed carbon we'll talk about so whenever you do a laboratory test okay so these are being tried in the laboratory as I was telling you there is different kind of kilometers which does that are used to determine the VM an erase the content of the biomass fuel so what we do basically for the full analysis is based upon the VM content ash and moisture with the FC determined by the difference in terms of proximate analysis.

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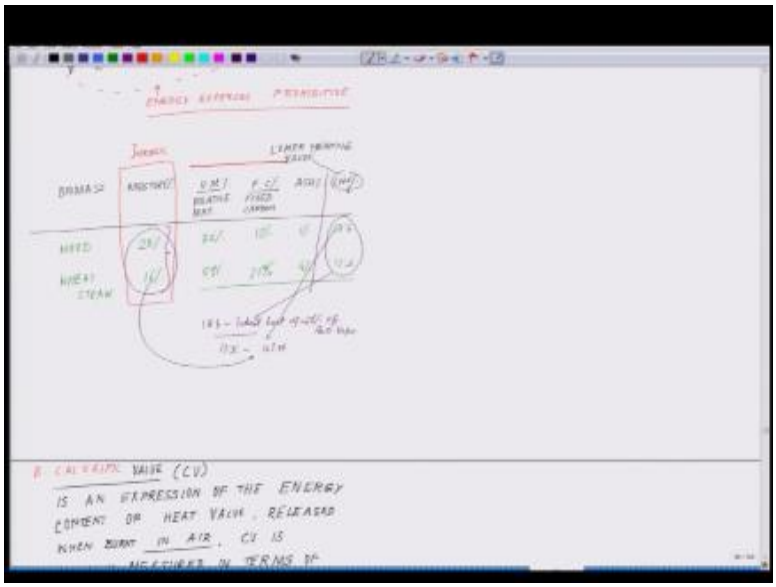

So there is one word which will come across which is called the proximate analysis this proximate analysis is very critical. So if you go back now where I showed you one of the tables which I give you in the very beginning out here so this is the table which is now is important for you to look at this value volatile mass percentage and fix carbon percentage if you look at it the values so that is why that tables when I drew this table I told you that this table will come very handy once we will kind of go through all the material properties.

So if you can see again looking careful into the table you will see but this is the amount which is lost and what is left behind will come next to this the ash content okay. So before we come into this there is a couple of very interesting aspects which I wish to discuss with you total okay. So that is basically the proximate analysis apart from it there is another thing which is being done out when we talk about the fixed carbon and the volatile mass that is called the elemental analysis of the fool elemental analysis of the fuel or of oil whichever way you want to tell it.

And it is presented as carbon, nitrogen content hydrogen content, oxygen content and sulfur together with plus the ash content in terms of the ultimate analysis of a field. So having said this I again wish to draw your attention to that first table I showed you where I showed you carbon, carbon, carbon hydrogen, m hydrogen, oxygen, carbon, sulfur likewise. So what you are essentially doing so you have a matter you do a complete elemental analysis what is the amount of carbon what is the amount of nitrogen what is the

amount of oxygen what is the amount of hydrogen based on that you try to draw the chart how much is the linkage between carbon, carbon how much is the linkage between carbon hydrogen,

How much is the linkage between hydrogen oxygen based on that you draw a very interesting chart and that is where we are now slowly so once you know the elemental analysis elemental analysis is generally done I can burn the stuff and you estimate after a complete burning charring rather you estimate the carbon estimate the elemental carbon you estimate the nitrogen with dell, dell process which is all trashes you estimate the hydrogen oxygen like when so and so forth.

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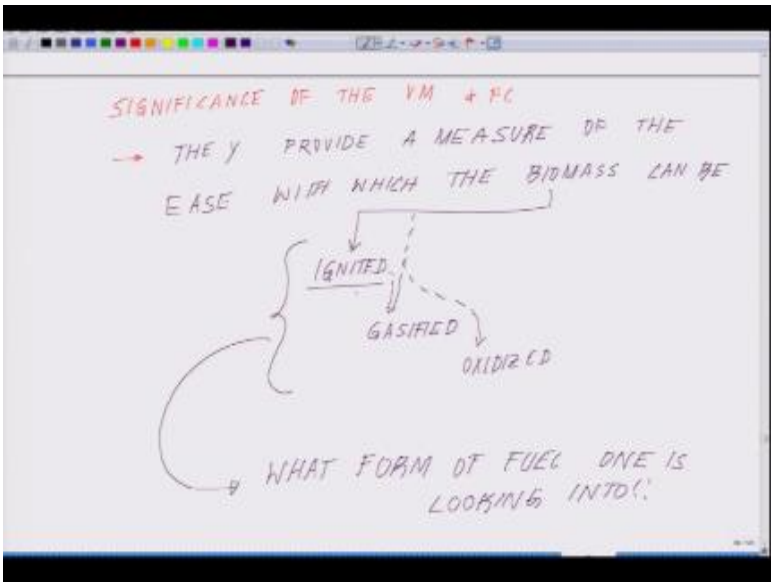

And there are other spectroscopic technique modern techniques where you can estimate them much more easily instead of following the old technique but these are overall techniques where you do an elemental analysis. So after you do an elemental analysis what next what is being done is the before I get back to elemental analysis and the van crave line diagram significance of the volatile mass and fixed carbon content.

So they provide a measure of the ease with which the biomass can make nitin and subsequently gasified they provide a measure of the ease with which the biomass can be ignited by mass can be my mass can be ignited this is very important and subsequently it could be gasified.

These are the different transformation okay yes if I would or it could be oxidized depending on how the biomass it utilized as energy source this all will eventually will be determined based on what form of will you are looking into one is looking into. What does this mean this essentially means that depending on the carbon, hydrogen, oxygen, nitrogen, sulphur ratio and the water content what we talked at the first point interest with water extremely quarter one decides what kind of transformation should be followed.

Shall we follow by chemical methodology by fermentation or shall we followed by a chemical free thermo chemical mechanisms or some other mechanism what form of fool do you want do you want solid food do you want liquid fuel do you on gashes will so it all depends there are three parameters what is the product what we want and what is the methodology will use these are governed by these material properties now from here I will come back to where I just left you about that elemental analysis.

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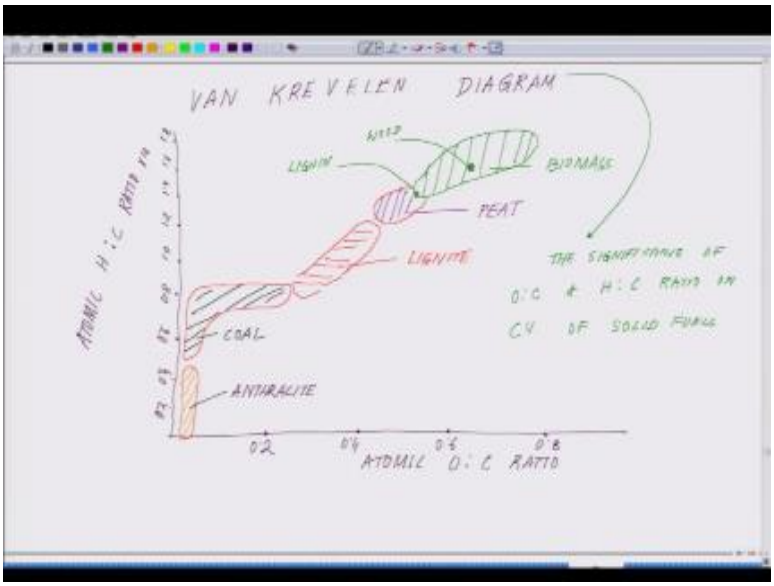

So there is a very interesting aspect so which is called the concept of Van Krevelen diagram Van Krevelen diagram what is in Van Krevelen diagram so I will draw 1-1 crippling diagram here for you people which you kind of the diagram itself is self-explanatory so you have on the y axis you have atomic h is to carbon hydrogen to carbon ratio 10 and on the x-axis you have atomic oxygen to carbon ratio and let me just two different points one minute okay. Now write down 0.24 0.6 0.8on, on the other scale hydrogen to carbon scale we have 0.2 0.4 0.6 0.8 11.2 1.4 1.6 1.8. Now if you look at it so here I will give

you a little bit of a tough to do I will be drawing few cylindrical shaped stuff and allow explained what does those me okay.

Now from here there is a third thing which will and then you have forced stuff which horse around here and then you have I'm just changing the color you realize what is the significance of it okay. Now what these different cylinders represents so this first cell first cylinder which is now I am putting the headlines with orange this represents anthracite I will request you people just go online and figure out what is anthracite okay.

These are different kind of tools second one which all of you know I am catching it in black this is Cole indicated by the color third one I am putting the red hatching here this represents like nine. So please look what is lignite this is your kind of an assignment take home assignment then next what you have is the pit which I am now putting together fit and the last which is in green out here is the biomass and within the biomass this is the zone where your wood.

And somewhere out here you have lignin so if you look at the so this is. Basically what land crippling diagram tells you it tells you the significance of significance of oxygen to carbon and hydrogen to carbon ratio on TV the calorific value of solid fuels okay and comparison of so do a comparison between fossil fuel versus biofuels. You will observe that there is clearly there is a higher proportion of oxygen to hydrogen if you look at this diagram carefully oxygen to hydrogen ratio as compared to carbon.

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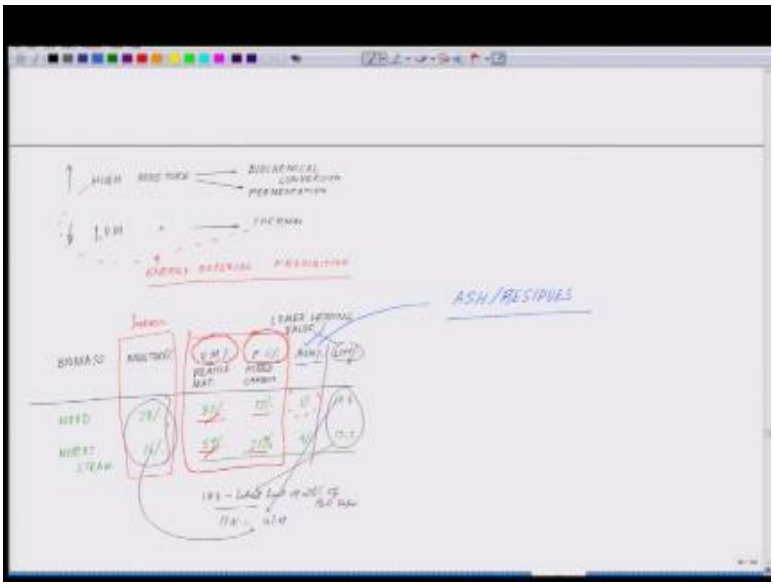

Thus reducing the energy value of these fools okay so as I have already told you it is mostly on the carbon-carbon where most of these energies are stored and most of these fuel analysis is the value of the biological conversion process. If we know like for example what does that mean is that these ratios decides what kind of technology has to be used for their conversion. If I know what is the carbon hydrogen or hydrogen carbon or oxygen to carbon ratio. One can make a call that this kind of conversion will be helpful or the other kind of conversion will be helpful this diagram in getting back to the diagram.

This diagram I wish should really critically look very, very carefully this diagram is kind of a taking call it of sort of a snapshot of any material what you are looking at that how really to evaluate where it stands with respect to traditional to is like coal and other schools which also solid but of course this is for the solid fuels as I have mentioned very clearly this is exclusively for the solid fuels okay. So this is what we have talked about today above the fixed carbon and volatile carbon after this what we will do coming back to the point.

So it is still now we have not talked about this part the ash, ash and so are adding one more thing as / or residues. So what we will do next we will talk about the ash/ this video so today we are closing at this point please go through the rank rev length diagram and whenever you have confusion about anything the best way to visualize this whole problem as I told in the beginning always look for how many carbon-carbon bonds are there.

How many carbon hydrogen bonds are there how many hydrogen oxygen bonds are there how many oxygen, oxygen bonds are there and just go to any standard textbook of chemistry or your high school chemistry or class a standard eight standard nine look at the values of those bonds those values will give you one indirect measure about how much energy will be able to derive out of it okay so it is a very straightforward deal but you have to put your logics in place okay. So thank you and please figure out what is fit what is enter site what is lignite that as you take home assignment thank you.

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