Renewable Energy Engineering Solar Wind and Biomass Energy Systems

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Lecture - 18

Properties and Structural Components of Biomass

Good morning everyone and welcome to part 2 of lecture 2 under module 6. If you recollect our discussion in the previous lecture we discuss about the characteristics of biomass how the characteristics of the biomass affect the properties of biofuel or you can say fuel. Then in that we discuss about different properties such as proximate analysis, ultimate analysis, structural component of biomass.

In proximate analysis specifically we discussed a different range of properties such as density, the moisture content in the biomass sample and we discuss about the volatile matter contained in the biomass sample ash content and then fixed carbon containing the biomass sample after discussing this compositional analysis mainly in terms of proximate analysis we although we discussed all these properties using ASTM standard technique.

Sometimes it may happen so that the determination of the approximate analysis by ASTM standard method is time consuming and also expensive. As a result thermo gravimetric analysis which is an alternative method to estimate the approximate analysis of biomass is used. So at the end, we also discuss about the approximate analysis and how to estimate this proximate analysis using a thermo gravimetric technique. So in today’s lecture we continue our discussion in the same topic that is characteristics of biomass. So today we mostly focused on the ultimate analysis of biomass sample.

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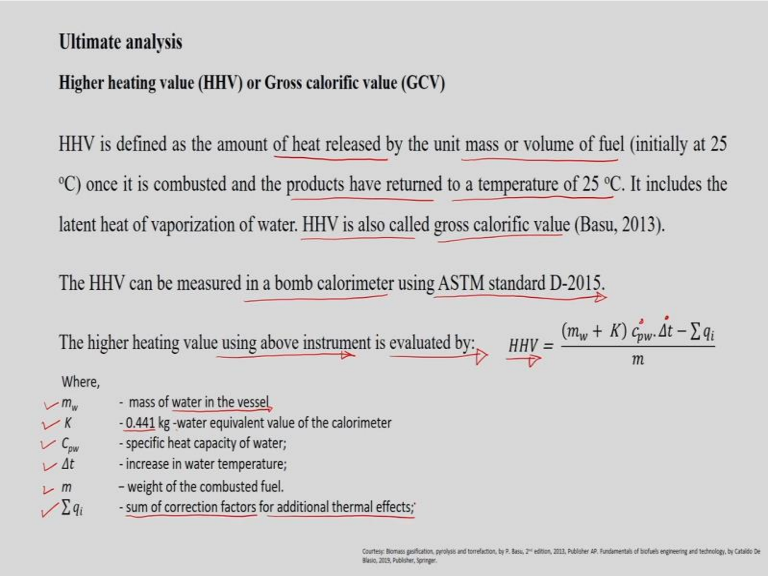

Ultimate analysis

Higher heating value (HHV) or Gross calorific value (GCV)

HHV is defined as the amount of heat released by the unit mass or volume of fuel (initially at 25 °C) once it is combusted and the products have returned to a temperature of 25 °C. It includes the latent heat of vaporization of water. HHV is also called gross calorific value (Basu, 2013).

The HHV can be measured in a bomb calorimeter using ASTM standard D-2015.

The higher heating value using above instrument is evaluated by: $HHV = \frac{(m_w + K)\, c_{pw} . \Delta t - \sum q_i}{m}$

Where,

m_w - mass of water in the vessel

K - 0.441 kg -water equivalent value of the calorimeter

C_{pw} - specific heat capacity of water;

Δt - increase in water temperature;

m – weight of the combusted fuel.

$\sum q_i$ - sum of correction factors for additional thermal effects;

Courtesy: Biomass gasification, pyrolysis and torrefaction, by P. Basu, 2nd edition, 2013, Publisher AP. Fundamentals of biofuels engineering and technology, by Cataldo De Blasio, 2019, Publisher, Springer.

So in the ultimate analysis the first thing is higher heating value of a biomass sample or we can say a higher heating value of a fuel sample. So higher heating value is also abbreviated as HHV or also it is called as gross calorific value and it is also abbreviated as GCV. So higher heating value is the amount of heat released by unit mass or volume of a fuel that means which is initially at say 25 degrees C and once this is combusted to product have to return to a temperature of 25 degree C.

It also includes the latent heat of vaporization of water and HHV is also called as gross calorific value as already mentioned. So gross calorific value or the HHV are both are the same. So you can estimate this HHV and the gross calorific value using bomb calorimeter and the standard ASTM method is this. So this HHV value can be evaluated using above experimental instrument and the equation for the HHV value is HHV= m w + K into C pw and then delta t.

We subtract this entire quantity from summation of q i / m. So where m w is the mass of water in the vessel when you are performing this instrumental analysis where k is 0.441 kilogram water equivalent value of the calorimeter. Similarly C pw is the specific heat of water as we are using water as a medium they are in the vessel delta t is the increase in water temperature after combusting the sample in the vessel and m is the weight of the combustible fuel. Now if you see here the summation of q i it is term as the sum of correction factors for additional thermal effects. So now what is invalid additional thermal effects.

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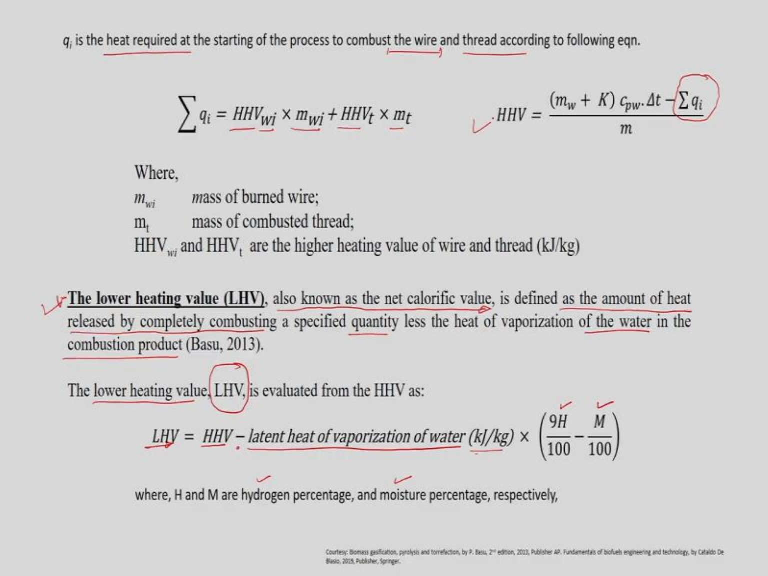

q_i is the heat required at the starting of the process to combust the wire and thread according to following eqn.

$$\sum q_i = HHV_{wi} \times m_{wi} + HHV_t \times m_t \qquad HHV = \frac{(m_w + K)\, c_{pw}.\Delta t - \sum q_i}{m}$$

Where,

m_{wi} mass of burned wire;

m_t mass of combusted thread;

HHV_{wi} and HHV_t are the higher heating value of wire and thread (kJ/kg)

The lower heating value (LHV), also known as the net calorific value, is defined as the amount of heat released by completely combusting a specified quantity less the heat of vaporization of the water in the combustion product (Basu, 2013).

The lower heating value, LHV, is evaluated from the HHV as:

$$LHV = HHV - \text{latent heat of vaporization of water (kJ/kg)} \times \left(\frac{9H}{100} - \frac{M}{100}\right)$$

where, H and M are hydrogen percentage, and moisture percentage, respectively,

Courtesy: Biomass gasification, pyrolysis and torrefaction, by P. Basu, 2nd edition, 2013, Publisher AP. Fundamentals of biofuels engineering and technology, by Cataldo De Blasio, 2019, Publisher, Springer.

So is the heat required at the starting of the process to combust the wire which is used in the analysis and the thread according to this following equation which is nothing but summation of q i is HHV value of wire and then the mass of combusted or you can say the burned wire plus HHV of thread and in the mass of the combusted thread. So once you take the summation of these values it reflects the heat required at the starting of the process for these 2 components that is wire and thread which is using the instrument during the analysis.

So once you have this summation of q i value we can put this value here in this equation. And then we can estimate the HHV value of biomass or you can say HHV value of the fuel. So once we estimate this HHV value so similar to the HHV value is also there is one other term which is called as a lower heating value which is similar to the HHV value only differences here in this case this is termed as net calorific value of a sample or you can say the fuel.

And it is defined as the amount of heat which is released by completely combusting a specified quantity of a sample and it is less than the latent of vaporization of water in the combustion product. So know why it is so because as once you combust this particular sample in the vessel the latent heat of vaporization of the water it cannot be recovered that means you can say the water in the field does not condense.

As a result the latent heat of vaporization of this component is not recovered. Therefore the effective heat which is available or you can say to use in a boiler or for any specific application is a lower amount because it is less than the exact energy in the form of chemical energy stored in the fuel. As a result while calculating the LHV value we subtract this latent heat of vaporization of water from the HHV value to get the exact lower heating value of a fuel or you can say the sample to be analyzed.

So in that case the lower heating value that is nothing but the LHV is evaluated from the HHV value itself. So there is a relation between the HHV and LHV value which is used to estimate the lower heating value of a sample. So that is nothing but LHV = higher heating value of a sample - latent heat of vaporization of water which is in kilojoules / kilogram into 9 H / 100 – M / 100. So now here this H and M represents the percentage of hydrogen and moisture content respectively.

So with the help of this we can also estimate the lower heating value of the sample as well as using the above equation we can also estimate the higher heating value of the sample which is widely known as the calorific value of the sample. So these 2 terms gives us the information about the heating value of biomass sample which can be used for the specific application.

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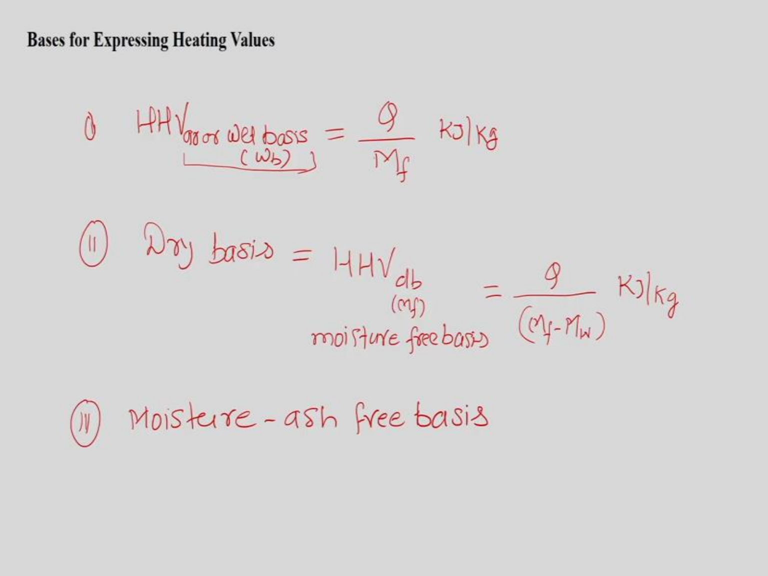

Bases for Expressing Heating Values

(i) $HHV_{\underbrace{\text{ar or wet basis}}_{(wb)}} = \frac{q}{M_f}$ KJ/Kg

(ii) Dry basis = $HHV_{\substack{db \\ (mf)}} = \frac{q}{(M_f - M_w)}$ KJ/Kg

moisture free basis

(iii) Moisture - ash free basis

Now if you recollect our discussion in the previous lecture about the proximate analysis in that also we discuss about the different properties. So in that specifically we discuss about the moisture content in the sample and the moisture content in the sample can also be expressed on the basis of different terms for example on the wet basis on the dry wet basis similar to moisture and the fuel composition.

Higher heating values may also be expressed in the same form as follows. For example if you say the higher heating value on the basis of air received basis that means we can say on the wet basis. So it is also abbreviated as the w b that indicates the higher heating value of a sample on as received basis means which is used directly for the estimation of higher heating value before doing any pre processing of the sample.

So the higher heating value on as received basis or on wet bases is indicated as Q / M f that is also in kilojoules per kilogram of sample basis. So higher heating value on the wet basis of sample can be calculated using this particular equation. Now similarly on dry bases if we need to calculate this value so we can also calculate the higher heating value of a sample based on dry basis which is also called as moisture free basis.

That means moiture free basis and the equation for this particular term to represent or express is nothing but Q / M f - M w that is also represented in the form of kilojoules per kilogram of sample. Now the heating value may also be expressed in another form that is represented as moisture ash free basis sample. So in this case if you try to see.

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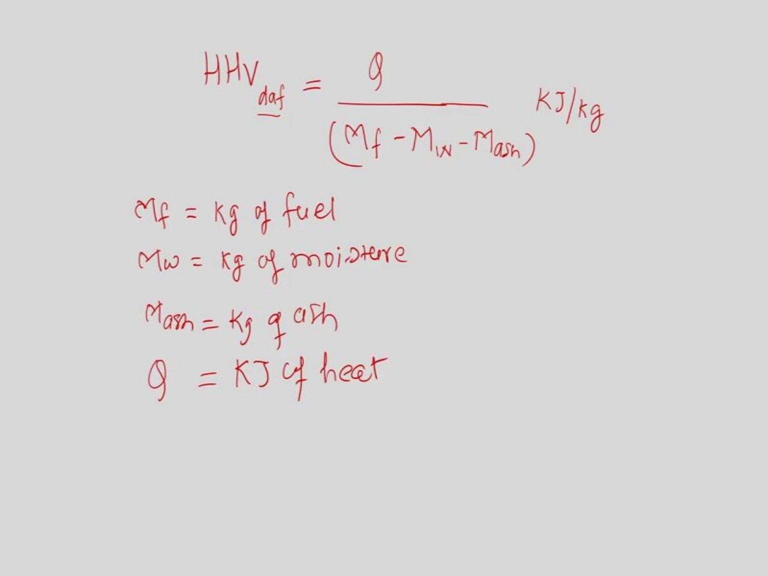

$$HHV_{\underline{daf}} = \frac{q}{(M_f - M_w - M_{ash})} \ KJ/kg$$

M_f = kg of fuel

M_w = kg of moisture

M_{ash} = kg of ash

q = KJ of heat

The expression to represent this equation in the form of HHV value on dry ash free basis also it is termed as moisture ash free basis sample and it is expressed in this particular way it is M f – M w - M ash and it is also in the form of again kilojoules per kg. Now if you see here this M f is nothing but a kilogram of fuel which contains M w kilogram of moisture then M ash that is nothing bird kilogram of ash in the sample and whereas q here is nothing but the kilojoules of heat contained in that specific sample.

So, these are the 3 different ways by which we can also express the higher heating value of a sample. So, based on the sample and its condition whether it is as received basis or whether the sample has been pre processed and then we have estimated the higher heating values or whether the sample has been pre processed and after removing the ash the sample is being used for the analysis purpose. So, there are different ways by which we can express the higher heating value of a sample or maybe you can see the fuel as well. So now based on this particular concept of higher heating value you can find out the calorific value of our sample.

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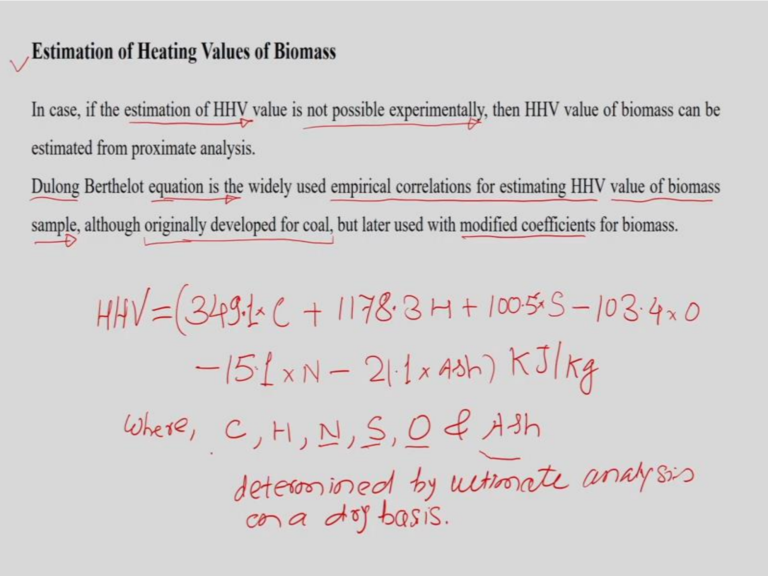

Estimation of Heating Values of Biomass

In case, if the estimation of HHV value is not possible experimentally, then HHV value of biomass can be estimated from proximate analysis.

Dulong Berthelot equation is the widely used empirical correlations for estimating HHV value of biomass sample, although originally developed for coal, but later used with modified coefficients for biomass.

$$HHV = (349.1 \times C + 1178.3\,H + 100.5 \times S - 103.4 \times O - 15.1 \times N - 21.1 \times Ash)\ KJ/kg$$

Where, C, H, N, S, O & Ash determined by ultimate analysis on a dry basis.

Or you can say the estimation of the higher heating value as we have discussed in the previous slide. The experimental methods are the most widely used reliable methods for the estimation of the higher heating value of biomass sample. In case if the estimation of HHV value is not possible experimentally then HHV value of biomass can also be estimated from the proximate analysis. So now for that reason Dulong equation which is widely used equation for the estimation of higher heating value using the approximate analysis.

And this equation is an empirical correlation for the estimation of higher heating value of biomass sample although this particular equation originally developed for a whole sample but later used with modified coefficients for biomass sample as well. So, the equation is in the form of HHV=349.1 into the carbon contained in the sample plus 117 8.3 hydrogen contained in the sample plus 100.5 that is the sulfur contained in the sample minus 103.4 the oxygen content in the sample -15.1 into nitrogen contained -21.1 into ash contained of the sample to be analyzed.

So that is also in the form of kilojoules per kilogram of sample which is used. So now here C, H, N, S, O and Ash is abbreviated as C is nothing but the carbon content in the sample H is the hydrogen contained N is the nitrogen sulfur oxygen and ash content in the sample these are all determined by ultimate analysis on a dry basis. So, a CHNS analysis that we already discussed this part in the previous lecture as well.

But the method for the estimation of the CHNS analysis is a very well, known technique with the help of CHNS analyzer we can estimate the CHNS component of the sample and oxygen we estimate by the difference as well. So, but the help of CHNS analyzer we can easily find out these particular components of the sample and ash contained we already discussed this part in the previous lecture. So, once you have this information about this component we can substitute in this equation and you can get the high heating value for the sample.

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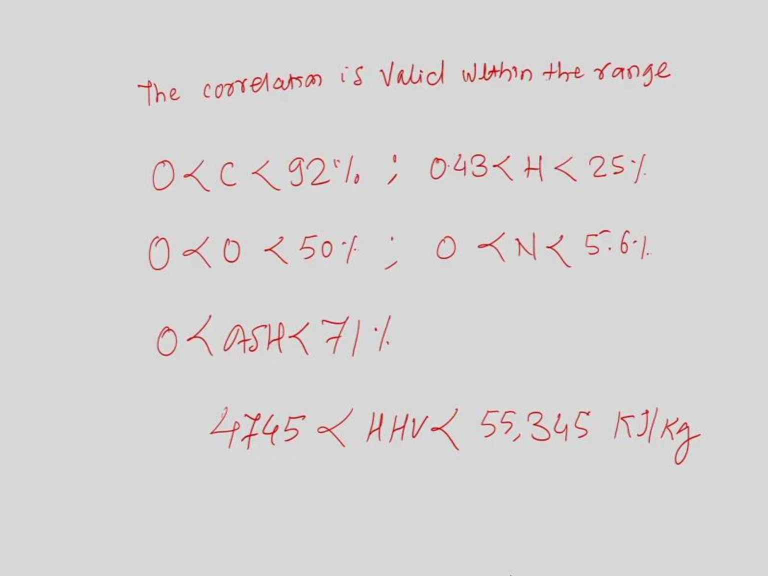

The correlation is valid within the range

$0 < C < 92\%$; $0.43 < H < 25\%$

$0 < O < 50\%$; $0 < N < 5.6\%$

$0 < ASH < 71\%$

$4745 < HHV < 55,345$ KJ/Kg

Correlation here or we will discuss the correlation is valid within the following range only that means when the carbon content if it is greater than 0 but it should be less than 92%. Similarly, the hydrogen contained the it should be greater than 0.43 but it should be less than 25% the oxygen content it should be greater than 0 but less than 50% in the sample the nitrogen contain again it should be in this particular range.

And the ash should be in this particular range and the calorific value which we can estimate using this correlation. If it is in between these particular range then this particular correlation is used for estimating the higher heating value of a sample. So now we will see 2 different ways by which you can calculate the higher heating value of a sample 1 by doing the extra burning the bomb calorimeter and another one with the help of ultimate analysis such as CHNS analysis and ash contained of the sample we can also estimate the higher heating value of a sample.

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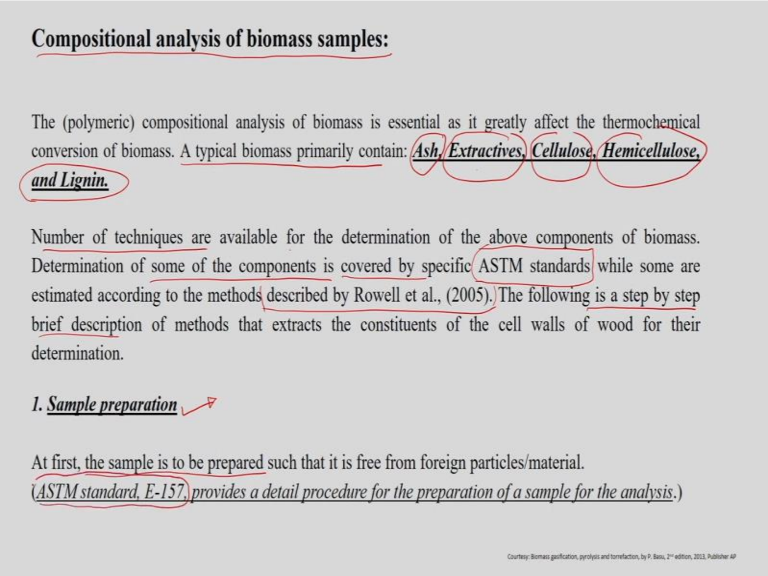

Compositional analysis of biomass samples:

The (polymeric) compositional analysis of biomass is essential as it greatly affect the thermochemical conversion of biomass. A typical biomass primarily contain: ***Ash, Extractives, Cellulose, Hemicellulose, and Lignin.***

Number of techniques are available for the determination of the above components of biomass. Determination of some of the components is covered by specific ASTM standards while some are estimated according to the methods described by Rowell et al., (2005). The following is a step by step brief description of methods that extracts the constituents of the cell walls of wood for their determination.

1. Sample preparation

At first, the sample is to be prepared such that it is free from foreign particles/material.
(*ASTM standard, E-157, provides a detail procedure for the preparation of a sample for the analysis*.)

Courtesy: Biomass gasification, pyrolysis and torrefaction, by P. Basu, 2nd edition, 2013, Publisher AP

So, with this now we can move to the next topic that is the compositional analysis of a biomass sample. Now the composition analysis of the biomass sample is very essential why? Because it directly affects the thermo chemical conversion of a biomass sample as a result because as we know the typical biomass primarily contains ash Extractives, Cellulose, Hemicellulose and Lignin as a component in its composition and if we recollect our discussion in the previous lecture under the cell wall component.

We already studied these 3, particular content of topic that is Extractives, Cellulose, Hemicellulose, Lignin and the ash contained. So here we are just elaborating our discussion about how to estimate these quantities in the biomass sample why? Because number of techniques are available for the determination of this component and the determination of some of the components of biomass is covered by a specific ASTM standard method.

While some are estimated according to the method which is described by Rowell and Ethel. So, there are 2 techniques are there we can either estimate using the ASTM methods or there are certain techniques which is established by the author Rowell Ethel that can be also used to estimate the composition analysis of biomass sample. So, the following is a step by step brief description of method that extracts the constituents of the cell wall of wood for their determination the first step is the preparation of sample.

And this is one of the most important steps before we do the composition analysis of biomass sample it is always necessary to prepare the sample first. So, at first the sample is to be prepared such that it is free from foreign materials and particles. So, this ASTM method provides detailed information about the preparation of sample for the analysis.

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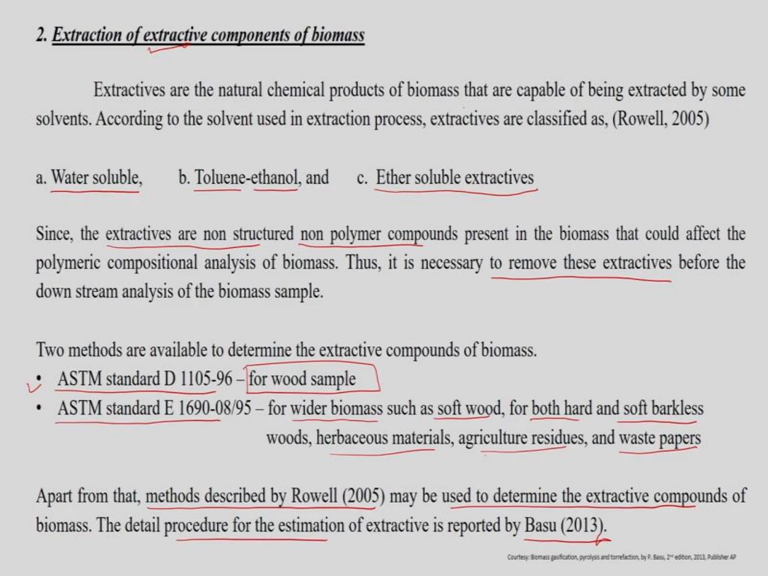

2. *Extraction of extractive components of biomass*

Extractives are the natural chemical products of biomass that are capable of being extracted by some solvents. According to the solvent used in extraction process, extractives are classified as, (Rowell, 2005)

a. Water soluble, b. Toluene-ethanol, and c. Ether soluble extractives

Since, the extractives are non structured non polymer compounds present in the biomass that could affect the polymeric compositional analysis of biomass. Thus, it is necessary to remove these extractives before the down stream analysis of the biomass sample.

Two methods are available to determine the extractive compounds of biomass.

- ASTM standard D 1105-96 – for wood sample
- ASTM standard E 1690-08/95 – for wider biomass such as soft wood, for both hard and soft barkless woods, herbaceous materials, agriculture residues, and waste papers

Apart from that, methods described by Rowell (2005) may be used to determine the extractive compounds of biomass. The detail procedure for the estimation of extractive is reported by Basu (2013).

Courtesy: Biomass gasification, pyrolysis and torrefaction, by P. Basu, 2nd edition, 2013, Publisher AP

So once the sample is prepared then we can go for the second stage of the analysis that is the extraction of extractive 2 components of the biomass. So, the extractives are the natural chemical product of the biomass and that are capable of being extracted by some solvents. So now based on the solvent use for the extraction use extractives are classified as Water soluble extraction, Toluene or we can say ethanol soluble extractive and Ether soluble extractive since these extractives are non-structured and non-polymer compound present in the biomass sample that could directly affect the composition analysis of biomass sample as well.

And hence it is very much necessary to remove the extractive before the downstream analysis of biomass sample. So now there are different methods are available by which we can find out the extractive contains of the biomass sample as well. The first one is the ASTM standard method which is used mainly for wood sample and another is nothing but again ASTM standard method but it is used for a wide range of biomass samples such as soft wood both hard and Soft barkless wood, herbaceous materials agriculture residues and waste papers.

Apart from that the method described by Rowell Ethel as I just mentioned in the previous slide it may be also used to determine the extent to components of the biomass and the detailed procedure for the estimation of the extractive components of biomass Rowell and Ethel is briefly described in this particular reference. So, one can go to this particular reference and find out the detailed procedure for the estimation of the extractive components of the biomass.

As it is not visible here to go in details of the estimation and the detailed procedure of estimation. So, I have just highlighted here the few points and with the help of this reference one can easily find out the extractive contents of the biomass sample as I already mentioned these extractives are the non-structure and the non-polymeric component which are present in the biomass sample. So now suppose if you are not removing these extractives before analyzing the biomass sample.

So these extractives while doing the composition analysis of biomass sample may also add up sugar or cellulose and hemicellulose content of the sample as a result it may not be appropriate that the cellulose and hemicellulose which you are representing as the values or the specific biomass it may not be appropriate value because first step is to remove the extractives and then to use the extractive free biomass for the compositional analysis so that we can find out the closed values of cellulose and hemicellulose and lignin content in the biomass sample. So once this extractive free biomass is available for the estimation purpose.

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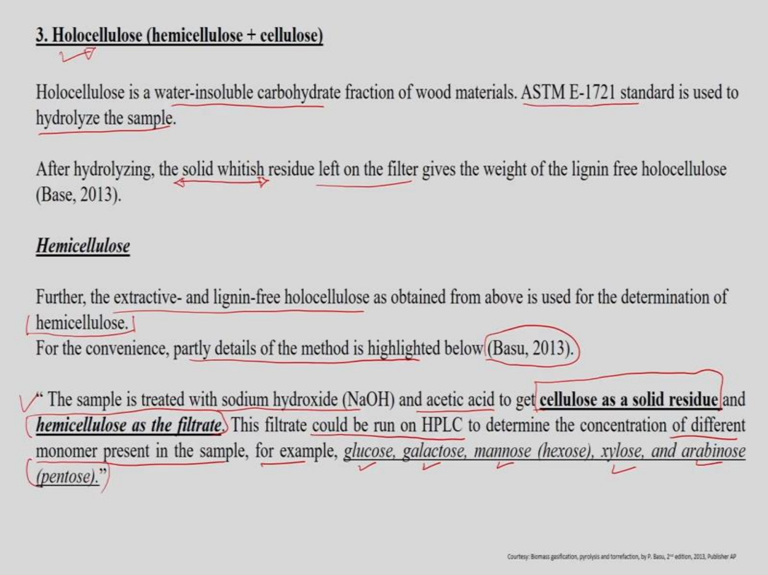

3. Holocellulose (hemicellulose + cellulose)

Holocellulose is a water-insoluble carbohydrate fraction of wood materials. ASTM E-1721 standard is used to hydrolyze the sample.

After hydrolyzing, the solid whitish residue left on the filter gives the weight of the lignin free holocellulose (Base, 2013).

Hemicellulose

Further, the extractive- and lignin-free holocellulose as obtained from above is used for the determination of hemicellulose.
For the convenience, partly details of the method is highlighted below (Basu, 2013).

" The sample is treated with sodium hydroxide (NaOH) and acetic acid to get **cellulose as a solid residue** and ***hemicellulose as the filtrate***. This filtrate could be run on HPLC to determine the concentration of different monomer present in the sample, for example, *glucose, galactose, mannose (hexose), xylose, and arabinose (pentose).*"

Courtesy: Biomass gasification, pyrolysis and torrefaction, by P. Basu, 2nd edition, 2013, Publisher AP

Then we can estimate the Holocellulose content of the biomass sample. So, the holocellulose is nothing but the cellulose and hemicellulose content of biomass sample and the holocellulose is a water insoluble cardboard fraction of wood material. And this is the standard ASTM method which is used to hydrolyze the sample. So, once you hydrolyze the sample after hydrolyzing the sample the solid whitish residue.

Which is left on the filter paper is a lignin free holocellulose which can be used further to find out the hemicellulose fraction and cellulose fraction of the biomass sample. So, this is a solid whitish residue which left on the filter and it gives the weight of the lignin free holocellulose contained in the biomass sample. Now once you have this extractive to free and the lignin free holocellulose sample as obtained from the previous step.

Then with the help of this sample we can easily find out the hemicellulose component in the biomass and what is this percentage in this specific sample. So, for the representation purpose here of partly details of method which is highlighted in this reference is shown here. So, in this case what happens is the sample is treated with sodium hydroxide and acetic acid to get cellulose as a solid residue.

And the hemicellulose which is as a filtrate and can be run on HPLC to determine the concentration of different components which are present in the sample that is the hemicellulose content of the specific sample and examples are the glucose, galactose, mannose, xylose, arabinose all these are represented as you can say the pentose sugar which are presenting the hemicellulose fraction of the sample. So now once you know these cellulose fractions and the hemicellulose fraction of the sample so now only leftover part in the composition analysis is the lignin content in the sample.

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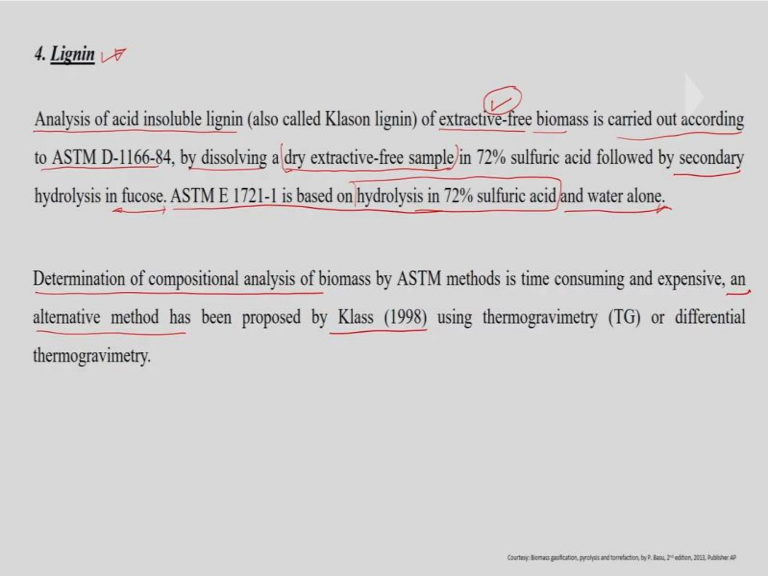

4. *Lignin*

Analysis of acid insoluble lignin (also called Klason lignin) of extractive-free biomass is carried out according to ASTM D-1166-84, by dissolving a dry extractive-free sample in 72% sulfuric acid followed by secondary hydrolysis in fucose. ASTM E 1721-1 is based on hydrolysis in 72% sulfuric acid and water alone.

Determination of compositional analysis of biomass by ASTM methods is time consuming and expensive, an alternative method has been proposed by Klass (1998) using thermogravimetry (TG) or differential thermogravimetry.

Courtesy: Biomass gasification, pyrolysis and torrefaction, by P. Basu, 2nd edition, 2013, Publisher AP

The analysis of acid insoluble lignin content of the extractive free biomass we are always expressing the biomass in terms of extractive free biomass and the acid insoluble lignin content of extractive free biomass is carried out according to these ASTM method by dissolving a dry extractive free sample because this is a dry extractive free sample in 72% sulfuric acid followed by a secondary treatment by fucose.

That is called as a secondary hydrolysis by the fucose. So another ASTM method is also used for these purposes. In that case the hydrolysis is carried out using 72% sulfuric acid and water alone. So, once we do this treatment, we can estimate the lignin content in the sample as well. So now all together it gives us the information about the compositional analysis of a biomass sample. And with the help of this we can calculate the cellulose, hemicelluloses, lignin extractives and ash content in the biomass sample very easily.

Now if you see here all these methods are the ASTM standard methods. So now in case if the determination of composition analysis of biomass by ASTM standard method is not possible because these are very time consuming you can save analysis and also expensive as a result an alternative method has been proposed by Klass which is using thermogravimetry analysis or differential thermogravimetry analysis.

So, in case of thermogravimetry analysis even the sample requirement is less compared to the conventional technique that is ASTM technique and along with the proximate analysis one can easily measure the composition analysis of the biomass sample as well.

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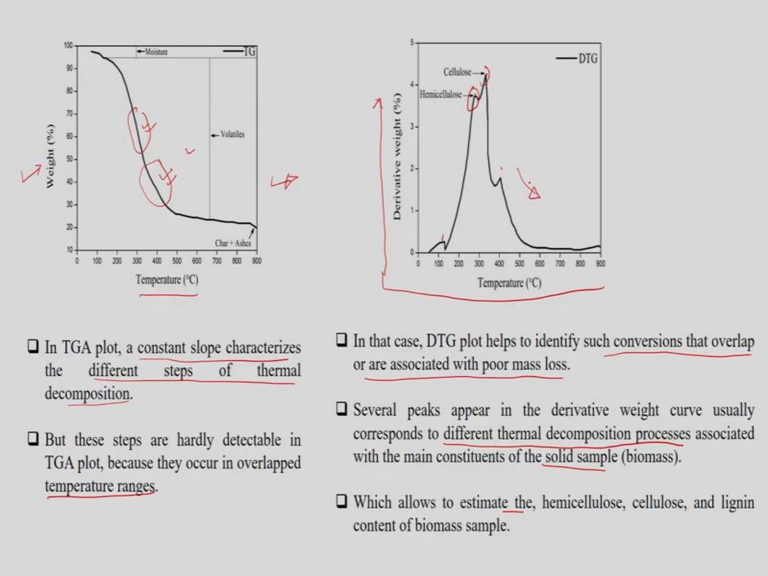

- ❑ In TGA plot, a constant slope characterizes the different steps of thermal decomposition.
- ❑ But these steps are hardly detectable in TGA plot, because they occur in overlapped temperature ranges.
- ❑ In that case, DTG plot helps to identify such conversions that overlap or are associated with poor mass loss.
- ❑ Several peaks appear in the derivative weight curve usually corresponds to different thermal decomposition processes associated with the main constituents of the solid sample (biomass).
- ❑ Which allows to estimate the, hemicellulose, cellulose, and lignin content of biomass sample.

So, in this case once you perform a TGA analysis using an instrument the data is represented in the form of weight loss of a sample or you can say the mass loss of a sample versus the temperature. So, once you plot this data for a specific sample so you get the nature of the curve like this. So, if you see here in this case a constant slope characterizes the different steps of thermal decomposition but now it is hardly detectable in this TGA plot.

Because we cannot distinguish the different steps of decomposition here because of the overlap temperature ranges as a result the differential thermogravimetry technique is used where you can say the derivative of the weight loss is plotted against the temperature. So, in that case what happens is like we can easily find out the conversion that overlaps as well as which are associated with the poor mass loss.

So, if you see here you can observe several peaks in this graph which you cannot see here in the TGA plot. And these particular peaks usually correspond to different thermal decomposition processes which are associated with the main constituents of the solid sample. So, but when we are mentioned here the solid sample here mostly, we are just specifying about the biomass. So, with the help of DTG it allows us to estimate the hemicellulose cellulose. And the lignin fraction which is present in the extractive free biomass or you can say the extractive free and ash free biomass.

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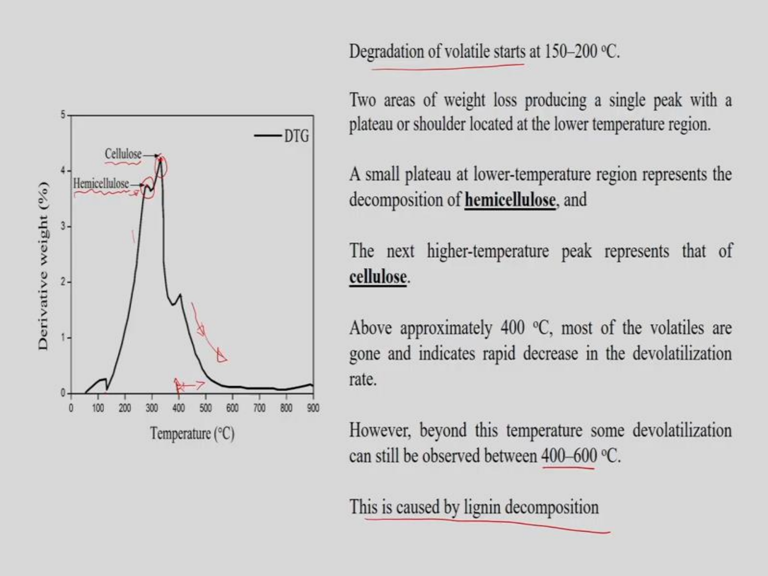

Degradation of volatile starts at 150–200 °C.

Two areas of weight loss producing a single peak with a plateau or shoulder located at the lower temperature region.

A small plateau at lower-temperature region represents the decomposition of **hemicellulose**, and

The next higher-temperature peak represents that of **cellulose**.

Above approximately 400 °C, most of the volatiles are gone and indicates rapid decrease in the devolatilization rate.

However, beyond this temperature some devolatilization can still be observed between 400–600 °C.

This is caused by lignin decomposition

So, in that case that happens is like once we have the DTG peak here and we have the different peaks which can represent the thermal decomposition behavior of the different constituents of the solid sample. So, the degradation of the volatile sample if you see here it starts at around 120 to 200 degrees C temperature range. And once you increase the temperature beyond these, we can see that there are 2 areas of weight loss producing a single peak or we can say a shoulder which is located at the lower temperature range here.

And this is a peak which is at a relatively higher temperature. So, the peak which is at a lower temperature it represents the decomposition of the hemicellulose fraction in the solid sample or you can say in the biomass sample and the next peak which is a relatively higher temperature it represents the cellulose fraction of the sample. And if you further increase the temperature above 400 degrees C suppose we can see the most of the volatiles are decomposed and indicates that rapid decrease in the devolatilization rate of the sample.

That means that the devolatilization rate here is decreasing rapidly with further increase in the temperature and however beyond 400 degrees C if you just try to see the temperature range here some devolatilization is still appearing in this particular range which is observed between 400 to suppose 600 degrees C and this is mainly caused by the lignin decomposition in the sample. So, once we have this specific graph of a specific sample, we can easily find out the cellulose hemicellulose and lignin fraction which is present in the sample using this simple technique.

So now up till this point we discuss about the composition analysis of the biomass sample. Now suppose after completing the entire characterization of the sample if we need to check.

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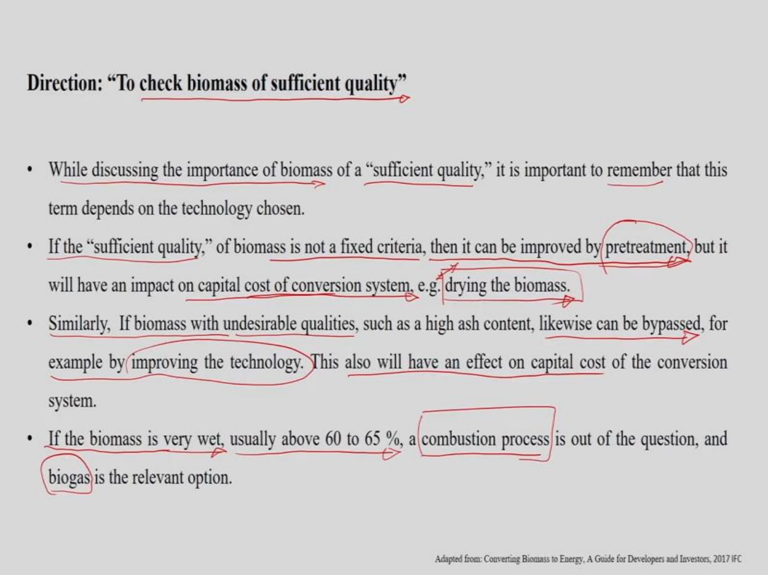

Direction: "To check biomass of sufficient quality"

- While discussing the importance of biomass of a "sufficient quality," it is important to remember that this term depends on the technology chosen.
- If the "sufficient quality," of biomass is not a fixed criteria, then it can be improved by pretreatment, but it will have an impact on capital cost of conversion system, e.g. drying the biomass.
- Similarly, If biomass with undesirable qualities, such as a high ash content, likewise can be bypassed, for example by improving the technology. This also will have an effect on capital cost of the conversion system.
- If the biomass is very wet, usually above 60 to 65 %, a combustion process is out of the question, and biogas is the relevant option.

Adapted from: Converting Biomass to Energy, A Guide for Developers and Investors, 2017 IFC

The biomass is of sufficient quality then how to do that. So, in that case rather are some directions are advised with the help up that we can easily find out in rather the specific biomass which has been characterized is acceptable or can be used for a specific process or it should be used for some other processes. So, it will of this if you see here while discussing the importance of biomass of a sufficient quality it is important to remember that this term is depends on the technology chosen for the conversion purpose.

Because in this case it is most important if the sufficient quality of biomass is not a fixed criteria in case if you are just trying to use any conversion system but in that conversion system the sufficient quality of biomass is not a strict criteria then in that case what you can do is like we can improve the composition of biomass by pretreatment techniques but by doing so it will have an impact on the capital cost of the process.

Or you can say the capital cost of the convergence system for example if the moisture content in the biomass is relatively high and if you are trying to utilize this specific biomass for thermal conversion system then obviously our pre processing in terms of drying steps of the biomass is required. So that we can remove the substantial amount of moisture from the biomass and the biomass with a specific moisture content which is advisable for the thermal conversion system.

Can be used so that this drying step is important before utilizing such biomass for the thermal conversion system. So instead if the biomass with lesser moisture content can directly be used for the thermal conversion so we can neglect this particular step and by avoiding that we can reduce the capital cost of the conversion system. So, this is the one direction by which we can convert the specific biomass into a required product.

Similarly if the biomass with undesirable qualities such as high ash content likewise in this case also if the high ash content biomass is bypassed for example by employing the technology again here so if you just try to implement another technology again so in that case it will also have an impact on the capital cost of the conversion system because this part we already discussed in our previous lecture for the thermal conversion system.

The low ash content biomass is preferable for the good conversion of biomass to a required product if the biomass is very weight as I mentioned earlier usually in the range of say for example 60 to 65% then it is better to use such biomass for biogas processes rather than using for the conversion process. So, by which we are just reducing the cost of the convergence the system as the high moisture content is also the requirement of the biogas process. So, it will compensate the moisture content in the sample and his it can be directly used for the biogas production.

So, these are the ways by which we can select a sufficient quality biomass for the conversion system. So, with this we end our lecture here. In the next lecture we will discuss about the biomass conversion processes and, in the biomass, conversion processes we will cover the biochemical and the thermo chemical conversion processes and later we will discuss bioconversion into biogas. For this lecture if you have any queries please feel free to contact me at vvgoud@iitg.ac.in. Thank you.