**Indian Institute of Technology Kanpur**

**National Programme on Technology Enhanced Learning (NPTEL)**

**Course Title**
**Bioenergy**

**Lecture-34**
**Feed Stock Properties**

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So welcome back to the bio energy course today what we will be starting off with we will be talking about the feed stock properties okay.

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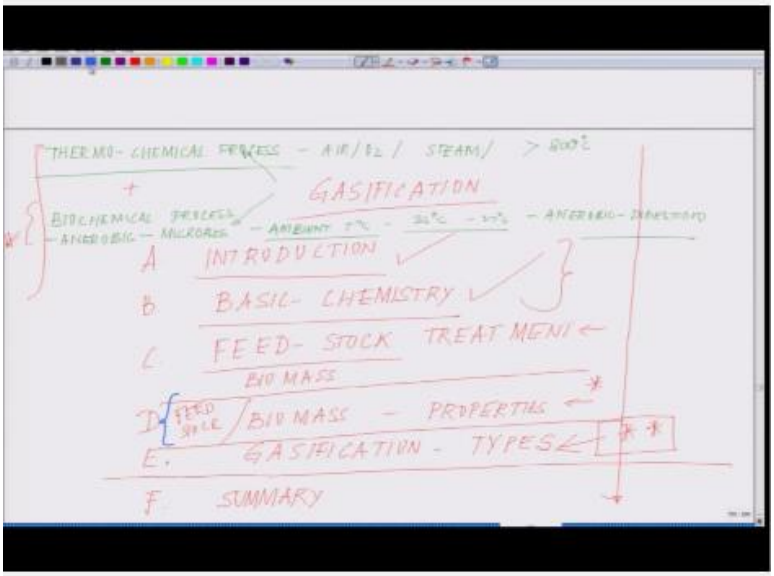


Which is the deal which is feed the stalk properties, so the different feedstock properties what we will be dealing with there are four different feedstock properties will be dealing with. Again the first one will be the moisture content next we will be dealing with ash content third will be dealing with volatile compounds like terpenoids, volatile compounds and the fourth will be

dealing with particle size. They are all interlinked to each other particle size okay these are the four parameters will we will talk about the feedstock properties.

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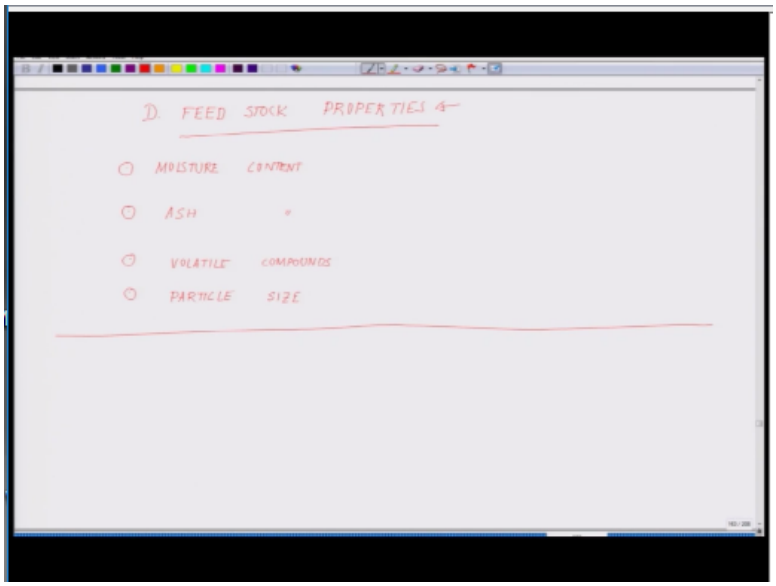


And just previously in the previous section we talked about what are the treatments again in the treatment is also function of the moisture alkali metals and the particle size okay so now let us talk about the moisture content while we talk about selecting the feed stock properties. So in terms of the efficiency we talk about let us talk about the moisture content okay. So it significantly influences the performance of the gasifier, gasifier performance, performance is significantly influenced by the moisture content okay.

So now feel with moisture content about thirty percent few critical points you need to remember well with moisture content of thirty percent make ignition difficult and leads to lower calorific value difficult and have I am just putting downward arrow for the low calorific value okay of product gas. So one has to ensure that this level is below thirty percent okay due to the need to evaporate the additional moisture before combustion so that essentially brings us that this needs to be evaporated out.

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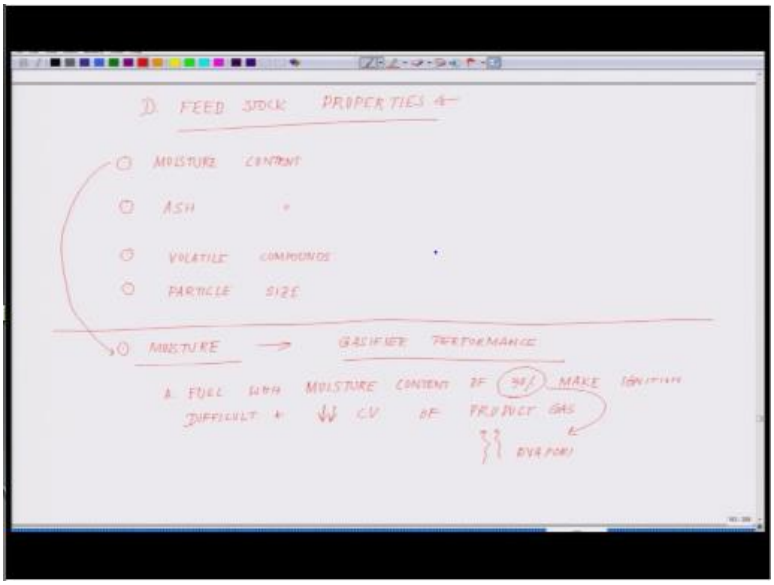


In order to raise the calorific value so you are seeing that each all these things are linked to each other like now you cannot do one thing by missing out on another. The second aspect what is important is that suppose say for example you have a higher moisture okay higher moisture content will lead to a lower temperatures in oxidation zone it leads to lower temperature so higher moisture leads to leads to lower the temperature. Thus lower temperature achieved in oxidation zone.

So we will talk about the oxidation zone we will talk about the gasified design and everything okay this situation this lowering of the temperature in the oxidation zone leads to a or resulting in two incomplete or incomplete cracking of the hydrocarbon released from the pyrolysis zone resulting in the incomplete cracking of the hydro carbon are released from the pyrolysis zone.

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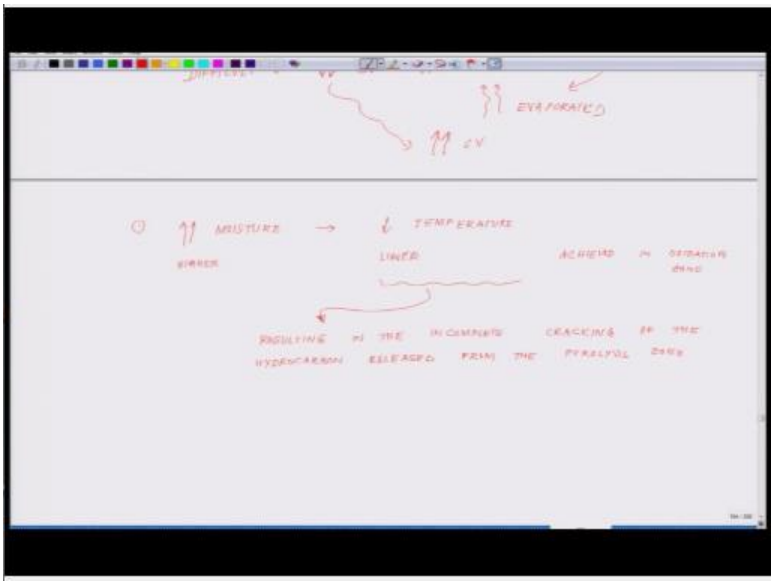


So from the pyrolysis zone, so here let me highlight something there are some few words which are coming like pyrolysis zone oxidation zone and likewise and so forth do not get worried because these are the different for different in the gasifier there are different locations where pyrolysis is taking place the gasification is taking place from where the tars and the volatiles are coming out. So these words when you talk about as pyrolysis zone we talk about oxidation so these are the different spatial location within the gasifier okay.

So just for the time being before we get into the gasifier schematics of the gasifier just accept these words so as soon as we get into the gasifier section everything will be clear what I meant by in the pyrolysis on which one is oxidation zone okay. So coming back so this will lead to the incompletion critical point I take home message here is that incomplete cracking of the hydrocarbon this is what is the most critical aspect in the pyrolysis zone.

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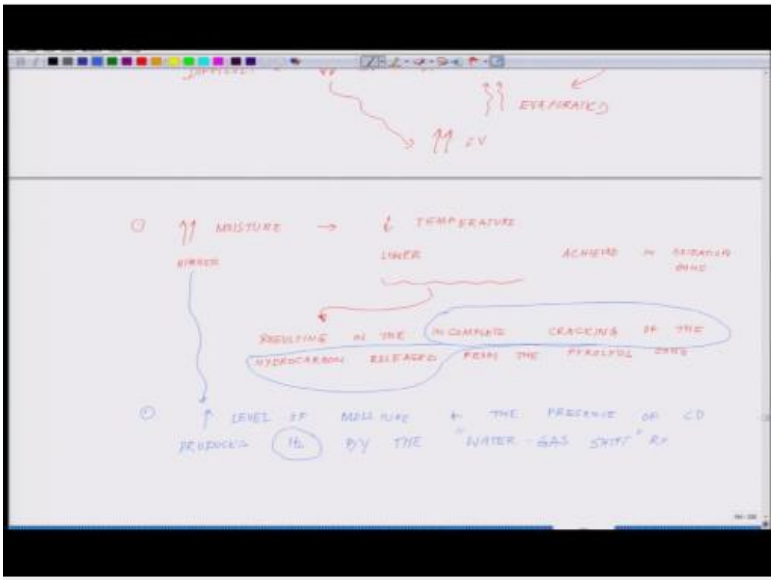


And this further leads to something very interesting higher level of moisture height so this arrow is again the same arrow higher level higher level of moisture and the presence of and the presence of carbon monoxide produces lot of hydrogen into the system okay, by the this is interesting because this is something which is a reputation. Now what I have covered in the chemistry water gas shift reaction, so just let me take you back to that reaction where we talked about water gas shift reaction somewhere here look at this reaction.

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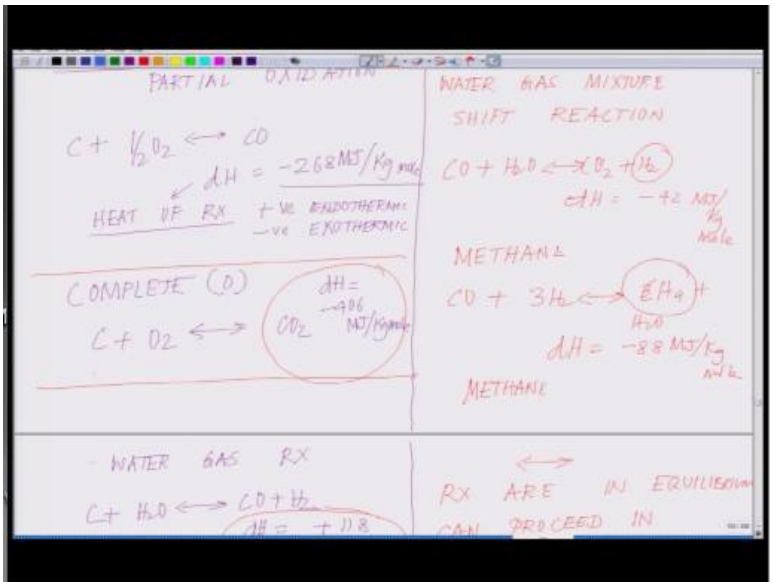


This is the water gas shift reaction to remember in the previous class we talked about is that here you have the CO you have the water so they are all linked $CO_2$ and I showed you that this CO in the presence of $3H_2$ forming the methane is the same chemistry. So remember one thing though these are very vast kind of voluminous topics but it is actually the basic chemistry if your basic chemistry is clear.

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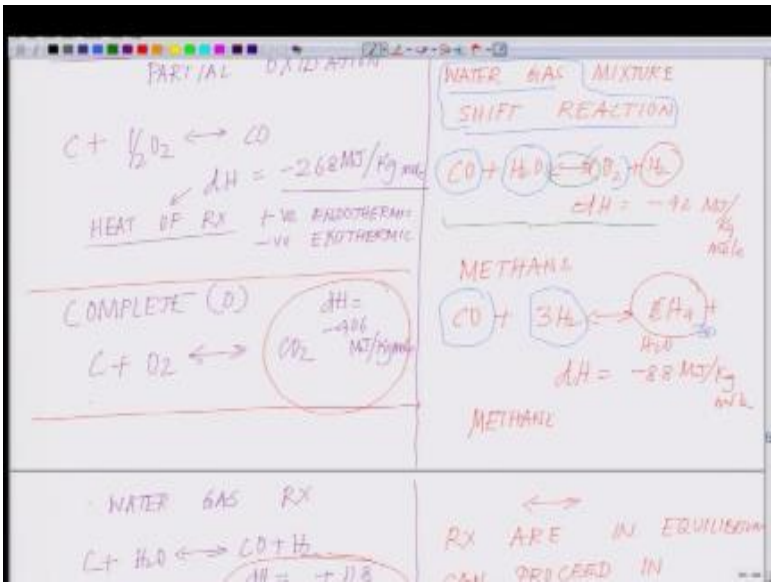


So if this slide what I taught you people to basic steps of combustion if these two are clear then the rest is all simple you can vary like think of it for a minute you have forgotten everything but if you know that this basic reaction C + ½ $O_2$ forming CO, C +$O_2$ from $CO_2$ & CO+ $H_2O$ form $CO_2$ + $H_2$ & CO + 3H to forming $CH_4$. If you know these four reactions look how logically you can rationalize it out.

So in every place you are seeing the arrow is bi-directional right so it means all the things are in equilibrium okay it can be dynamic process reactant as well as the product may be equal you know they can move no dynamically they can shift. Now if some way or other you increase the reactant what will happen the reaction will move towards the right the more product or vice versa okay.

So in other word these four reactions so if you see the parameters so if you see all these things so water content so if you increase the water say for example let us take this if you increase the water content and if you can the possibility we will have more hydrogen and $CO_2$ falling on the right hand side similarly out here if you increase some way or if you could increase the carbon monoxide or really the reaction will be shifting more towards the methane production right.

So whenever you get confused you should have is your key the critical like you know what is the take home how I could really you know get this whole philosophy clear in my mind I have to remember the chemistry it is all in that simple chemistry what is happening in nature. Anything which could pushes the reaction to the right will let two more product and anything which pushes the reaction to the left we will have more reactant accumulating in one place.

And you can vary them and play around with you can figure out how the reaction of course it is a limit but that is a different story but these are the four reactions which will govern it.

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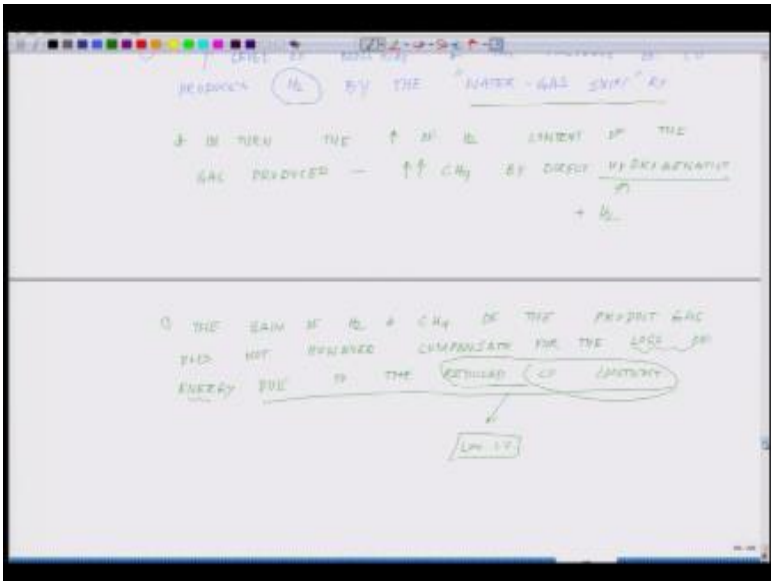

Now coming back where we just shifted gear so by shifting the water gas water gas shift reaction this is what you are doing essentially by ship reaction and in turn what you are doing and in turn the increase of a hydrogen content of the gas produced gas produce. And it contains more and more methane by direct hydrogenation addition of hydrogen okay.

Hydrogenation which is basically addition of h2 now if you again refer to that same reaction you will see the same thing what is happening see for example like here Coh2o making CO 2 NH 2

and the same co reacting this is that hydrogenation process what I am just writing Co plus3h to for ch4.

So if you have higher concentration of co here if you have higher concentration of it he will have higher concentration of meeting. So you are shifting the reaction towards right so the arrow will now be more on this side towards right okay. So you have a more product out of this whole reaction so coming back where we were so this is how water is interesting there is a third aspect to it in terms of the moisture content the gain of hydrogen the gain of hydrogen and methane ch4 of the product gas okay.

Does not however let us remember this does not however compensate how we compensate for the loss of energy due to the reduced level of co-produced see you content okay so the gain of hydrogen and ch4 of the product gas does not however compensate for the loss of energy due to reduce your content and if you reduce the co content what will happen this particular aspect reduce your content will lead to low calorific value we have talked about this in the last class okay.

So you realize if you follow the basic reaction right all those four reactions what we talked about you can actually predict in which direction the reaction is going to move and what is what will be the stoichiometry how you can compensate what will be the what will be the calorific value of the product. What you will be getting so the next aspect into this what you are about to add is the ash content okay or the mineral content okay.

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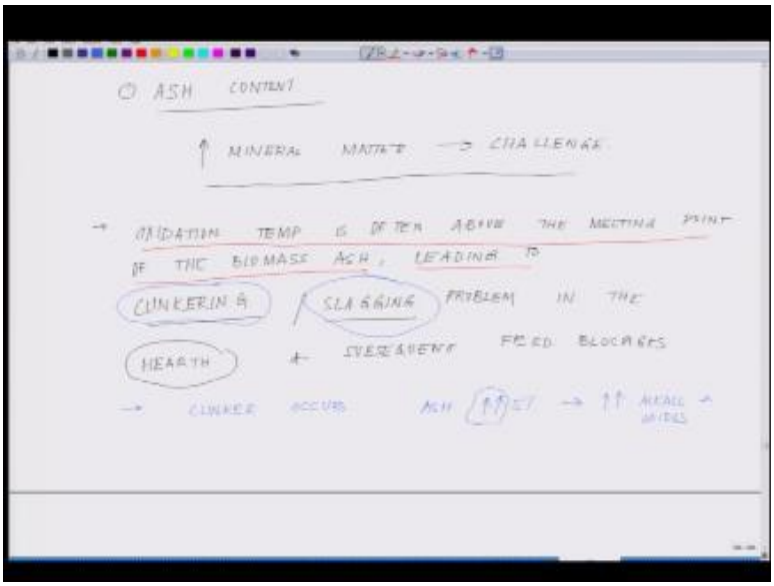


So now we will talk about the ash content in terms of the parameters so in terms of the ash content one of the biggest challenges that higher the mineral matter okay. Hire mineral matter it will pose extreme challenge for further processing so that gives you an idea that whenever you are picking off materials what properties we should look forward to. You should look forward to materials which has lower alkali content lower ash content because otherwise it will create a lot of problems and what are the problems. Now we are going to do it leads to the clinkering it leads to accumulation of slurries and kludges and everything will come to that now.

Okay because the one of the classic feature of most of this alkali metal is that they can act as adhering agents calcium they will kill eight things will accumulate things okay. Use magnesium so there are several such they have a very neat deleting property they can pull like another arms like this I know they can pull things and they these particles from this much they become this much and they start clogging the different port through which you know you are the gas really there is the air in Proton like when and so forth.

They all get clocked and the walls of the reactor gets clocked so it is very, very critical while you are picking up the feedstock you have to really understand. That this ash content should not

bother in the processing okay so now coming to the mineral matter and how it is posing challenge so the first thing is to deal with the oxidation temperature is often above the melting point of the biomass circuit oxidation temperature is often above the melting point of the biomass, biomass ash leading to,

Leading to clinkering, slagging problem as well as lagging okay, okay. In the so this is a new word which we have not come across in the hurt and subsequent I will explain this subsequent feed blockages so hurt is essentially all of you have seen the fireplace where really the burning takes place in a fireplace that is called the hearth area so the oxidation temperature is often above the melting point of the biomass ash so what happens think of it just read through the line you realize.

So the oxidation temperature is often above the melting point of the biomass ash so what will happen the biomass ash the alkali will melt because your oxidation temperature is higher than that if your oxidation temperatures here and your bio mass will be melt here. So automatically what will happen all the biomass ash which is present there is going to melt here and if it would not make it melt its form a thin climbing fluid. And this kind of reading material covers kind of forms a coating on the surface of the mixing along with the tar and everything it forms a coating it blocks the walls it blocks the pipes and everything.

And that is why this leads to what we talk about is these two word clinkering or the slagging, slagging is basically that tick high viscosity fluid which is flowing through in our clogging the different faces likewise okay. So that is the present clinker lockers so let me add one more thing clinker Occurs well ash percentage is more than five percent I am just saying is more than okay when ash is more than five percent.

So which is essentially leads to the formation of it is more than that it forms alkali oxide and salt I told you that most of these materials have this peculiar chelating power first of all these alkali metals from oxide sometime they form lot of chelation, chelate with other different kind of functional group of organic material they from this bolas kind of thing. They are from the slug kind of stuff and it really, really close the system. So one has to be very particular one has to

really know from the beginning that what kind of what are the properties of the material what we are using for it okay.

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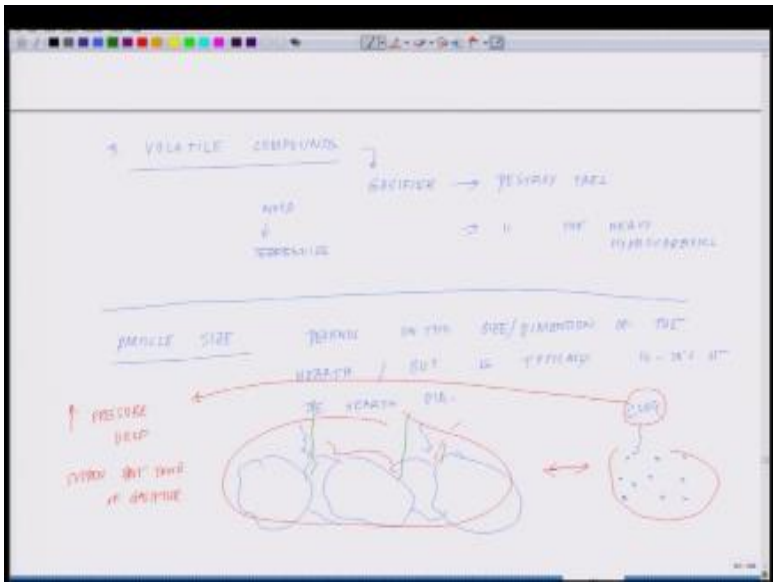

So next in the category comes less volatile compounds so in terms of the volatile compounds say for example you have would they have lot of terpenoids okay and terpenoids are, are volatile materials so what is very important is that if it has lot of volatile material then gasifier what you are choosing for your industrial work it should be able to destroy the tar. Which is basically the product coming from all the tough androids and should be able to destroy the heavy hydro carbons because these are source of different kind of volatile material and most of these volatile materials are not very healthy for, for human to be exposed.

They create a lot of irritants they create a lot of skin rashes and lot of other problems and a lot of lungs related issues so it is very critical from the environmental pollution point of view as well as from the sustainability point of view that we should be able to remove or destroy these different stars which are formed these are their very carcinogenic too so we should have a way to either process them or convert them into some user friendly product or some way or other getting rid of it, it is exceptionally important from the green chemistry point of view okay.

So now from the volatile compounds we will move onto the particle size which is the last parameter which has to be taken into account particle size okay in terms of the particle size particle size of the feedstock material if you look at it particle size depends, depends on the depends on the size or the dimension of the hearth because we're the reaction is going to take this dimension of the hurt but is typically ten to twenty percent of the first diameter heard I okay large at the particle.

So here is the catch if you have very large particles like this they will almost form a bridge like structure which will prevent permitting the movement of the gas and other things whereas if you use very smaller particle size something like this they will forma clogging here the movement will be restricted and I have this is kind of a reputation if you think of it and here this will detour clogging so we have to have a trade-off in between the two and if there are smaller particles in it leads to clogging it leads to some other very interesting things which are very detrimental for it, it could basically lead to the available air voyage leading to the very increased pressure drop which is very dangerous for the system pressure drop.

And lead to a sudden shutdown of gasifier so we really cannot make it very, very fine okay whereas if you have this large particles what you will be seeing is that it will prevent the movement of the feed so nothing can you know moves through them okay. So what do you observe in this whole process is this there are kind of multiple points of trade-off which has to be done what kind of particle size you are picking up what kind of gasified you have if you have summarized it what kind of material.

You how much does the noise and Tars which is coming out of it because more the tar you have to have a process to continuously filter it out and since from where the gas is really coming out you need particle filters in order to you know get rid of some of the particulate matter which are present there so based on these parameters based on this parameters as well as their pretreatment one has to decide what kind of gasifier we are going to use. So what we will be doing after this we will talk about the design of different kind of gasifiers which are currently being used all over the world okay.

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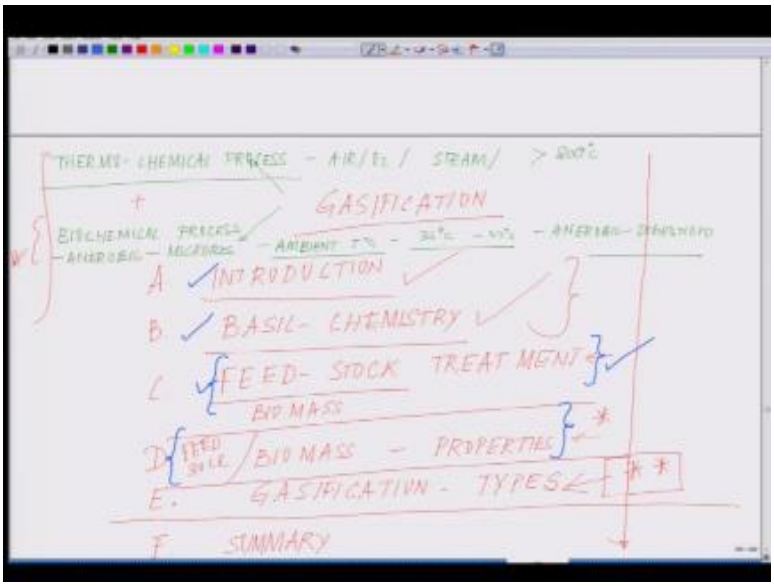


So I will close in here so today what we have covered let us again so we already did the introduction basic chemistry feedstock treatment and today we talked about feed stock properties now our goal will be to understand this interesting portion which is the gasification types under this everything will be able to appreciate it much better. But what I wanted to highlight today is please go through this part very carefully this is very important the basic chemistry you should understand the basic chemistry.

As I was mentioning or today number of times if you understand the basic chemistry right then it will be very easy to correlate these two aspect very easily that you know. How the reaction is going to happen so that is why my take-home message will be those four reactions what we have talked about in the very beginning is what is most important for you people to look at and those four reactions are here partial oxidation partial oxidation stage to stage two oxidation these are very, very critical and, and this unique is step where we talk about water gas shift reaction okay. So I will close it here thank you so next we will follow with the gasifier design.

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