Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

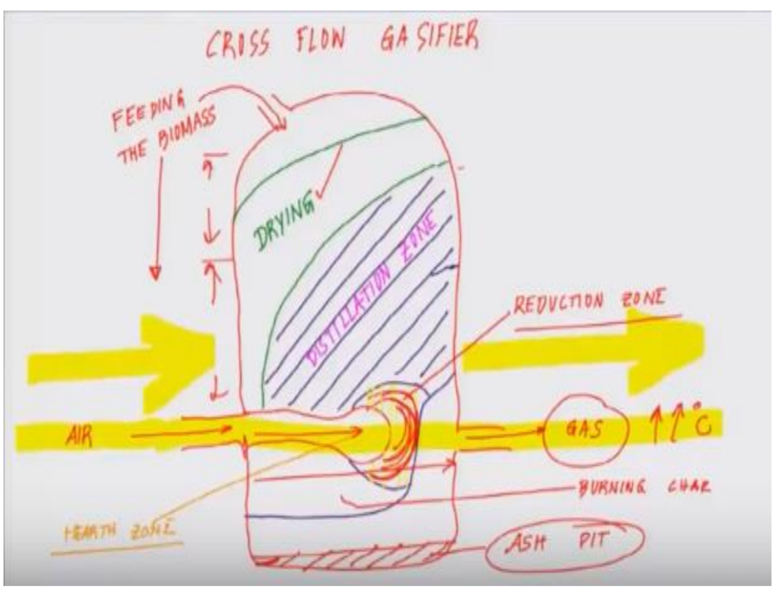
Course Title
Bioenergy

Lecture-37
Operation & Performance of Fixed Bed Gasifier

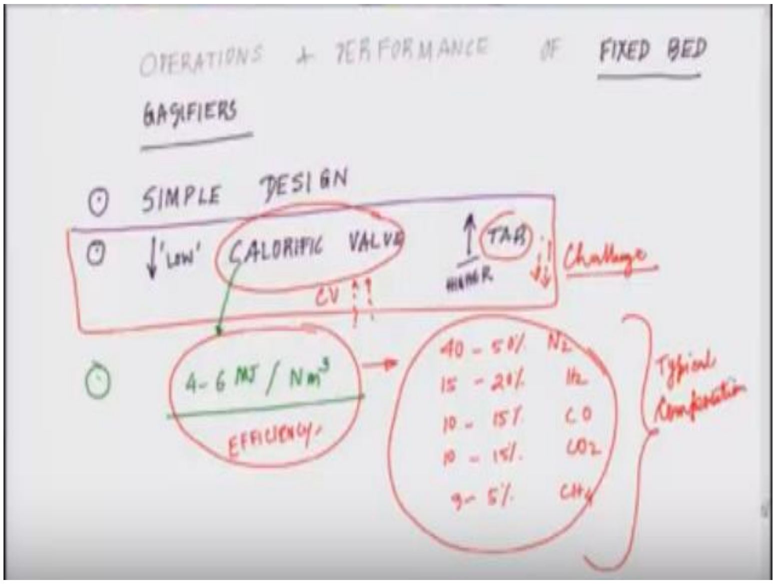
By
Prof. Manik Das
Biological Sciences & Bioengineering &
Design Programme
IIT Kanpur

Welcome back to the lecture series and bioenergy let us start with the efficiency of these gasifiers okay that is our next section. What we are going to dealing with so this particular part will come with the title of this will be okay.

(Refer Slide Time: 00:36)



(Refer Slide Time: 00:44)



Okay operation and performance of six bed gasifier operation and performance of fixed-rate gasifiers okay so the first point to remember out here it's a very simple design and this is the very first one which were utilized by mankind simple design there is no complexity by this time must have seen so you have the feeder you have the drying zone you have the combustion zone any of the airflow and you have a collector and you have a gas output.

So you have deal volatilization zone you have reduction zone you have a combustion zone you have a feeder so it is very straight forward simplistic model of gasifiers so the very simple design an easy to develop an easy to you know work and do a lot of research on these kind of things as well as for the production unit this is the first part.

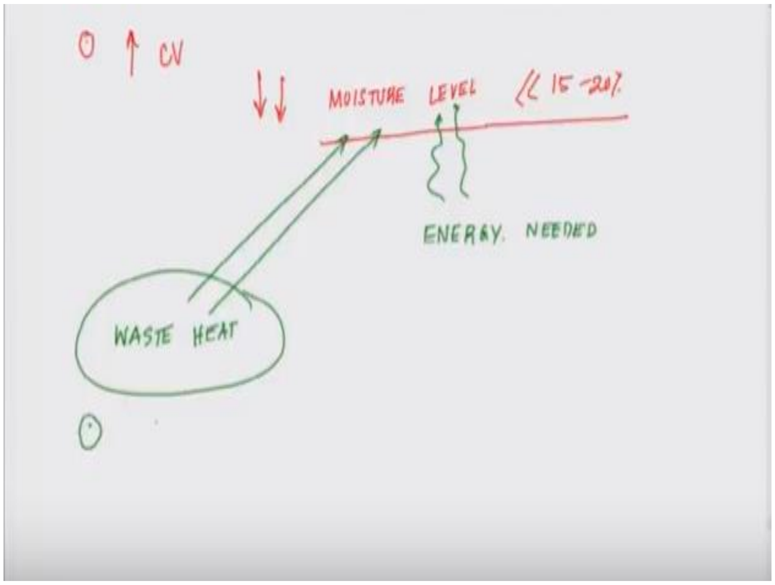
Second generally these kind of fixed bed gasifier gives you low this downward arrow indicates low calorific value of gas okay and they have higher concentration of tar this is upward arrow showing higher concentration costs are and this particular part and boxing it this is a challenge so there is a lot of work which goes on to improve upon this so obviously CV or the calorific value how we could you increase it and this one how we could reduce it this is the most fundamental challenge what you face in these kind of cigs bed gasifiers.

Now third important point what are the composition what is really this what kind of calorific values you get it around if you remember in the previous class we have talked about mega Joule per Newton meter cube okay this is the kind of calorific value which is fairly low and if you remember the national gases we talked about if you see this for 4-6 you always have to compare with the natural gases which is around 36 so which is at least six times mode or if not fix if you are getting four it is almost like an online times more efficient what you get from nature okay so currently what man can do is in the range of 4-6 using a simple design of a flat bed or a fixed bit gasifiers.

Okay so now let's see appreciate what are the concentration of this the product gas what you are getting generally it is 40-50% of nitrogen 15-20% of hydrogen 10-15% of carbon monoxide again 10-15% of carbon dioxide CO_2 you have 3-5% of methane CH_4 this is a typical typical concentration of product gas what you obtained by gasifying the feeder stock or the biomass in a six bed gasifier.

I mean the number may vary here and there a little bit depending on if you are using down drift or are up drift or a cross flow system so this is something what one has to appreciate that this is the kind of efficiency we get efficiently or calorific value which is fairly low and this is the typical composition typical composition.

(Refer Slide time: 05:10)

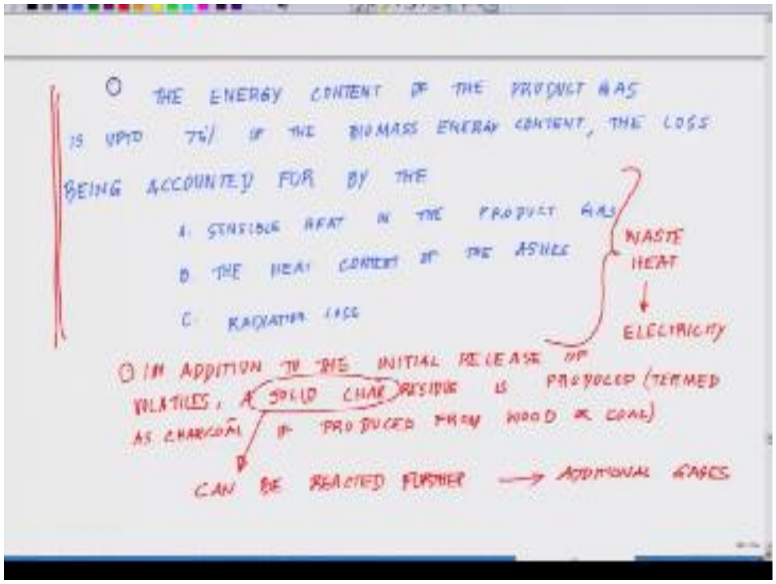


Okay next important aspect is how one can increase so this is a challenge how you can increase the CV order calorific value so one approach is that you have to reduce down on the moisture level. So reducing the moisture level to something less than 15-20% is a challenge but as few people remember in the last class at the very moment you wanted to do this reducing moisture level.

So you are talking about energy input and there are suggestions which have been made and which are being followed energy needed this can be achieved by using a lot of waste heat moisture level reduction could be done by waste heat which comes out from gasifiers waste heat so waste heat to it is a huge problem across the globe there's a lot of waste heat which is being generated which has no utility value it is kind of you know thrown out into the environment.

So how we can utilize that waste heat one of the approach is that you can reduce the moisture content by using this particular heat too you know reduce it down to below say 15% that is one approach by which you can increase the calorific value of the system now the fourth aspect which what's highlighting is that the energy content of the product gas

(Refer Slide Time: 06:41)



That the energy content of the product gas the energy content of the product gas is up to 75% of the biomass energy content of the biomass energy content okay the loss being accounted for so where are we having the loss the loss being accounted for laws being accounted for by the sensible heat in the product gas either a by the sensible heat in the product gas one way.

Second is the heat content of the ashes is there is huge amount of radiation loss so while discussing this if you go through these three points one thing which will definitely strike we need strategies to utilize the waste heat there is lot of radiation loss in most of the engines what we are using there is a huge amount of loss sensible heat loss there is a lot of heat which is being absorbed by the ashes which is getting lost and if we have somewhere.

We could utilize it transform that heat energy using some form of thermo electric materials where is going to use the heat to generate electricity it could be a very big asset in a small capsule which will be covering the end I will show you one of the technologies what we have developed where you can use natural fibers which will absorb the waste heat and convert it into electricity.

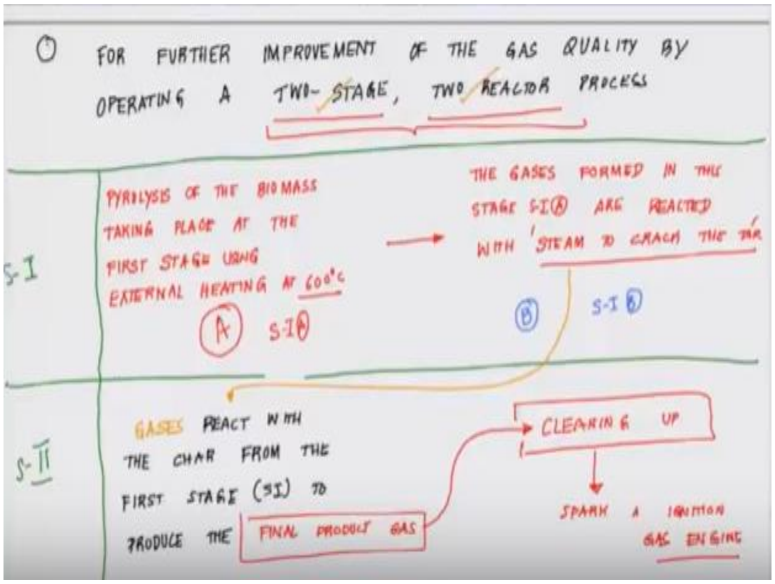
So this area not only one has to think how we can increase the efficiency of the system how we can really you know do a better level of methane and everything one has to keep in mind these are very very robust system we generate tremendous amount of heat energy if someway or other we can translate some of those heat energy one can make tremendous difference and that will be highlighting in the later half just remember this part like we are not done with it.

We will come to this where we will be talking about how to waste heat management a small capsule I will be adding okay waste heat to electricity this will be coming at the fag end okay so now after this the next point which is what highlighting here is that in addition to the initial degrees of volatiles a solid char residue is produced. On this charcoal it produced from this char can be reacted further to have additional what does just mean so during this process you are developing lot of charred products.

And those charred product mostly go as a loss or the waste but there are technologies by virtue of which we can do further processing of the char to develop some really high efficiency good quality gas so this is what we are highlighting here so coming back in addition in addition to the initial release of volatile initial release of volatiles a solid char residue solid is produced.

Okay which is also termed as charcoal from this charcoal if produced form wood or coal interestingly this char what you are obtaining is a these charcoal or discharge the solid char is solid char what we are talking about this solid charge can be reacted further can be reacted further to produce additional gases.

(Refer Slide time: 14:04)



So this is another aspect which is worth considering that could reconsider this kind of charge material further processing by virtue of which we can generate gas and store it now we'll come to the last point about this six bed reactors or flat bed reactors how we can increase the efficiency of the system back in 1995 almost 20 years now a little more than 20 years ideas have been proposed that if we do this whole process in two different stage we can increase efficiency so let us highlight what does that mean how what it means in two stage of combustion okay.

So this is what has been proposed okay so further improvement so for further improvement of the gas quality by operating this is the take home message to stage 2 reactor process to stage 2 reactor process so what we meant by to stage 2 reactor process so this design which has been proposed is slightly more cumbersome but it produces much higher quality of gas so let's divide it into parts.

So okay these are the two stages we will be talking about stage 1and stage 2 okay s-I s -II so the first thing what is being recommended here is what we do is pyrolysis of the biomass takes place in the first stage so pyrolysis of the biomass taking place at the first stage at the first stage okay using external heating using external heating.

So you are kind of breaking up the molecule thing at 60^{O}C which is reasonably low so we look at it no so next in this stage what is being talked about is that the I told you the two stage two reactors is going on okay so there were four different stages will be dealing with the gases formed during this pyrolysis process in this stage 1A so A is this section okay a ok so that's why it wrote it 1A okay you see that s1A are reacted with steam to crack the tar are reacted with steam to crack the tar.

As I told you the tar is a huge problem so what you are doing is they cracking the top so what you did it took the raw material externally you pyrolyzed it a lack of oxygen okay so you could pretty much create you know a lot of you know cracks in all over the structure lot of rearrangement and after this rearrangement what do you do the gas which is getting liberated consists of lot of tar so you put a high steam know it has a very high temperature.

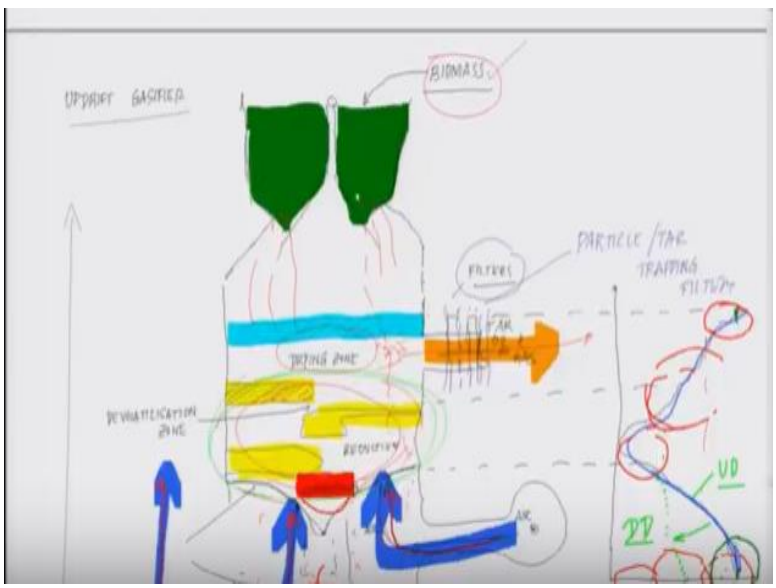
You pass a steam through it what steam will do because already the structure is kind of cracked up it will embed into it and it will further crack the whole star which is getting generated you remember I told you in previous save that you can actually convert the tar into high-quality gases but you need technologies ok so now this is stage be of stage one so this we number it has d so this is s 1 B now what you do what is getting generated out here .

You take this now we are starting the stage 2 so I told you two stage two reactors okay so gases react with the char gases react with the char from the first stage or s1 to produce the final product gas to produce the final product gas and this product gas is further the last stage is further went through a cleaning up and if with certain degree of energy efficiency this is achieved then this is good enough this Parker ignition gas engine.

So if you look at in light of the chemistry what you are doing you are essentially if you remember those four reactions what I taught you in the beginning if you understand the chemistry what there researcher suggesting is that you do those reactions at separate level so instead of processing the whole thing in one combustion unit you split it up you first of all do the pyrolysis pick up the gas into it.

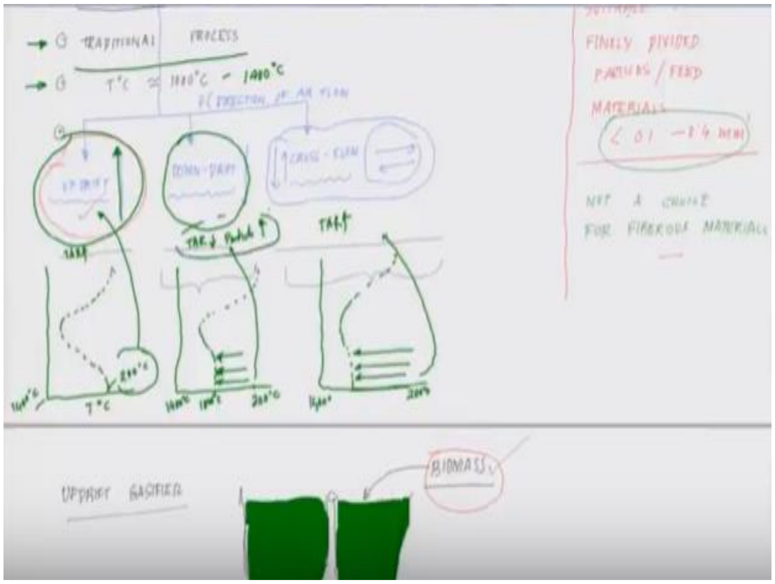
That gas reacted with the steam further break up guitar then use that gas which you produce the next level of gas so in that whole process and at the end you clean it up so this seems one of the strategies which has been suggested fairly late around 1995-96 almost 20years and people are working towards it in order to increase the efficiency of these kind of reactors so having said this let's once again go through where we started with the gasifier kind of help us to know revive the whole thing.

(Refer Slide Time: 21:30)



Okay so we talked about the six bit gasifiers as I told you it's a very traditional process and functions at around thousand to know 1400^{O}C I they could see and it is classified under up drift system where the air is coming from bottom and going up let's again look at it ok here is coming from bottom and going up the next arch and the by the way in the up drift the gas which is coming out.

(Refer Slide Time: 22:31)



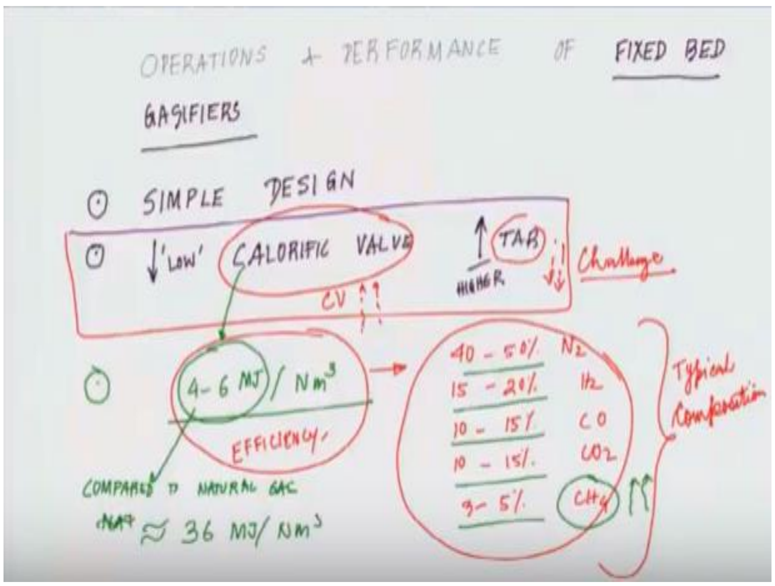
Is that a much more lower temperature is almost the same temperature as the drawings own 200OC where it started likewise okay so if you mark it here a sticks to market here you can go see the temperature ok rounds 10^{O}C then we talked about the down drip gasifies in the down drib gasifier so if I to draw here so what is happening with respect to T ^{O}C.

It is started like this and move and comes back like this right and in the down drift if you look at it the temperature so this temperature is around 200 okay and this is what we told 1400^{O}C. So again same thing here 200^{O}C here 1400^{O}C and if we look at it here the temperature is like that, so she should see there is a shift there is a very interesting shift which took place okay, and similarly in the cross flow.

Even though it is much more steeper so if it is 200°C and 1400°C, so you will see it is even much more so efficiency wise in this case in the up drift you are getting a gas back at 200° which is the most efficient one here you are getting a gas around 1000°C 900 to 1000^{O}C which is slightly lesser efficient and this one is maybe near two down ripped or may be less than down drift okay.

And the other area where this whole thing happens is that our concentration so in the down dress if you remember your tar is low whereas compared to here tar is higher here also tar is higher, but here particle is higher so overall it is always a big tradeoff you cannot have the best under the sun you will always have to do a tradeoff between the two. So this is in summary if you look at it this is what we have undergone and we talked about the design of these reactors down drift, up drift, and the cross-flow actors.

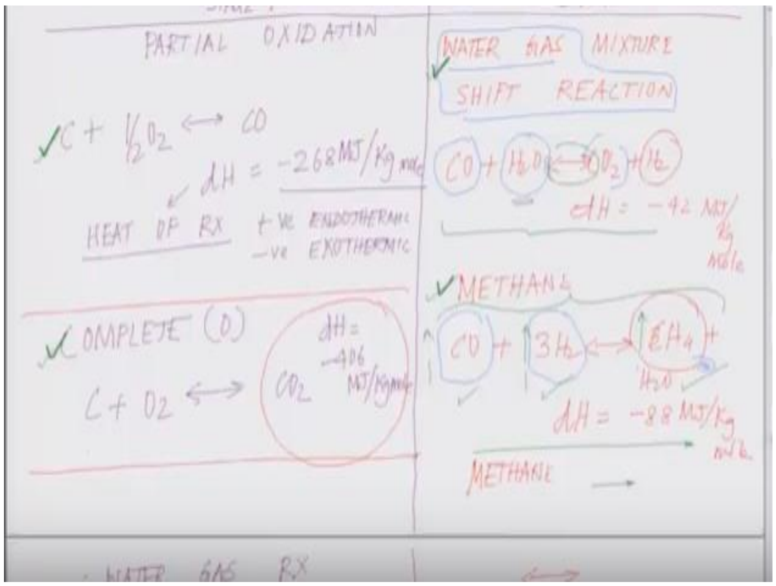
(Refer Slide Time: 24:38)



And we talked about all the basic fundamental properties of this gasifier and in between we talked about the composition the typical composition of 40 to 50% nitrogen, 15 to 20% hydrogen, 10 to 15% carbon monoxide, 10 to 50% CO2, 3 to 5% CH4. So now if some way or other you can increase this percentage you are going to improve this number which as we remember again just to highlight for natural gas if you are comparing with natural gas compared to naturally available gas from natural gas wells which is sorry which is around 36 megajoule per newton meter cube whereas man-made ones using a fixed bed reactor is around four to six.

So the take-home message is that there is no optimal design when you will be in the field you will be running industry of bioenergy, bioenergy production or gasification there cannot be any uniform thumb rule what you have to do you have to understand this basics, based on that you have to see your feed stock what you will be using or the biomass what will be using for gasification based on its basic fundamental properties.

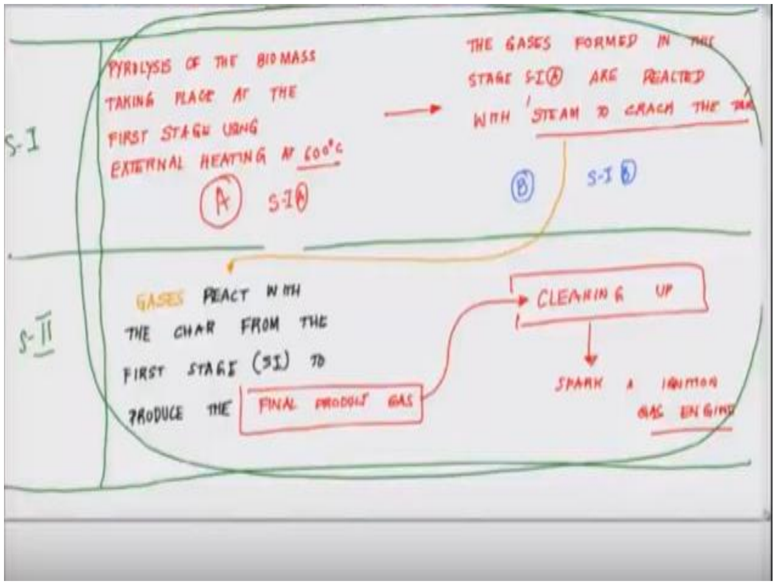
(Refer Slide Time: 26:00)



So you guys remember when we talked about in the beginning of this section the basic property is what has to be dealt with the feedstock properties the moisture content ash content volatile compounds and particle size based on these things the feedstock properties and keeping in mind these critical things what kind of treatment has to be given one has to optimize so your feedstock treatment which is the most fundamental basics of it which will cum covered in the section C and you have to remember always the basics.

So again this is that comparison so we are at this point out here for 26 Megajoule per newton meter cube okay and always remember these four reactions this is very, very critical these four reactions should be your guiding principle this one this one this one in this one water gas shift reaction maintain production partial combustion to form co between carbon and half oxygen or lack of oxygen or a complete combustion Percy trousseau to these four reaction should be always should be in your tips whenever you are doing this kind of science if you know these and you know the nature of the biomass for the feedstock and if you cleverly or wisely design the pre treatment strategies and you have a fair knowledge about the gasifier designs.

(Refer Slide Time: 27:30)



One can really harvest a lot of energy from these kinds of biomaterials okay so with this section now will after this will move into the fluidized bed reactor. So I will close in here please go through it, keep the chemistry in mind, keep the properties in mind and then things will be very clear to you okay 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