Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Bioenergy

Lecture -32
Thermo Chemical Process of Gasification

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

Welcome back to the lecture series in bio energy. So in the last class we talked about the gasification.

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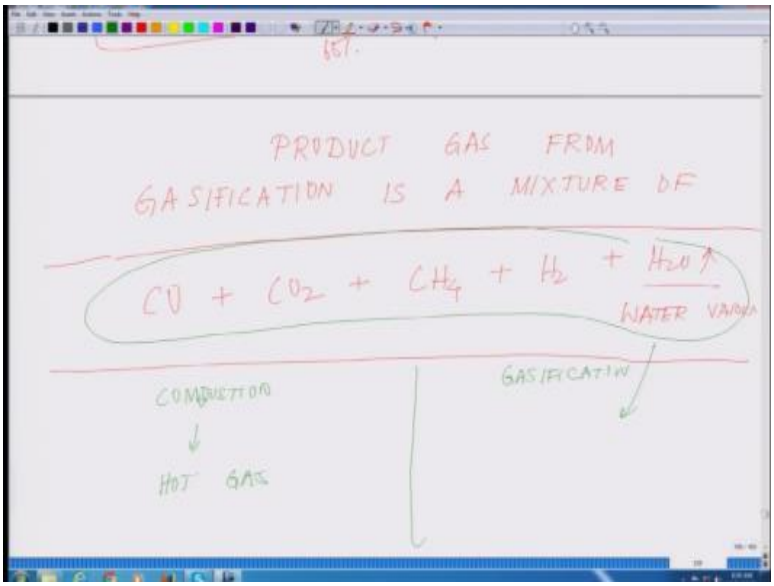

If you look at the advantages of this gasification process.

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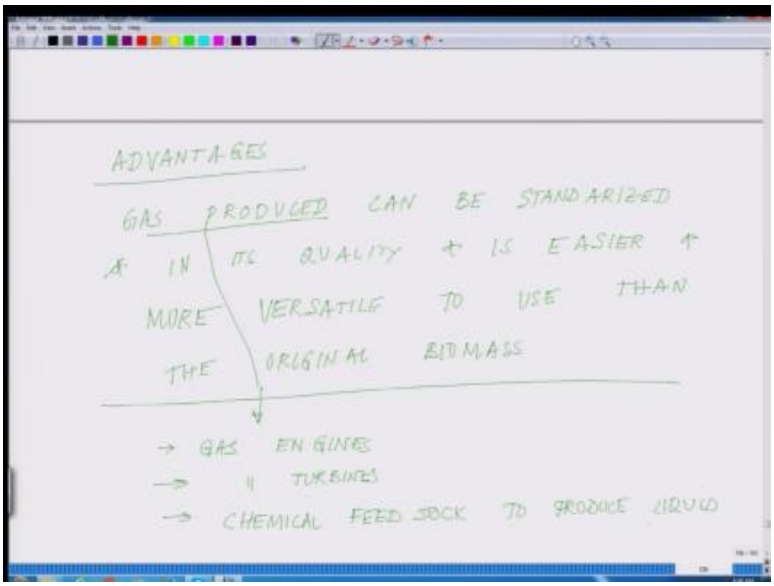

So advantage of gasification let us talk about the advantages so advantages is basically the gas produced can be standardized and in its quality and is easier and more versatile to use then the original biomass and as a matter of fact this gas could be used could be used for gas engines it could be used for gas turbines it could be used for chemical feedstock for producing liquid fuels okay.

Chemical feedstock to produce liquid fuel, and here I wish to since now we have talked about the whole process. So we have talked about we introduced the concept of gasification and then from there we moved on to the basic chemistry. So we talked about the basic chemistry where we showed in the stage one you have partial oxidation of carbon you have complete oxidation of carbon followed by the production of methane in the second phase.

So here one interesting thing what I wish to highlight you might be wondering that this is what is happening in a very the kind of conditions what we create is kind of a very high temperature, high pressure whereas nature produces it through geological era can create that, because it is far below the earth's surface where you have high temperature you can do that. So whenever we talk

about any process which requires high-temperature, high-pressure we are talking about increasing our input cost to produce a field.

So whenever we have to talk about economics whether this will be a feasible technology or not one has to keep in mind that this is the input cost what is being fought in order to produce this kind of materials. But if the input cost is good enough that we can compensate for it sure there is no issues, but there is another route this gasification is not purely happens by thermo chemical processes those will not talk about it today.

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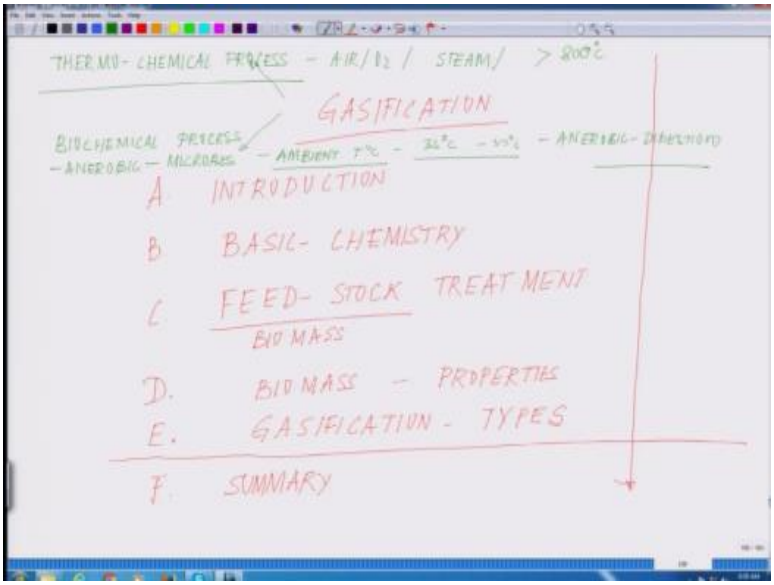

But just to give you an idea about when we talk about gasification if we go back out here there are two routes by which one can think of gasification one route of gasification is the one what we are just now discussing which is basically a thermo chemical process okay, thermo chemical process where you are giving high temperature and high pressure and you are developing it and using your using air they have already talked about it you are using oxygen, you are using a steam and at a temperature more than 800ºC.

Whereas the other route is the biochemical process which is a very, very lucrative route biochemical process this route essentially use microbes or mostly anaerobic microbes anaerobic means the microbes which grows in the absence of oxygen anaerobic microbes and they could carry out the reaction at an ambient temperature which is around you know 35 on 37ºC okay.

So if you think of it so it is basically the process is called in aerobic digestion. So we have not yet touched upon this point we were coming will be coming later. So what I wanted to highlight here is something which always struck me that whenever we talk about the sources of natural gas I personally believe that it was not exclusively a thermo chemical conversion which has taken place in nature probably thermo chemical conversion have been supplemented with microbial digestion processes.

Because otherwise the process efficiency will be not that high, so another approach of studying gasification are with the microbiologist who are working towards energy where they look for different kind of microbes which could produce methane from biomass okay, or you know they could produce other different kind of combustible compounds from biomass. So we will talk later about that, so at this point what we will be delving into is we will be talking about the thermo chemical conversion okay.

Now from here what we will do we will move on to the part 2 of it what are the three product qualities which can be produced by gasification. So there are different kind of different range so what are the different kind of product that is what we are getting okay, there are three different kind of product gas what we obtain from this whole process three and here we will be making a comparison with the natural gas which is produced in the nature.

And how close we are to that and how far away we are from that and that will help you to kind of figure out what kind of technology we needed to really use in order to get good quality gas. And this is one more thing which I kind of skipped through to realize that the reason for there is so much thrust on gasification process is this, because it is a lighter feel whenever we talk about liquid fuel or solid fuels or heavy right gaseous wells are lighter they are easy to carry they are easy to transport from one place to another.

So if we get the right set of conditions to produce a whole tons and gowns of such gases then it could be easily transported from the existing gas lines which are already laid all over the world. So it is a very interesting journey of mankind where this is aspect which I wished for you people to philosophize very clearly. We are now engineering nature by learning from nature because this is the first time possible in the history of mankind is happening.

We are exactly following the protocols or the blueprint what nature might have followed through geological eras and through ages to produce all these natural resources for us which are very good quality fields okay.

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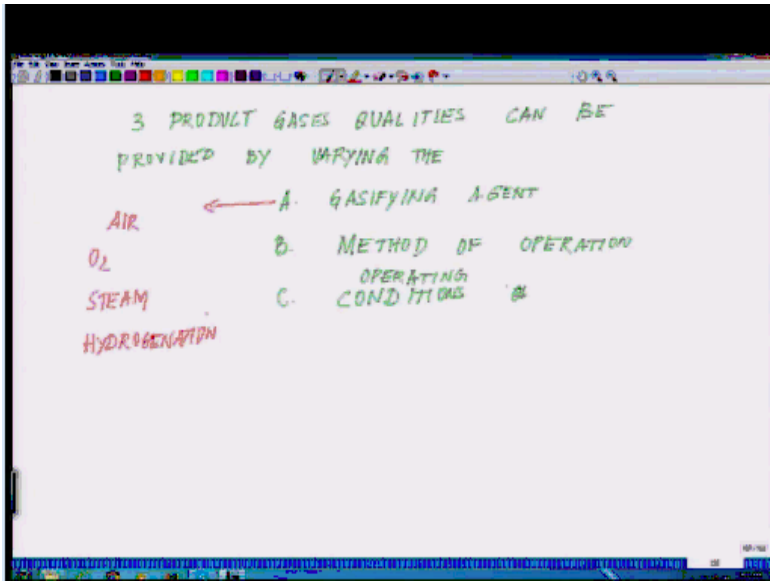

So now coming to the three different kind of product gases product gases which are produced three different with basically quality control wise product gas qualities can be provided by bearing I told you they are different conditions which you can vary during gasification by varying the three parameters you can vary the a) gasifying agent one and b) the method of operation, method of operation c) conditions or operating conditions okay operating conditions.

Now if we talk about the gasifying agent there are three different kind of gasifying agent we have talked about we have talked about the air, we have talked about oxygen, we have talked about steam and we have also talked about hydrogenation where you are giving hydrogen in other word you are reusing the product okay.

And sometimes further you can do catalytic steam gasification is also further followed okay, you are using different kind of catalysis catalytic routes or catalyst okay catalytic steam gasification okay, so these are the different gasifying agent which are being followed and what you get out of this is you have three class of stuff with different calorific value which you obtain one is a low calorific value series 10 for low calorific value you get medium calorific value and you get high calorific value product, high calorific value products and in terms of the numbers the numbers vary from newton meter cube 4 to 6 okay ,4 to 6 okay.

Now mark at this number so you have medium one which is you get 12 to 18 mega joules that newton meter cube, whereas for a high calorific value you get mega Joule per newton meter cube and in terms of the utility so, before we get to the utility what are the different kind of gasifying agent which are used so here you are using air steam / air okay, here you are using oxygen and steam, here you are using oxygen steam and hydrogen or hydrogenation what you are doing so, these are the low calorific value is directly used as an engine fuel, are whereas these two are used these are the feedstock for subsequent conversion into basic chemicals principally methane,into methane and methanol and all those kinds of products okay.

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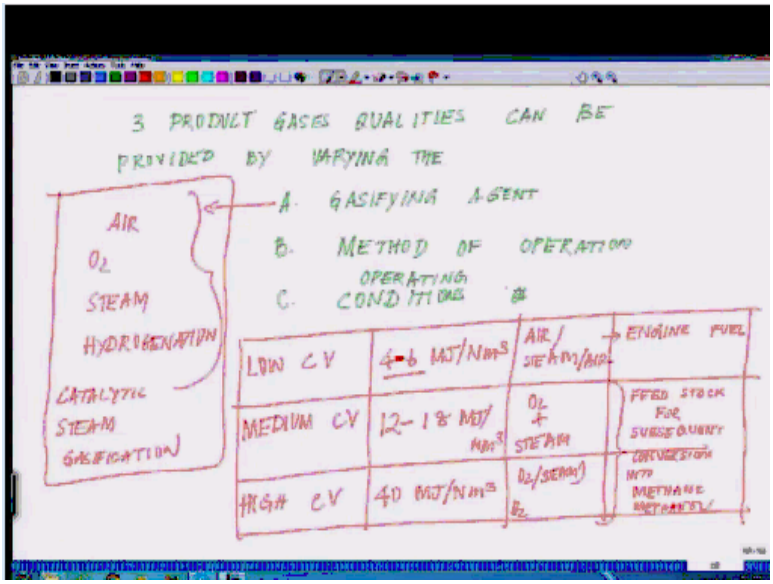

So now the question arises that why there is such a low calorific value obtained when we are using here or steam, steam / here now if you look at it again carefully so look at the value compare the value 4 to 6, 12 to 18 and 40 this is a significant difference even, if I take the higher values is 6 18 40 that three times and this is another three times almost three times okay, 18 ok twice okay it into the 36 okay at least twice why there is such a huge difference? Now here is a catch and that's something what tinkering about when we use air here has a high percentage of nitrogen presented and nitrogen actually dilutes this reaction big time.

And since so what you see out here is you look at it carefully this air what you are having it has nitrogen and this nitrogen is our problem whereas, if use your oxygen which is being used here this is expensive you have to have a pure oxygen to do this reaction this is not something very easy to do okay, and here you have another added feature you are using hydrogen which is also become expensive as well as risky affair, when you are dealing with hydrogen you have to be very careful while dealing with hydrogen have every chance for blast or something you know.

Now it's a kind of a trade-off, now in the hindsight or edit prospectively, if you think when nature has developed these kind of gasifying products are like you know the product gases under the earth there are hardly any air there it was lack of oxygen it was all kind of partial combustion so, the route possible it has followed is a very tricky route and there are a lot of microbes there which has led to the production of lot of carbon dioxide by a cheaper route.

So if you are a thermo chemical guy and if you have another collaborator with a microbial guy the challenge will be both of you sit on the table and really optimize this process where you can introduce microbes do you know bring down the energy of it and think of it this is this brings us to another aspect of it when we talk about this hydrogen.

Hydrogen production is a big story if you remember well we talked about four senses I told you there is lot of work happening across the world where they want to produce hydrogen because, hydrogen itself could be used as a fuel hydrogen itself could be used as a reducing agent there are so many things, where hydrogen could be very helpful okay. So what I wish to highlight here is that we have to think very holistically and now this is the really I catcher if you look at it if we talk about if we compare these three values with natural gas here is the number for the natural as I'm just keeping for you people all the three values and if you see the natural gas the calorific value of C V stands for calorific value of the natural gas that is 36 mega joule per newton meter cube.

Now you just compare so, here is the natural gas which is 36 you have 6 low calorific value I'm just taking the higher values okay you have18 which is medium calorific value here the highest calorific value 40 of a lot of expenses in terms of you know you have to have oxygen hydrogen and likewise and hear what nature has produced. So challenge is to consistently get something in between, between a medium and a high calorific value feed and this is not something and if you look at the efficiency of conversion of both so what we did previously the pyrolysis and gasification, so classification flash pyrolysis for both the technique the biomass conversion efficiency is around 75 to 80%.

So here is the catch if natural gas is 36 mega Joule per newton meter cube whereas the calorific value whereas with our highest expenses we are getting 40 which is marginally different and our low calorific value is at least one sixth of what we get from natural gas which is 6 if you if you again visit this because this is what is the take home message here you have the 6 here you have 36 which is six times so, how we can reduce that from six to 36 what will be the root how you will do it I am supremely confident that this cannot be achieved by one particular route, it has to be done in conjunction with a microbial route which will becoming later into it okay.

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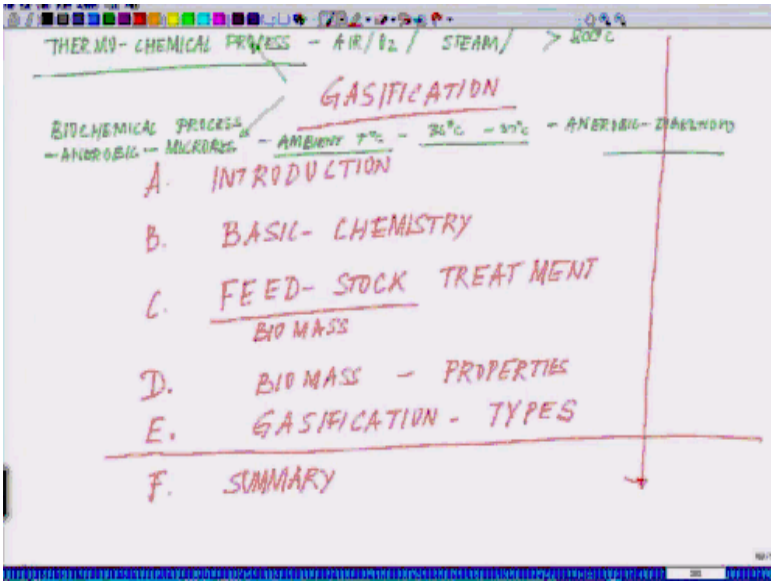

There has to be a microbial approach into the game which will help us to realize our dream of moving from a 6 the value of the calorific value to 36 which is standard natural gas wherever you obtain. Now we're all you can really put your fingers into the process so one of the processes where you can think of is what will be so, if you go back what all we have covered now as of now so we have talked about two roots thermo chemical and biochemical process but we haven't talked about the biochemical yet this is what we will be dealing later.

But we have started with the thermo chemical so, we talked about the introduction this is we are done we have talked about the basic chemistry we have done so you have talked about the basic

chemistry and we have talked about all the different efficiency parameters and what I am proposing for you guys to think the thing differently you have to put you have to integrate these to us.

We'll talk about the Y chemical process later you will realize why I'm telling what we have to think very differently very judiciously, now what we are talking about is where we can intervene, where we can make the process go more efficient so one of the pros where one can make the process or increase the efficiency of the process is by selecting the right kind of biomass or right kind of feedstock, so what kind of feedstock we'll be using for this purpose it is very, very essential because this will bring take you back to the original ideas what we have talked about what kind of and will discussing in depth about it.

And then could we do some kind of a pretreatment before we introduce these materials in the gasifier because we can allow the reaction to take place much more faster or could use different kind of catalyst which will increase the action faster could you introduce some kind of microbial treatment which will make this kind of heat is talk much more amenable to modification to for methane or those kind of things faster.

So what we will do next is we will talk about the feedstock treatment processes and the properties of the feedstock and the third aspect which is out here which is the gasification type it is more of an engineering aspect of it what kind of gasifier we will be using for what kind of materials, because different materials needed different forms of a different kind of treatments different pressure, oxygen tension different temperature, different level of steam.

So what will be the material what will be the process and what will be the safety measures for using different kind of gasifiers, because if we think that one day we'll have this as kind of part and parcel just the way you see most of the petrol pumps you will have you know gas filling stations, just like them the natural gas filling station all across India. Similarly so what you have to do you cannot so you will have a local hubs this is aspect will be dealing later local hubs.

So this region you have a local refinery the next village has an another refinery third village another so you have different locations where you will have eco-friendly hubs where you'll be converting the biomass or the feed is talked into different form of energy like you know gaseous form liquid form solid forms and it likes one and so forth.

So it will be a long journey which will bring us it will be kind of a consortium of microbiologist engineers, high engineers, chemist, chemical engineers reactor designer's economists and socio politicians who understand what people like to use, because it's not that every time you introduce the technology. It will be accepted by everybody it has to go through the whole regurgitation process of this liking or introducing it in the right way so what I will do, I will close in here today and we will start with the feedstock treatment in the next class and we will talk about the biomass properties and followed by we will talk about the gasification types.

So this is what will be in store for winding of the gasification process and after that we will move on to the anaerobic digestion process which is another route of gasification and what are the seminal discoveries in that area, what are the modern technologies which are being used on it okay. So with this I again wish to reiterate the fact please go through these nodes because I do not have any other separate notes as such, because this is what I am putting exclusively so you do not have to refer to anything and try to understand the basics do not get bogged down, once you get the basics right then you can refer to any book and it will be clear to you instead of really getting bogged down by the books all over the place 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

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