Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Bioenergy

Lecture -31
Introduction of Gasification

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Welcome back to the lecture series in bio energy so in the last class we winded up with pyrolysis is and we talked about some of the very interesting routes by which pyrolysis product could be used to store electrical energy making nitrogen-doped grapheme so in the last class we talked about the next process where we will be talking about classification as the name indicates what really gasification is gasification is a process by virtue of which a biomass is converted into gaseous in some of the gaseous product.

You can store just like all of you have seen gas cylinders many of you are from rural background have must about heard about goober gas plant or where cow dung is being used to generate gas by fermenting it in a reactor or you must have heard about methane gas to be used for instrumental things and another thing which all of you have heard is natural gas is being used for cooking so exactly the same thing the biomass is getting converted into gas.

Now as we do in every class we kind of philosophize the aspect before we get into the nitty-gritty details of out of this whole thing Apple so in nature if we look around nature through billions of years of evolution through geological eras the biomass under intense pressure temperature lack of oxygen inside the earth crust has converted into different form of gas and there are gas wells from where you know either onshore or offshore there you drill and you take out the gas or regular consumption this is how nature has produced natural gases and they have certain calorific value.

And we will talk about it now what we are trying to talk today is this process of gasification which has taken place over billions of years now we wanted to emulate that process or we want you to mimic that process in a laboratory conditions and so that we can further scale it up to make gas refineries or gas plants where we will know more depend on natural gases or the natural gas will be supplemented by synthetically produced gas and it has been observed you might be wondering why we really wanted to do this.

Because there are several routes the program's will you take a solid biomass okay you can do a combustion it will generate heat which is a good form of energy but it has been observe as we walk through this lecture or couple of lectures it was observed that the calorific value of transforming solid through combustion to hot gas is lesser than the calorific value which is obtained when a proper gasification process is done and welcome as we will walk through realize that combustion process is directly a single step process where you have bio mass you burn it and it generate carbon dioxide and hot air and everything.

Whereas when we talk about gasification process it is a multi-step process definitely there are two discrete steps which are involved so the way we will be covering this topic will be will be talking about this under five different headaches and here I wish to highlight one thing there was a question in the forum requesting for the notes so what I did instead of really you know photocopying with whatever little bit notes I have here and there I am writing down all the notes here.

So that you do not have to refer to anything else and another question which I wish to answer through this forum is many people are asking for different books so to be honest to you there is no one book really one can refer to because the way the whole field has revolved is there are several people with expertise somebody is expertise in gasification somebody is in expertise in engine somebody in bio oils somebody in combustion some other people who are on other economics aspect of it so every book is written with certain degree of biasness or the expertise of the writer.

So what I have tried to do is that I erect through several literature which are their up-to-date research references and I am bringing the g's for you so that you do not really need to go through a book for the basics but if you learn this basic then you can open any book and really can figure out what the author wants to express what they were author wants to communicate okay so there is no single book as per se or I am not doing any specific notes so whatever I am writing here so I'm just pulling out the very G store the whore of the subject which will inspire you prefer to think beyond and so that when you pickup any book or any research review you exactly know what we are talking about.

So that is why what we did in the course if you realize we have divided it into different kind of conversion processes and we are proceeding that accordingly okay so now coming back to the gasification what to talk about.

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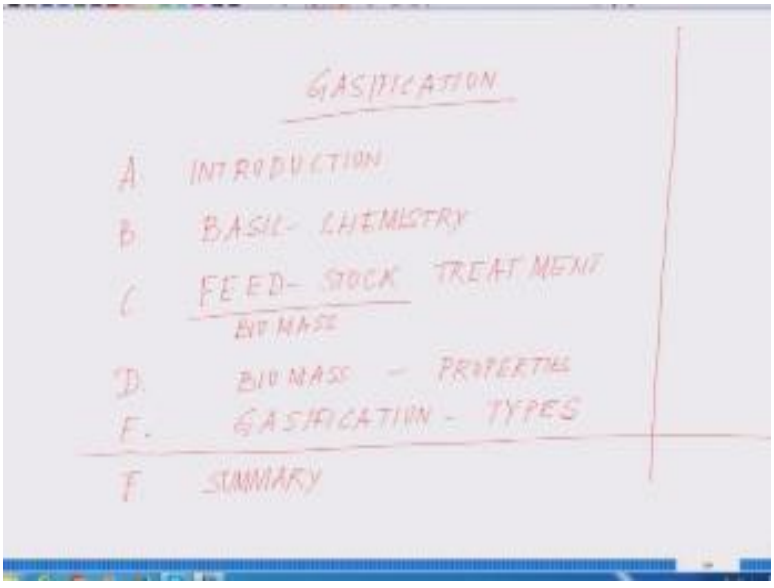

So this is what we'll be dealing today okay, gasification so in gasification therewith five different subheadings under which will be dealing with gasification so first we will talk about we will introduce ourselves to what is meant by gasification the whole process then we talked about the basic chemistry it is very essential that we understand the chemistry first without understand the

chemistry nothing will make sense that why it is different from combustion and other processes or pyrolys is then comes feedstock treatment this will be this will take you back to the earlier lectures where we talked about what kind of treatments what has to be done what are the properties of the feedstock.

So in terms of the feedstock treatment will be talking about before you put something in a gasifies or the whole assembly in which you are converting the biomass to get you need to do some form of a pre-processing of that biomass or the feedstock here what he meant by is basically the biomass so it is a biomass pretreatment or biomass treatment what which / we call it then we will be talking about the biomass properties we have partly covered and here we will be covering it in the context of gasification.

So here it will take us back to those basic properties if you remember carbon cellulose ratio then we will talk about ash content will talk about the mineral content because those will help us to realize what kind of feedstock or biomass is more suitable to produce high calorific value gas as compared to low calorific value products okay so that will be our biomass property is what we will be dealing with next we will talk about the gasification types what are the different methods by which gasification is being done under of course gasification type under the basic aspects of the basic chemistry will be the same.

But different designs of classifiers and everything but we will talk about and then of course in conclusion after this five aspects we will do a summary of the whole what we have covered here okay. So this is the blueprint or the part of the nodes what will be following today.

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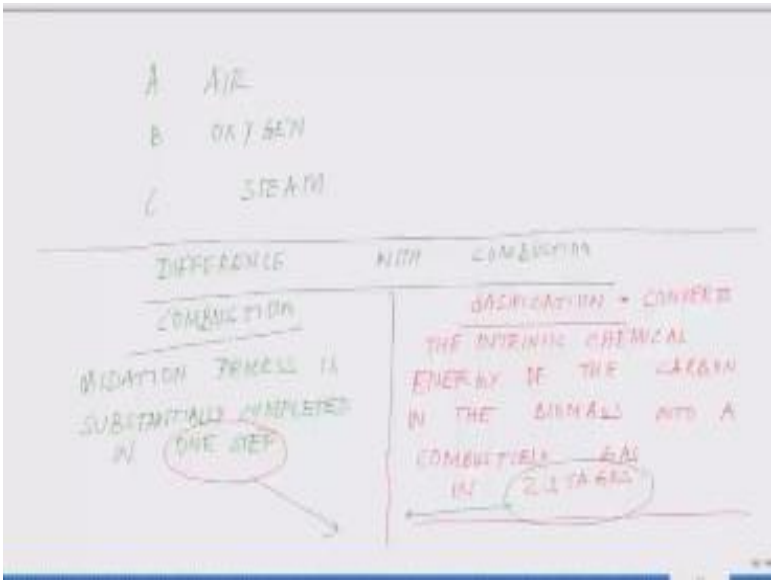

So now talking about the introduction what keys really so this is what is gasification by definition so gasification by definition we talked about gasification okay so this is the process of conversion of biomass conversion of biomass into combustible gas mixture we will talk about what is that gas mixture consists of okay combustible gas mixture this is the basic process and the process which is involved in it how we do so.

so the process which is followed is by a partial oxidation of biomass at very high temperature which is around 800 to 900^0 centigrade okay approximately 800 to 900^0 centigrade and in a gasification medium and what is the gasification medium will come to this now in gasification medium and gasification medium consist of either it could be here it could be oxygen it could be steam and there are a few more which we'll talk about it later okay.

Now if we talk about what is the basic difference with combustion okay difference with combustion so we will just do a one-step comparison so if we talk about combustion as such the combustion is a process the subset substantially or the oxidation process where you're burning biomass oxidation process is substantially completed substantially completed in one step so

remember this it is completed in a single step process so let me highlight this part it's a single step.

Whereas if we talk about gasification process gasification convert the intrinsic chemical energy of the carbon intrinsic chemical energy of the carbon in the biomass if you remember this is what I have highlighted earlier in the biomass into a combustible gas in two stages into some vegetable gas in two stages okay so this is the basic difference so if you have to highlight part this is the basic difference this is where comes a basic difference so what are those two steps. Our next goal will be to understand what those two fundamental steps are which differentiates basic combustion from the gasification process so let us talk about that two basic steps.

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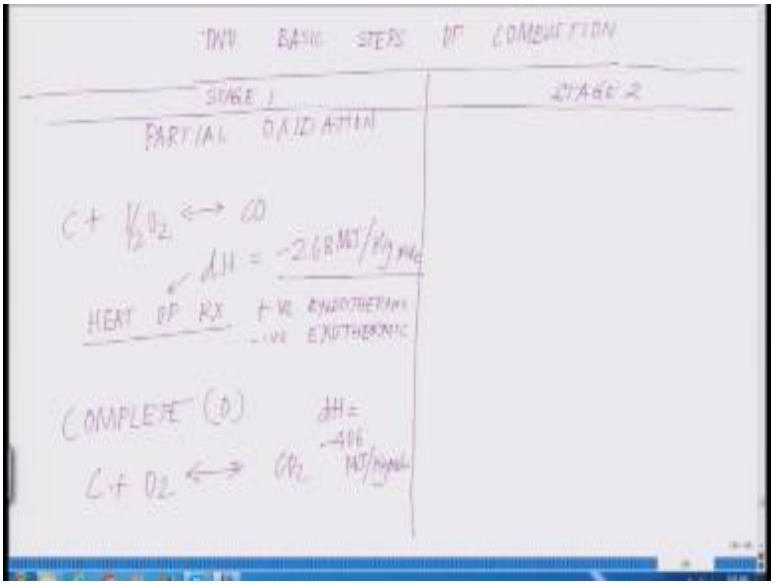

To basic steps of combustion okay so that step one what we will be talking about is we will have a say for example step one will have a partial oxidation step this is step one so let us do it into table so this is our stage one and this is our stage two okay so in the in the partial oxidation that first step is where carbon is getting partially oxidized oxygen carbon with lesser amount of oxygen the arrow shows that it can move in both direction depending on the conditions okay so most of the time in the absence in the lack of oxygen what you get is carbon monoxide.

And if you look at the heat of the reaction or D HSN for heat of reaction or acceptance for reaction is it could be positive if it is an endothermic process where you are absorbing Heat okay and it will be negative it is an exothermic process where you are generating heat so if you see the heat of reaction that is around minus 268 make a Joule per kilogram mole okay now if the same carbon goes through a complete oxidation for example it goes for complete oxidation okay. Let us see +o2 making it co2 and if you compare the heat of the reaction or the D H value that will be around just almost 406megajoule plus kilogram mole.

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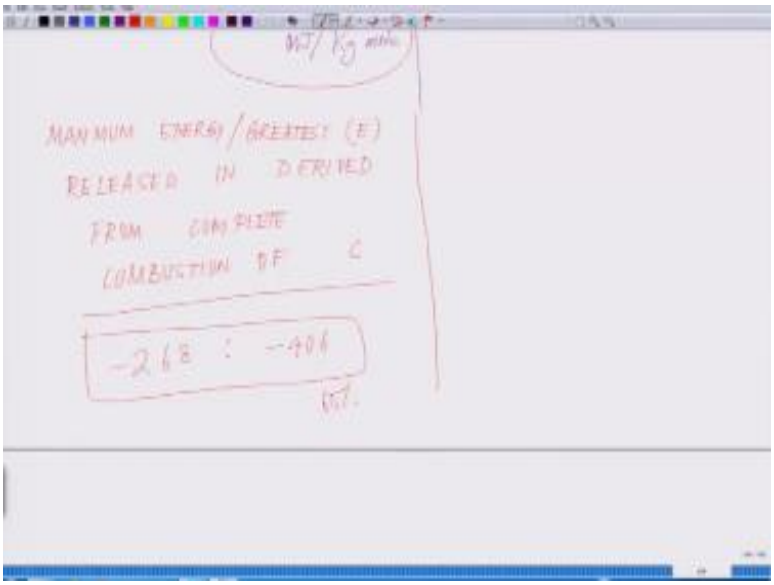

Whereas and the third reaction in that area where we talked about stage one where you have water gas mixture which is involved in it where you have just continued in the next page okay so the water gas reaction which is basically in the presence of steam water gets reaction where you have C + h2o making c 0 + h2 and if you see the heat of reaction this is very critical plus jewel plus kilogram small so if you compare the three reactions in the presence of water gas reaction the reaction become endothermic as compared to say which you can see here this reaction is become completely endothermic it is absorbing the heat energy.

Whereas these two reactions are exothermic and among all these the biggest exothermic reaction is this one which is minus 406 mega joule per kilogram moles okay so now if you look at it if you compare these two values of268 and 406 it will be around kind of you know around sixty-five percent of it so if you compare so the conclusion from the stage one what you're drawing is maximum energy or the greatest energy released is derived from complete combustion of carbon is derived from complete combustion of carbon and the values you can compare in the case of incomplete combustion.

You have minus 268 and the case of competitive 406 ok I am just not putting the unit's here but just for your comparison you can see the comparison and you can figure it out put the advantage which is approximately 65%. Now this is stage one where you see what are the products you are getting you are getting carbon monoxide carbon dioxide and hydrogen as well as there are lot of high temperature steam and everything present there. So you have four different kind of mixture which is present there but then what happened is stage two now will come to the stage two of gasification so let us go back where we were we're doing okay now we are in the stage two.

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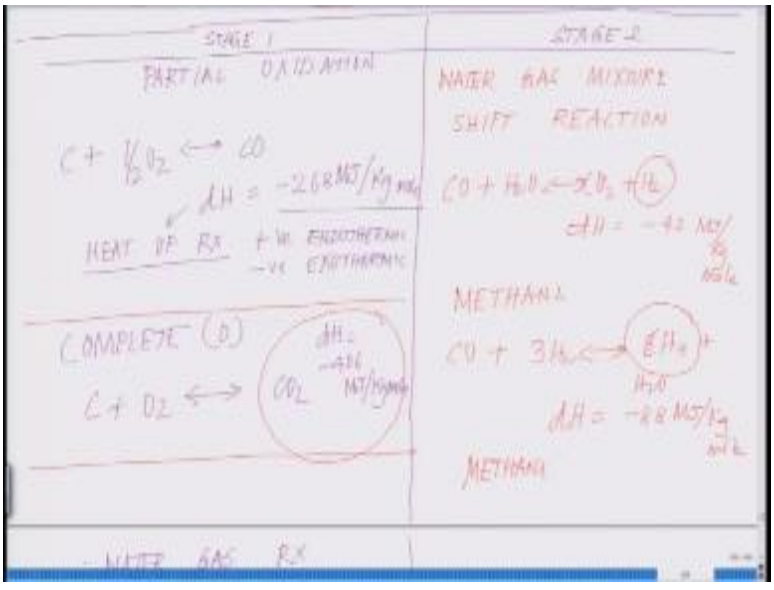

In the stage 2 or what happens this water gas mixture shifts reaction okay what does that mean water gas mixture shift reaction okay so that essentially means you have C 0 plus water this becomes either co2 + h2 and heat of reaction for this is minus 42 gradual plus kilogram mold whereas in another reaction what you get is the formation of meeting where you are having Co plus3h to you are seeing out of hydrogen which is getting generated it makes thech4 k plus h2o okay.

So and the reaction what you are getting here is minus eighty eight you first kilogram moles so what you are producing here is methane in the second step and every time you are observing that I am putting an arrow like this.

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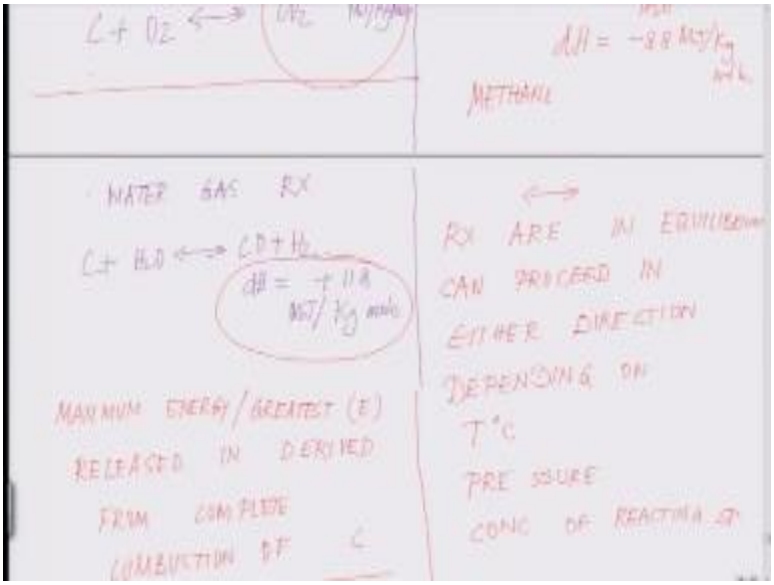

Which basically shows that the reaction are in equilibrium so the reaction are in equilibrium and can proceed in either direction so this is your control point for a reactor can proceed in either direction depending on depending on temperatures pressures and concentration of reacting species okay. And essentially the product gasps what you get out of this whole process.

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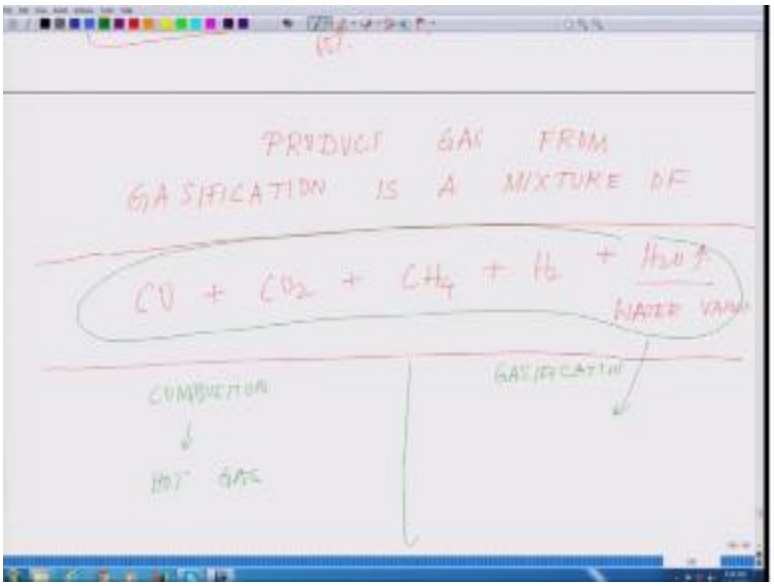

What we call as the product gas he is a mixture of so this is you remember I told you that there is a mixture plot a gap from gasification is a mixture of is a mixture of Co plus CO 2 plus n plus hydrogen plus steam or water vapor this is a complex mixture what you obtain out of this whole process and unlike combustion now if I compare it to an unlike combustion which produces only hot gas so if I see combustion if you compare it with combustion whose end product is basically hot gas.

If you compare with combustion you will see on the contrary in gasification what you are getting is a complete mix of these different things in the gasifies so the amount of product is totally different and what are the advantages of such things if you look at the advantages of the gasification process the gas produced can be standardized so I will close it here thank you.

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