Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

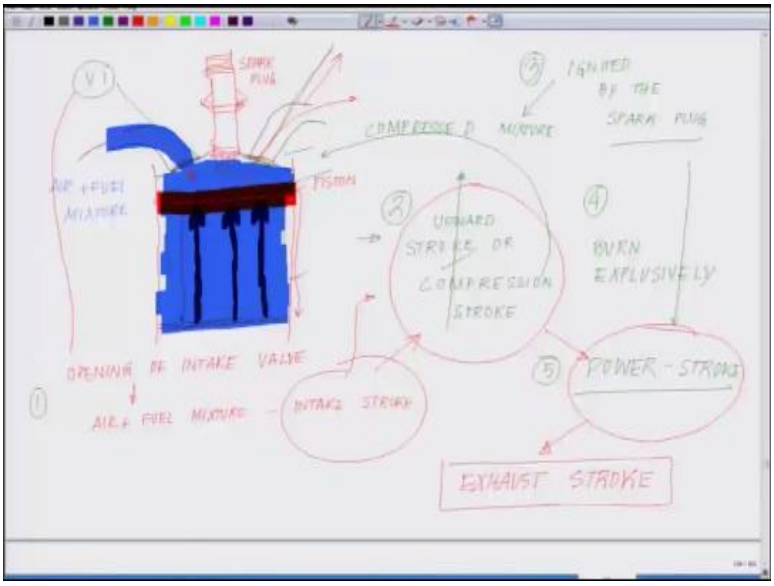
Course Title
Bioenergy

Lecture – 29
Compression Ignition Engine

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

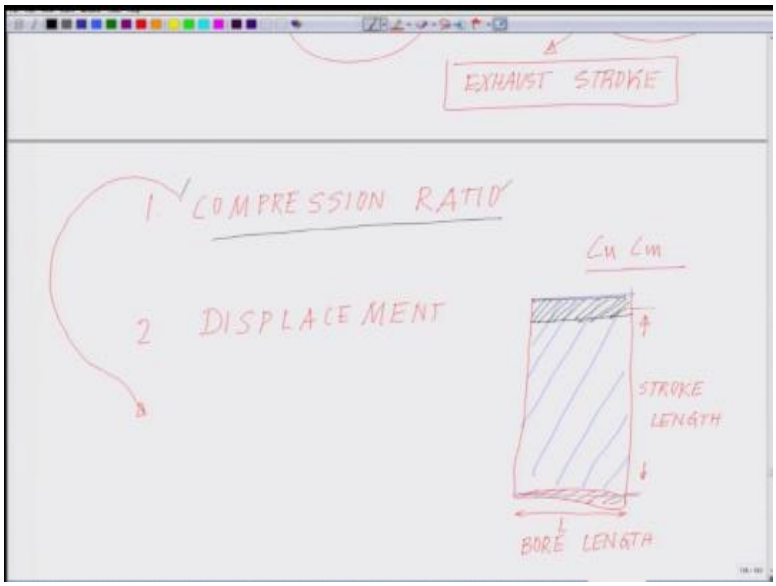
Welcome back to the lecture series in bio energy.

(Refer Slide Time: 00:23)



Now this brings us to two parameters how they could be described.

(Refer Slide Time: 00:28)

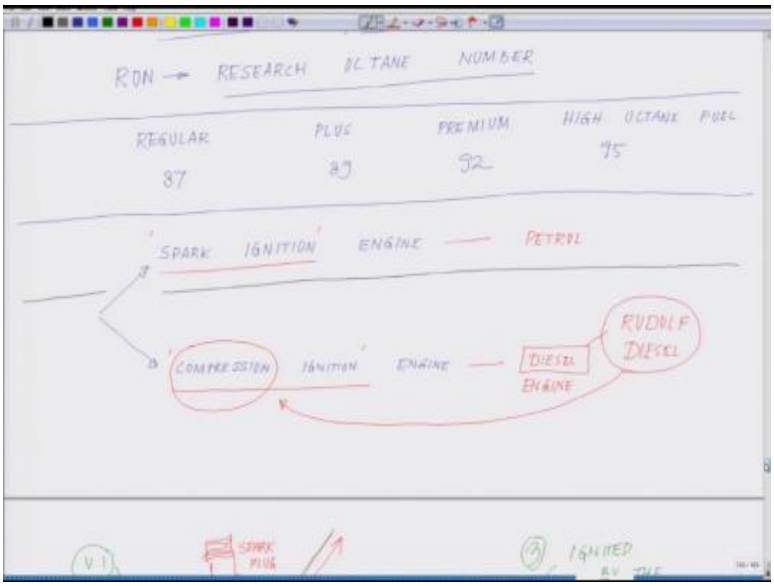


And their efficiencies tested based on one is called and this is what is most important for you called compression ratio and other one is called what is the amount of displacement okay so just to briefly talk up to about the displacement what we talk about when you talk about a cylinder like this okay. So the displacement is basically in terms of the cylinder the length which is kind of you can call it as the bore length of the cylinder which is kind of the diameter of the cylinder and the stroke length stroke length and this is called the bore length.

So generally it is expressed in cubic centimeter so we multiply it with the number of cylinders what you are having in any kind of vehicle you can calculate what is the displacement now talking about a compression ratio this is very important. So say for example if this is your size of the vessel initially it feels like this much completely with the air-fuel mixture when you are compressing it what is how far you can compress it without it getting self ignited.

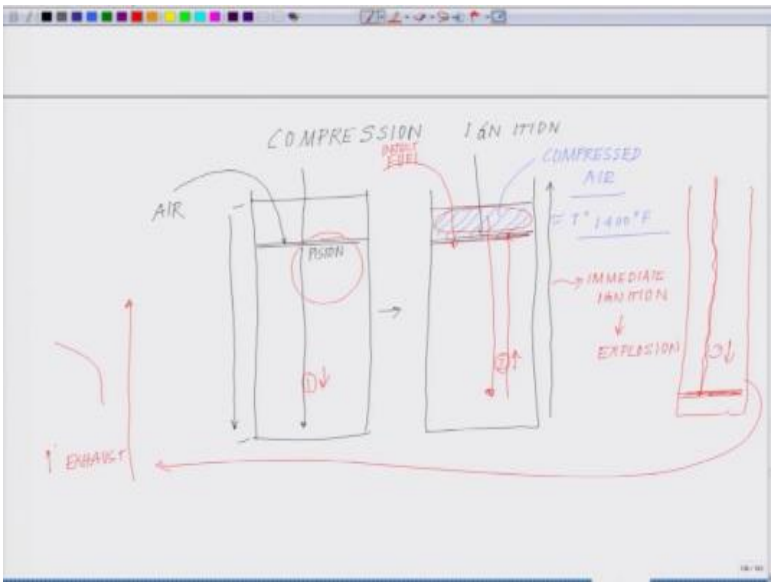
Because of the thermal agitations that decides what is the compression ratio and this compression ratio is very, very important for you people to understand because based on that we will be defining the features of the octane so this is one out of among the two what we talked about.

(Refer Slide Time: 02:36)



This is spark ignition engine this is the most simplistic way you can understand the spark ignition okay. Now what about the compression ignition once we will finish the compression ignition then we will talk about the octane number okay.

(Refer Slide Time: 02:54)



So now talking about the compression ignition this is slightly different so compression ignition works in a different way in compression ignition what happened you have again a cylinder like this in which what you do there is an intake of air simple air okay this is an air intake. And so the air cells, so this is air have filled it up just like the way you saw it in the previous situation then the next step is so once the air is feeling you are moving the system down.

So here is your question okay now you are compressing the air back second motion so in a very limited area you are again pushing the pulling the piston back so what you are having is out here is compressed air okay which is step two compressing the air and this compression of the year because of the closeness of the molecule they come so close.

As I was trying to explain you in a spark ignition engine they, because of the collision of these your molecules out there they attain a very, very high temperature the temperature of around approximately be attained around 1400° Fahrenheit this is the kind of temperature heat rises and at this stage what is being done you inject when the air temperature is so high, you inject the fool into the system and when you inject the fuel to such a system what happens.

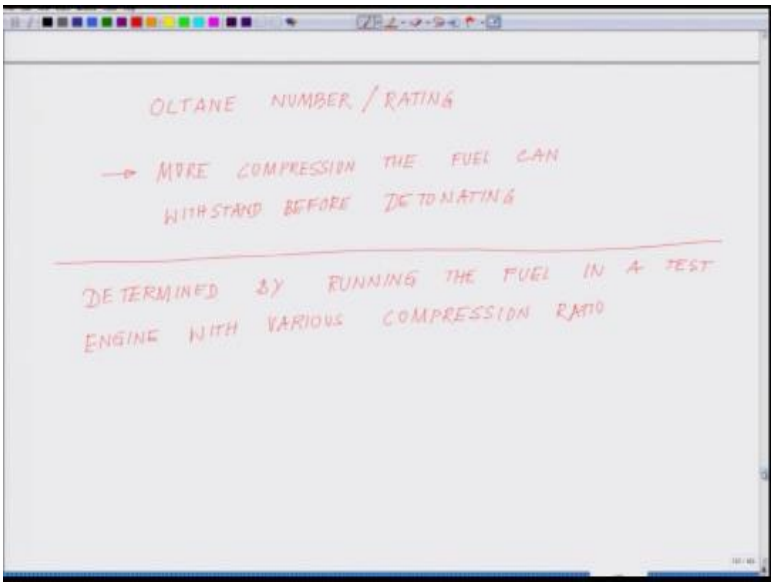
Because of so high temperature of the air it leads to a immediate ignition and an explosion immediate ignition followed by an explosion and this explosion as you remember the previous situation leads to this system. Now again follow the same thing so the system now goes down automatically because of the explosion because it pushes the piston down. So this is the third time is making a motion the next all that exhaust as you did in previous one.

So this is the first situation when air filling the first stroke second stroke where you are compressing the air third at this stage you are adding injecting the fuel, because of the explosion the plunger glow cider piston goes down. So this is the third motion first motion second motion which is going up sorry, which lead is going up and this is the third motion when it is again coming down up down the fort is where you are the exhaust is being thrown away.

So this is the fourth time system is making moving, but this time it is going up ward as we did in this park ignition. So what are you observing is in both of them the fundamental difference is this that one uses air fuel mixture the other one only uses the air and compress the air and use that compressed air for ignition.

So that brings us to the concept what we talked about compression ignition engine. Now having saved this now we will go back after having exposed you to the two these two different kind of engines. Now we will go back to the concept of octane number in the light of this information your fundamentals will be clear what does octane number means.

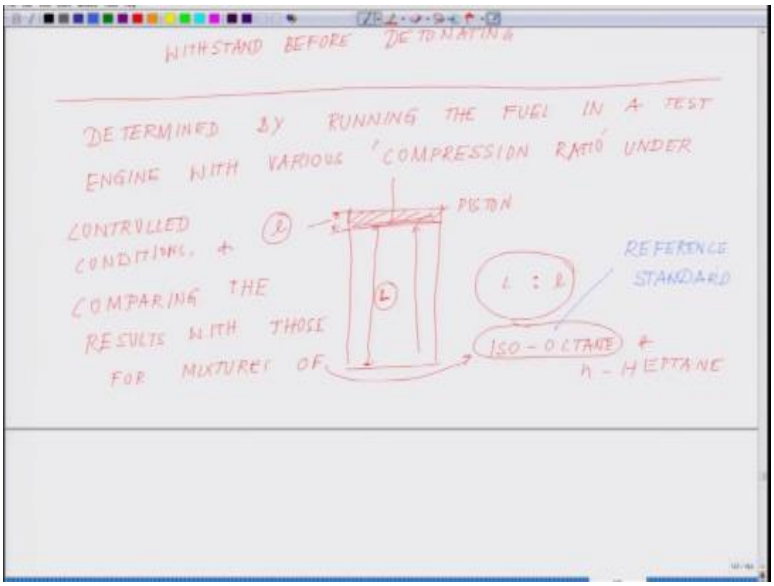
(Refer Slide Time: 07:41)



So octane number the first information or first concept you have the gate octane number or octane rating is this octane number or rating. So the more compression the fuel can withstand before detonating okay, what does that mean more compression the fuel can withstand before detonating okay. So any fuel which could be compressed with respect to another fuel before it detonates is the octane number.

So going by the definition of the octane number you can call it basically it is determined. So let us see how do you link determined it is determined by running the fuel in a test engine by running the fuel in a test engine with various compression ratio. Now you remember what is compression ratio compression ratio is basically. Once again if you go back to the previous diagram, so amount of okay.

(Refer Slide Time: 09:58)



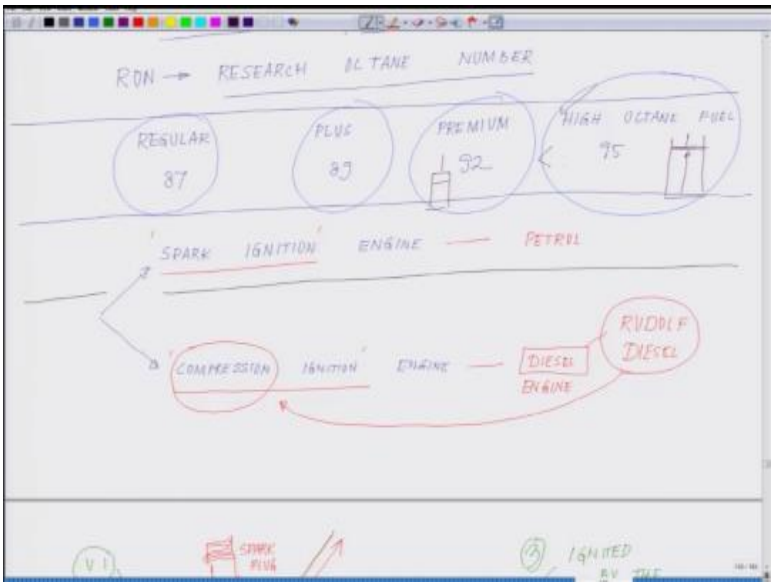
Let me redo it for you, so say for example if this is the piston, so this length which is the length when it fills the whole cylinder vs upon compression when it goes up this length which is I am denoting by small L. So the compression ratio is versus a small L. So high you can compress a mixture without it getting self ignited mix you are much well controlled better feel okay. So it will have a higher octane number.

So let me finish this definition with the various compression ratio under controlled condition and comparing the result with those for mixtures of isooctane and heptanes okay. So these are also called isooctane is also called a reference standard. So in other words what does that mean, so whenever we are measuring a number we give a value say we talk about a pH or we talk about any other side values.

So we have to have a reference, so in the case of octane number the reference is being done with an octane or sorry isooctane. So I saw octane is used for all the compression studies and based on that, so with respect to isooctane. So however this bias will be or some other filled with respect to that how much is my ratio how much I can compress it if I assume this is one with respect to

how much I can complete. So there is a scaling which is being done based on that scale what you get here, now let me go back where I started.

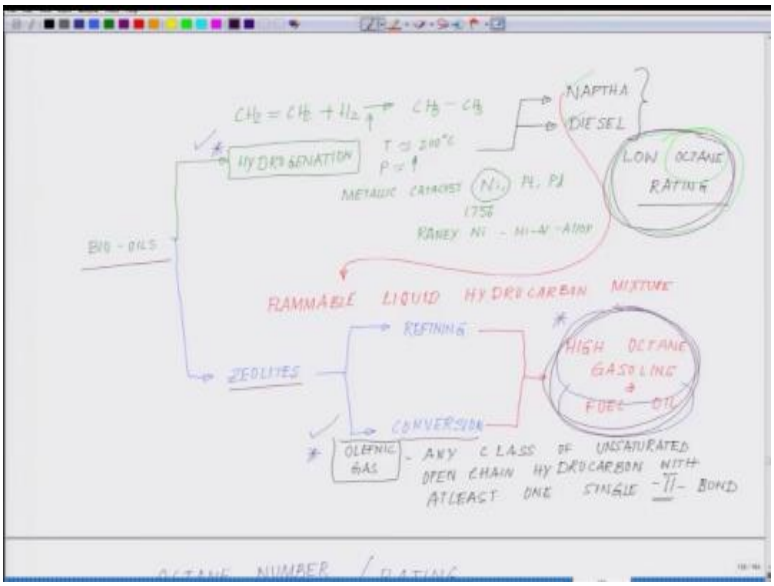
(Refer Slide Time: 13:03)



So these are the numbers what you see regular 87 + 89 premium 92 high octane fuel 95 what does this signifies that different kind of fuel great decide how much you can compress this particular oil or the fuel with respect to other. So in other words if you have a high10 fuel as shown out here we will see this one high octane fuel it means you can take suppose this is your cylinders essentially you can compress it much more as compared to this one or as compared to this one this will be more.

So in every case, so the compression if I have to put the compression ratio look you will have the more compression here, more compression here, more compression here how much you can compress how much really you can bring it close in how much you can pull the plunger back and, you know shrink it ensuring that it does not self ignite that is very critical we will come to that what does dance.

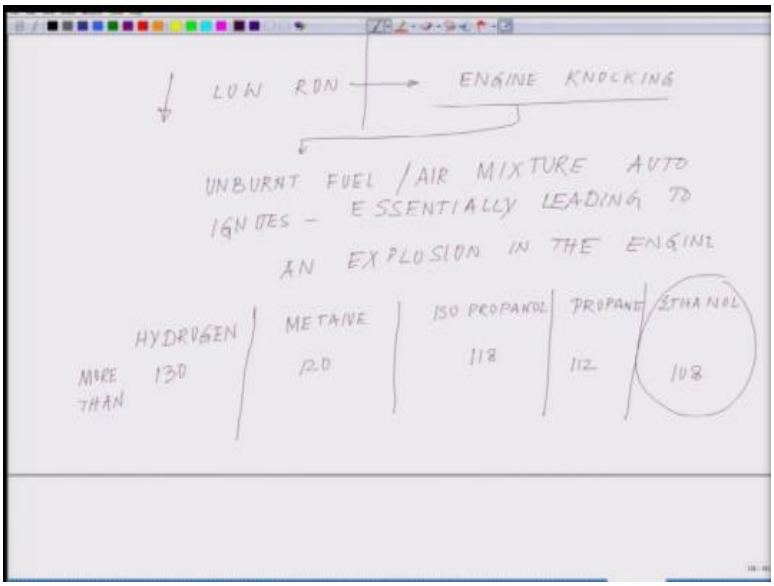
(Refer Slide Time: 14:16)



And if you follow this picture you have seen something you see low octane rating so remember I told you and high-octane gasoline it means when you are refining it with zeolite the bio oils and converting it using different kind of zeolites through the nano reactor concepts what I told you actually can obtain very high octane fuel that means in other words the flammability of those fields within much more higher.

And their efficiency will be much more higher as compared to the low octane rating ok doc so as compared to that if you look here so what you are having is the low octane rating out here there is an high octane rating so these octane ratings are nothing but how much compression you can do okay.

(Refer Slide Time: 15:11)



Now to give you some idea about what are the different octane rating. So say for example, you have a high octane rating higher whereas you have a low are okay. Now these things with low octane rating will lead to something called a engine knocking and what is engine knocking? Engine knocking is basically occurs when unburned fuel mixture of ignite. So this is a situation when unburnt fuel flash air mixture or to ignites which is in away very dangerous essentially leading to an explosion in the engine.

So most of the low octane number fuels leads to the engine knocking problem. So what happens, because of certain degree of non uniformity in the fuel molecules and certain of their physical properties they when you are compressing leaving them say something mechanic remember if you remember that I was repeatedly telling they should not self ignite, if they do self ignite then there will be issues.

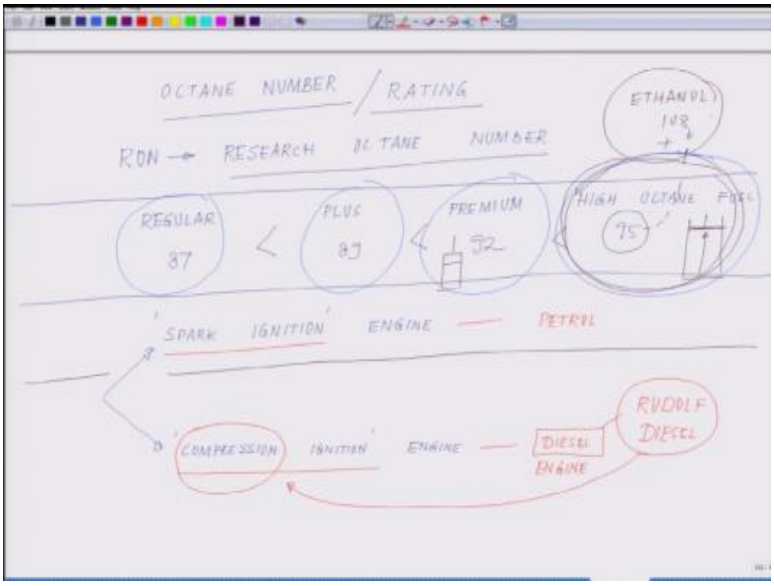
So you want a fuel mixture to be compressed as much as you can and then you spark or ignited using a spark plug. Whereas low octane number of swirls like diesel they have this problem and these are being removed and there are ways to you know get around it. And their engines are

designing a such a way to handle those kind of knocking issues. Now if we talk about you for examples which I wanted to give you about some of the octane rating.

So if you talk about three all of you have heard about hydrogen as a fuel okay and if you see what is the RON number or the octane number of hydrogen it will be more than 130 okay, just to give you an idea about different kind of octane ratings what we have then you have methane which is 120 you have isopropanol which is 118, you have propane which is 112, and you have ethanol which is 108.

Now having said this the ethanol it is very interesting there ethanol which are being mixed in the fuel in the liquid fuel you mix ethanol. Apparently ethanol is our if you see the number so you see the number out here 108.

(Refer Slide Time: 19:05)

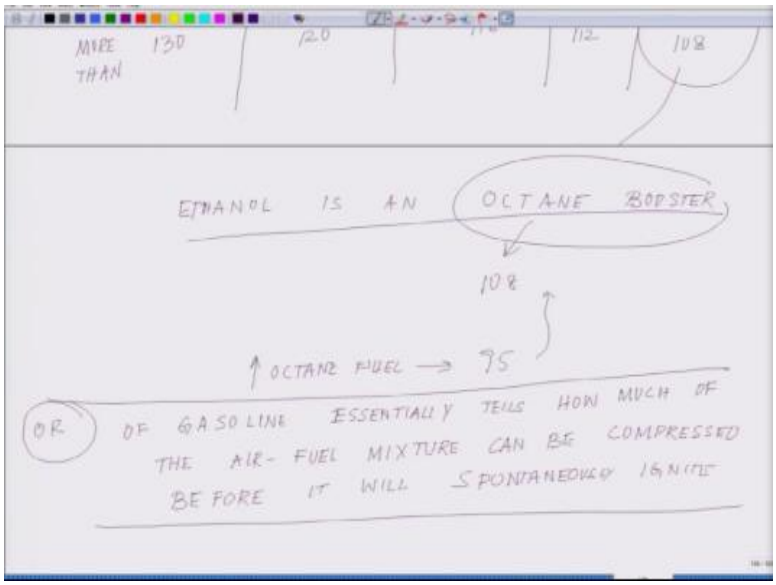


Now check this number what I showed you in the beginning check this number you have a high-octane fuel 95 we have a 95 and you have ethanol now let me add something here okay ethanol which is say you have 108. So if you take a high-octane fuel mix it with partly with ethanol what

will happen this number is going to go little up and this is going to come a little bit, but you are using a smaller amount of it okay.

So this is going to go up so what you are attending is you are getting in high octane fuel. So from an high-octane fuel you are increasing the octane number, so you are increasing the efficiency of the fuel. So there are many such additives which are being used and one of the most common additives which is considered is that ethanol.

(Refer Slide Time: 19:53)

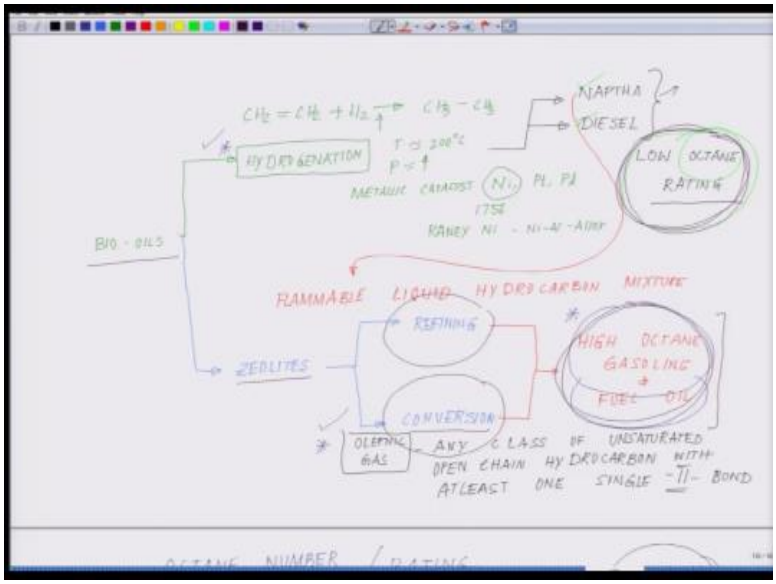


So there are several one second, ethanol it is also can even octane booster okay I think it is clear evil white is called an octane booster, because it has a higher octane number which is around 108 and you mix it with something which has 95 which is high octane fuel you can actually certain perception or 10% whatever percent you pick up. So based on that you can really raise the octane value of it.

So octane rating of gasoline essentially tells how much of the air-fuel mixture can be compressed before it will spontaneously ignite. So let us put this definition is of octane rating for OR and their footing OR for octane rating of gasoline essentially tells how much of the air fuel mixture

can be compressed before it will spontaneously ignite, why it will spontaneously ignite if you compress it for and beyond because the molecules will be so close and will be so much collision between the molecules that will generate sufficient heat to reach it ignition temperature okay.

(Refer Slide Time: 22:34)



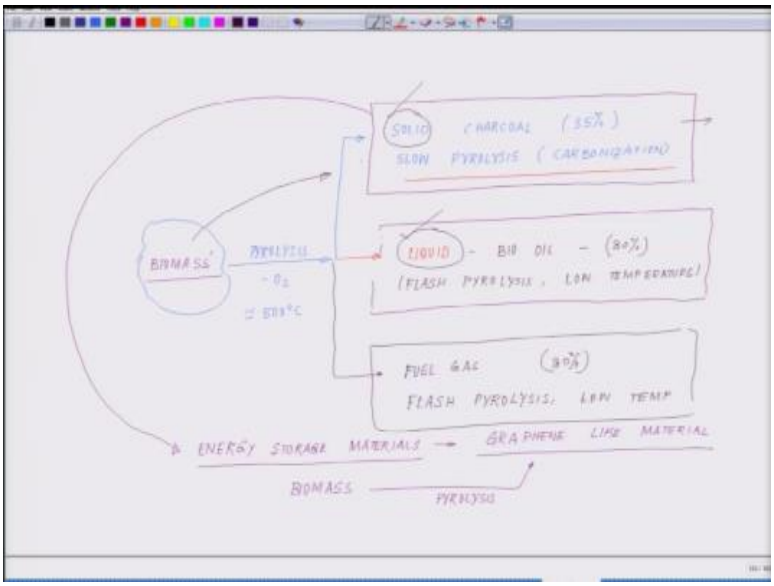
So if you now go back where we started in the beginning we talked about by different route if you do hydrogenation you get low octane rating fuels like naphtha and diesel which follows compression ignition systems we have already talked about it if you use your light and further refining and conversion if you do you get high octane gasoline and fuel oils which uses spark ignition system.

So once this fundamental basics are clear to you then whenever you buy a car you exactly no one can fully or you go to a gasification you knowing what is octane number and how that matters okay. So these concepts are very important and that is why I kind of bring it in a very simplistic note for you, so that you understand these why you have to understand the basic engine design and where all these concepts.

And there are so many modification do this if you pick up a go to Google or go to Youtube or any other good media you will see very nice animations which are being shown and I expect you there is read through them. So one important thing a take-home message is depending on the kind of treatment depending on the kind of processing you do, you can change the physical properties of different bio fuels or you can change the faint of the biomass very significantly.

As a matter of fact the next lecture we will talk a little bit about pyrolysis where you will see as of now you have seen that we can convert by pyrolysis we can like you know.

(Refer Slide Time: 24:27)



So we talked about when we were by realizing it we could make solid charcoals, we can make liquid bio oil of course, we can make fuel gas which we have not dealt as of now we will talk about it later. So among the solids depending on what is the source or what kind of biomass you can make very different kind of product.

In the next class what we will do we will talk about one such product where using a natural fiber you can convert it into graphing like materials which is one of the key material for energy storage okay. So in the next class we will deal with that concept thank you.

Acknowledgment

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