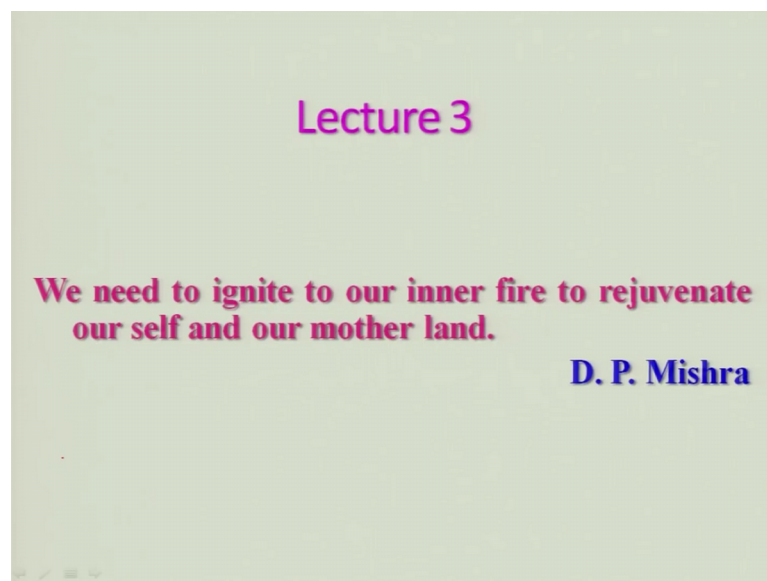


Fundamentals Of Combustion (Part 1)
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Lecture - 03
Scope of combustion (Contd...) And types of fuel and oxidizers

Let us start this lecture with a third process; we need to ignite our inner fire to rejuvenate our self and our motherland.

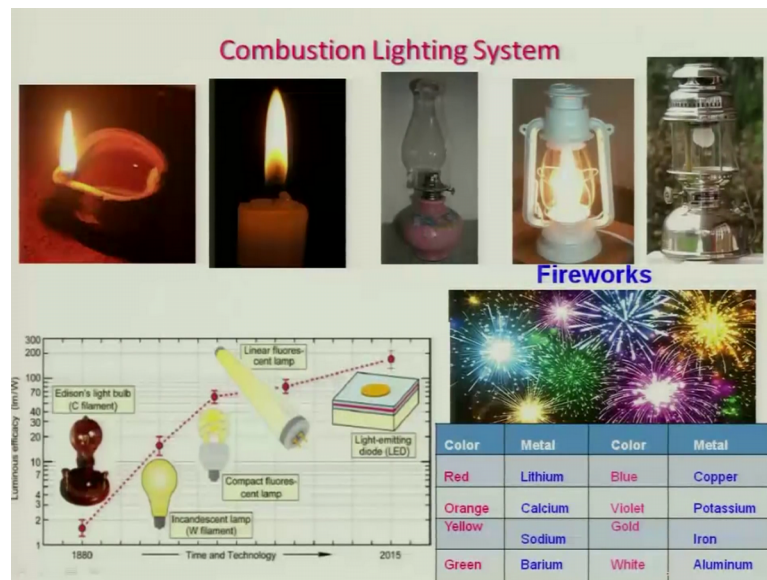
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So, let us recall what we learnt in the last lecture, we basically looked at you know some of the applications of the combustion. In which I was trying to give an impression about the scope of the combustion which is quite vast.

So, let us look at you know in earlier days people were using lighting systems, unlike today where we are using a very sophisticated lighting system, but they were depending at the time earlier on the combustion system.

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For example, this is a flame right, it is to give light to the people also right and it is also being used today as the part of rituals in our life. And which also indicates that you need to ignite the inner fire and similarly candle light this is you might be might have enjoyed at the candle light dinner.

So, and whenever there is a black out or the light it will of or the electricity would not be there, then we always search for a candle you know to get and lamp this was being used earlier days, even it is being used by the poor people of this country who are not having privilege to have a electricity.

So, they do use and even today if you go to slum areas in cities and villages you will get this right. And still people are using and of course, the this is the petromax light which is having a mantle here this is the mantle, which will be containing some kind of a chemical here whenever it will be heated it will blow right.

So, these are the systems were use and are being used also on emergency and is used by the poor people of this country, and which is if you look at that way it is sustainable also to some extent and simple system, but; however, this efficiency luminous efficiency if you look at it is quite low, but in modern time after the this industrial revolution you know people started looking at what you call better lighting systems using the technology like if you look at Edison's, which is around 1880 and then after that we got this incandescent lamp of course, recently compact florescence lamp and this is of you

know linear florescence lamp we are using from long time and the today we are at led. If you look at the luminous efficiency is something this is lumen per watt is increasing keep in mind that these are all items.

Whatever I had shown you which is as having higher luminous efficiency is basically worked on the consuming the electricity. And background back of it what from where I will get electricity mostly from the fuel combustion. So, the background you know this is your 4 front are the you know what you could see, but background is that your combustion.

So, combustion plays a very important role of course, the luminous efficiencies there, but in this luminous efficiency let me tell you that it is from the electrical power what they have given, but if I use the combustion and then from that electricity conversion, then this will be very very low values keep in mind are you getting for example, this is around something may be 100 60 70 kind of thing led.

So, it will be very low why combustion efficiencies with be low than conversion efficiencies will be low to mechanical energy and then mechanical to the electrical that also will be low. So, therefore, this will be very low values, because the power whatever you are consuming is much higher.

So, another things which we enjoy particularly in your marriages or any other occasions and Diwali, what is this this are fire crackers? And you could see there are several colors you could get can anybody tell me how I can get this colors, because this colour we like and that too when it is sky open sky of course, noise we do not like, but lot of people like to because also noise pollution right particularly in Diwali night and 2 3 days before and after will be having lot of problems. Yes like how I will get this colour any idea chemicals. So, what are those chemicals [FL] very good likewise.

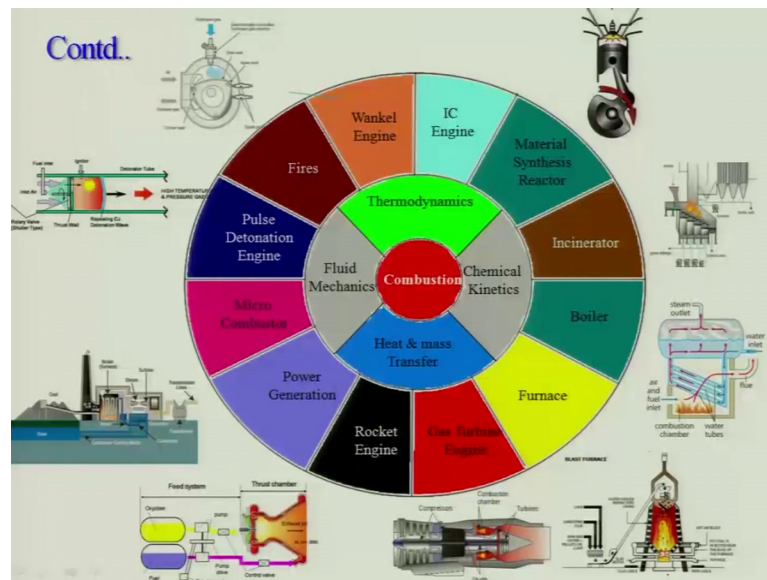
So, these are basically let us look at will get rate and from the lithium and calcium if I will use basically we are using metal not chemical of course, all chemical it is not am taking, but it is not that sense, but metal, calcium, orange and sodium yellow and then barium green, copper of course, blue and potassium and you know iron gold all those thing white aluminum, there is various combination they do and then get various colours.

Why am saying that you should take interest in those things, you know how they make and what are those things it is not that only we will have to look that fundamental fundamentals is essential. But you should generate some interest why am talking about this thing. So, that you will interested in that you know that is the main motive of talking about it.

And if you look at there is a another applications what I have not discussed, but I would like to draw your attention is that ammunition you know. A re you getting ammunition mean what basically weapons right like we got subdued by the invaders because of what? Because of we are not having fire arms, that is the reason what people gave because technologically advanced and the fire arms is basically from the combustion sources. Your, what we call even the you will fire a bullet or a any other things you know like will be missiles system and most of the things will be basically combustion.

So, therefore, combustion plays a important role. So, what else now I will have to summarize some of the applications in this diagram.

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So, if you look at we started with a fire, because fire plays a very important role and today also fire is being celebrated, but one has to worry about it is uncontrollability or you should not you know destroy the people or the properties.

So, therefore, control fire is very essential and then of course, there is a Wankel engine, which is a very nice engine. Which is some of you may not aware this engine I have shown here, which comes under internal combustion engine it is not been used very much. And unfortunately in India only a in one place in Anale National aeronautical laboratory in Bangalore, they are doing some work I do not know the status, but it is the a very interesting what we call compact engine.

And IC engine of course, you may say what is IC engine that it is also a IC engine Wankel engine IC engine can be of 2 types. One is 3 types rather one wankel piston engine and the gas turbine engine. There is a several other engines also under piston engine, if you look at that there will be spark ignition engine, compression ignition engine, and may be gaseous fuel engine people are now developing. And there will be sterling engine external combustion engine and also combustion can be used for processing materials.

For example I had done some work earlier on this syntheses of Nano material using combustion engine using flame and it is not only for the Nano material you can use also micro material, size materials and also other material also process most of the you know like a synthesis. You can do also you process the metal and incinerator I have talked about incinerator of not only the human body, but also the other you know waste materials you can incinerate. So, these are as shown a figure here.

And boiler which is a main heart of the power plant is the boiler is not it boiler is the and nowadays people are talking about super critical technology boiler; that means, you know critical super critical you might be knowing [FL] from thermodynamics point of view steam. So, that is also being used and furnace various kinds of furnace, you know like starting from your domestic furnace like where we use for a heating purposes to very complex furnace like a blast furnace.

So, gas turbine engine which will be coming under IC engine, but I have separated it out that is different thing and which is being used keep in mind that this what will be the power level of gas turbine engine any idea order of it will be megawatt. And whereas, if you go to some other small thing like you know IC engine for example, piston engine what do use for UAV Unman Air Vehicles what will be the power? Will be few watts you know something few watts may be 20 watts or 50 watt kind of thing not kilo watt.

So, and rocket engine of course, is a big you know engines and rocket engines will be various kinds, which you might be knowing that solid propellant rocket engine, liquid propellant rocket engine, and then hybrid rocket engines, like these are all combustions based rocket engines.

And power plant of course, power generation can be by the you know various ways you can use gas turbine engine you can use boilers or the steam engines, you can combine it. And there is in recent time there is a lot of interest in this micro combustors, we are my group is working on this on micro combustors this is the micro scale; that means, small one. You might be people might be aware that in MIT they were trying to develop a small micro gas turbine engine you know, that was the motivation where which has a you know generated interest in micro combustors.

And there is also a Pulse detonation engine, which is coming out well of course, it is a challenging one and people are working on that this I have shown here. This is if you look at like I have now trying to give a very broad pictures, but there might be several engineering applications, which might not becoming under this which might I might not have included here.

But all those things if you look at you need to understand fundamental of combustion and now for knowing this fundamental of combustion you need to aware or learn about the thermodynamics, which you are already I will be trying to give view some of the things related to the combustion thermodynamics.

And chemical kinetics is very important which you might have studied in your class 2 and other engineering particularly chemical engineering people they always you know use it. And there is of course, when you talk about this eh you know thermodynamics chemical, then you need to know look at fluid mechanics right fluid mechanics plays a very important role in combustion. And it is not only the fluid mechanics, but also to the heat and mass transfer also plays a very important role.

So, in the first part of this course what will be doing we are basically first looking at the thermodynamics will just review it, I would urge upon you people do relook at it and then we will be moving into the chemical kinetics part, then I will be talking about both this heat and mass transfer and fluid mechanics. So, there is a long way to go why

because it is very important to have a grip over this subject and how you can utilize and how can you do then only you will think talk about combustion?

So, therefore, combustion is not that easy subject it is quite complex in positive way it is a very challenging to have a mastery over the combustion. If you are master you know your having the mastery over the combustion; that means, you will be knowing all the subject are you getting and which is quite challenging. Therefore, you know it is important to work on this so, that you will have a better knowledge about a lot of things, which are inter related particularly from the practical point of view.

So, now, coming back to that like question might be coming in your mind that what do you mean by fuel? Because fuel and oxidizer are like 2 side of a coin that is combustion as I told.

So, therefore, what you mean by fuel any idea?

Student: (Refer Time: 15:23)

Energy contain inside it fine. Now if it is not having energy content it would not be considered as a fuel it will be considered as a oxidizer, can I say this way right can I say this no. For example, like wood I cannot call it as a fuel as compared to the petroleum or the diesel, diesel is having more amount of energy.

If I say alcohol, alcohol is having lower amount of energy or energy per unit you know kg or per unit volume will be can I call it as a oxidizer, because we know alcohol is a fuel or not alcohol. What you people might be taking? Because now a days people are taking say what we call prestigious think, earlier days it was prohibited you know you should not take it you should take it as a medicine, today you take it as a prestigious modern. So, now alcohol is having low energy level can I call it no [FL]

So, then how I will define how will you define difference a it is very important to differentiate it aright. So, you will have to look at what really happening in the chemically, because this fuel oxidizer when they you know react. Then only some heat will be formed and then some light may be there you know then only combustion will take place right; that means, there is some chemical reaction.

So, we will have to look at from that point of view that is like what happens in the during the chemical reactions, what happens? You know there will be bombardment, there will be breaking bunts, I mean breaking of bunts how does it happen there will be change of some electron.

So, from that point of view let us define that is basically a fuel can be defined as one which donates electron

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What do you mean Fuel and Oxidizer?

What is fuel?
Fuel can be defined as one which **donates** electrons during chemical reaction.

How can an oxidizer be defined?
Oxidizer is one which **accepts** electrons.

Electronegativity: It is a measure of the tendency of an **atom** to attract a bonding pair of electrons.
Amount of **pull** that one atom exerts on the electron that is sharing with other atom.
The term electronegativity was coined by **Linus Pauling**, a Noble Laureate.

Element	Electro-negativity	Element	Electro-negativity	Element	Electro-negativity
F	4	Br	2.8	B	2.0
O	3.5	C, S, I	2.5	Be, Al	1.5
N, Cl	3.0	H, P	2.2	Mg	1.2

Fluorine is having **highest electronegativity** (most powerful oxidizer).
Oxygen has **second highest electronegativity**.
Carbon, Hydrogen, aluminum and magnesium have **low electronegativity** (Fuels).

During chemical reactions right; that means, if someone something is you know donating there should be some receiver; that means, whichever will receive that is the basically oxidizer giver and taker. So, in life if you want to live a very good life therefore, you will be a giver and you will be also donor more you give more you enjoy, more you are you getting my point.

Therefore, in our scripture people talk about [FL] donate, donation is very important we will have to give contribute for the society for the your family for others then only; that means, you will act as a fuel not act as a oxidizer all the time will be accepted. We are doing now all the time we are grabbing materials, but you know fuel is should be there oxidizer should be there for the combustions to occur similarly in life that is what we donor. So, that is very important.

So, you can relate that your life human life to the combustion. So, oxidizer is one which accept the electrons, now in order to look at that thing we will have to define a property can anybody tell me what is that property?

Student: Electronegativity.

Electro negativity very good. So, electronegativity is basically measure of tendency of an atom to attract a bonding pair of electrons, that is the property of course, you can consider is as a extent of pull that one atom exerts on electron that is sharing with other atoms, because it will be shared we will have to take it out you know kind of things.

And this term electro negativity was coined by Linus Pauling, a noble laureate, who was the first person to talk about this then you know that comes. According to that this is also known as Linus scale if you look at the elements; the fluorine is having 4 oxygen is having 3.5 and of course, the fuel if you look at carbon hydrogen all other thing can be act as a fuel also you know Bromium a you know and boron magnesium aluminum is having magnesium is having lowest values and others are increasing order.

Now a question might be coming to your mind, whether oxygen will act as a fuel right and can oxidizer act as a fuel is it possible oxidizer.

Student: (Refer Time: 20:49).

What is that you can table is there. So, if fluorine is there right then oxidizer will be acting as a.

Student: (Refer Time: 21:00).

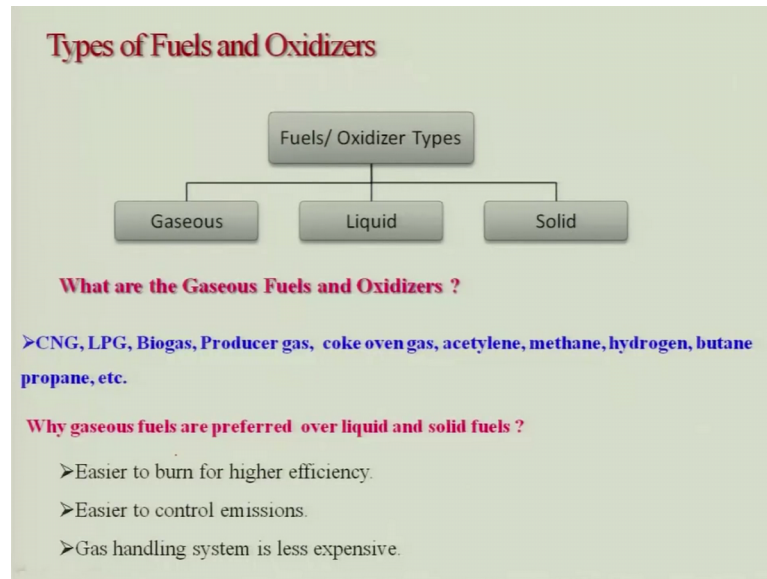
Fuel. So, you should keep that in mind very interesting thing. So, you should keep in mind because fluorine is having highest electro negativity most powerful oxidizer. Of course, when you look at rocket engines then you know we will be very much excited to use fluorine and it is very difficult to handle the fluorine. And oxygen as the second highest electron that you can see from this table so, it is the second right.

And of course, the other thing like carbon hydrogen, aluminum, magnesium, you know these are basically used routinely as a fuel you might be knowing carbon hydrogen means hydro carbon means carbon hydrogen is not it, but the aluminum magnesium

boron and other things they are used in the rocket engines, you know rocket propellants as a fuel metal.

So, it is having what you call the now you know what is the what you mean by fuel and oxidizer how will just under the things right is that clear.

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So, now we will be looking at various types of fuel and oxidizer.

So, there are several of them, but I have we will be discussing basically some of them and fuel and oxidizers can be broadly divided in to 3 categories based on the you know physical these thing. So, that is the gaseous, liquid and solid right. So, gaseous fuel if you look at is being used within much gaseous and oxidizers in modern time particularly. In earlier days oxidizer means air there will be no problem it is a gaseous form, but the fuel mostly wood in very old days am talking about later on coal came or a charcoal you know charcoal.

What is charcoal any idea charcoal coal charcoal.

Student: Coal are (Refer Time: 23:16) or removed.

Student: We get charcoal.

No it is a wood you can say that is a you can say coke, that is a coke, but the charcoal means wood particularly when you will Pyrolyze it right in the absence of oxidizer, then the volatiles will go away the carbon will remain and that carbon we call charcoal.

So, that is a even a solid fuel now, but in modern time we are very much interested in gaseous fuel and gaseous of course, oxidizer always will be gaseous, but why what are the reasons any idea.

Student: Ash (Refer Time: 24:02).

Student: Ash container.

Ash container is very good like ash contain will not be there what else.

Student: (Refer Time: 24:09).

Mixing will be good what else?

Student: (Refer Time: 24:14).

Gassive fire.

Student: Yes sir.

Right to convert and if you look at the reaction will be very much you know taking place in gaseous ways it is very easy for the gaseous waste to react and solid you know it will react difficult. And it will be ignite igniting the mixtures will be very easy I had mentioned in the last lecture, that you know we want to ignite a wood you will have to do a lot of work you know like igniting wood is very difficult, but igniting any gas is much easier.

So, if you look at it is easier to burn and then if it is easier to burn it will be having higher combustion efficiency even and easier to control a machine that is why it is what you call important? And gas handling system is less expensive for example, like I want to handle the coal in a power plant, what I will have to do? If I will burn the coal, if I will not the way we do in a stove bigger size lumps.

So, then what will happen? We will not get the amount of heat generated per you know you need volume higher, I want intensity should be higher, then I will have to make it

powder and making powder also will have to make a crusher and the size should be good and then you will have to do this thing put energy. So, therefore, it is interceptable.

So, of course, some of the you know gaseous fuels are basically CNG, CNG means compressed natural gas LPG liquid petroleum gas, biogas producer gas, coke oven gas, acetylene, methane, hydrogen, butane, propane and extra any other gas you know you can use of course, it should have certain good heating values and you know.

And similarly oxidizer if you look at gaseous oxidizer will be air and oxygen. So, these are the things and we will stop over here and we will look at in the next lectures about various applications of the various gaseous fuel and oxidizer.

Thank you.