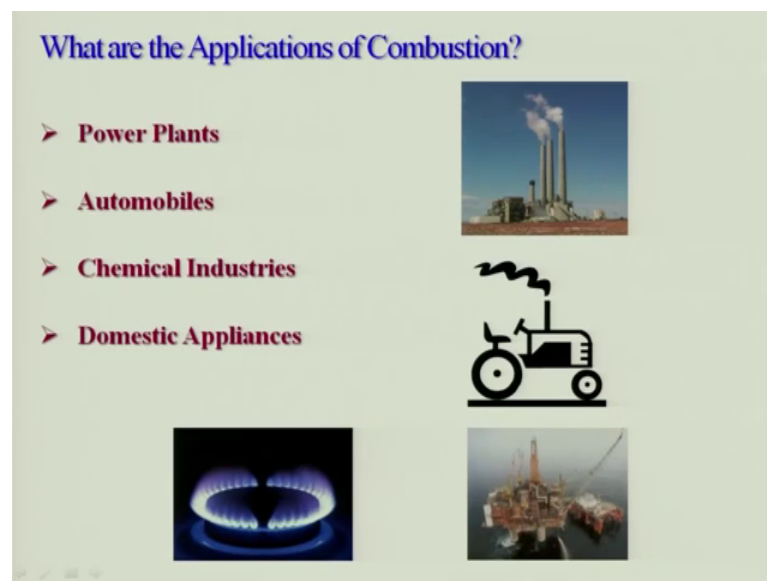


Fundamentals Of Combustion (Part 1)
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Lecture – 02
Scope and applications of combustion

I welcome all of you to this, course Fundamentals of Combustion. So, what are the applications of combustion?

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If you look at I can broadly divide that into 4 categories, right? Ok what are those can anybody tell me for example, I can say power plants, you know power generating power, right? For generating power, I need to have power today without that, you cannot really live alive ok, but there are peoples who are not depending on power, you are aware? There are some people in you know tribal people who are staying deep jungles, they are not depending on power, right? Yes or no they are more intelligent, then you are your more intelligent than them, think about it.

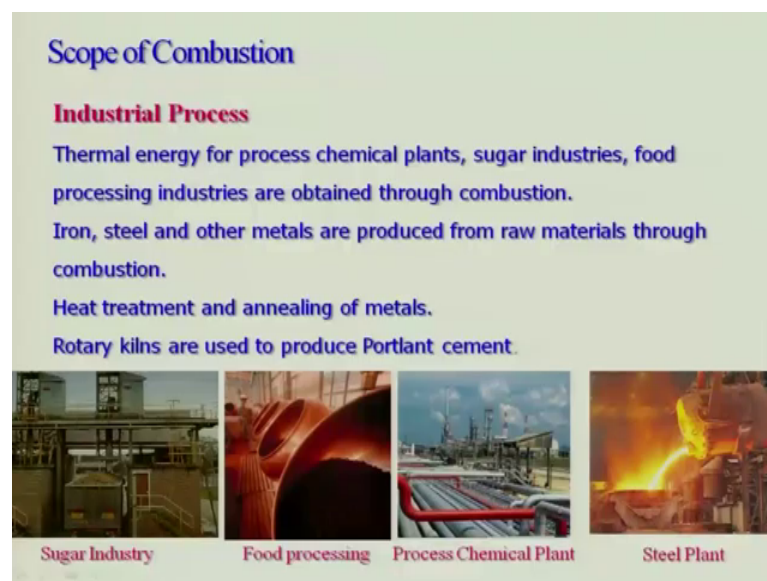
And once you generate power you will have to also pollute and you will also would not get, you know you would not go to bed early in the morning, right? Or you will go to bed early in the morning are you getting my point. So, that light is there if light were not there electricity were not there, what could have you could have go to sleep. So, your lifestyle has been changed and it is spoiling your body mind and spirit.

So, automobiles of course, will have to move around transportations, right? And which is very important if you look at I have shown a figure here tractor, tractor has created a havoc. So, for agriculturists concern yes or no it has spoiled the soil, and then farmers are committing suicide ok, and all those thing you people may not be very much concerned, but please be concerned about the other people as well and chemical industry because, today modern world without chemical technology it is very difficult to sustain ok. So, therefore, and the another things you know like, a is the domestic application very much if you look at here, I have shown you a LPG burner will be discussing more about it and. So, if you look at these figure I have shown can anybody tell me, what is the figure? Any idea?

Student: (Refer Time: 2:55)

Petrochemicals, right? Then we also spoiled the sea oil spilling and other things, right? So, this is the inside sea ok, this figure shows to you.

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So, let us look at the scope of combustion if you look at I am giving you know birds eye view of the application of combustion. It is not that all I will be discussing, right?

So, if you look at industrial processes, there are several of them like for example, chemical plants you know like sugar industries up is known as as a what you call sugar bowl of India, but not no more today and now, it is the Maharashtra. So, sugar is a very

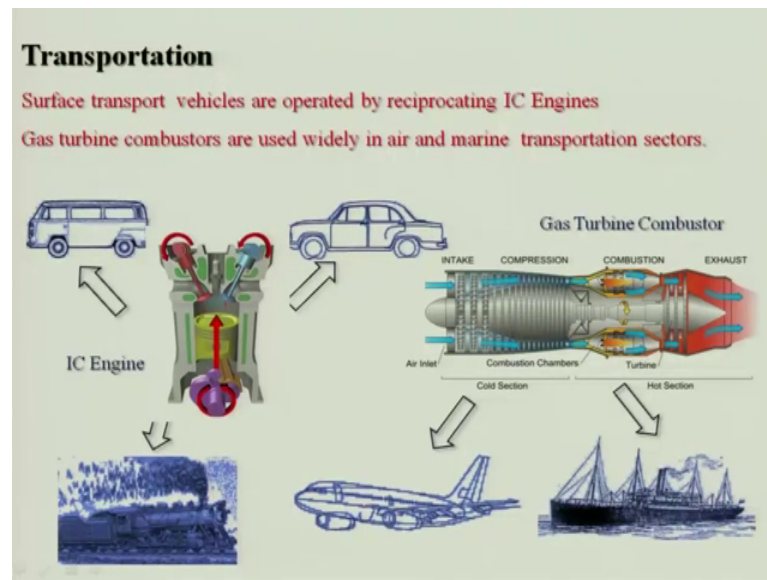
important of course, the sugar has spoiled us there do you agree with me sugar has spoiled our body and mind and getting more diseases and means sugar means sugar means, what whatever your taking the white colour very nice crystals you know like, man-made crystals not you know nature made crystals and those are not good for health, but if you go to the good at jaggery what they call that is very good ok, but we lost technology of making jaggery indigenous technology.

So, food processing industries and all of you are very much happy with the process food, but if you take process food you will spoil your body and pay more money, and similarly iron, steel other metals you know a any other metal except aluminum are being processed basically from the raw materials using the combustion root, because it is cheaper, because will go for a electricity it will be very costly ok. And heat treatments annealing of metals and then even like cement, Portland cement if you look at you know is basically made using the rotary kilns and let me tell you also am against the Portland cement, because it is spoiling the environment the best way of making house is [FL] lime ok..

So, food processing and then, all those things are there, but I must tell you that, we are part of this industrial revolution which has started something at 1760 and we are still continuing, this industrial revolution really spoiled India to a large extent, why? Because we lost our indigenous technologies. Today companies are having, what? Companies are having the technology common people are [FL] they do not have any knowledge, am I right? Our society is other way wrong our society is that, common peoples should have liquids and knowledge for living a life they do not depend on others.

So, this is a diametrical opposite philosophy of what western people think and what we think what our ancestors will think not we, right? So, therefore, we need to think about how will develop the technology particularly combustion technology, which will be useful for the people not for industry, industry will use is ok, but they should not loot us. So, and also spoil our beautiful earth the environment what we are having. So, we should keep that in mind. So, if you look at I have taken some engines here, right?

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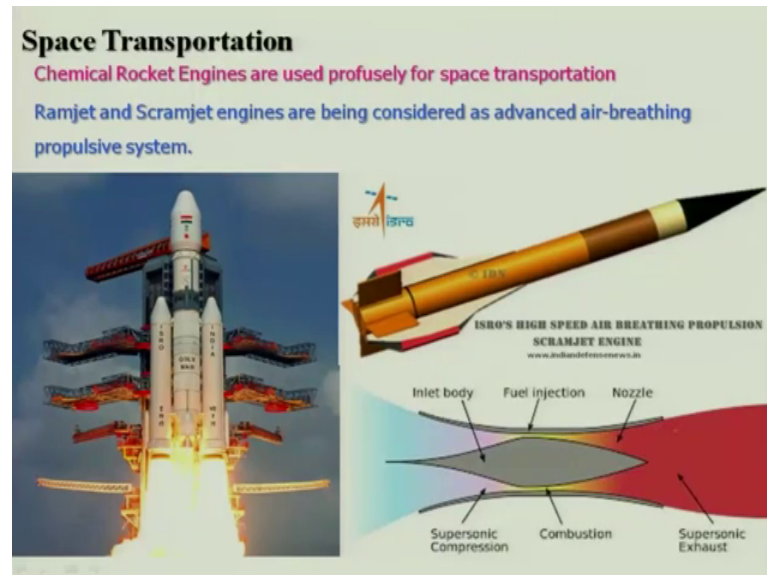
Ah if you look at this is basically a which engine, piston cylinder engine, right? It can be diesel engine, it can be gasoline engine, I can use also biodiesel, I can use also various other gas like producer gas and other gas engine CNG, I can use this piston engine and this is your also a gas turbine engine in that, the this is your combustors, right? And both are internal combustion engine, right?.

Because, the combustor is a part of the entire engine this it is inside similarly, here the combustion will be taking place, right? Combustion will be taking place in this place or not yes or no this is piston this is cylinder in between it will be occurring of course, this spark ignition engine SI engine, but in place of spark ignition engine you can put a injector diesel injector and then, you can use you can of course, change the location depending on your design and also it is utility.

So, if you look at what are this these are the what you call workers, because you know of the power plant these is the power plant, you can say for particular rate transportation sectors which is being used and this can be also used for the generating electricity, right? Both the engines can be used for generating electricity also like, transport you know as I told the surface transport vehicles are operated by reciprocating IC engines, right? Of course, in western countries people are using gas turbine of certain trucks and other thing, they are saying gas turbine combustors are used widely in air and marine transportation sectors. So, if you look at this is basically you know this car and then other

vehicles of course, the this is your locomotives, right? Rail engine than can be used your air craft ships and other thing.

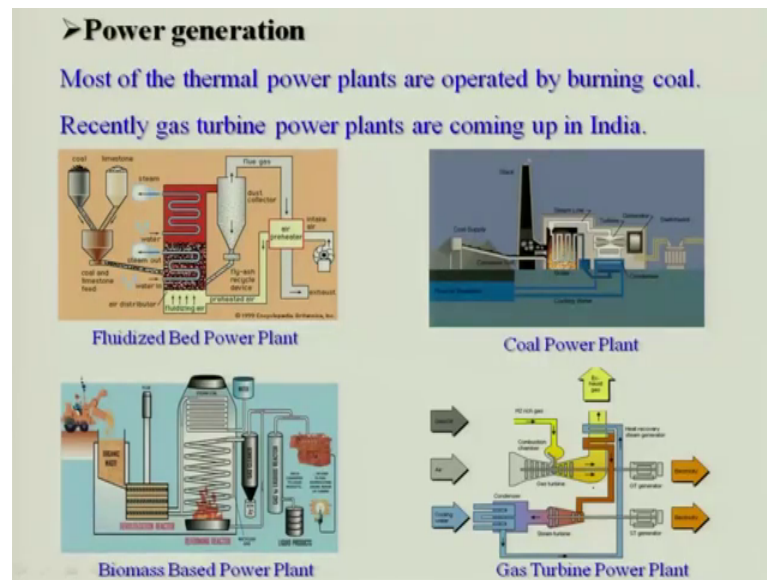
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So, space transportation if you look at generally chemical rocket engines are used profusely for space transportation and we are having a very good program ISRO is doing successfully lot of launching of space vehicles not only you now putting a satellite, but also the big space machines like you know [FL] and [FL] other thing. So, we are having a very vibrant programs and of course, in recently you know the scramjet engines, which are made the you know views that, we are having and which consider as an advance air breathing engine this is ISROs high speed air breathing propulsion systems scramjet engine, right? And of course, the ramjet eh is also being used that is of course, not for transportation purpose for the desire applications.

And in this case, if you look at basically the fuel will be injected here, and then the combustion will be taking place then it will be expanded in a nozzle. So, there therefore, combustion is very important you know like to device you know systems for transportations, the power generation; most of the thermal power plants are operated by the burning of coal, right? Is it true.

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Actually it is not that, true today it was you know let us say 30 years back it was today around may be 60 to 70 percent of the power are generated by the burning of coal rest are you know being done by the nuclear by the unconvinced energy by the diesel power and the other things, right? And gas turbine power plants are also in India and this thermal power plants there are several technologies if you look at this is the coal power plant where, traditional you know boiler will be a there, right?.

And this is your boiler there are various kinds of boiler, there and this are powder coal being used to burn that thing, and if is a fixed to a great combustion which will be taking place in this and steam turbine being used, but there is a recent and there is a fluidized bed you know combustor taking place, because the air will be used if it air where, the particulates coal particulates will be floated will be fluidized. So, that will be suspended in the air and you can have a better combustion and also this a circulating bed fluidize bed combustors which will be circulate the particulates.

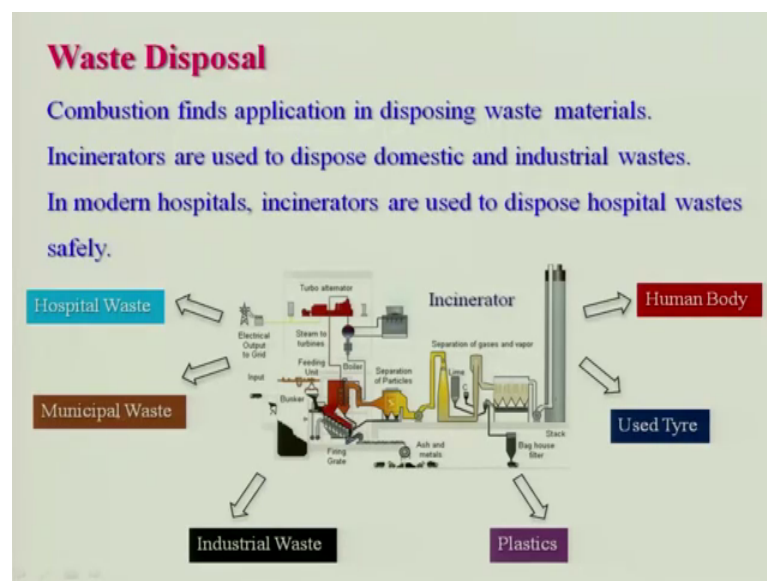
So, that you know particulates will be not getting into atmosphere, that extent what it will be occurring in the traditional power plant. And there is also bio mass-based power plant, because it is coming up well and there is lot of problem associated with the coal, particularly Indian coal see if you know like, we are having a coal which will be containing large amount of, what? Certainly, no sulphur basically a you know will be

there in coal and which are coals are being those coals which are being used by china, right? And whereas, our coals will be containing large amount of ash, right?.

That is a very big challenge for that you know fluidize bed technology is required and also the when you use this hybrid kind of what you call coal and then biomass together, then you can overcome that problems (Refer time: 13:00) So, of course, the biomass is another way of generating power using in the boiler and there is a of course, the gas turbine power plant you can combine this 2-combine cycling you know coal gas turbine and then coal. So, that together you can enhance the efficiency of the system and also the emission.

So, there is a lot of technology of power plant which are coming up and then of course, we are not the leaders which should do you know our self. So, that we will be hired of them.

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And the waste disposal is a very important aspect, right? because of fact that, we are producing more waste than the anything else, because of modern life we are producing more waste per person if you look at it is in Kanpur I was told something per day around 150 grams per person, you know I may be wrong I will be habit way wrong that, is a waste we are producing because the pack packing foods and then lot of other things packaging you know, that is the waste now this waste disposal was started when, any

idea? Indians were very good in disposing the waste in ancient time for example, dead bodies ok, dead body is also a waste and India was a populist country earlier also.

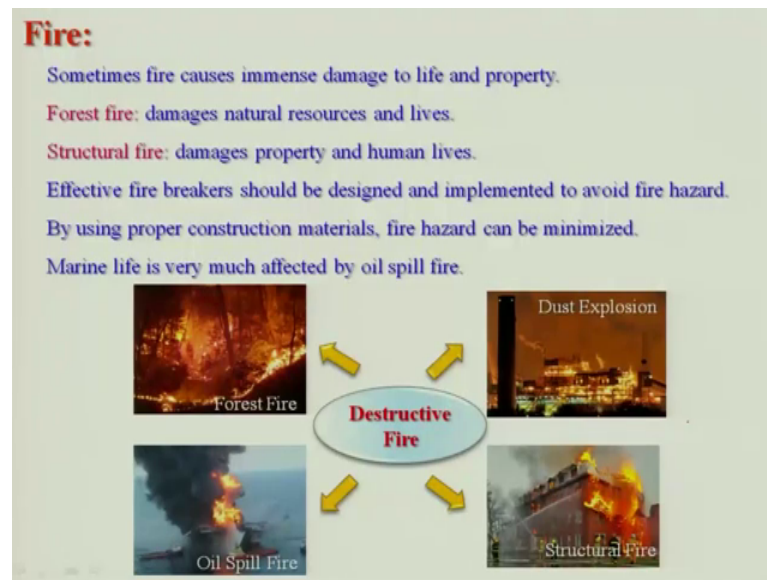
So, therefore, if I dead body is there, I cannot put into the ground then it will be creating more havoc, why? Because there will be bacteria development other things you know it will be contaminated more disease will spread, so if I burned it all will go. So, therefore, the you know incineration of the dead bodies is being taking place, since time in over year, am I right or wrong?.

So, therefore, we were doing earlier, but unfortunately, we are not kept those thing with time, those thing technology has to change, we are having so many engineers, but we have not come out a combustion technology for what we call burning the dead bodies, right? And it is a part of our culture you should do that, and combustion find application in disposing waste materials incinerators are used to dispose both domestic and industrial wastes, right? You might be knowing that, keeping the incinerator in a hospital is a must today by law, but unfortunately most of the private hospitals even some of the government hospital do not have incinerators, right?.

But so, as I have shown you a incinerators here, where you can have human body and then even plastic you know you can incinerate, which is a very deadly material and industrial wastes, municipal waste and hospital waste and when you can use used tyre, you know tyre is also waste, right? So, therefore, it is a very important aspect which need to be designed and blocks us that, we can you know disposal waste otherwise we cannot be a [FL], right? Clean India green India, right?.

How can we possible unless we find out the technology and the mid or what you call clear the things, what is created by this what we call companies and industries, because they are the things which are producing this all this wastes, right? We will have to clean, because we are consuming their products yes or no, right? So, therefore, will otherwise we will have to face the problem. So, fire is the genesis of life as I told it can also you know destroy our life.

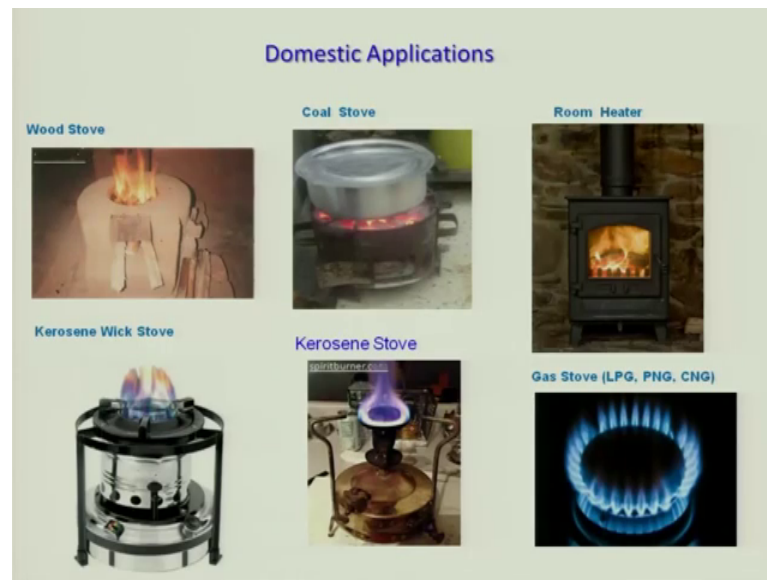
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So, forest fire you might be aware there is a story in Mahabharat, right? There is a fire you are aware you people might not have read Mahabharat ok. So, right? The fire also at that time were there it is not that today a fire is there of course, today very less number of forests are there in this country and fire is less like talker, but; however, the forest has to be protected and so, all has to we will the forest fire. Similarly, there is a dust explosion which is taking place, because we are producing lot of dust; that might be explosion also the structural fire you know like, you might be seeing high rising building and earlier days thatched house were being used in villages, right? How they were managing the fire, fire I have seen also.

When I was a kid of you know thatched house or thatched house, right? Of fire and oil spill fire is a great problem, right? And so, also the several other fires like your glab fire like it is the very important, that also occurs and as I told that, it is very important to develop the device how to arrest the fires and to avoid the fire hazard and by using proper construction material and fire hazard can be minimize, even the ma marine life is very much affected by oil spill fire we need to see..

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I will tell you the modern technology is really causing a havoc and my always suggestion that use minimum, that technology and the live with a nature maximum, right? Maximize and have a relationship with the mother nature is more important, than the going away from her.

So, at the same time we will have to use something is not that, we should not use and there is domestic application if you look at the cooking stove I have shown here, right? This is basically traditional wood stove, right? Now, any of you have used this wood stove? You have used? 3 of you have used traditional wood stove my god am very happy oh 4 half also, but I will tell you how you will ignite it, that is the question now, if you have used it. I want to initiate the fire how I will you do it

Student: (Refer Time: 20:04).

Ha.

Student: (Refer Time: 20:07).

Blowing air no.

Student: (Refer Time: 20:09) you cannot it is difficult.

Student: (Refer Time: 20:12).

Kerosene suppose kerosene is not there in ancient time.

Student: (Refer Time: 20:17).

Yes, not dry woods also you cannot ok.

Student: (Refer Time: 20:23).

Yes, that is the otherwise when I was a kid we used to because, this was a job given to me by my mother, right?

So, I will have to ignite we used to use the paper, at that time paper was there paper is easier to do, right? So, it is the very difficult and particularly rainy season like now, it is very difficult to maintain, right? Now, later on of course, you know this is a wood stove, right? What is it contains what kind of what is the difference between both, any idea? This one am talking about here hm.

Student: (Refer Time: 21:10).

This is basically a coal ok. Now, why you might be thinking this a very simple thing, we are talking about application wise, but it is very important because, without food you cannot survive our [FL] says [FL]; that means, food is important ok, and whatever you people are doing whatever all people are doing for what for food, but at the end of the day what kind of food you get do you know, all pesticide, insectides and then chemicals which are bad for health are you getting you purchase from market and most of the market and you used food processed food it will be more dangerous, right?

So, now this is a another stove I have shown you have seen these kind of stove here, what kind of stove it is kerosene. So, how it is being burned this flame is there here, any idea no idea what you are saying I couldn't get.

Student: (Refer Time: 22:24).

Pin no it is a wick flame do you know, what is wick? it is cotton sticks you put it and then kerosene wick flame, right? And this whatever your saying this is a a basically kerosene stove also, right? Here, what is happening, what is happening there will be a jet liquid jet, right? And it will be atomized and spray will be coming then you will burn;

that means, this is for that what you will do I will have to pressurize it any of you have used this thing this one, right?.

You will have to use pressure, if pressure will be reduced then it would not burn properly, right? So now, this is your LPG stove, that you are aware and it is not only LPG, you can use PNG, you can use CNG, you know what is PNG? What is CNG? Pipe natural gas compress natural gas CNG or you can use biogas we can use some other things you know, but of course, the design might be different.

Now, what will be the power range of this stoves, any idea? What will be power is it may be 0.5 kilo watt, whether 1 kilo watt or whether 2 kilo watt, or 2.5 kilo watt or 4.5 kilo watt or 5 kilo watt, what will be the range of course, do not think that you know what will be the range of for example, let us say I you want to buy a LPG stove, right? And you go and I want 2 you know 2 stoves will be there one is small other is big..

So, what is the power of small what is the power of big any idea let me tell you, because you people may not be aware one is 2.5 kilo watt other is 5 kilo watt find out just check it if it is not right, please get back to me do not go by me, because I always tell do not follow me follow the truth, follow the logic ok. Now, you are given a chance to cook food and you want to make it tasty.

So, which stove you will choose out of this these are the options are given, any idea? Because you want to make the food tasty isn't it and it will be nutritious, right? Any idea?

Student: (Refer Time: 25:22).

Which one?

Student: (Refer Time: 25:25).

No no all are same power let us say, assume it is same power I have designed, that way LPG will give you tastier food, right? Yes or no agree no idea.

Student: (Refer Time: 25:48).

No all are LPG am using same power level na, when mode comes into picture.

Student: (Refer Time: 25:57).

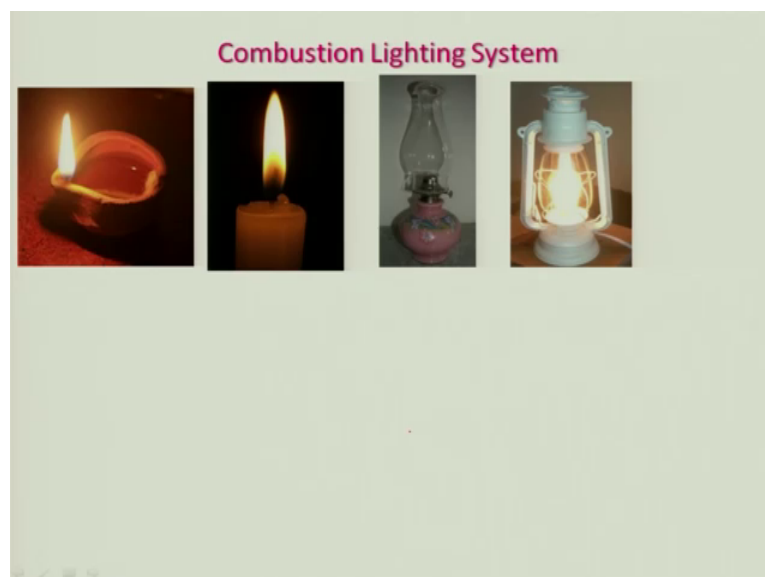
I am telling the same power means, flame will be same you know then only suppose there is a solar cooker here ok, and I have adding I have not put this figure because, this is not a part of combustion and which will be tastier solar cooker 1 2 3 1 2 3 4 5 and solar cooker, which will be tastier food solar cooker, why?

Student: (Refer Time: 26:29).

Oh no no no you have not understood, solar cooker will be tastier that is true it is a uniform rate of heating plays a important role rate of heating, right? Any of how given go any of you have gone to the this one what we call Poori Jagannath temple have taken the food there, which is cooked and it will be very tasty even same rice you will come and you know cook it in your home it would not be that tasty, people say it is Jagannathi told no it is a technology ok.

Are you getting. So, I will tell you that rate of heat in which it will be low, that will because slower heating makes the food tastier why nutrients the com components would not get detoriated, but unfortunately we are cooking in LPG, which is higher heating things and it spoil the food ok, similarly the way you take food in pressure cooker you spoil the food to the point of no heater you know. So, there is another applications I will tell you this is about heating of the room a actually it is not being used now a days, because we are having electric heaters and these heater where, used when bittisers were there they were using this is the.

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Room heater. So, let me talk about lighting system this is you know [FL] whatever we use for [FL] lamp and this is a wick also we use this is your candle light and this is the lamp what you use and this is your lantern ok..

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Course contents	
Introduction to Combustion :	Definition of combustion , Types of fuel and oxidizers, their properties, Types of Fuels and various modes of combustion, Scope of combustion
Thermodynamics of Combustion:	Thermodynamic laws, Reactant & Product mixtures, Adiabatic flame temperature, Chemical equilibrium and equilibrium products
Chemistry of combustion:	Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics
Physics of Combustion:	Simplified governing equations ,Momentum, energy, mass conservation, Multicomponent diffusion ,Concept of conserved scalar
Text Book:	
Mishra D. P, Fundamental of Combustion, PHI Learning Pvt Ltd, New Delhi 2010	
Reference Books:	
Mishra D. P, Engineering Thermodynamics, Cengage Learning Pvt Ltd, New Delhi, 2011	
Kuo K K, Principles of Combustion, John Wiley & Sons, Singapore, 1986	
Turns S R, An Introduction to Combustion, Tata McGraw Hill ,New Delhi, 2012	

So, we have discussed about some of the applications, and later on we will be discussing about these more of them in the next lecture, but before that, let me talk about the course content what I will be covering in this lecture, that is introduction to the combustion that is definition of combustion, types of fuel and oxidizers and their properties, types of fuel and various modes of combustion and scope of combustion.

And scope of combustion already I have discussed to some extent and later on we will move to the thermodynamics of combustion in which, we will be reviewing the thermodynamic laws. And we will also learn how we will apply those things for handling the reactant, product mixtures, estimate the adiabatic flame temperature, chemical equilibrium and equilibrium products and the chemistry of combustion we will be discussing about basic reaction, kinetics, elementary reactions, chain reaction, multistep reactions, right? And simplification of reaction mechanism and global kinetics.

Later on we will move to the physics of combustion, simplified governing equation part, right? And momentum and energy equation, right? Mass, conservations and multi component diffusion actually rather I should say I should discuss basically binary diffusion and I will be extending to multi component diffusion, then I would not be

discussing about multi component diffusion, concept of conserved scalars you know if you look at these are the portion first portion, which is preparing yourself to learn the combustion ok, that is why it is fundamental..

So, this will basically end the course material, and then as I told earlier that my book the fundamental of combustion will be basically a text book. And you can refer this other books like Engineering Thermodynamics of course, you may refer may not refer, but definitely KK Kuo; Kenneth Kuo Principles of Combustion and S R Turns An Introduction to Combustion Tata McGraw Hill. There are several books by various authors on combustion, you can also refer I will stop over here, fine.

Thank you very much.