

**Fundamentals Of Combustion (Part 1)**  
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**Lecture - 01**  
**Introduction to Fundamentals of Combustion**

I welcome all of you to this course Fundamentals of Combustion. A question might be coming to your mind, why combustion is important may be another question will lurking in your mind what is combustion, is it relevant today or it is a very old subject if you look at it is an old subject. And when really this combustion you know as a science, and its applications started lot of question be coming on your mind, how it is relevant to your curriculum or you know this things, whether it is relevant to life or not. So, some of the question might be coming to your mind is it, really coming.

Student: Yes.

See if questions are not coming then you know, then you cannot learn because questions can never be a silly it can be a beautiful lily in the garden of knowledge that it is the truth as after age. So, therefore you must you know encourage the questions to come up in your mind, that is the first step and next step would be to explore it to get answer for you know this things.

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**Introduction**

- Combustion is as old as Human civilization.
- Fire is one of the greatest discovery of mankind.
- The man's subsequent mastery over fire has made all the developments in science and technology the fruits of which we enjoy today.
- Most of the modern technological developments have emanated from the discovery of fire.
- Modern civilization is built upon the combustion of fuels both for heat and electrical power.
- The knowledge of combustion is very relevant today due to the stringent emission regulation and scarcity of fossil fuels.

So, if you look at combustion is as old as civilization human civilization; civilization means, human civilization you are aware of how many civilizations, were there in this beautiful planet, and which you are know very great any idea.

Student: No.

No.

Student: Roman.

Roman civilization what else.

Student: Indus valley civilization.

Indus valley civilization, Mesopotamia civilization, Greek civilization, but if you look at all this civilizations today are.

Student: Still alive (Refer Time: 02:22).

Still alive they are dead except one civilization. What is that civilization? Except one civilization you will not get the signature of the civilization, in that country for example, if I will go to Rome, can I get that about whatever it was happening let us say 5000 years back or 6000 years back, but there is a one civilization, which is having that legacy those signatures are still alive. What is that any idea?

Student: (Refer Time: 02:59).

Certainly no it is only civilization which is still alive, but it is about to die due to.

Student: (Refer Time: 03:12) culture invasion.

Due to cultural invasion right are you getting my point, and what was the turning point for the civilization to prosper human civilization people were living in jungles. What was that?

Student: Discovery of fire.

Discovery of fire. So, therefore fire is one of the greatest discovery of mankind. And if you look at if you go to our Vedas, if you go to our scriptures what it says what this

scripture say [FL] means fire. If you take bath in our culture if a baby will take bath you know, then what will welcome with a lamp [FL], you know welcome [FL], we incinerate it. And that is why and also in between lot of our rituals are having you know lamp with a lamp always am I right.

So, that is say because we always remember fire is important for life, it is a external fire also the internal fire. So, fire is one of the greatest discovery of mankind. And you should you know people might have learnt how to make a fire set a fire, but it is important to also set in a proper control manner. So, control is important.

So, if you look at mans subsequent mastery over the fire, and you know has culminated into all the developments what we say if you go to our Vedas, you know there is a [FL]the people were saying that they were these are not [FL] only they were knowing how to manufacture, the material you know how to process the material, how to manufacture the product, they claimed why am saying this thing you know I had done one course ancient Indian technology. You can see in their in YouTube as part of mooc course, the platter of knowledge were there in our country, but those are you know all extinct unfortunately. So, that was the genesis the fire, you know has made all the developments in science and technology that we enjoy today. There is nothing wrong in enjoying the fruits of the science, and technology, but we are abusing, it misusing, it as a result what is happening, instead of developing instead of moving on the path of development. What we are doing? We are on the path of destruction, what people are calling it as development you know this is not development.

So, therefore also the combustion plays a important role, in the sense it is a should be used for the you know boon not as a bane. Unfortunately it has been you know not been used, and we are part of this present days and we are responsible for it. So, most of the modern technology development have emanated basically from the discovery of fire.

And as a result what will happen, we have all metallistically developed you can say, and we are what you call spoiling the mother earth resources. And there is a segregation of the wealth, you might be aware we should aware about that thing, and this is related bit to the combustion to tangentially you know little remotely, but you must understand that it is important. As a result that modern civilization is basically built on the combustion of fuels, both for the heat and the electrical power, what you see today in electricity, you

can see this computer, you can see all those things this electricity is very important is not it.

So, also like for your heating purposes, and all process industries and keep in mind that as a result there is a what you call problems of emission, pollutions, emissions from the various combustion devices plays a major role for the air pollution. Do you think that it also affect the water pollution yes or no, it does because in power plant and other things you know, you will have to also spoil the water. So, water pollution, air pollution, and also the soil being polluted, and we are all in big trouble. So, when you talk about that there is a always you know, hampering the development what we are having, we are a which country today, we are developed country developing country or under developed country.

Student: Developing country.

We are developing country. So, at the parlance of the terminology used by the western people, but is it development according to me it is destruction are you getting, but even if you accept that; that means, if you want to develop will have to use more energy that is the thumb rule, but that is not the case that is the what you know they are talking about it then will do that; that means, we will use more fuel more you know emissions, will be making. Will make that then they are putting a pressure on us that you should change your systems.

So, that emission will be minimized, otherwise you will have to pay price for that you know carbon, foot prints, and then credits you know carbon credits, all those nonsense things they are doing. Why they are doing? Because they want to they have spoiled the world. Now they are saying you do not do that you know are you getting. So, now, is a challenge, for that we need to study the combustion because the knowledge of combustion is very relevant today, what it was let us say 100 or 200 years back.

So, as there is a stringent rules, global rules, you know like international arena coming up, and which we will have to follow. Otherwise they will twist our arm, how they will twist our arm, why they will twist our arm. Because we are depending on them we are not independent although India got independence in 1947 are we independent, are you independent, no we are day by day getting dependent on them.

So, therefore, now it is a vicious circle how will come out of it god only knows of course, I am having a plan for that, but that I will not discuss in this course. So, that, but even if you want to follow, the whatever it is going on the way of development we cannot do it, because the stringent emission rules are coming, and which we will have to you know redesign our combustion systems, and other related systems such that we will you know go eyed in spite of dust engine rules, and regulations.

And also there is a scarcity of fuel is precious am I. So, therefore, we will have to minimize the utilization of fuel, rather in other words you will have to enhance the efficiency of the systems means, combustion efficiency thermal efficiency, and other thing. And even emission minimize the emissions. So, that is a need therefore, we need to look at the fundamentals of combustion, such that we can know how to tinker how to you know understand the process. So, that we can develop better engineering combustion systems.

So, that is the main motivation why we should really look at, and look at the fundamental question arise as a what is combustion, can anybody tell me what you all you know aware of the these thing so; that means, burning of fuel. Now question might be arising what is fuel, but in a common man language, you can say that you can say setting fire to the fuel, and when you say that setting fire to the fuel, and that must be in a controlled manner.

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### What is Combustion?

- A process of setting fire to fuel in a controlled manner.
- A chemical process in which fuel is burnt in the presence of oxidizer producing heat and light.
- Combustion is a self sustained chemical process in which heat is liberated due to overall exothermic chemical reaction.
- It is a complex sequence of chemical reactions between fuel and oxidizer accompanied by liberation of heat and light.
- Examples: LPG Burner, Furnace, Candle Flame, I.C. Engines, Gas Turbine Engines, Rocket Engines, etc



If it is uncontrolled what will happen, it will lead to destruction. If you look at a fire I have shown here, can anybody guess this fire is having particular set, can anybody guess this fire we do once in a year. What is this fire? And around this thing people will be moving around in the night, what is this fire related to.

Student: (Refer Time: 12:37)

(Refer Time: 12:38) fire. And it is related to our culture, I will not get into detail why it is celebrate that we are having enough things to celebrate, then that of celebrating your birthday, valentine day, and blah blah blah which is coming from the outside, and they do not fit into our cultural milieu. We should resist those thing because those are not our culture.

So, therefore, you know this fire is important it should be controlled right and.

Student: (Refer Time: 13:12).

So, when you say these thing then what is really happening; that means, there is a when the combustion is taking place means what there will be heat, if we go to and this is generally occur in winter you will go and take the heat enjoy the heat right; that means, heat will be produced by the combustion, yes or no. And you could see also can we not see it colorful, and then you see means; that means, during the combustion heat will be generated so also light. How does it taking place? It is basically a chemical reaction. In which fuel is burnt in presence of oxidizer producing heat, and light. You heat is there and light is there, when you talk about heat; that means, what kind of chemical reaction will be taking place.

Student: Exothermal.

Is it there any reaction which will be endothermic or not there is a two kinds of reactions so, far the heat is concerned, one is exothermic, and other is endothermic. In exothermic heat will be liberated in endothermic, you will have to provide it or it will be consumed you know. So, is there any exothermic reaction will be taking place or not.

Student: (Refer Time: 14:29).

There might be, but overall effect will be exothermic is that clear. So that means, combustion is a process also self sustained chemical process, in other words combustion in the self sustained chemical process, in which heat is liberated due to overall exothermic chemical reaction. Overall you know you can sum it up as a single reaction then you will say it will be exothermic in nature.

And it is not that simple that you know like only single reaction, will be going on it is a complex sequence of a chemical reaction, between fuel, and oxidizer, accompanied by liberation of heat and light. There will be heat, and there will be also light. There might be some combustion in which the heat is being liberated, you know all the time is there any combustion where heat won't be liberated certainly no, but; however, there is some type of combustion in which you won't see the light. Any idea about that what kind of combustion it would be, and what gives it light that also a question might be coming to your mind.

Why I could see, but you might have you know from done some experiment in your chemistry class, where the reaction will be taking place, but you won't be knowing you cannot see, even am I even if you are doing a reaction test tube, you would not see am I right, but there is no light as such there is some chemical you may feel it is hot, is not it. If it is hot means it is exothermic overall. So, will you call it a combustion that is a question that may any chemical reaction need not to be a combustion process?

Student: (Refer Time: 16:40).

So, what are the examples of you know combustion, you have encountered during your know life time any idea.

Student: While cooking food.

Cooking food. What kind of you know cooking food means what like?

Student: (Refer Time: 16:59) LPG.

LPG burners, you have seen LPG burner. How many of you people have seen LPG burner? All of you have seen very good. So, what about any other things.

Student: Candle.

Candle flame you know you people are fond of candle light dinner. Yes or no right no. How come you know, it is a modern day candle light dinner in restaurant go you know like, they will you won't eat food, if there is a you know let us say snap of lighting system, or the electricity has gone off you won't take food late you will wait till the light comes, but you will go to restaurant pay money, and then celebrate candle light dinner, in your home you won't. And what else other examples?

Student: Internal combustion engines.

Internal combustion engines. What are those example internal combustion engine means what?

Student: Diesel engines, petrol.

Diesel engines, petrol engines what else?

Student: Gas turbine.

Gas.

Student: Turbine engine.

Gas turbine engine is it a internal engine, combustion engine.

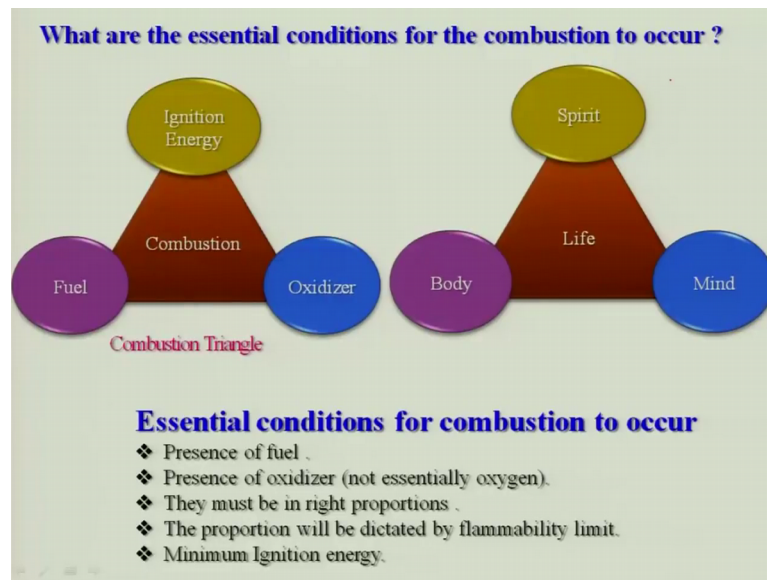
Student: External

External is it internal or external. How many of you saying external? 1, 2, 3, 4 as a how many of you are internal combustion engine gas turbine engine. Aerospace people you have studied, I think some of you I have taught you no combustion proportionate, I dint teach fine alright, but actually it is internal combustion, let me tell you it is not a external combustion engine fine.

Now what else other thing what else [FL] rocket engine, you aerospace people are there you should tell me you know, I think some of you I taught in the last what you call semester, what else fun as you know like lot of other stoves, you have looked at fireworks you know, those are also combustion. So, there is a lot of application you could see will be discussing more about it.



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But let us look at what are the essential condition for combustion to occur, as you have already told fuel is a essential yes or no. Without fuel there won't be any combustion. So, when fuel is there therefore, the oxidizer will be there, it is like you know if you look at life. Is having a one component is male and other is component female, it is like a head and tale of a coin, but we do for is not it.

Like that fuel and oxidizer what they quarrel they will be part of combustion, they cannot be combustion cannot take place without anyone of them; that means, both are essential if the fuel and the oxidizers are there, then the combustion can take place is it possible for example, in this room I will fill the LPG gas, and air is already there. So, therefore, combustion will occur.

Student: (Refer Time: 20:33).

That means I need to.

Student: (Refer Time: 20:36).

Ignition right. That and that is known as basically what you call combustion triangle, that is fuel oxidizer and ignition energy, because to initiate the flame you are having, but can you relate this to the life. Because always if you look at our scriptures of course, must most of you might have not aware about what Indians scriptures where, you might be

aware [FL] like Indians were having lot of scripture,s which are destroyed due to invasion am I right, you are aware.

Student: Yes sir.

Right, but still, but whatever this thing left over it is plethora you know it is too much to read it, but most of you are not aware, but anyway. I will not get into that, but I would encourage you people to look at it they are more scientific than the science we are talking about. So, life if you look at it is the body, and mind and the spirit are you getting without spirit; spirit means, you know what we call [FL] that if body is there will it work, it won't work if it is mind is there will it work useless.

So, is it related and once you have taken birth you are getting consumed your life is getting resided. So, similarly life is that if fuel is there it will be getting burnt oxidize there, and it is ignition are there then it will be getting consumed. So, therefore, I have related to that you can see this is life triangle. Now even if fuel is there oxidizer is there, ignition energy is there is, it combustion will take place. Suppose for in this room there is a enough oxidizer is there air is basically an oxidizer. What is the constituent of air any idea?

Student: 29 (Refer Time: 22:48).

29 percent what?

Student: Oxygen.

Oxygen what else?

Student: 78 percent nitrogen.

Student: And 1 percent other gases like carbon, carbon dioxide.

Student: And other.

What else other?

Student: Water vapors.

Water vapor very good argon right.

Student: Argon (Refer Time: 23:06).

Ok, but generally we assume it to be 79 percent nitrogen, 21 percent oxygen, but rest of the things are very less.

So; that means, air is basically one of the oxidizer let us say in this big room, I will put may be 1 gram of LPG. And air let us say it is having 10 gram, will it and I will give enough ignition energy, whether combustion will take place or not.

Student: (Refer Time: 23:45) it depends.

Depends on what?

Student: (Refer Time: 23:50).

It is mixed properly, I am having fan here, I will make it to mix its mixed.

Student: (Refer Time: 23:55).

That means I will give enough ignition energy. So, that it will reach temperature will it ignite, will it even if ignite will it combustion will be self-sustainable, there is a lot of combustion am I right. So, what is that it depends you told [FL] like can you tell me like what is that?

Student: Fuel air ratio.

That means, fuel air ratio will be proper. What you call? There is a limit between which it will work, it is mixed properly it should be mixed otherwise it won't work. Now what you call that, and that is basically known as flammability limit. So, we will be.

Student: (Refer Time: 24:46).

Looking at little later on, but essential condition presence of fuel, and presence of oxidizer not essentially oxygen. And they must be in the right proportion ratio must be proper. And this proportion the fuel ratio, air fuel ratio whatever the you call, it should be within certain limit certain range. In which the combustion can take place, and that is known as flammability limit. And there is also ignition limit, because if you give very little ignition energy, then it would not so, therefore, there is also known as minimum

ignition energy, all those things we will be discussing little later on much later you know the course.

Student: (Refer Time: 25:40).

So, therefore these are the essential condition for the combustion to be you know self-sufficient to propagate, and then move I will stop over here.

Thank you very much.