IC Engines and Gas Turbines

Dr. Pranab K. Mondal
Department of Mechanical Engineering
Indian Institute of Technology, Guwahati

Lecture – 10
Carburetor, Mixture requirements

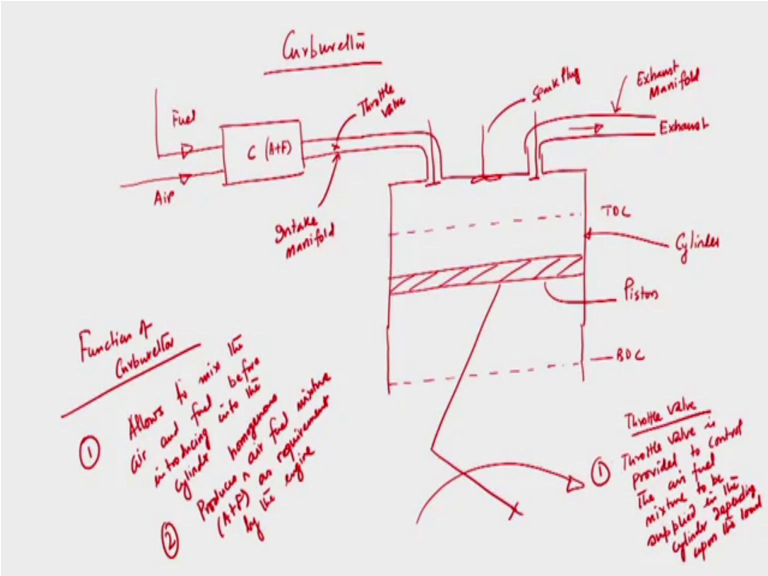
So, we will continue our discussion on IC engine. Today, we will discuss about Carburettor and mixing requirements Mixture requirements. So, we have discussed about OTTO cycle and SI engine and we have seen that carburettor has an important, there are integral part of the spark ignition engine where we need to supply air plus fuel mixture during intake stroke. We have seen that, either we have discussed in case of a SI engines spark ignition engine ah, what we are doing during intake stroke? Instead of supplying only air, we are supplying air fuel mixture during intake stroke and then we are compressing it and towards the lid of the compression we are igniting the charge that are air fuel mixture by switching on the spark plug.

So, as compared to CI engine, compression ignition engine where we do not require carburettor because we are supplying only air during intake stroke and even for the for initiating combustion, we do not require an external agent like you know spark plug, what is important for spark ignition engine but we do not require any external agent for compression ignition engine, for initiating combustion because in case of a CI engine, we are utilizing the high pressure and temperature of the or the high temperature, high pressure temperature of the air itself to start or to initiate combustion.

So today, we will discuss what is carburettor and what is it is function and then mixture requirements. I mean as I said you that carburettor is a device that is a mechanical anyway this component or a device which supply air fuel mixture depending upon the requirement of the load of the engine. Sometimes, we use a term which is known as stoichometric air fuel mixture that is chemically correct air fuel mixture. So, the function of the carburettor is to allow not only air and fuel rather homogenous mixture of air fuel and that will supply required amount of air fuel mixture depending upon the load of the engine.

So, today we will discuss about carburettor and probably ah, we will discuss about the mathematical analysis of carburettor how carburettor supplying air fuel mixture depending upon the requirement of the load and also how it you know allow you know as a homogenous mixture of air fuel mixture.

(Refer Slide Time: 02:41)



Today, we will discuss about Carburettor and which is an important part of SI engine. So, we are having instead of supplying only air, suppose this is carburettor c. So, we are having ah, we are having supply of fuel and supply of air.

So, this is air, this is fuel and we are having in a carburettor air plus fuel. And then, it is coming to the internal combustion engine just I am drawing the schematic because this will be required. So, we are supplying, so this is top dead centre, this is bottom dead centre. So, this is exhaust rather exhaust manifold and piston we will this is a piston. So, this is piston. This is engine cylinder; cylinder and this is exhaust manifold. This is intake manifold and we are having spark plug. So, this is spark plug right.

Of course, we are having one valve over here; intake and exhaust valve. And very importantly we are having one throttle valve over here. So, this is throttle valve which control the air fuel mixture to be introduced in the engine cylinder. So, this is all about the you know we have drawn the schematic while we have discussed about the nomenclature of SI engine but still today we are drawing. So, the function of the carburettor is what is the function of carburettor and throttle valve? Throttle valve is very important because it throttenly amount of it function is to provide that to control the air fuel mixture to be supplied into the cylinder depending upon the load.

And carburettor where carburettor, function of the carburettor is allows the mixture of air and fuel before introducing. So, the function of carburettor, this is very important, function of carburettor. Number 1, it allows mix this carburettor is allows to mix the air and fuel, air and fuel before introducing into the cylinder before into the cylinder. Number 2, produces air fuel mixture, this produces air fuel mixture that is air plus fuel mixture rather homogeneous rather produces homogeneous mixture of air fuel and as depending air fuel mixture as requirement as requirement whereas, throttle valve to control. So, this is produces homogeneous air fuel mixture as requirement by the engine.

So, this is the carburettor while throttle valve that is also important. So, function of throttle valve is to supply or to provide is provided. So, function is, this throttle valve is provided right to control the air fuel mixture, to control the air fuel mixture, to control the air fuel mixture. Throttle valve is provided to control the air fuel mixture depending upon the load in to be supplied in the cylinder, depending upon the load; depending upon the load.

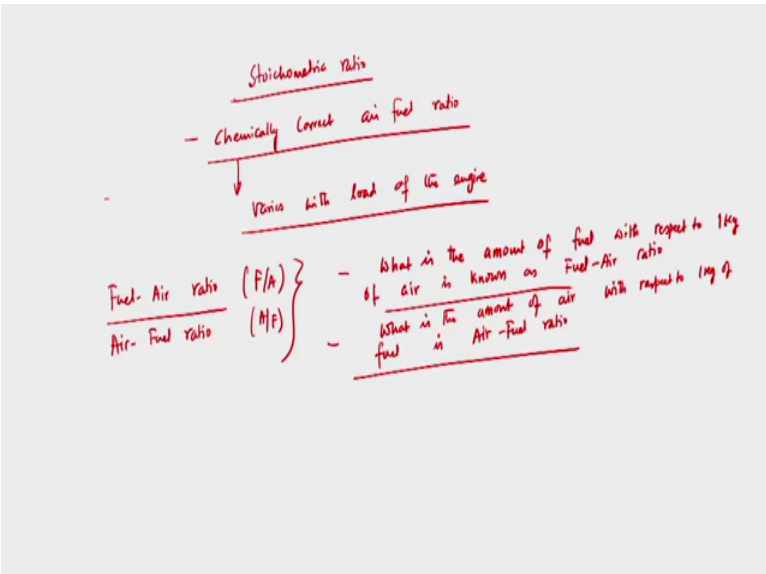
So, carburettor and throttle valve these are you know important parts of a spark machine engine. That is what we have discuss; the carburettor function is allows to mix the air fuel mixtured to be before introducing into the cylinder. Not only air fuel mixture, it allows to mix and rather it produces homogeneous mixture of air fuel mixture homogeneous mixture of air fuel as requirement by the engine while throttle valve is provided only to control the air fuel mixture to be supply into the cylinder depending upon the requirement or load, fine.

Now, before I go to discuss about you know rather function of rather the carburettor and how carburetor. So, we have discussed about the function of carburettor, but we need to know by how carburettor provide, you know requirement of rather we can if you need to, if you need different amount of air fuel mixture depending upon different depending upon the loads of the engine, then how carburettor by how carburettor provides that you know varying air fuel mixtured for varying loads. That we need to know and for that we will do a mathematical analysis considering a simple float type carburettor. But before I go to discuss about this aspect, let us first discuss about that carburettor ah. I have discussed about the producers homogeneous mixture, air fuel mixture as requirement by the engine, not only that sometimes carburettor is used provide stoichiometric air fuel mixture that is known as chemically correct air fuel mixture.

So, it is not always possible that the carburettor will be provided chemically correct air fuel mixture, but it will be very close to chemically correct air fuel mixture. So, now, we need to know what is chemically correct air fuel mixture or what is stoichiometric air fuel mixture. So, before I go to discuss about the you know parts of the carburettor, what are that different parts of a carburettor and by how it provide the it provides air fuel mixture depending upon the load of the engine rather varying air fuel mixture for varying loads, we need to know that carburettor is provided to supply homogeneous air fuel mixture. Not only that, sometimes it provides stoichiometric air fuel mixture that is chemically correct air fuel mixture but it is not fact that always it will provide chemically correct air fuel mixture, but it will try to provide chemically correct near about chemically correct ah very nearer to chemically correct air fuel mixture.

So, we need to know what is chemically correct air fuel mixture or stoichiometric air fuel ratio.

(Refer Slide Time: 10:57)



So, stoichiometric ratio, what do you mean by that? So, stoichiometric ratio is chemically correct air fuel ratio. Stoichiometric ratio is chemically correct air fuel ratio with engine load chemically correct air fuel ratio and this chemically correct air fuel ratio which varies with; which varies with the load of the engine; with the load of the engine.

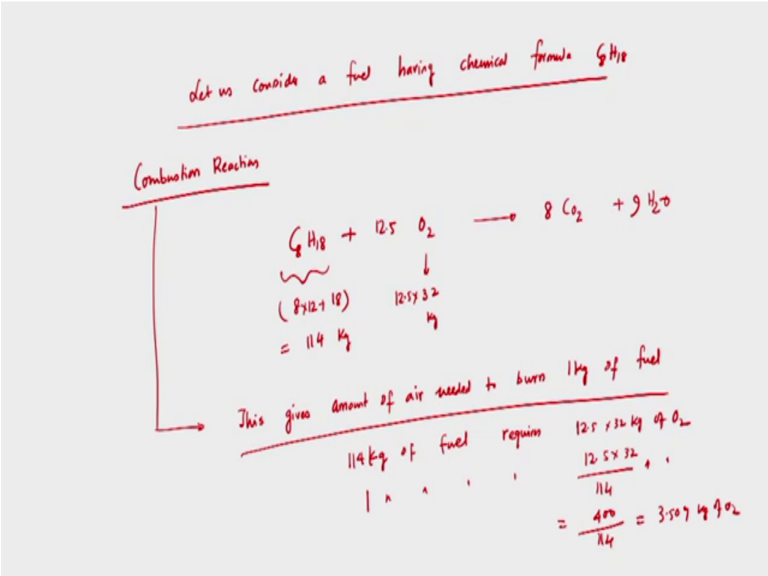
So, for a given fuel, we can calculate what will be the chemically correct air fuel mixture ratio, but for the efficient combustion we should supply chemically correct air fuel ratio but depending upon you know this chemically correct air fuel ratio will vary with the load of the engine. So, what before we go to do, so let us discuss probably we have discussed that what do you mean by fuel air ratio? Fuel air ratio or sometimes it is known as air fuel ratio, fuel air ratio that is F by A ratio or air fuel ratio that is A by F. So, what do mean by this? This is very important that. So, I am writing what is the amount of; what is the amount of fuel with respect to with respect to 1 kg of air, what is the amount of fuel with respect to 1 kg of air is known as fuel air ratio or if you would like to define air fuel ratio, so that means, what is the amount of air with respect to 1 kg of fuel is the air fuel ratio.

So, these two, air fuel ratio and fuel air ratio that is the amount of fuel per kg of air or vice versa, that is the chemically correct air fuel sorry that is the air fuel ratio or fuel air ratio fine. So, now, we will discuss how we can, how come I know that chemically correct air fuel ratio will be supplied to the engine and what would be the chemically correct air fuel ratio for a given fuel.

So, I need to know how do I calculate the chemically correct air fuel ratio for a given fuel and for that we will work out an example. So, let us consider a fuel having chemical fuels are normally hydrocarbon, we will discuss one day that fuels are normally family of hydrocarbons whatever I mean. So, depending upon the whether it is used for SI engine or CI engine normally, fuels are a family of hydrocarbons. So, let us consider, so if you need to calculate what is the chemically correct air fuel ratio or fuel air ratio whatever it is for a given fuel, then how do I calculate it?

So, for that we will take up an example.

(Refer Slide Time: 14:42)



So, suppose or let us consider fuel; let us consider fuel; let us consider a fuel having chemical formula; having chemical formula C 8 H 18 let us consider a fuel having chemical formula C 8 H 18. That is this is known as what this is a Butane. So, if it is chemical formula C 8 H 18 that is butane, so, if we would like to calculate chemically correct air fuel ratio; that means, we need to know the combustion reaction. So, if we now we need to write the combustion reaction for where for there from there, we can calculate what will be the amount of fuel per kg of air or vice versa.

So, if you write now write chemically you know combustion for[mula]- combustion reaction, combustion reaction for this fuel combustion reaction for this particular fuel C 8 H 18, this is Butane, then how we can write plus oxygen we are supplying air during combustion. So, oxygen present in the air will take part in the combustion and it will produce carbon dioxide you know you know water vapour and sometimes carbon monoxide is produced. So, it will produce definitely carbon dioxide plus water vapour. So, if we balance this reaction, I will write that it will be 12.5 O 2 is equal to 8 CO 2 plus 9 H 2 O, this is the you know balanced reaction.

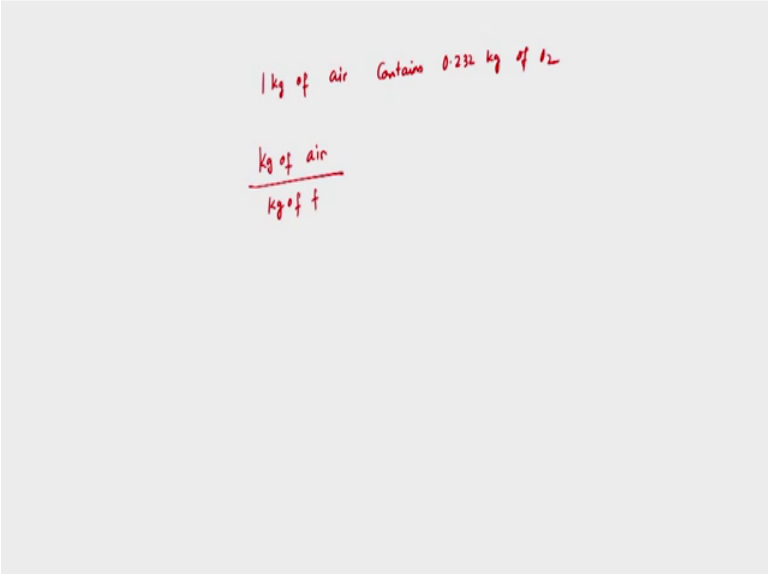
So, the combustion reaction for this particular fuel having chemical form[ula]- chemical formula is you know C 8 H 18 butane. So, this is the combustion reaction. From there, so what is the you know molecular weight of this particular fuel, then this is 32 and this is 8 into 12 plus 18, that is 114 kg. So, this will be 12.5 into 32 kg. So, from this you know balanced reaction combustion reaction, we can write that this gives the amount of air needed to burn 1 kg of fuel. So, this reaction this combustion reactions, if you balance it this gives amount of air amount of air needed to burn 1 kg of fuel. So, this gives amount of air needed to burn 1 kg of fuel.

So, here how can I write, so, I can calculate that what will be the amount of oxygen required to burn per kg of fuel. So that means, from there I can write that 114 kg of fuel requires 12.5 into 32 kg of O 2. So, per 1 kg of fuel, we requires 12.5 into 32 divided by 114 kg of oxygen. So, this will gives that is 400 divided by 114 that equal to 3.509 kg of oxygen.

So, we can calculate, if of if we use fuel which chemical formula is C 18 H C 8 H 18 and if you like to write the chemically correct air fuel ratio stoichiometric air fuel ratio; that means, if you write the combustion reaction and balance it, then from there balanced reaction I can write that if I need to burn 1 kg of fuel, I require 3.509 kg of oxygen and this oxygen will come up this oxygen will this oxygen this amount of oxygen will come from the air that is being supplied during intake stroke ah through carburettor.

So, now because this is the amount of oxygen we I need to burn 1 kg of fuel. So, this much of oxygen will be obtained from the air we are supplying. So, from how? So, amount what will be the amount of air for which I can get this much amount of oxygen that I need to know, from there only I can calculate what will be the chemically correct air fuel ratio or fuel air ratio fine and for that we need to know something that what is the amount of oxygen present per kg of air. So, that information is very important.

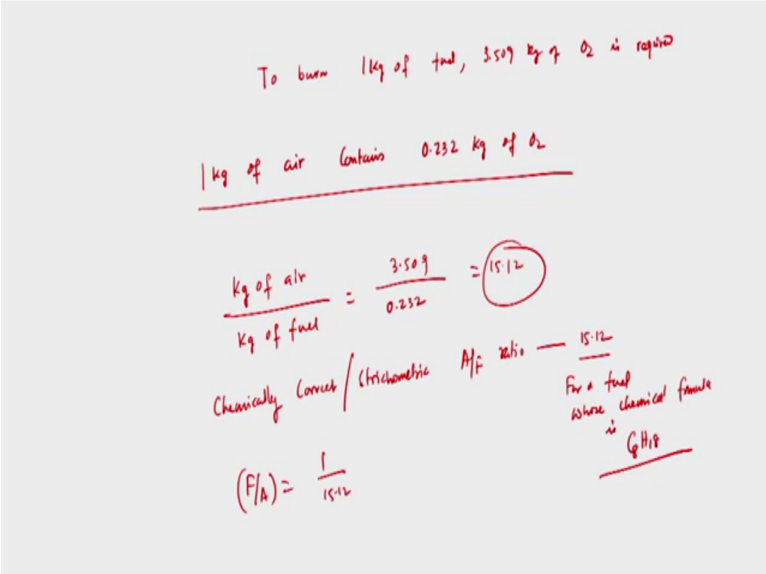
(Refer Slide Time: 19:17)



See, 1 kg of air contains; 1 kg of air contains 0.232 kg of oxygen.

So, if I go back to my previous slide, here we have obtain that this much amount of oxygen is required per kg of to burn per kg of fuel and this much amount of oxygen will be obtained from the air we are supplying during intake stroke. Here I am writing that if I supply 1 kg of air, then I will get only 0.23 kg of oxygen; that means, to obtain 30.509 kg of oxygen, how much air will be required? So, kg of air, so, kg of air by kg of fuel, kg of oxygen kg of fuel will be now. So, we have seen that it is very important that if we would like to burn per kg of fuel, we require 3.509 kg of oxygen that is what we obtained.

(Refer Slide Time: 20:16)



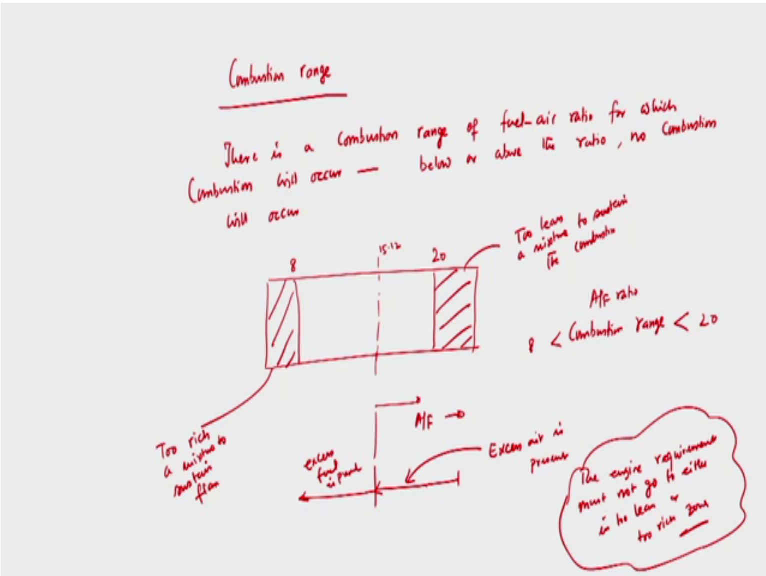
So, to burn 1 kg of fuel that is what we have seen we fuel ah, one 3.509 kg of oxygen is required that is what we go[t]- obtained from the chemical combustion reaction, that is balanced combustion ah balanced reaction. Now, this amount of oxygen we will get from the air that is being supplied during intake stroke and for that we need to know how much amount will be how much amount of air will be required to burn this amount of fuel and to do that we need to know what is the amount of oxygen present per kg of air. So, 1 kg of air; 1 kg of air contains 0.232 kg of oxygen. So, this information is required to calculate the amount of air required to burn 1 kg of fuel where the fuel is C 8 H 18 chemical formula is C 8 H 18.

So, from there, now I can calculate what is the kg of air by per kg of fuel, that will be equal to 3.509 divided by 0.232, that is equal to 15.12. So, this 15.12 is the is the call air fuel ratio; that is chemically correct or stoichiometric, stoichiometric air fuel ratio is 15.12. This is for a fuel whose chemical formula is C 8 H 18, this is for a fuel whose chemical formula is C 8 H 18 that is Butane.

So, from a combustion reaction, we have calculated how much amount of oxygen required to burn 1 kg of fuel. Then, we have calculated how much amount of air required to supply that much amount of oxygen which is required to burn per kg of fuel. And from there, we have calculated air fuel ratio that is this is for C 8 H 18 that is 15.12. So, the fuel air ratio will be similarly, fuel air ratio will be 1 upon 15.12 that will be the fuel air ratio.

Now, this is a combustion range. It is very important that there are these particular range of fuel air ratio for which below above the no combustion will occur. So, this there will be a combustion range for which, may be as I said you that it should always operate ah, I mean it is always better to supply chemically correct air fuel ratio or stoichiometric air fuel ratio but it is not always possible to supply chemically correct air fuel ratio or stoichiometric air fuel ratio and, but there is a combustion range in which the engine should operate. But if the supplied air fuel ratio rather fuel air or fuel air ratio is beyond that particular combustion range, then no combustion will occur.

(Refer Slide Time: 23:41)



So, there is a combustion range, there is a combustion range and of fuel air ratio for which a below ah. So, there is a combustion range, I am writing, there is a combustion range, there is a combustion range of fuel air fuel air ratio or air fuel ratio and below or above for which air fuel fuel air ratio for which combustion will occur below or above the above that you know ratio no combustion will occur; no combustion will occur; that means, it is always better to supply chemically correct air fuel ratio, but it is not possible to supply chemically correct fuel air ratio all time depending upon the function of carburetor because which is after keep, if you keep on using carburettor carburettor, will start malfunctioning. So, it is not always possible that it will supply chemically correct air fuel ratio.

It also depends upon the composition of fuel you know and also depends upon the oxygen present in the air and it also depends so many other things, but there is a combustion range of fuel air ratio for which combustion will occur, but if we supply chemically or, if we supply air fuel ratio either below above that combustion range there is no combustion will occur. So, that is why for this particular fuel, that is what we have taken to carry out to calculate the chemically correct air fuel ratio that is Butane and for that it is experimentally observed that the you know if we now write the range of combustion. So, maybe ah 15.12, 15.12 is the this is air fuel ratio 15 point air to the stoichiometric or chemically correct air fuel ratio but it will operate between so, it will operate, so this is 20 and this is 80 a 8.

So, this is combustion range for this particular fuel combustion range; for this particular fuel is less than 10, greater than 8. So, air fuel mixture, so, air fuel ratio for this particular fuel combustion range is within 8 and 20. If it is less than 8 then ah, but again I am titling if too rich. If it is less than 8, this is too rich mixture, too rich mixture to sustain flame ; again if it is more than 20, this is too lean mixture too lean a mixture to sustain the combustion, to sustain the combustion right.

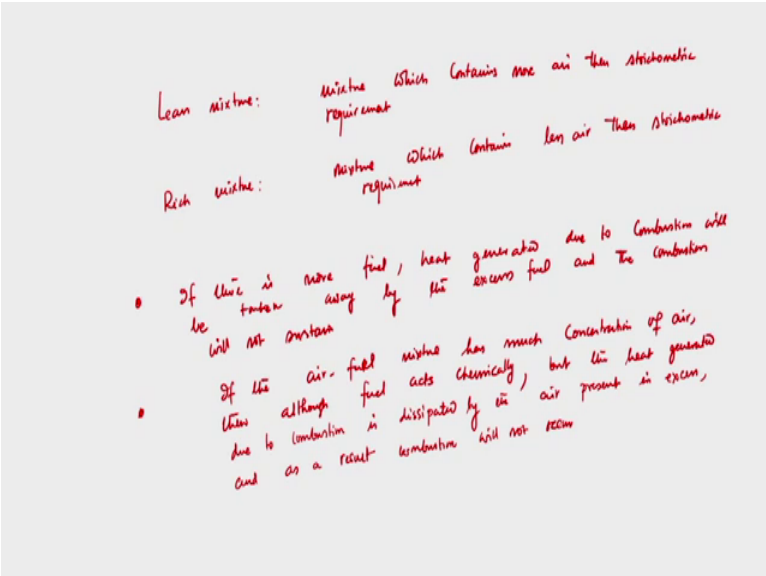
And if it is greater than 15.12 and up to 20 or more than 20, then excess air is present. So, in this region if it is greater than air fuel mixture is greater than 15.12, then this is excess air is present; excess air is present. But if it is less than 15.12 and it becomes closer to 8 or even less than 8, then excess fuel is present, excess fuel is present. So, chemically correct air fuel ratio is 15.12 if it becomes less than 15.12 then excess fuel is present, if it becomes higher than 15.12 excess air is present whatever it is whatever may be the case, but the combustible range in between 8 and 20. If it becomes higher than 20, then mixture is too lean to sustain the combustion. If it is less than 8, then mixture is too rich to reach with the fuel to and the flame should not sustain.

Flame might develop, but it would not be you know propagate immediately after development it will be extinguished. So, this is this is the combustible range for this particular fuel ah butane that problem for that we have calculated stoichiometric air fuel ratio. So, that means, the engine requirement must not go to either too lean or too rich;

that means, from here I can write the engine requirement, engine requirement, engine requirement must not go to either in too lean or too rich zone right.

Its engine requirement should not or must not go either too lean and too rich zone. It will be within the combustible range, then only combustion locker if it goes either in too rich or too lean zone combustion will not occur. So, what is lean mixture?

(Refer Slide Time: 29:07)



So, there I have discussed, I have written the lean mixture and rich mixture what is lean mixture? Mixture which contains more air than stoichiometric ratio. So, lean mixture; lean mixture the mixture which contains more air than stoichiometric, than stoichiometric ratio stoichiometric requirement.

And rich mixture this is also important mixture which contains which contains more fuel or less air, that is less air than stoichiometric requirement this is very important. So, if it is rich mixture, mixture is not eventually essentially stoichiometric, but it will contain more or less. So, less air if it is lean mixture, it will contain more air than the stoichiometric requirement. So, if we use fuel C 8 H 18, we have calculated stoichiometric ratio and it is found to be 15.12. So, it should be always operate and we have calculated it is experimentally obtained data that the combustible range for this particular fuel is 8 to 20.

So, the engine should operate between this range, if it if the engine requirements falls either below or above that requirement then combustion will not occur. So, ah it should be always operate between the zone of 8 and 20, but not exactly at the correct stoichiometric air fuel ratio which is that it should always operate within the combustible range. May be ah, if we use fuel it is not necessary that engine has to operate in a load condition for which we need to supplies chemically correct air fuel ratio, it would be better if the we supply. But as I said you that chemically correct air fuel ratio changes depending upon the load whatever may be the load that demanded by the engine, but the air fuel ratio that we need to supply if we use fuel that is 8 to 20, if it is goes more than 20 mixture is too lean to sustain combustion. If it is less than 8 the mixture is too rich that is less amount of air is present in the than this stoichiometric requirement and flame should not sustain.

So, this is the case. So, if I write if there is a more fuel, so more fuel if there is more fuel; if there is more fuel; then a heat generated due to combustion will be taken out by the excess fuel, heat generated more fuel; that means, less air more heat generated by the due to combustion will be taken away by the excess fuel and the combustion will not sustain. So, if it is more fuel that is less amount of air that is too rich mixture heat generated by the combustion will be taken away by the excess fuel and combustion will not sustain.

If the air fuel ratio has more concentration much concentration of air; that means, if the air fuel mixture or ratio has much concentration of air, then although fuel is acts chemically although fuel acts chemically because fuel will gets sufficient amount of oxygen the requirement required amount of oxygen. If see if we have less amount of air, then fuel it is not getting sufficient that the requirement ah required amount of oxygen to have chemically correct reaction.

But if we have much concentration of air in the air fuel mixture, then maybe although the fuel is getting chemically correct whether you know ah correct amount or rather required amount of air to have a chemically correct you know combustion rather you know stoichiometric rather fuel will get, required amount of oxygen from that air to have a you know proper combustion following the stoichiometric ratio, but the question is heat generated is dissipated by the air present in excess. But if the air fuel mixture has much concentration of air that is what I was discussing that although the fuel acts chemically due to the you know exact or chemically correct due to the required which is due to the availability of required amount of oxygen.

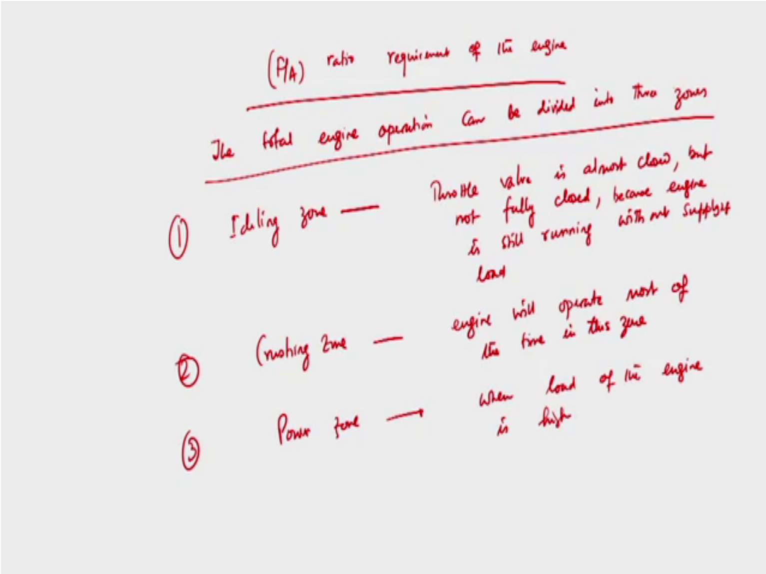
But the heat generated, but the heat generated due to combustion, due to combustion is dissipated by the air present in excess and as a result and as a result, combustion will not occur, combustion will not occur. So, we have seen that if we have less amount of air, a high amount of fuel heat developed or heat generated due to combustion will be taken out by the excess fuel and flame or combustion will not sustain ; flame would not sustain while, if the air fuel is ratio is having air fuel mixture is having ah, you know mass amount air then although the fuel will acts chemically due to the availability of required amount of oxygen, but heat developed due to combustion heat generated due to combustion will be dissipated due to the air present in excess and as a result combustion will not sustain.

So, that is why engine should operate between the combustible range and that is what I was discussing a few minutes back. And if the requirement of engine is such that, that the chemically correct ok, sorry that is air fuel ratio goes either above or below that the stoichiometric or that combustible range, then combustion should not occur fine. So, even SI engine the liquid fuel and air are generally mixed by to the as I said you that in a SI engine liquid air fuel and liquid liquid fuel and air are mixed generally before it goes to the engine cylinder and the process is carried out by you know as carried out by a device I call carburettor.

So, carburettor is a device which allow the homogeneous or you know homogeneous mixture of air and fuel before it goes to the engine cylinder; that means, in a SI engine we are supplying air fuel mixture together liquid air liquid fuel plus air is allowed to mixed before it goes to the engine cylinder and this process is carried out by a device which is known as carburettor. And in fact, engine need not to be necessary run as I said you that it is not necessary it is not mandatory that engine should always run taking a stoichiometric calcu;ation stoichiometric air fuel ratio.

But the fuel and air ratio supplied the engine depends upon the load and also the power requirement, it is not mandatory that if we need to supply always chemically correct air fuel ratio depending upon the load it may varies, but always it will be within the combustible range, otherwise combustion should not sustain ah. And depending upon the fuel air requirement of the engine to total engine requirement operation can be given to 3 regimes you know a fuel air ratio requirement of the engine.

(Refer Slide Time: 37:37)



And now we will deeply discuss today that you know a fuel air ratio or air fuel ratio that is the reciprocal of fuel air ratio, fuel air ratio requirement of the engine; that means, we need to it is not necessary that we should always supply chemically correct fuel chemically correct air fuel ratio, stoichiometric air fuel ratio rather engine should run with a chemically correct air fuel correct air fuel ratio; that means, or fuel air ratio.

It depends upon the load. So, fuel air ratio requirement of the engine. So, the total engine requirement can be given to three regime that depends upon the load; the total engine operation can be divided into three regimes, into three zones, that depending upon the load. So, what are that what are those three zones? Number 1, idling zone; in this zone throttle valve which is provided to supply to control the air fuel ratio depending upon the load throttle valve is almost closed is almost closed, but not fully closed, but not fully closed right.

And fully closed because in idling zone engine is running but without you know supplying load; that means, idling zone is a zone where throttle valve is almost closed, but not totally, we need to supply air fuel ratio because engine is still running because engine is still running without supplying load. So, we are not getting any load from the engine is still running for there for that we need to supply air fuel ratio and this is known as idling zone engine is in ideal condition and in for in that zone throttle valve is almost closed, but not totally.

Then it is called Cruising zone. This is very important zone cruising zone; in this zone engine will operate most of the time at cruising zone engine will operate most of the time in this zone. And number 3 is power zone; power zone that when load of the engine is very high, is high. So, engine most of the time should operate in the cruising zone; idling zone is engine is supplying no load. So, throttle valve is almost close not totally and power zone is a zone when load of the engine is very high. So, the total engine operation can be divided into this three reasons. Whatever may be the fuel we are using for to run a particular engine, depending upon these three zones, requirement of fuel air ratio varies.

In most of the time the fuel air ratio the requirement of fuel air ratio, air fuel ratio is very less is in cruising zone. It is also high in idling zone and in the power zones. So, fuel air ratio requirement is very high in the idling and power zones while it is almost constant and relatively lesser as compared to other zones in the cruising zone. We will discuss that aspect if we even take up that particular example butane as a fuel and then what will be the fuel air requirement during idling zone and cruising zone and power zone and we will explain why the requirement of fuel air ratio, air fuel ratio is high in idling and power zones while in cruising zone is almost constant while most of the time engine is running at a cruising zone. So, with these I stop here today and I will continue our discussion next class.

Thank you.