Thermal Engineering Basic and Applied
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Lecture – 46
Introduction of Carburetor and Regimes of Engine operation

I welcome you all to the session of thermal engineering basic and applied today, we shall discuss about the carburetor. We have seen that in the context of SI engine operation, carburetor is an important element and though we did not discuss in detail, but the objective of providing this particular element is to supply homogeneous mixture of fuel and air. So though it is not possible to discuss this particular element in a greater detail.

But still we shall briefly touch upon important aspects of this particular element, while we are discussing the SI engine operation. So if we recall in the last 2 classes, we have discussed the classification of internal combustion engines and we could classify internal combustion engines based on the number of strokes and types of combustion. These two are the important classifications while internal combustion engine can also be classified based on the cylinder arrangement. We have seen in the nomenclature of both SI and CI engine, piston is having a reciprocating movement inside the cylinder between 2 centers to be precise, top dead center and bottom dead center. Now when the piston is traveling between these 2 centers inside the cylinder depending on the requirement, we need to have multi cylinder engines and if we need to have multiple cylinders then arrangement of cylinder can be a criterion to classify internal combustion engines.

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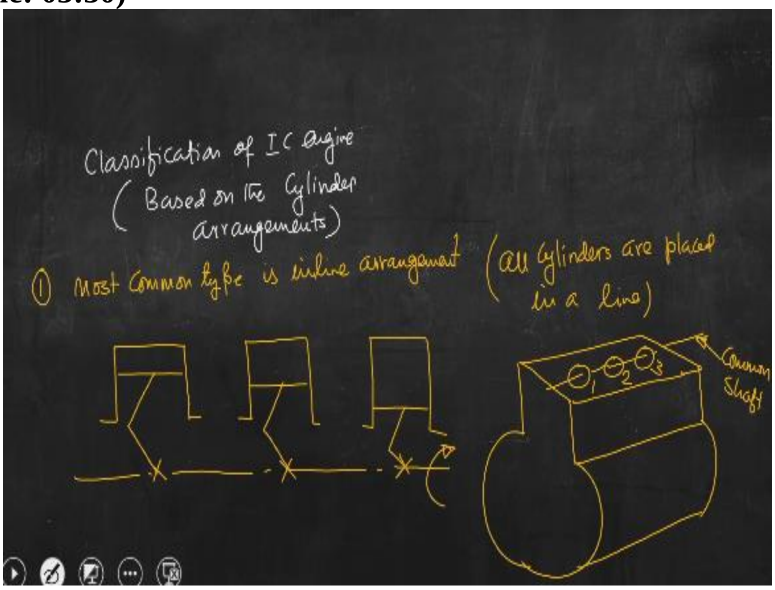

So before going to discuss the carburetor let us discuss about the classification of IC engine and this is based on the cylinder arrangements. So 1) most common type is the inline arrangement so you can see there are 3 cylinders which are connected to one common crank shaft and this is called inline arrangement and cylinder placed in a line. So you can understand all cylinders are connected to a common shaft and power is supplied to this common shaft so this is most common type inline arrangement.

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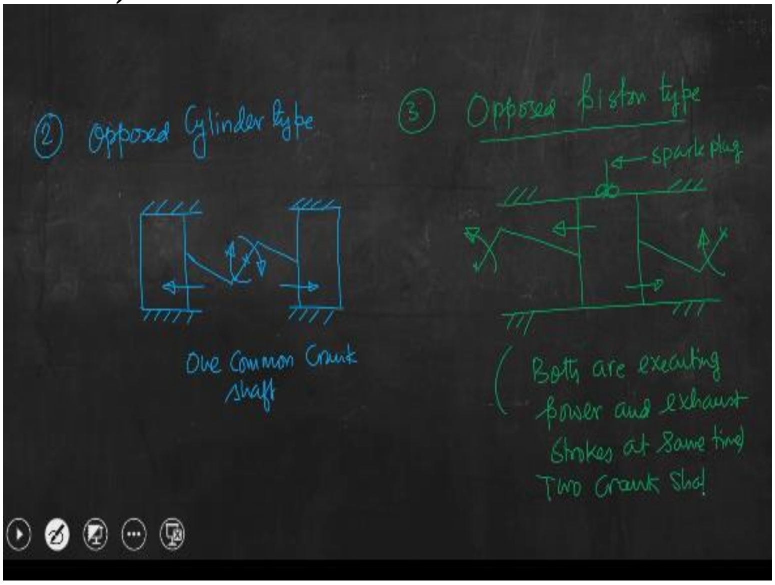

2) Opposed cylinder type this particular classification is based on the criterion of engine cylinder arrangement provided if the engine is having multiple cylinders. So these 2 cylinders are opposing each other and you can see there is one even common crank shaft.

3) Opposed piston type and so this is spark plug, if this is not this SI engine instead of spark plug, we will be having fuel nozzle. So you can see that these 2 pistons are having opposite movement and the specific feature of this particular type is both are executing power and exhaust stroke at same time. But we have 2 crank shaft.

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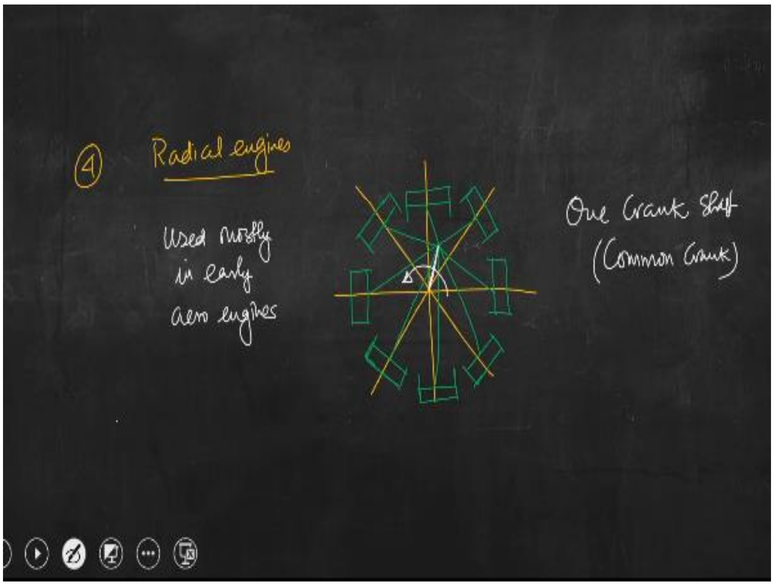

4) Radial engines and if we try to draw the schematic and say this is the crank and you can see all cylinders are placed along the periphery of a circle having equal radius and all cylinders are connected to this common crank shaft and this crank shaft is rotating in this direction.

So a radial engine, one crank shaft and that is common to all cylinders and this particular radial engine used mostly in early aero engine, this type of arrangements is what we could not discuss in the last class, but today we have discussed that engine can be further classified based on the cylinder arrangement and we have seen most common type is the inline, then opposed cylinder type, opposed piston type and finally radial engine.

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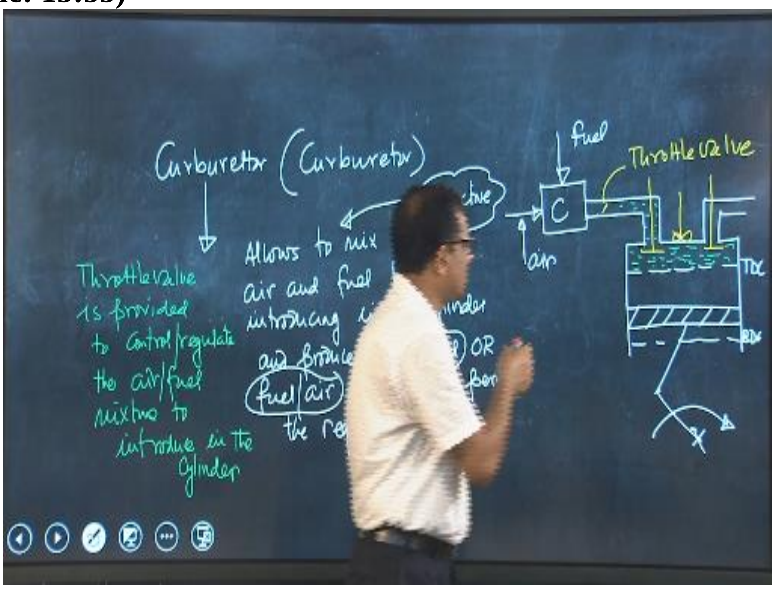

So with this now let us move to discuss about carburettor. So today we shall discuss, about why this particular element is needed for the SI engines, we have discussed that for the SI engines fuel air are allowed to mix prior to the arrival in the cylinder before combustion and this particular mixing is carried out by a device which is the carburettor.

So carburettor is a mechanical element or device, the sole purpose of this device is to provide homogeneous mixture of fuel and air to the cylinder depending on the engine requirement. So this particular device allows to mix air and fuel before introducing in the cylinder and produce air fuel or fuel air mixture as for the requirement and this is also known as charge for the SI engine.

So essentially to obtain homogeneous charge depending on the requirement of the load or power of the engine, carburetor is needed. Now if we try to draw the schematic, this is top dead center this is bottom dead center and this is the fuel path and this is the air path and this device is carburetor and we have another component this is called throttle valve.

So adjacent to this particular element that is carburetor, there is a valve which is called the throttle valve and we have intake valve, exhaust valve and of course we have spark plug, so you can see that when piston is at the TDC both valves are closed, piston is traveling from TDC to BDC intake valve will open and there is a pressure difference between the upstream and downstream of the throttle valve.

So if we consider after a particular cycle of operation this space which is the clearance volume is filled with combustion gases and there is a pressure difference between the upstream and downstream parts of the throttle valve and that is why this throttle valve is given, because this pressure is relatively higher inside the cylinder while pressure upstream the throttle valve is also less.

Now when piston is coming from TDC to BDC, intake valve opens and the pressure inside the cylinder reduces exhaust is remaining closed. When the pressure difference is such that upstream pressure becomes higher than the further downstream pressure of the throttle valve. This fuel air mixture comes from the carburetor into the cylinder and this carburetor you can see that the fuel will come from fuel path that would be supplied to this carburetor by a fuel pump or any pressurizing system while air should be taken from surroundings.

Now we need to supply air by overcoming the frictional resistance of the flow because air will flow through a conduit intake manifold. So there will be frictional losses and overcoming the frictional losses we need to have flow of air. So pressure upstream the throttle valve should be even less than the atmospheric pressure. Now when throttle valve is fully open then pressure at the upstream and downstream of throttle valve is almost same whatever is the case issue is that throttle valve is also there adjacent to the carburetor.

And this throttle valve is provided to control or regulate the flow of air fuel mixture to introduce in the cylinder. So carburetor will provide homogeneous mixture of fuel air or air fuel mixture but what would be the ratio of fuel and air that would be decided based on the engine load or power while how much homogeneous charge or air fuel mixture will go into the cylinder that will be control by this throttle valve.

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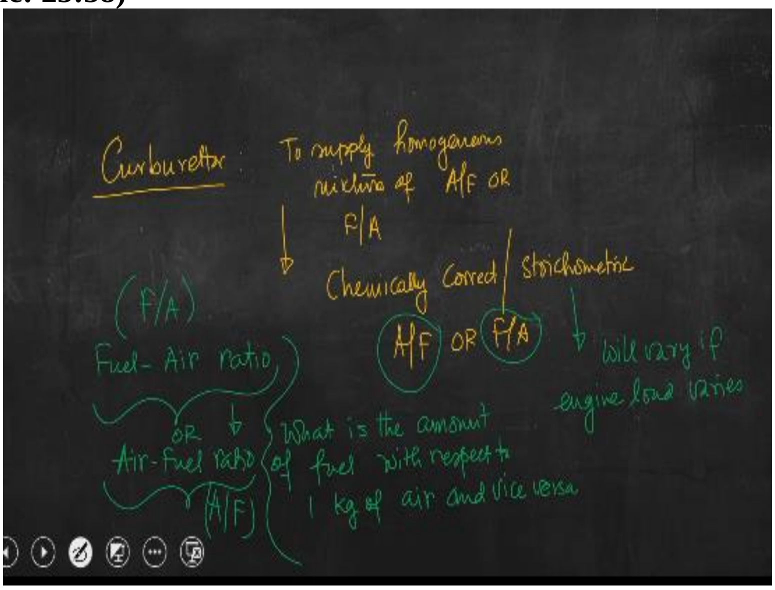

So carburetor is provided to supply homogeneous mixture of air fuel ratio or fuel air ratio. Now homogeneous mixture fuels are families of hydrocarbon. Now when you take any particular fuel that fuel is introduced inside the cylinder and it will be combusted. Combustion is needed and combustion is an exothermic reaction.

We will be getting energy in the form of heat and also will be getting several components those are the combustion gases, so that high pressure high temperature is needed. Now for the combustion we need to supply air because the oxygen content in the air is needed for the efficient combustion. Now when you are talking about homogeneous mixture of fuel air mixture or air fuel mixture.

We need to ensure that the amount of oxygen needed for the efficient combustion of that particular fuel would be there in the air which is being supplied. So in a way the carburettors are used to supply chemically correct or stoichiometric air fuel mixture or fuel air mixture because the amount of air that should be supplied must contain sufficient oxygen which is needed to burn that fuel that is to ensure that combustion should be efficient.

And if we can ensure that provided if we supply chemically correct amount, that is the stoichiometric. So the chemically correct or stoichiometric air fuel or fuel air mixture should be supplied by the carburetor and the special feature of this particular element is to provide chemically correct air fuel ratio as per the requirement of the engine and it may vary if load or power required by the engine varies, so stoichiometric A/F or F/A will vary if engine load varies. So now issue is we can see that carburetor is not only used to supply homogeneous mixture of air and fuel, it is also used to supply chemically correct or stoichiometric air fuel mixture even at varying load condition.

So engine when it is running, sometimes it may operate in a given load condition, after that particular period may be load demanded by the engine is increased that time also carburetor would be able to supply chemically correct air fuel ratio. So fuel air ratio indicates what is the amount of fuel with respect to 1 kg of air that is chemically correct. So we really do not know what is the amount of fuel needed for that particular condition when the load is constant and for a given load if we know that this much amount of fuel is needed. So to burn that fuel what is the amount of air needed that needs to be supplied using this carburetor.

So the fuel air ratio is the amount of fuel with respect to 1 kg of air, if it is air fuel ratio it is the amount of air with respect to 1 kg of fuel. So fuel air ratio F/A or air fuel ratio that is A/F is what we have discussed now. Now if we take a particular fuel and if we can write the chemically balanced equation for that particular fuel and then we can quantify what would be the fuel air ratio or air fuel ratio.

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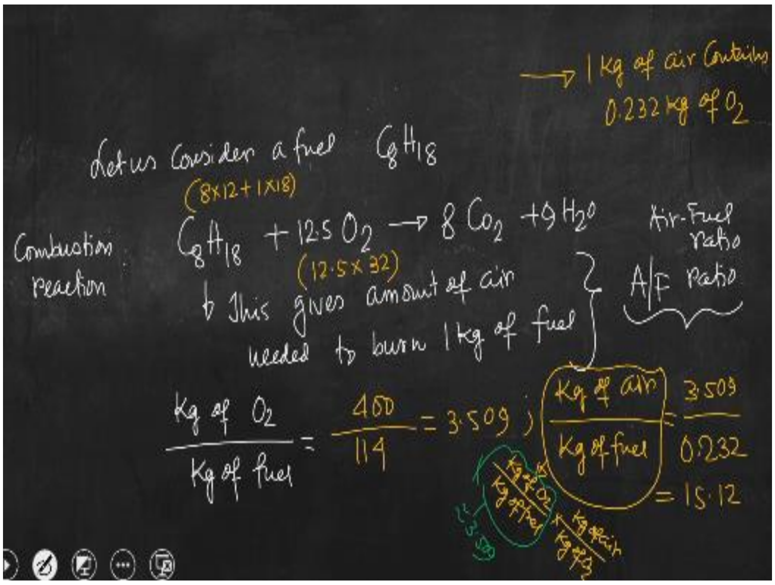

So let us consider a fuel and that fuel is C_8H_{18} so suppose this fuel is used for the SI engine and that fuel would be supplied to the engine cylinder through the carburetor, because we need to supply chemically correct or stoichiometric air fuel ratio. So what would be the chemically correct air fuel ratio for this particular fuel essentially for the efficient combustion, we need to write the combustion reaction.

$$C_8H_{18} + O_2 \rightarrow CO_2 + H_2O$$

So this is the combustion reaction. So if you need to supply chemically correct then you need to balance this equation

$$C_8H_{18} + 12.5\ O_2 \rightarrow 8\ CO_2 + 9\ H_2O$$

Now C_8H_{18} gives amount of air needed to burn 1 kg of fuel. Now we are trying to find out amount of air that is needed to burn 1 kg of fuel that is your fuel air ratio. So this will give air fuel ratio. So what we can do next?

$$\frac{Kg\ of O_2}{Kg\ of\ Fuel} = \frac{12.5 \times 32}{8 \times 12 + 1 \times 18} = \frac{400}{114} = 3.509$$

So that means this is kg of oxygen per kg of fuel we have calculated. Now if we consider 1 kg of air contains 0.232 kg of oxygen. Then we can straight away

$$\frac{Kg\ of air}{Kg\ of\ Fuel} = \frac{Kg\ of O_2}{Kg\ of\ Fuel} \times \frac{Kg\ of air}{Kg\ of O_2} = 3.509 \times \frac{1}{0.232} = 15.12$$

So this is basically air fuel mixture, so kg of air by kg of fuel that is air fuel mixture.

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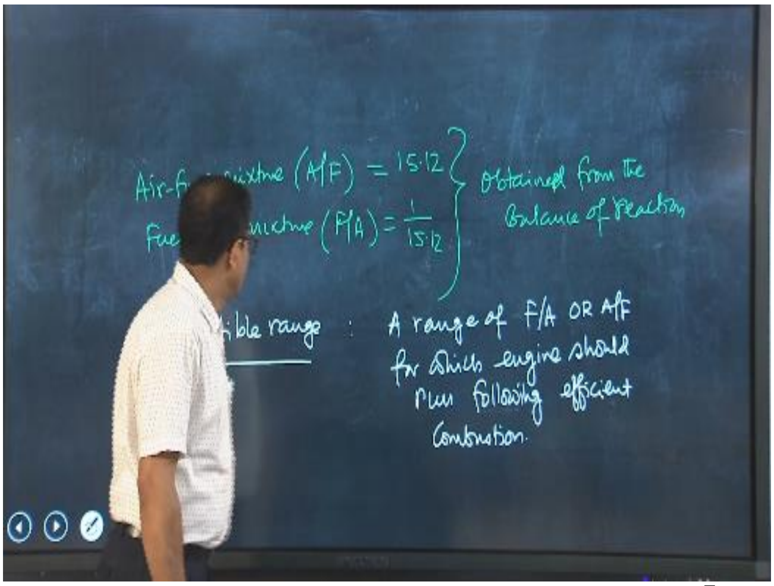

So we have calculated for this particular fuel, air fuel mixture = 15.12. $\frac{F}{A} = 1/15.12$. So these two are obtained from the balance of reaction for that particular fuel. If we need to supply to the engine cylinder the chemically correct air fuel ratio should be 15.12 or fuel air ratio should be 1 upon 15.12. Now it is very unlikely that always this carburetor would be able to supply chemically correct or stoichiometric air fuel ratio.

And it is also not necessary that always engine needs stoichiometric air fuel ratio, it is not possible even from any mechanical element or device. So there must be a specific range of the fuel air ratio or air fuel ratio for which combustion will occur efficiently so this particular range is known as combustible range. Let me tell you once again we could calculate the air fuel ratio or fuel air ratio for this particular fuel that we have calculated from the balance reaction. We had seen that this stoichiometric air fuel ratio is 15.12 or fuel air ratio is 1 upon 15.12. If we need to run at this condition so carburetor would be able to supply this ratio but it is very unlikely that a particular mechanical element or component will be able to supply this particular ratio for a long time and it is also not needed that engine needs stoichiometric air fuel ratio always.

Instead, there must be a specific range for which engine would be able to run efficiently following the proper combustion and that particular specific range is known as combustible range. So combustible range is a range of fuel air ratio or air fuel ratio for which engine should run following efficient combustion. So we need to specify what is the combustible range for this particular fuel.

And if carburetor is providing fuel air ratio which is beyond this particular ratio then combustion will not occur so that means whenever a carburetor it is designed it is design keeping in mind that it would be able to supply stochiometric fuel ratio but it is a mechanical element so it is very unlikely that this particular element would be able to provide chemically correct airflow ratio for a long longer period of time.

We need to specify a range of the air fuel ratio or fuel air ratio for which combustion will occur efficiently and engine should run. If the air fuel ratio is above or below that particular range which is being supplied by the carburetor then no combustion will occur. So carburetor would be able to supply fuel ratio within this particular range instead of supplying fuel air ratio at a stoichiometric condition always though it is designed to supply stoichiometric air fuel ratio.

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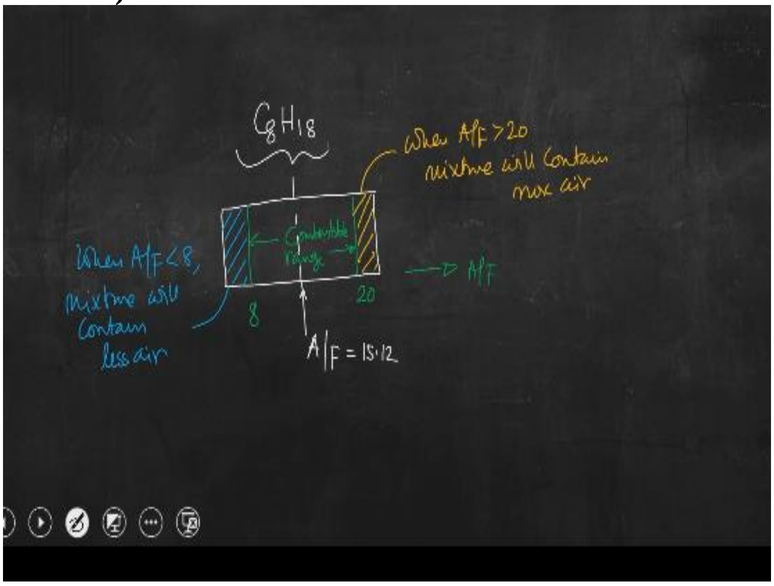

So for this particular fuel C_8H_{18}, if we try to draw this is air fuel ratio 15.12. Now we need to specify the range say this is 8 and this is 20. So when air fuel ratio for this particular fuel is measured from experimental investigations, that combustible range of this particular fuel is 8-20. When the air fuel ratio is 8 though it is not stoichiometric but engine should run, when the air fuel ratio is even above 15.12 more amount of air is present in the mixture, when it is less then less amount of air is present in the mixture, but so long as the ratio is maintained within this range then combustion will occur efficiently and engine will run and this is the combustible range. If it is above 20 then we can see that the mixture will contain more air while when air fuel ratio is less than 8, mixture will contain less air so you can see that means the carburetor will not supply air fuel mixture which is above 20, below 8. If this is the case then no combustion will occur if the mixture contains more air then combustion will not sustain, because the flame that will produce, the temperature that will produce will be taken by the excess air present in the mixture so flame will not sustain.

If the mixture contain less air that means it is having rich in fill less air that is if it is less than 8 then that means the amount of air needed for that particular fuel is not there. So it is rich in fuel so what will happen that the flame that will produce will be absorbed by the excess amount of fuel present in the mixture and hence combustion will not sustain. So in both these two cases combustion will not sustain and it is not desirable one.

So for any particular fuel we need to specify the combustible range and carburetor would be able to supply fuel air ratio or air fuel ratio within this range though it is designed to supply always stoichiometric air fuel ratio. In fact engines do not require to get a stoichiometric air fuel ratio always and that is why this combustible range is identified. So, to summarize today's discussion we have discussed about the classification of engine based on the cylinder arrangement.

Then we have discussed about the carburetor why this particular element is needed for the operation of SI engine then we have discussed about the functioning of this particular element and taking an example we could obtain the stoichiometric air fuel ratio which is very important for the efficient operation of the SI engines. So, with this I stop here today and we shall continue our discussion the next class. Thank you.