Fundamentals of Automotive Systems
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Module No # 04
Lecture No # 20
Combustion in CI Engines and Carburetion - Part 02

Having looked at the combustion process in both SI and CI engines the next important topic which we are going to discuss is that of how do we first of all determine what is the correct proportion of fuel and air that needs to be introduced into the engine. And second how do we realize the introduction of this fuel air mixture into the engine right depending on the operating condition of the same ok.

So we are going to discuss topic which is called as mixture preparation. Let us consider SI engines. So let us look at mixture preparation in SI engines. So and what are the different factors that affect the same and also like how the mixture is introduced right. So we will look at those concepts. So in general the term carburetion is used to refer to this process of preparing the appropriate fuel air mixture ok in an engine.

So what is carburetion? It is nothing but the process of forming a combustible fuel air mixture by mixing the proper amount of fuel with air before admission of the same right of the mixture into the combustion chamber. So that is what is called as a process of carburetion ok. And a device used for achieving this carburetion in general is what is called as a carburetor ok. But we will see that there are many devices now which are used to prepare this mixture ok.

But in general ok this is general term a carburetor is a device used for carburation ok so carburetion is a process ok. So now let us look at what are all the factors that affect carburetion and discuss them. So the first factor which we would consider is engine speed ok. So let us say we have a 4 stroke engine. So I think if I remember correctly we have done this calculation before let us say that the engine is rotating at 1500 rpm this calculation is similar calculation right.

What is the time available for the suction stroke if the engine is rotating in at1500 rpm its 1500 rpm that means that how many revolutions per second divided by 60 it will give me 25 revolutions per second. So 25 revolutions per second means one revolution will be how many milli seconds? 1 by 25 which is will be 40 milli seconds. So in a 4 stroke engine one revolution would in that is one cycle convert completed in two revolution of the crankshaft right. So that means that we would have around 20 milli seconds for each stroke including the suction stroke on an average ok. So on an average we are going to have 20 milli seconds ok.

Now the same engine speed is increased to 3000 rpm let say we double it. So what should happen this time? On an average we are going to have 10 milli seconds for each stroke. So consequently what is that we can observe. If I increase the engine speed the time available for the carburetion process decreases right. So the time available for introducing the fuel air mixture decreases. So any system that essentially does this operation should factor this one right.

So this is an important factor to consider. So we can immediately observe that higher the engine speed lower is the time available for charge induction ok. So as we recall the term charge is also used in this context to denote a fuel air mixture right so that is what it is ok. So that is important ok so that is one factor that is important in engine speed. So the next factor which is also important are the vaporization characteristic of the fuel.

So please note that if I want to prepare a combustible and homogeneous fuel air mixture in a spark ignition engine machine already we have discussed that there are two attribute which are important for any combustion process right. So that is involving in this fuel and air right in engines. Please recall again for combustion we need hydrocarbon that is fuel we need oxygen in the correct proportion and we need a mechanism for initiating the combustion.

But when I introduce the fuel and mix it with air as we have already discussed the fuel should first atomized that means that we should break larger droplet of fuel into finer particles and then those particle should vaporize and mix with that ok. Then only we will get a nice homogenous mixture of fuel and air in the combustion chamber correct. So the vaporization characteristic of the fuel become very important ok.

When we look at the process of carburetion ok. So in that regard the temperature of the incoming air also becomes important right so in general right why? Because higher the temperature better is the or quicker is the vaporization process right because if I want to go from the liquid form to the vapor form I need to provide the fuel with the corresponding latent heat right corresponding to the fuel latent heat of vaporization right to go to the go from the liquid form to the vapor state correct.

So if I increase the temperature of incoming air is better is going to be vaporization process. But what is one what to say limitation with this. as we have already discussed if we increase the temperature of incoming air the in SI engines the chances of knocking may also increase the tendency for knocking also may increase. And also the volumetric efficiency would also decrease right as we have already discussed you know like if we increase the temperature of the incoming air even slightly the density of the incoming air would decrease.

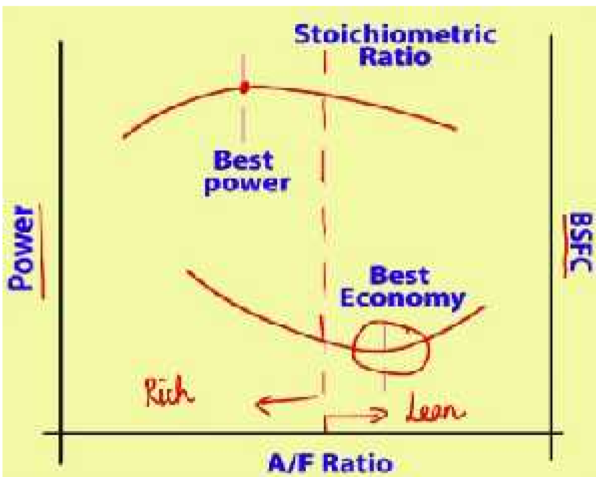
Then for the same volume I am going to take a lesser amount of charge right in the combustion chamber right. So that is going to decrease the volumetric ratio. So if we look at the temperature of the incoming air increasing it would lead to better or improved vaporization and mixing. However in addition to that is even if we ensure that knocking is avoided with a small increase in temperature ok the volumetric efficiency would be affected ok.

So we have to balance all these factor ok. So when we look at this one is a of course the design of the device itself you know like place a big role as we will see ok. So depending on various philosophies and methods the actual instrument or the device itself is designed carefully ok. So that that is something we will look at like as we go along ok. Now the question becomes ok so these are the factors affecting carburetion so depending on the operating condition of the engine and the position of the throttle what is the composition of the mixture that we want?

See because we have already seen that there is something called as the chemically correct mixture or the stoichiometric fuel air mixture. And there is a rich mixture that has more fuel than the chemically correct mixture and a lean mixture which has less fuel than the chemically correct mixture. So depending on the operating condition of the vehicle see what do you mean by operating condition of the vehicle?

If I am starting from rest and accelerating what is the type of the mixture which I would require? Ok. If I am cruising at high speeds let us say on a highway right. What is the type of mixture I want to have? Suppose while cruising I want to overtake another vehicle. So then what is the type of mixture that I would once again require right. So those are the important questions to ask ok. So that is where even like the type of mixture requirement is also come in right.

So what do we expect the mixture to be right? Qualitative right for various operating conditions. So if I if you want to look at it in a qualitative manner right. So what is it that we want so if we look at the air fuel mixture itself ok.



Air-Fuel Ratio

For higher power output → rich mixture

For best fuel economy → lean mixture

Air-Fuel Ratio comparison with power and BSFC

So considering air fuel mixture and the air fuel ratio we can immediately see that in this diagram is once again a qualitative diagram ok. So this a plot of the air fuel ratio ok is given against the power output from the engine and the BSFC. Please recall the BSFC stands for Brake Specific Fuel Consumption. Of course, ideally I would want the BSFC to be as small as possible right that would lead to better fuel economy obviously right.

So if we look at the stoichiometric mixture this vertical line indicates the chemically correct air fuel ratio. So we already know that to the left of this we have a rich mixture to the right of this we have lean mixture because we are plotting air fuel ratio right. Air fuel ratio lower than the stoichiometric ratio implies a rich fuel air mixture and vice versa right for a lean mixture. So if I want to get the best power you know like we would typically require a rich mixture right because I would want to get more energy output from the engine right.

So I would want to burn more fuel right and essentially get more energy output ok from the engine. So typically for high power output we would want a rich mixture. See for example when would I want to have a high power output in the scenario that we just discussed. Suppose let us say I am cruising on a highway right and I want to overtake of the vehicle so what is the that we typically do?

We are already in the highest gear, what we will do is that we will press the accelerator pedal or throttle pedal little bit more and then we expect the corresponding energy to be given to the car to overtake the vehicle in front of us right in the another lane right. So essentially, we would do that. Then in order to get the process done you know I should introduce the rich mixture in the what to say cylinder ok.

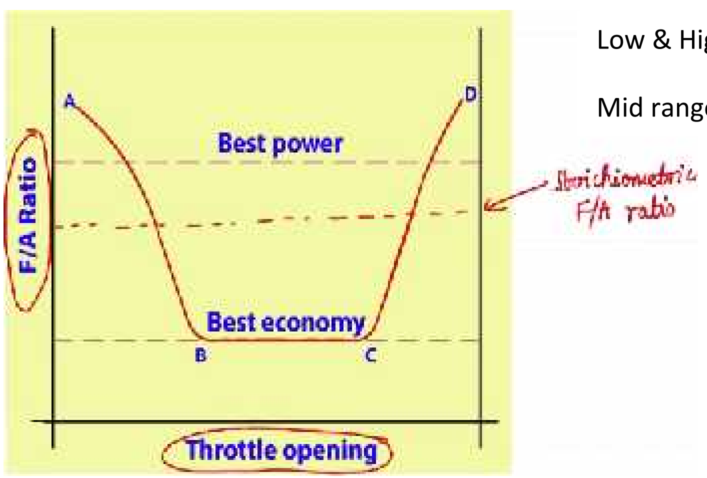
So this is one scenario ok it also see where the rich mixture is required under other operating conditions. So for best fuel economy ok or mileage ok a lean mixture is obviously preferred right. So and that is what happens when we are cruising ok. So typically when we reach to what are called in a cruising speed in a typical car right or a typical vehicle and we are essentially going on a constant speed on a highway you know like we would typically want to operate around this region ok where our BSFC is low ok.

And when we come to transmission we would also relate all these points to the overall vehicle requirements also ok. We will discuss what are the traction forces requirement of a typical automobile road vehicle and we will correlate all these operating condition to the gear box and the vehicle traction requirements ok. We complete the process or complete the discussion when we discuss transmission also. So I have come back you know when we do the discussion of transmission ok.

So we can see that a carburetor also needs to factor this one in right because it needs to vary the air fuel ratio such that depending on the requirement of the vehicle the air fuel ratio needs to be varied in a range ok. So a carburetor must be able to meet varying air to fuel ratio requirements ok depending on operating condition of the vehicle ok and the engine ok. So one needs to see that you know like one can immediately realize that we need the device you know to have this capability ok to vary the air fuel ratio ok depending on the requirements.

And typically how does the driver convey these requirements you know suppose let us imagine that we are driving a car right or a 2 wheeler you know what ever vehicle we want to consider right. How would we convey the requirements to the engine by pressing the throttle pedal right in a car or in a two wheeler in a motor cycle we essential rotate the throttle right which is hand actuated right.

So essentially we are displacing the throttle pedal right in a typical car let say ok. So that displacement of the throttle pedal results in its displacement opening of what is called as a throttle valve ok. We will look at it in the next class ok. So but the important thing is the following so depending on where the throttle position is one needs a varying what to say mixture ok. So what do we mean by that right.



Low & High Throttle opening ⟶ Rich mixture

Mid range Throttle opening ⟶ Lean mixture

A/f ratio requirements depending on the operating conditions

So let us look at this curve, so in this curve you see that we have throttle opening on abscissa right and fuel air ratio not the air fuel ratio ok it is just the reverse of it inverse of air fuel ratio it is fuel air ratio ok. So higher fuel air ratio than stoichiometric means it is rich a mixture right please remember that. So fuel air ratio in the ordinate or the vertical axis. So now we can immediately observe that the throttle opening goes from that is nearly zero that is if we do not press the accelerator pedal you have very small throttle opening to flooring the accelerator pedal.

So we can see that the mapping of the fuel air ratio versus the throttle opening in general in a qualitative sense follow this profile ok which is given by ABCD ok. So at low throttle openings we can immediately see that low throttle opening and low and high throttle opening we can immediately see that we would require a rich mixture right. I am sure all of us can observe that ok. So let us say stoichiometric mixture is somewhere here ok. So that is the stoichiometric ratio okay.

On the other hand, when we go for mid-range throttle opening typically we prefer a lean mixture. The question is why right why would one want to have a rich mixture at low and high throttle openings and typically a lean mixture in the mid-range throttle opening ok. So we would discuss this in the next class along with what we expect from the vehicle when we press the throttle. As where we control the opening of this throttle valve ok. So let us continue with the discussion in the next class.