IC Engines and Gas Turbines
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Lecture – 24
SI engine injection system, Energy distribution, Engine temperatures, Heat transfer in combustion chambers

We will continue our discussion on IC Engine. Today we will discuss about SI engine injection system. And then we will discuss about the you know Heat transfer in combustion chamber and of course, the energy distribution inside the cylinder.

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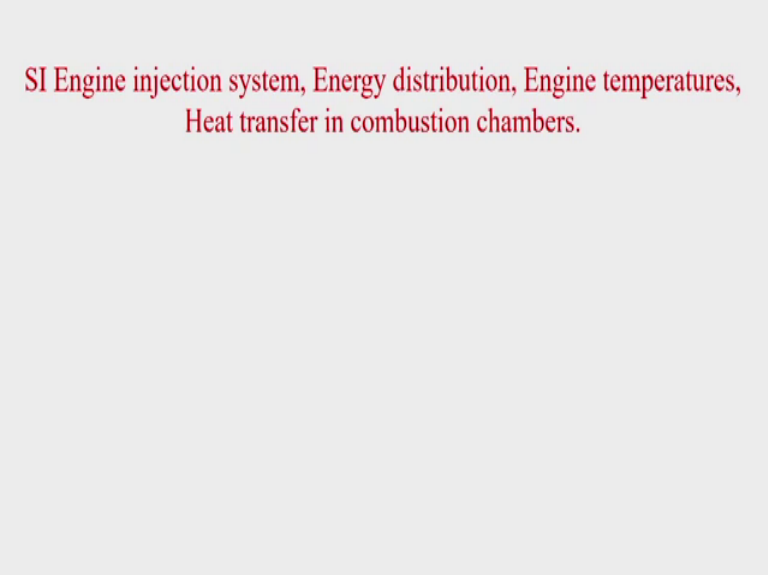

So, before I go to discuss about the heat transfer in combustion chamber and in particular heat transfer in the engines, we will briefly discuss about the SI engine fuel injection system. If you try to recall that we have discussed in spark ignition engine, we have special device which is carbureted which is essentially used to I mean supply of stoichiometric air fuel ratio. That is chemically correct air fuel ratio, to have a efficient combustion rather to have a better fuel economy.

Now, carbureted is used to supply homogeneous mixture of air fuel into the cylinder and you also have 1 external agent like spark plug which is used to initiate combustion inside the cylinder. Now question is if we use carbureted, we have discussed that that we have discussed a simple float type carburetor. And then we have discussed about the limitation

of a simple float type carburetor. And we also have discussed about the you know the criterion rather criteria or you know what will be the objective of having modern carburetor rather while we are designing modern carburetor what will be your objectives.

So, today we will discuss about the you know SI engine injection system. We have the seen that in a CI engine the rather in a compression ignition engine, we do not have carburetor. And what is done air is taken through intake manifold a during intake stroke then at the end of the compression a when the temperature and pressure of the air is sufficiently high to initiate combustion without helping of any external agent like spark plug. That means, when a fuel is injected or fuel is spread into the cylinder at the end of the compression stroke, the high pressure temperature of the air itself allows the fuel to ignite. And for that we have a fuel injection system. Essentially that is that consist of you know fuel pump and fuel nozzle.

So, now we will see that if we use when we need to use fuel injection system in SI engine. And what are the you know what are the disadvantages you know if you have a fuel supply through a carbureted system and if we use fuel injection system, can we really remove those problems which are there with the decorate system. So, now, briefly I will discuss about SI Engine Injection system.

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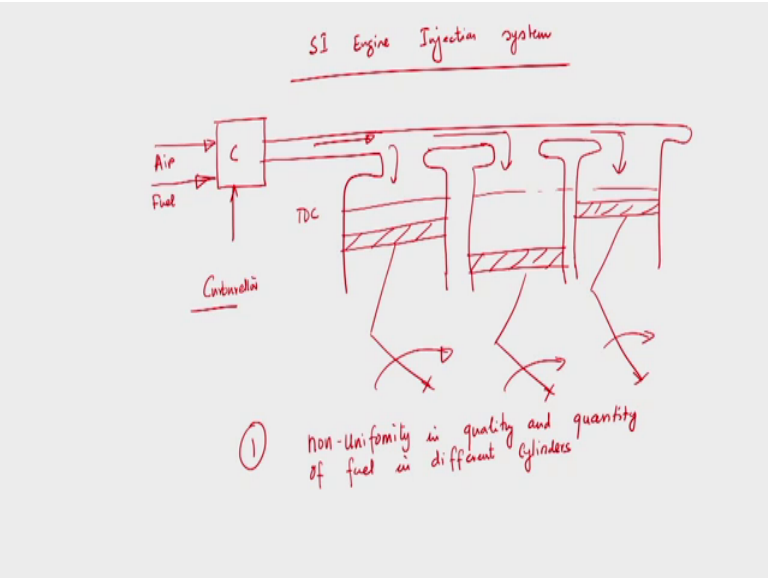

So, if you try to recall that we have divided three zones of engine operation idling zone crushing zone and powered zone. Most of the time engines are operated at crushing zone

of course, idling zone is required because when there is no load we are not expecting any load from the engine, still engine is running; that means, during start you know start up condition now an powered zone of course, it is required because when you are having you know we are we need higher high powered.

Either you know for we are when we are writing half feels and we are pulling some you know heavy weight from that using that engine. Then we required to run engine you know powered zone mode. So, if you try to recall that if we have a carbureted system. So, if I draw schematic, so this is a carburetor. So, we have air which is supply into the carbureted, then also we have one another line through which fuel is supplied to the carbureted. Then this air fuel mixture is taken if it is a multi cylinder engine; if it is a multi cylinder engine.

So, this is a multi cylinder engine, so this is top dead centre location. And maybe piston is because you have seen that you need to reduce to the energy; that means, when there is a there is power stroke in a 1 cylinder, you have 3 either intake or compression 3 idle strokes in different or the cylinder essentially to have a the distribution of energy otherwise there will be a very Jackie operation.

Now, when air fuel mixture is supplied; so air fuel mixture is supplied, so what are this is this is carbureted. So, this is carbureted. So, when you supply air fuel mixture in a multi cylinder engine using a carburetor, we cannot ensure that there will be a uniform distribution. There will be uniform distribution of air fuel mixture in all these three cylinder.

So, 1 problem is non uniformity, non uniformity in quality both in uniformity both in quality and quantities rather in quality and quantity of fuel in different cylinder. So, not only the quality, but also quantity is important. So, using a carburetor if we need to supply air fuel mixture in multi cylinder engines in multi cylinder engine, we cannot ensure to have a uniform supply of air fuel mixture in all the cylinders.

Rather non uniformity in quantity as well as quantity of fuel will be there as a result of which it is not possible to it is not possible to have a you know higher efficiency from that engine. Another example, so this is one of the problem, we cannot ensure because of the inertial effect.

So, air will try to move into the furthest cylinder may not get the sufficient fuel while the because of the liquid whenever you are supplying air fuel mixture of course, it is true that in SI engine we are supplying air fuel mixture almost in a gaseous state. So, because of these you know inertial effect it will the tendency will be to go the furthest cylinder rather into the first cylinder.

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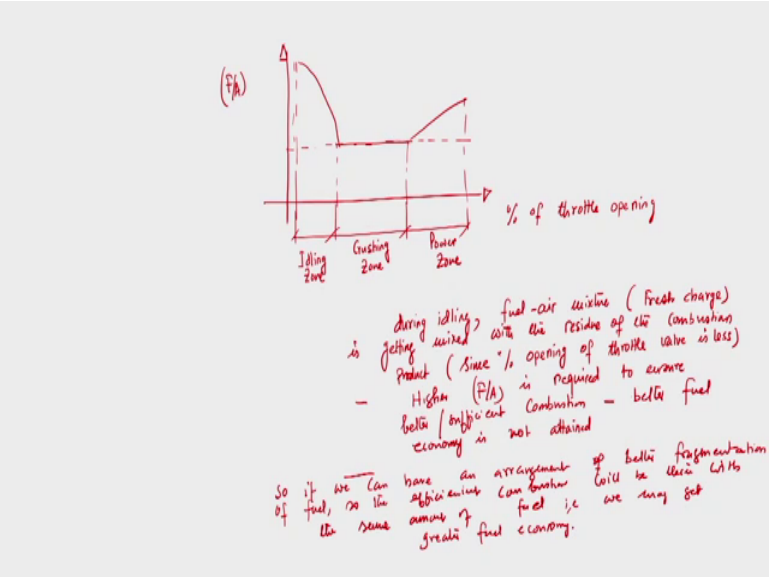

And this is one problem. Another problem is if you try to recall our you know fuel air ratio versus first you know if you try to recall that, 3 different zones of engine operation that is if I have fuel air ratio and this is percentage of throttle opening, then most of the time although engine is running you know in crushing zone, but still we have. So, this is idling zone, this is crushing zone, this is powered zone.

So, idling zone; that means, is we have started engine, but we are not extracting load from the engine. So, we need to supply higher fuel air ratio that is what we have discussed while we have discussed about the you know engine operating zones; and we have discuss the reason behind it. Now question is in these zone percentage opening of the throttle value is very less as a result of which what might happen is that, there will be a huge pressure drop across the throttle valve and combustion. Whenever we open the intake manifold during intake stoke essentially to take the fresh air fuel mixture or fresh charge into the cylinder.

Then a portion of the combustion product will rush towards that throttle valve location. As a result of which the fresh charge will be mixed with the residue of the combustion product. And as a result of which we require more amount of fuel and that is why fuel air ratio will be higher to have a you know better contact with the air fuel mixture, and for efficient combustion.

So, that means in the idling zone if we do not provide higher amount of fuel, it is really not possible to have a we cannot ensured that the all the fuel air mixture will get enough time for a close contact. Rather a fresh charge will be mixed with the residue of the combustion product. And to ensure the combustion otherwise engine will stop engine would not start. Sometimes we use, that when cold start cold start up during winter season when you need to run engine we sometimes we use a terminology that please choke open the choke.

That means, what we need to do? We need to provide the gap rather we need to open the you know percentage throttling. So, that sufficient amount of fuel air mixture will be there essentially to have a better combustion; so that we can start our engine; now we can start the engine rather whatever it is. Either it is 2 wheeler 4 wheelers whatever it is

Now to have a better fuel it is not a fuel economy; that means, then idling zone when you when into supply air fuel air ratio, essentially to ensure the efficient combustion because of the you know high mixing of the fresh charge with the combustion product we are supplying higher amount of fuel. So, it is not a fuel economy. That means, if you use a carbureted system we cannot have a fuel economy during idling zone. Rather if you can think of having and alternative arrangement.

So, that we can get read out of this problem and we may assure better fuel economy. So, 1 problem is that you know during idling fuel air mixture, rather fresh charge during idling fuel air mixture of the fresh charge is getting mixed with the residue of the combustion product.

This is since percentage opening of throttle valve is less during idling fuel air mixture is getting mixed with the residue of combustion products and percentage opening of throttle valve is less. So, the and that is why higher fuel air ratio is required to ensure better or sufficient combustion. And so we and better fuel economy is not rather is not attained.

So during idling, fuel air mixture is getting mixed with the residue of combustion products. So, we have we cannot ensure to have a better fuel economy. Not only that, rather this is important condition. And so if we can have an arrangement of better fragmentation of the fuel, so the so the efficient combustion can be ensured efficient combustion will be their with the same amount of fuel amount of fuel.

So; that means, instead of supplying fuel through carbureted, if we have an alternative arrangement; so that we can fragment fuel into a finer smaller and smaller number of droplet. So, that we can have efficient combustion we using the same amount of fuel that is we may get greater fuel economy right.

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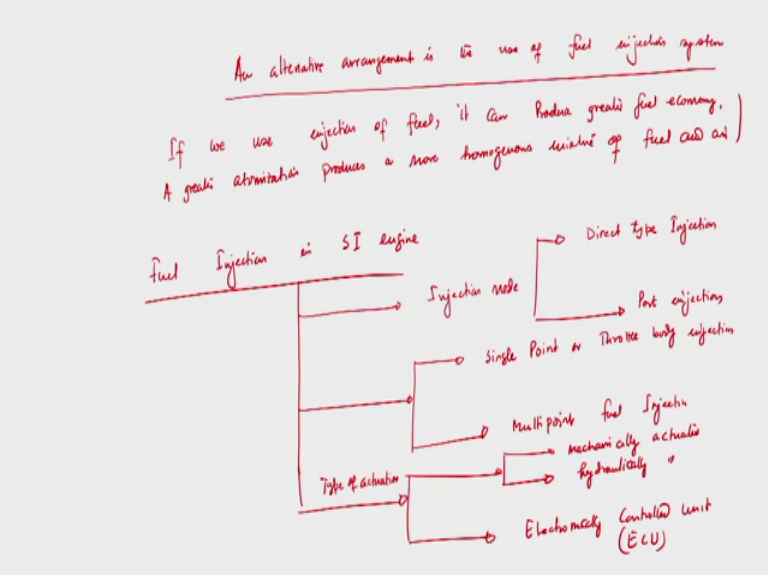

And to an alternative arrangement an alternative arrangement, is the use of fuel injection system. So, alternative arrangement is the use of fuel injection system. And that means, if we use you know injection of fuel injection of fuel it can produce greater fuel economy. Greater atomization greater atomization produces more homogeneous mixture of fuel and air. It is very important.

So that means, if we instead of carburetion system carbureted system; if you use fuel injection system, we can produce better fragmentation. And more homogeneous mixture of fuel and air and we can have rather we can attain greater fuel economy; so this fuel injection system in SI engine, so this fuel injection in SI engine.

There are you know two types this can be classified into different category. First one is injection mode, injection mode it can be again two types. One is direct type, another one is port injection rather direct type injection another is port injection right. Otherwise we may have single point or throttle body injection or multiple point fuel injection. We may have single point, or throttle body injection or we may have multipoint fuel injection or finally, depending upon the type of actuation depending upon the type of actuation.

We can classified either it is mechanically actuated or it may be hydraulically actuated. Or it may be electronically controlled unit you known as E C U. These are the different categories of fuel injection system in SI engine. It may be direct type direct injection or port injection it is either it is a single point and throttle body injection or multiple fuel injection.

Or depending upon the type of actuation we can classify it either mechanically actuated or hydraulically actuated or we can have a electrical control unit for injection system. Direct type is direct injection; that means, we have engine and we have direct injection of fuel. So, fuel is injected direct type maybe we are taking air.

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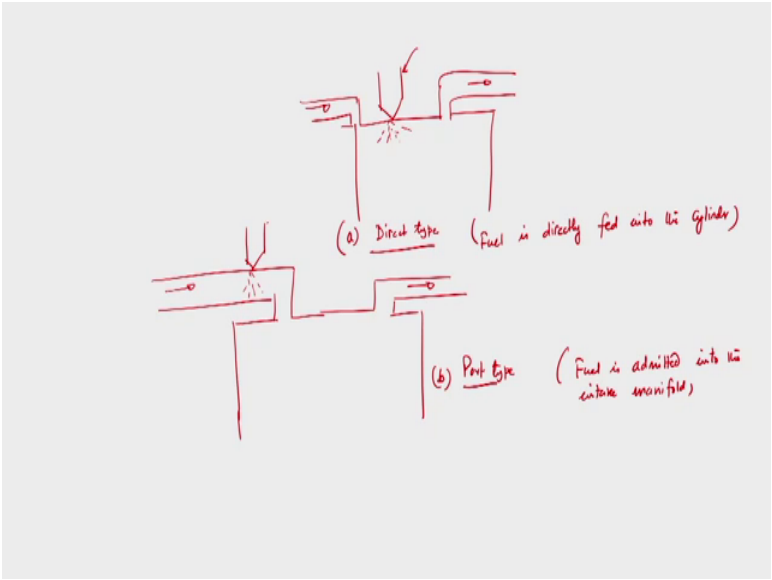

So, this is direct type. So, this is exhaust manifold this is intake manifold this is fuel injector of fuel nozzle through which fuel is injected. So, direct type fuel is directly fed into the cylinder fuel is directly fed into the cylinder right. Or if it is port injection fuel is admitted into the intake manifold.

Now they are might be a case that we a cylinder. So, we can supply fuel. So, this is port type where fuel is admitted into the intake manifold into the intake manifold. So, instead of directly feeding the fuel into the cylinder we supply fuel into the intake manifold. So, this is exhaust this is intact and this is port type b this is a direct type now. So, this is the direct type or port type very important.

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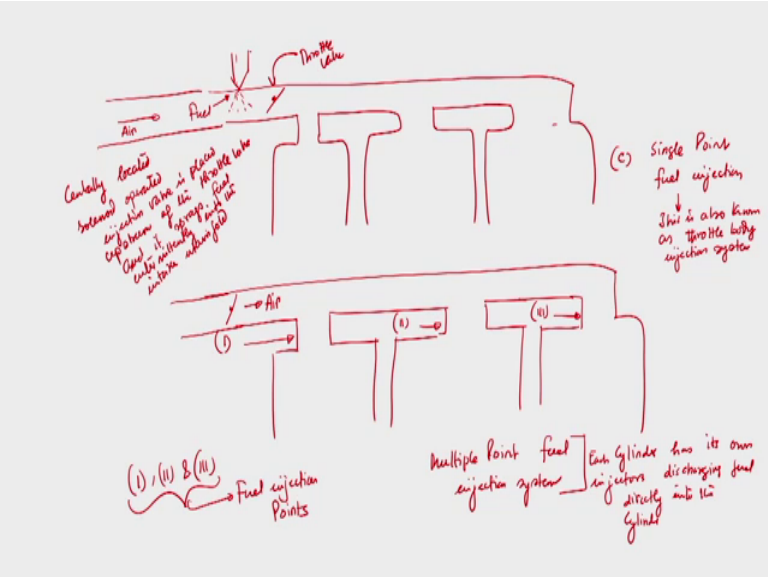

Now, we will see the single point fuel injection system as I said that, if we have a multi if we have a multi cylinder engine. So, we can supply fuel over here; so this is fuel, and air is going over here, this is fuel this is air. So, this is c single point fuel injection. This is single point fuel injection.

Or we may have multiple point fuel injection, see whatever you have discussed direct type, port type, single point and I will discuss about multiple point multiple point fuel injection. So that means, we again have, so we have these are the so 1 2 3; this 1 2 and these 3. They are the deep fuel injection point these are. So, these are we have a throttle valve and this is air at the fuel injection points.

So, 1 2 3 are the fuel injection point. Where we can supply fuel this is known as multiple point fuel injection system. So, this is multiple point fuel injection system. And this is multiple point fuel injection system right. That means, we can supply fuel at multiple point instead of supplying in 1 points and this is multiple point.

So, we have discussed about direct type port types single point and multiple point in all these cases. It may be the supply of fuel, it may be a mechanical type or we may supply through injection you know multiple point fuel injection you know. The type of system is cylinder has in this in this type. Cylinder each cylinder has its own injectors. Injectors discharging fuel directly into the discharging fuel directly into the cylinder right.

Single point single point this is this is also known as throttle body injection system throttle body injection system in this case a centrally located solenoid operated injection valve is placed upstream the throttle valve. So, for this case very important that centrally located centrally located you know solenoid operated; solenoid operated injection valve is placed upstream of the throttle valve. So, this is throttle valve.

So, this is throttle valve upstream of the throttle valve throttle valve and its spray fuel intermittently into the manifold and it sprays fuel intermittently into the intake manifold. That means a single point fuel injection system or throttle body fuel injection system where we have one centrally located solenoid operated valve which is placed upstream of the throttle valve and which sprays fuel into the manifold intermittently.

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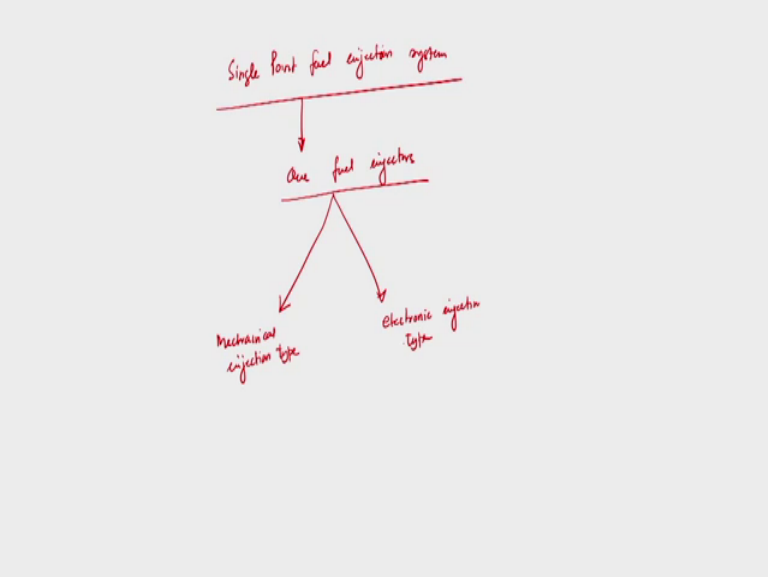

Now the single point fuel injection system the single point fuel injection system, where we have 1 valve that is we have seen 1 valve. 1 injection .1 fuel injectors which is placed upstream of throttle valve in the intake manifold. Now this operation of this fuel injector

can be further sub classified that is what we have seen either it is mechanical injection type mechanical injection type or it is electronic injection type right.

So, we have discussed about direct type port type direct type; we are supplying fuel directly into the cylinder port type fuel is admitted into the intake manifold. Single point where we have only one injector which is placed upstream of the throttle valve in and which supplies or which sprays fuel intermittently into the intake manifold. Now and this single point injection system you know only 1 fuel injectors which can be operated either mechanically or you know electronic injection system.

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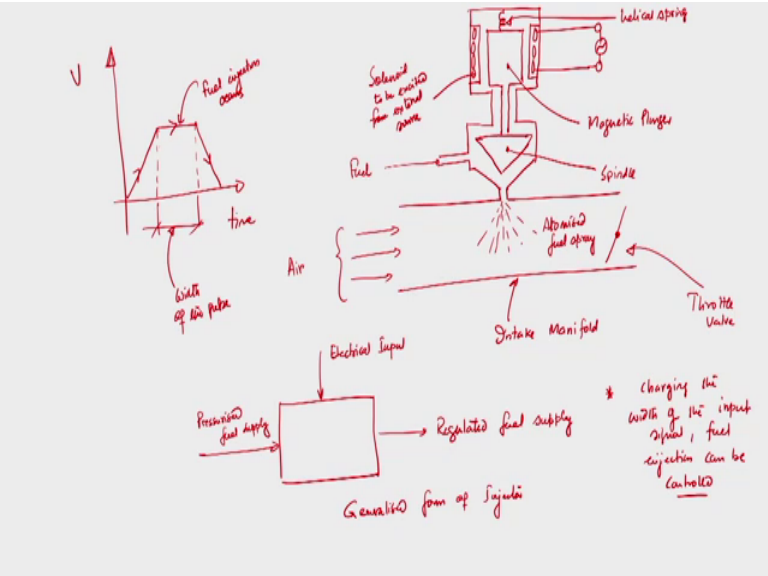

Now, multiple fuel injection; so here we have seen that each cylinder has it own injector discharging fuel into the cylinder. Now we will discuss about very important that what is you know mechanical. So, if I now draw; suppose we have we are supplying fuel into the intake manifold. So, this is intake manifold air is coming. So, this is air, this is intake manifold right. And we have a throttle valve so this is throttle valve.

So, purpose is to supply fuel to ensure greater fuel economy only through better atomization or better fragmentation of the fuel droplet fuel particles. So, now we have we have 1. So, this is basically this solenoid is we have. So, here we have atomized fuel spray; we are having fuel through this manifolds this is fuel supply right.

This is spindle and this is magnetic plunger, magnetic plunger this is helical spring helical spring and these are solenoid this is solenoid to be excited from external source. So, this is solenoid to be excited from external source, we have an external electrical supply Now, if we plot this you know time versus this you know voltage.

So, weight of the pulse now increases these valve opens, then valve close then it comes. So, this is this and this is width of the pulse the fuel injection occurs. So, here fuel injection occurs width of the pulse here the solenoid is magnetized in such a way so, that interaction so that, interaction of the field that means, if we draw the block diagram. Now if I draw the block diagram so, we have 1 we are getting regulated fuel supply, electrical input and pressurized fuel supply. So, this is generalized form of injector. We have a solenoid which is to be excited form external source.

So, by providing a voltage we can excite the solenoid, which will essentially try to have you know linear motion of these you know magnetic plunger which in turn, we will try to open the you know gap by lifting the spindle from the from its initial position. That means, if we excite solenoid by an external source which can be control by changing the signal.

So, now that is by changing width of the pulse we can change the excitation of the solenoid which in turn we will try to move the magnetic plunger; rather which will try to have a because of which that will be a moment of the magnetic plunger. And during the moment of the magnetic plunger since it is connected with helical spring at the top, the spindle will have a uplift. Now, depending upon the you know excitation rate or width of the pulse we can control the opening rather we can control the moment of the spindle.

So, that we can control the opening area through which pressure will be pressurize fuel will be supplied. So that means, what we can do now changing the width of the input signal fuel injection can we control. That means, very important that is changing the width of the input signal fuel injection can be control right.

So, this is what is you know mechanically injection system. That means, through an external input electrical inputs we can excite the solenoid which in turn we will try to have which in turn we will try to create the; you know that is the magnetic plunger. When magnetic plunger is having moment rather you know displacement a spindle will

have a uplift and we can control the opening area through which pressurized fuel will be supplied into the intake manifold.

Now, what you can do by changing the width of the input signal, we can control the excitation rate which in turn will try to you know alter or control the opening area; and we can control the injection rate. So, this is what is the, you know mechanically operated fuel injection system. Now we have another injection system that is known as electronically control unit.

That means mechanically control unit it is it because we do not know a priory because as I said you depending upon the pressure temperature inside the you know cylinder. We need to supply the required amount of fuel air ratio essentially to have a greater fuel economy at the same time Asia combustion. But we have an external a mechanical injection time fine we can control the fuel you know opening area through the excitation rate.

And essentially by altering the width of the pulse; but we do not know when we need to supply. So, if you would like to have a automatic system depending upon the rather sensing the pressure temperature in other condition of the engine; if you would like to if you would like to supply the required amount of fuel air ratio. Rather required amount of fuel as well as the air into the cylinder.

As I said to have a greater fuel economy and to have a efficient combustion we should have a electronically control unit issue. And we will discuss that how an electronically control unit supplies the required amount of air fuel ratio or required amount of air fuel mixture into the cylinder depending upon the at depending upon the condition of the engine.

I mean may be high load condition no load condition or the intermediate load condition; and we how we can control that we will discuss that issue in my next lecture. And I with this I stop here today, and I will continue in the that aspect in my next lecture ok.

Thank you.