Fundamentals of Automotive Systems
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Lecture-06
Operation of 4 Stroke Engines
Part 02

So moving on.

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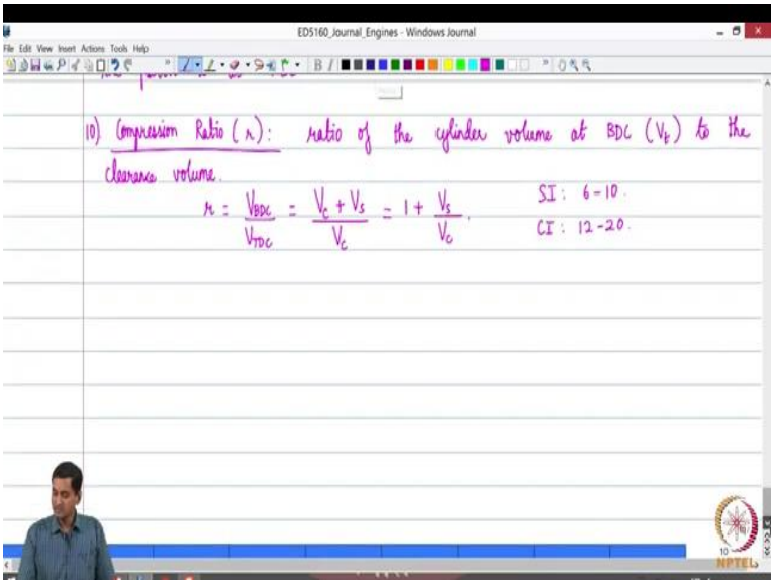

So let us now look at, let us now go back to the 4 stroke petrol engine and then like look at the strokes themselves right. So we are looking discussing the operation of this SI engine and we looked at this diagram.

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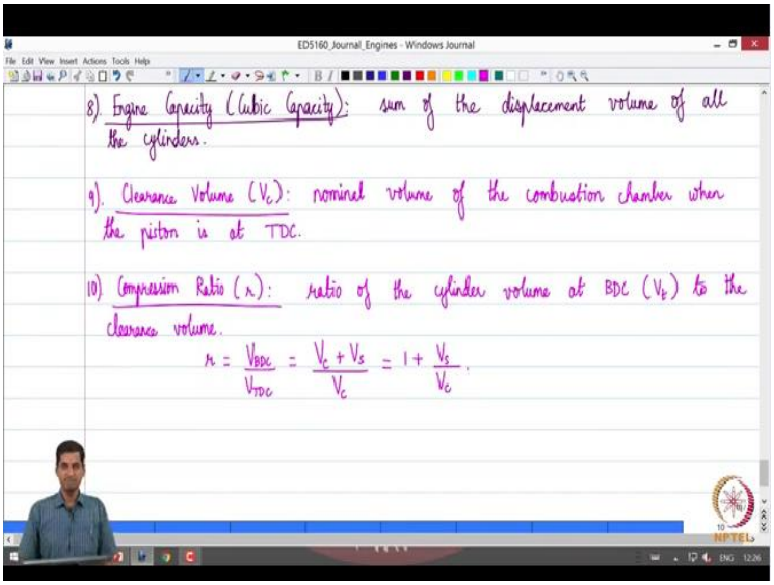

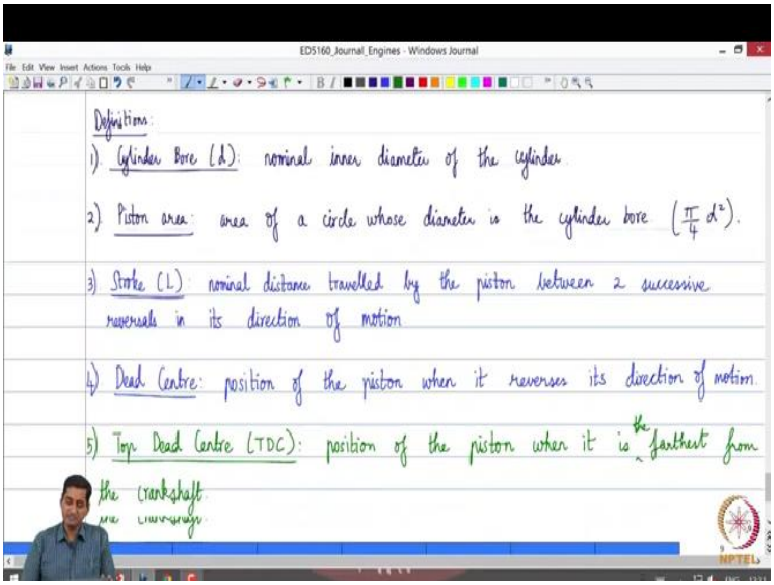

Now let us look at the 4 strokes of a 4 stroke spark ignition engine.

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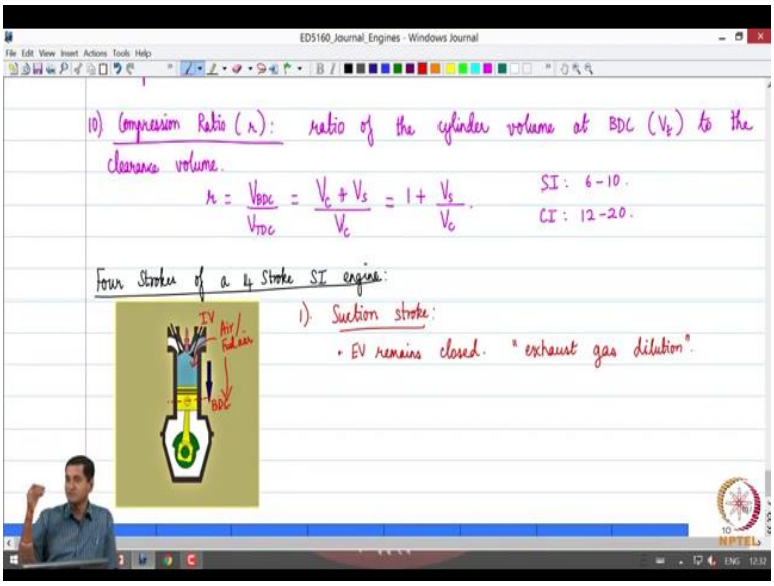

So let us see what happens in each of the 4 strokes.

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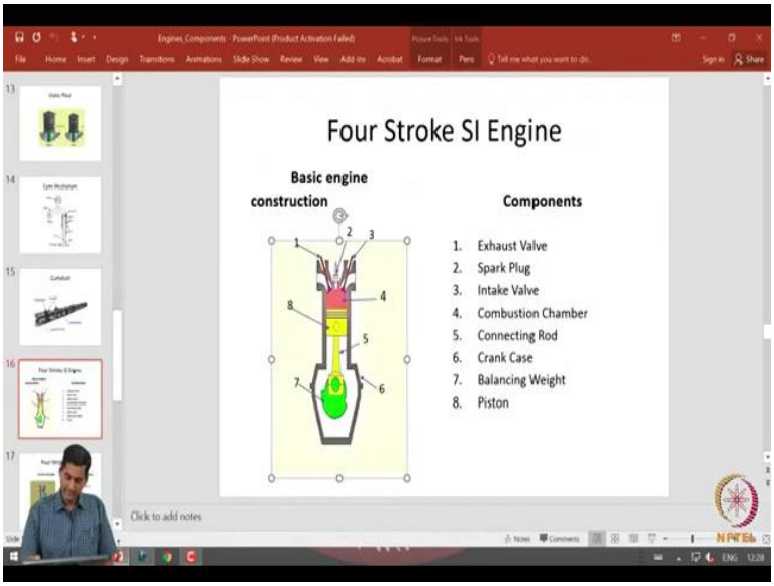

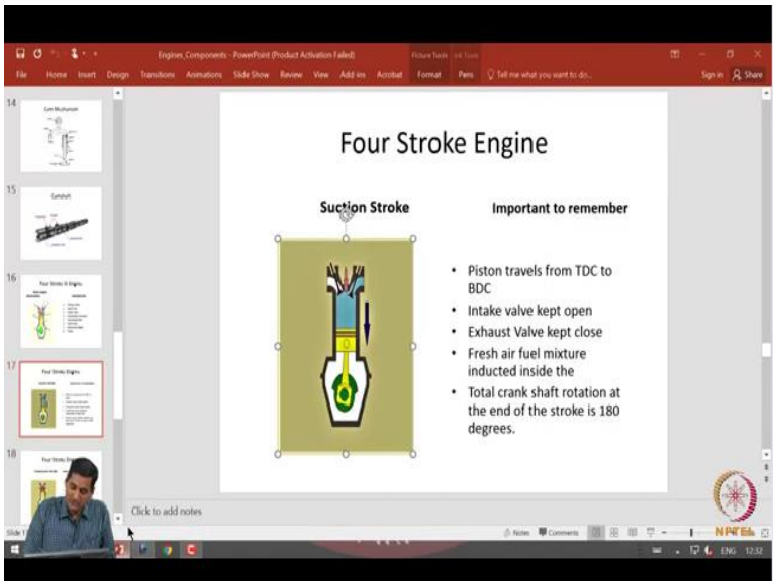

So first, let me take the suction stroke. So what happens in a petrol engine is there when the engine starts one operating cycle as a first stroke the piston starts to move down okay as we can see in this finger. So during the suction stroke the piston starts to move down okay, the piston is going from the top dead center towards the bottom dead center.

And inlet valve is opened okay. So, what happens is then either air or fuel air mixture is taken into the combustion chamber due to pressure difference during the suction stroke, we are going to see what are the different mechanisms of introducing this fuel air mixture okay in typical petrol engines, when we go to what is called mixture preparation. So either air or fuel our mixture is taken into the combustion chamber during the suction stroke they exhaust all domains closed right.

Because we do not want what is called as exhaust gas dilution right. So, the camshaft becomes very critical here it has to operate in such a way that during the intake stroke it opens only the in intake or inlet valve but it closes the exhaust valve why. Because if the exhaust valve back open the exhaust gases right which are present in the exhaust manifold may come into the combustion chamber due to the pressure difference.

The pressures in the exhaust manifold is going to be higher right and in the combustion chamber is going to be lower during the suction stroke because volume is expanding right during the

suction stroke. So, we do not want the exhaust gases from the previous cycle to come into the combustion chamber and that is why we want the exhaust valve to remain closed during the intake okay. So that becomes very critical.

So, what is exhaust gas dilution it is the process by which exhaust gases mixed with fresh charge okay fuel air mixture is called as a charge right and diluted because obviously as you can see you know you mix exhaust gases the combustion process is going to be affected right is a non okay. So the effectiveness of the combustion process will go down. So during the suction stroke, the piston moves towards the BDC.

And when the piston reaches towards closer to the BDC right the inlet valve is closed okay. So, if the air fuel mixture or air has been taken into the chamber under inlet valve was closed on the suction stroke yes okay. So, just to recap during the suction stroke the inlet valve was open, the exhaust valve is closed and the piston moves from the top dead center to the bottom dead center and the inlet valve was closed when the piston reaches the bottom dead center okay.

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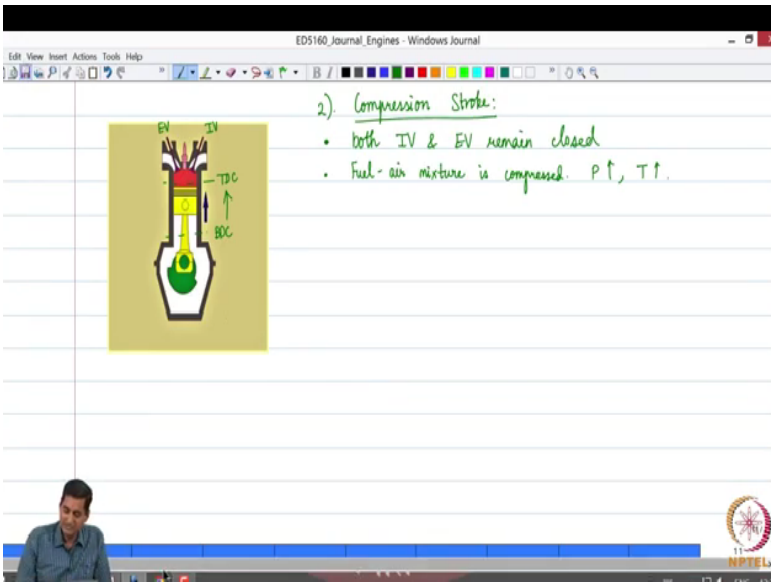

So at the end of suction stroke we have the fuel air mixture in the combustion chamber in a spark ignition engine okay. So now what happens in the next stroke, so the second stroke is the compression stroke. So, in the compression stroke, we can observe that both the inlet valve and

the exhaust valve remain closed. So, the piston starts to move from the bottom dead center and starts to go towards the top dead center okay.

So that is what happens during the compression stroke. So, what happens the fuel air mixture is compressed. So, as a result the pressure increases and the temperature in the cylinder also increases okay, the pressure in the combustion chamber and the temperature in the combustion chamber both increase during the compression stroke and during this process we will later observed that the fuel air mixer mixes well.

So that like we may get almost what is called as a homogeneous mixture of fuel and air that will promote more efficient combustion when the spark ignites the fuel air mixture okay. So, there is also one important aspect of the compression stroke okay. So, the compression stroke ends when the piston reaches closer to the top dead center okay. And obviously, we want both the valves to be closed right.

We do not want any fuel air mixture to escape through any of the valves and this is where the importance of compression rings is also felt right because we should have very good compression rings such that there is no leakage between the piston and the cylinder valve right. So that becomes very important okay. So these are the critical attributes of the compression stroke. So, once the compression stroke is completed the towards the end of the compression stroke, the fuel air mixture is ignited by means of the spark plug.

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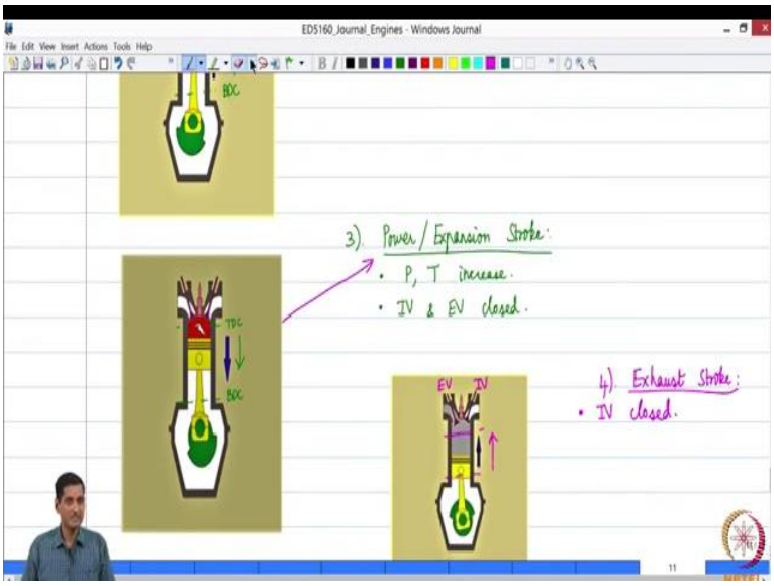

So, what happens here. So, the piston goes closer to the top dead center and the spark plug gives a high voltage spark which ignites the fuel air mixture. So, the fuel air mixture combust right. So, close to the top dead center the fuel air mixture is ignited and obviously combustion happens. We are going to generate a lot of thermal energy, high pressure gases that are going to push the piston here okay.

So the pressure and temperature increase tremendously during the stroke okay, I am using P for pressure and T for temperature, right. So the pressure and temperature of the fluids inside the combustion chamber increase tremendously during this expansion stroke or the power stroke. And obviously we want both valves to be closed. We do not want any leakage. And once again the importance of compression rings can be felt here, right because we do not want any leakage once again right.

If there is a leakage then the effective work that is done on the piston would reduce. So we do not want that also to happen. And this is the main stroke where energy is transmitted from the fuel to the piston and that is why it is also called as a power stroke. The term expansion stroke is very obvious. Because the hot gases expand the piston moves from top dead center to bottom that center.

Power stroke because the energy to drive the other strokes is up and also the vehicle is obtained during this particular stroke okay. So that is the power stroke other expansions. So, let me so this is the power stroke okay this diagonal. So, the last one is the exhaust stroke. So, when the piston reaches close to the bottom dead center towards the end of the power stroke the exhaust valve will be open.

And the hot the gases which are the products of combustion are now going to be pushed up okay, so that is what will happen during the exhaust stroke. So now you can see that the exhaust valve is open the inlet valve remains closed, right because we do not want the exhaust gases to pollute the next cycles fresh charge right. So, the exhaust valve is open and the piston moves from the bottom dead center to the top dead center and push us of the exhaust gases right.

When the piston goes towards the top dead center, the exhaust valve is closed and the inlet valve opens and the next cycle starts yes. So, the first stroke is a suction stroke right. Although the volume in the cylinder is expanding, energy is not transferred to the piston okay, energy is transferred to the piston only in the power stroke or the expansion right. In the what to say case where, the strokes where the volume is decreased in the compression stroke and the exhaust stroke.

You can see that in the compression strokes the valves are closed, whereas in the exhaust stroke the valve is open. So, what you need is the correct sequence of strokes right. So, when you start the engine the piston is going to be at some location and there is going to be a mechanical what to say a marking of the stroke yes. So, there will be like the mechanisms which are there will be sort of coded right with information of these strokes.

When you come to the lab you will look at all these aspects right the exact mechanism by which it makes, for power stroke as you have already said why temperature increases because it is an exothermic reaction and the expanding the volume increases how is agree is the pressure also increases, pressure increases because the volume increase is not so significant when compared to the amount of thermal energy you release.

So, even if you look at the ideal gas equation of state TV = MRT right temperature increases due to the tremendous increase in the energy right which is thermal energy is created from the chemical energy of the fuel. So, if you keep the M and R to be the same, PV is increasing. So, but the volume is increasing but not to the extent to balance it off, so, pressure also increases okay ok.

That is an important factor we will come back to and we study emissions. So, her question was when I want to push out the exhaust gases through the exhaust manifold to the exhaust valve into the exhaust manifold and to the what are called after treatment systems what happens is that like I need a pressure difference right. Because the pressure there should be lower otherwise the gases are not going to move correct.

So how do we what to say assure that ultimately you can see that if you do not have any of those, you just have a pipe in obviously you are dumping to the atmosphere, right and that is going to be a significant delta P which will enable that flow, but when once you start adding all these elements, you are going to have what is called a significant backpressure. Then we need to start worrying about what will happen right.

So that will figure out no it would not right okay so we are going to exactly the next point which I am going to discuss . So, we have looked at all these 4 strokes, the strokes do not happen in phase in all the cylinders, what do I mean by that. You will not let us say you consider a 4 cylinder engine, the suction stroke will not happen at the same time in all the force engines and so on, they will be spread out okay.

So there are multiple reasons for that, because you want the power stroke to be spread out, right so that like you sort of get a uniform energy output on the crankshaft. And imagine another reason is that like imagine that all 4 cylinders are going through the power stroke at the same time, that is going to create a lot of mechanical load on the crankshaft at the same time, right. So that is also something which is undeserved right okay.

So the point is the energy obtain from the expansion stroke is essentially providing the energy for the compression suction like exhaust okay, we look at that when we do the analysis even if you have a single cylinder engine that is what happens right, if your perspectives okay if you have a multi center region but I will slightly reoriented because even if you have a cylinder, cylinder engine, the suction compression and exhaust stroke in that single cylinder engine has to have to be sustained right.

A flywheel smooth under the door, but the energy obtained from the expansion stroke sustains okay which one not only that because the you have a lot of kinetic energy right, that essentially ensures that it provides energy to the other strokes, okay. When we do thermodynamic analysis using PV diagram it will be completely okay. So, these are the 4 strokes in a 4 stroke engine and the power stroke or the expansion stroke provides the energy.

And the other 3 strokes are what to say take energy you know like from the crankshaft right. So, we will when we do the engine analysis, we will calculate expressions for the net energy output or the network output from these 4 strokes. Now, that is an analysis that we will do when we come to what are called a standard cycles analysis in a few classes. The next before I go to the next topic of 2 stroke engines, a quick discussion on how a 4 stroke compression ignition engine works.

The strokes remain the same, but the main difference is now that the spark plug is going to be replaced by a fuel injector and during the suction stroke only air is taken into the combustion chamber in a compression ignition engine okay. And during the compression stroke only air is compressed okay, no fuel only air is compressed during the compression stroke in a diesel engine or a compression ignition engine.

And towards the end of the compression stroke when the app has been compressed to a high pressure and temperature fuel is injected into the combustion chamber by means of fuel injectors. It sprayed in at high pressures and the fuel self ignites and that phenomenon leads to the power or the expansion stroke and the exhaust stroke follows. So that is the fundamental difference

between the petrol the 4 strokes in a compression ignition engine as opposed to a spark ignition engine okay. So, those are the main pictures okay.

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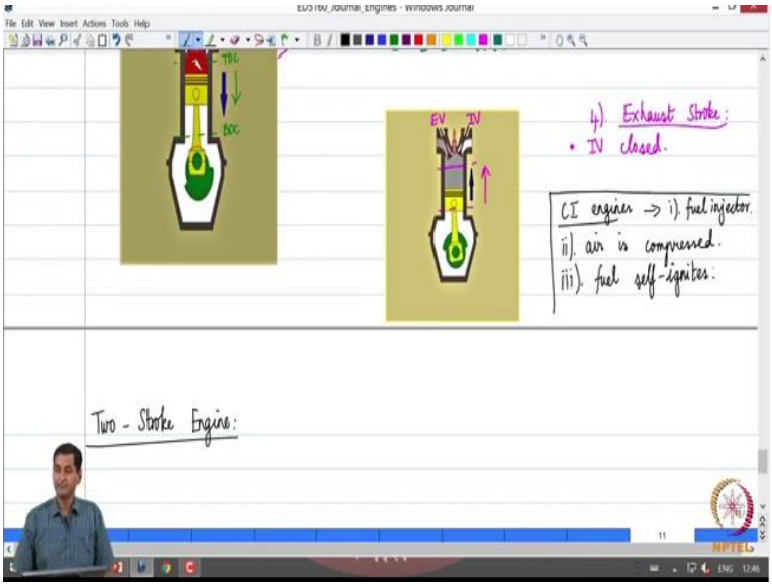

So, let me present a brief overview of 2 stroke engine and then we will see how it works right. So, let me just write down what I orally told about the strokes and the conditioning engine. So, first differences the presence of fuel injector right no sparkler. The second main defenses only add is compressed okay not fuel air mixture okay and fuel which is injected towards the end of the compression stroke self ignites okay.

So, that is another important aspect in a compression ignition engine okay. So let me give you a brief overview of 2 stroke engines and then like we will continue the discussion in the next class.

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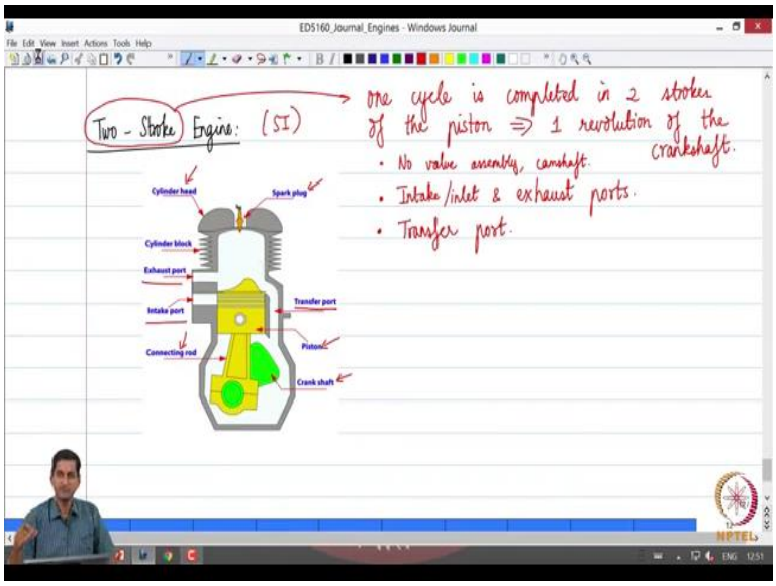

So, how does a 2 stroke engine differ from a 4 stroke engine. So this is just a simple schematic of 2 stroke engine. Of course, I am just taking a spark ignition engine once again and draw we can draw a similar schematic for a compression ignition engine as we have already discussed, main difference is going to be the spark but being replaced with a fuel injector, right. So we can immediately see some big differences.

The crankshaft is still there right. The piston and the cylinder and the connecting rod are on still around, right. We still have the spark plug, we still have the cylinder head. However, what is missing is the valve assembly right. So, no valve assembly camshafts right as a result no mechanisms for driving the camshaft timing, belt, gears and so on right. So then how are fuel air mixtures and taken into the combustion chamber.

And how our exhaust gases removed from the combustion chamber, we have what are called as the intake port or the inlet port the exhaust port and what is called as a transfer port okay. So, rather than valves in place of valves, we have intake or inlet ports and exhaust ports okay. So these are the mechanisms by which the fuel air mixture is taken in an exhaust there is a remote respectively.

Now, of course the ports means that they are also like some openings or channels right. So, we will shortly see when we discuss the operation of a 2 stroke engine that the piston itself covers

and uncovers the ports at the appropriate time okay we are going to look at that aspect. And anyway as the objective to stroke indicates, we have already discussed right one operating cycle is completed in 2 strokes of the piston.

So, this corresponds to how many revolutions of the crankshaft in place, 1 revolution of the camshaft. So, we can really see that one cycle is completed in 1 revolution of the crankshaft whereas in a 4 stroke engine, 1 revolution is completed in sorry 1 cycle is completed in 2 revolutions of the crankshaft right, that is primary difference okay and something called as a transfer port in a 2 stroke engine, okay.

We look at what is the role of the transfer port okay in the functioning of a 2 stroke engine in the next lecture okay. So, in the next class we will discuss some more critical aspects of the 2 stroke engine and look at its operation fine. Thank you.