**Fundamentals of Automotive Systems**
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**Lecture-07**
**Two Stroke Engine and Engine Cycles**
**Part 01**

Greetings.

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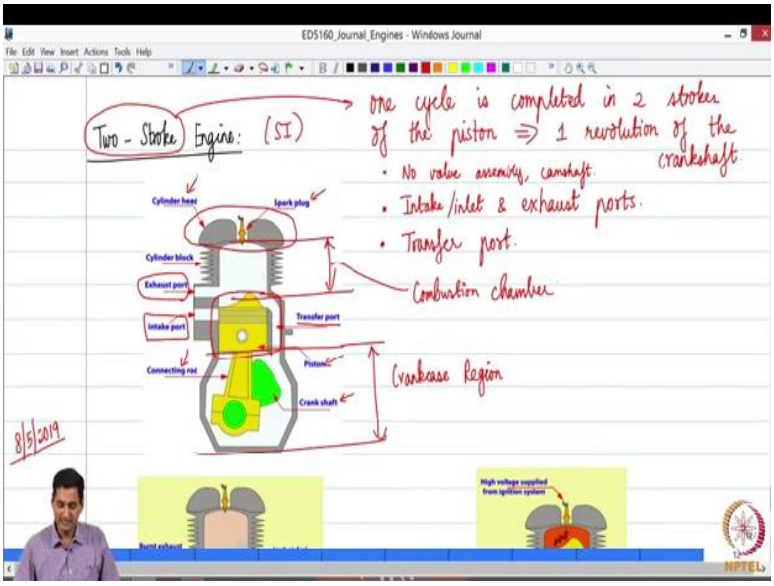


So welcome to today's class. So a quick recap of what we did in the previous class, we looked at the operation of a typical 4 stroke internal combustion engine. We learned what the 4 strokes were and what were the characteristics. And we also learned a few definitions right associated with the engines. And we stopped with a brief introduction to 2 stroke engines. That is what I am going to build on today.

So, as we have already learned that 2 stroke engine is one in which one operating cycle of the engine is completed in 2 strokes of the piston okay. And so that corresponds to 1 complete revolution of the crankshaft. And if you look at the schematic of a 2 stroke engine, we can immediately observe that as opposed to a 4 stroke engine in a 2 stroke engine, we do not have intake and exhaust valves.

And we also do not have the actuation mechanism for the intake and exhaust valves with a form of camshaft timing, belts and so on okay. So, those are absent. So, as a result we can observe that the cylinder head is pretty much still when compared to a 4 stroke engine right. So, that saves a lot of mass right in a 2 stroke engine. So, we do not have those assemblies right as far as in taken exhaust valves are concerned.

So how are air fuel taken into the cylinder and exhaust gas removed from the cylinder in 2 stroke engine, these functions are performed by what are recalled as the intake ports and exhaust ports respectively okay. So, we shall shortly see how the 2 stroke engine works. So, let me consider a 2 stroke spark ignition engine to begin with as we know already in a spark ignition engine we have a spark plug which ignites the fuel air mixture that results in combustion.

So, we have an intake port, we have an exhaust port, we also have what is called as a transfer port okay. So, in a 2 stroke engine, we can observe the piston divides the entire engine assembly into 2 broad regions, right. So, one is the region below this which in general you know like we call as a crankcase region, right. So, because most of it is in the crankcase right and another region above this, which is the combustion chamber.

So what happens in a 2 stroke engine. Let us go and look at simple schematics, which explain the various operations that take place in a typical cycle of a 2 stroke spark ignition engine. As we can really observe from this schematic, we can see that the piston itself opens and closes the ports, there is no separate valve assembly for opening and closing the say the restrictions through which air or fuel admixture comes in and exhaust gases go right. The piston itself covers and uncovers these various ports. So let us look at what happens. So this stroke.

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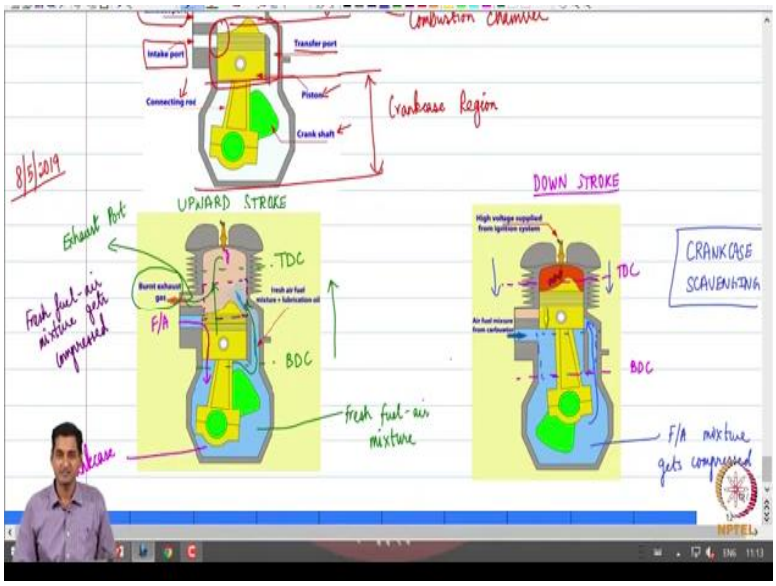


The first stroke that we are going to look at is what is called as the upward stroke of the piston. So what is this upward stroke, the upward stroke of the piston as the name indicates is what happens when the piston is going from the bottom dead center to the top dead center okay. So let us say somewhere here is my bottom dead center and somewhere here is my top dead center. So the piston is moving upwards from the bottom dead center to the top dead center.

So let us look at what are all the processes that happened when the piston does so, when the piston moves from the bottom dead center to the top dead center it starts pushing out the burnt exhaust gases that have accumulated in the combustion chamber from the previous cycle. So you can immediately see that the exhaust gases start being pushed out and not like through the exhaust sport okay.

So this is the exhaust port. At the same time when the piston starts moving the fresh fuel air mixture which is present in the crankcase, we will see how this comes in okay when we look at the downward slope. So, the fresh fuel admixture which is also pressurized right, it essentially gets transferred to the top part of the above the piston okay, this is the combustion chamber through what is called as it transfer port, okay.

So, the fresh fuel air mixture for the next ignition process gets transferred through the transfer port into the combustion chamber and the piston head is shaped in such a way that the fuel air

mixture does not directly go and mix with the exhaust and go out of the exhaust port right because that will be resulting in unburned fuel air mixture in the exhaust which is not beneficial. And we do not want the exhaust also to come in mixed with the fresh fuel air mixture.

Because there is going to inhibit proper combination of the fresh fuel air mixture right. So, the shape of the piston head becomes important. So, the fresh fuel air mixture starts to come into the combustion chamber. And as the piston goes up, what is going to happen we are going to observe that it is going to essentially close the exhaust port on the transfer port after some time. Then what will happen, the fresh fuel air mixture gets compressed correct.

So, whatever has come in through the transfer port through the initial part of the upstroke that starts getting compressed once the exhaust port on the transfer port are covered by the piston. So the fuel air mixture gets compressed, but you can immediately observe that the inlet port at some point is opened. So, what will happen through the inlet port, the fuel air mixture for the next cycle starts coming into the crankcase because we know that this is the crime. This is the crankies right the fuel our mixture for the next cycle starts coming into the crank.

So, this is the crankcase right the fuel air mixture for the next cycle starts coming into the crankcase. So when the piston reaches close to the top dead center, what is going to happen is that this fuel air mixture is compressed and then we are going to have a spark right from the spark plug and the fuel air mixture gets ignited. So now let us come to the down stroke, before combustion we have to crank the engine you need to provide the mechanical effort to make the piston go upwards and downwards.

In a real car the energy or in a real automobile the energy which is released is consumed for this process okay we are going to a part of the energy is used for this upstroke, in fact in a 4 stroke engine we observed that there is only 1 power stroke right. So, that is the in a during the stroke, a significant amount of energy is transferred to the piston and a part of that is going to be used for the other 2 strokes.

Energy basically it is essentially the energy which is transmitted via the burning combustion of the fuel that is converted to thermal energy right. The thermal energy is converted to kinetic energy, a part of that is going to be used for moving the what to say piston in the other 3 strokes, in addition to other aspects which we will see when we do the analysis okay. So, coming to the down stroke we can immediately observe that once the fuel air mixture gets ignited by the spotlight.

We are going to have a conversation right, so we are going to have a lot of thermal energy being what to say created from the chemical energy or the fuel and we are going to have high pressures and temperatures in the combustion chamber. That is going to push the piston down when the piston is pushed, what is going to happen. Let us say at some point of time, it has come to this right it is moving down and the piston is pushed, it will close the inlet bore.

And since fuel our mixture has already been taken for the next cycle through the inlet bore with during the upstroke that fuel our mixture will get compressed right in the crankcase, so the compression of the fuel air mixture for the next cycle happens in the crankcase and as the piston keeps on moving down, the exhaust port is open. So that the exhaust gases from this cycle escapes to the exhaust system from the cylinder.

And then the transfer port is open, so that the compress fewer admixture in the crankcase is then transferred through the transfer port up to the combustion chamber. So, all the steps keep on repeating okay one after the other. So, we can immediately see that many of these steps happen simultaneously in a 2 stroke engine, what do I mean by this, the process of introducing fresh fuel air mixture into the combustion chamber for the next cycle happens through a part of the what is a downward stroke towards the end.

And also the initial phase of the upward stroke okay. The exhaust of the burn gases also happens during the later part of the downward stroke and also through the initial part of the upward stroke. So, you can see that many of the strokes happen, many of these operations right happen at various phases of these 2 strokes okay. So, this is essentially this process is what is called as crankcase scavenging okay.

So, the reason being that you know the fresh fuel air mixture for the next cycle is scavenged or taken from the crankcase okay. So, the for the next upcoming cycle, the charge is first introducing the crankcase pressurized, then taken from. So these are a typical 2 stroke engine operates. So, now, a few critical points as far as a 2 stroke engine operation is concerned right.

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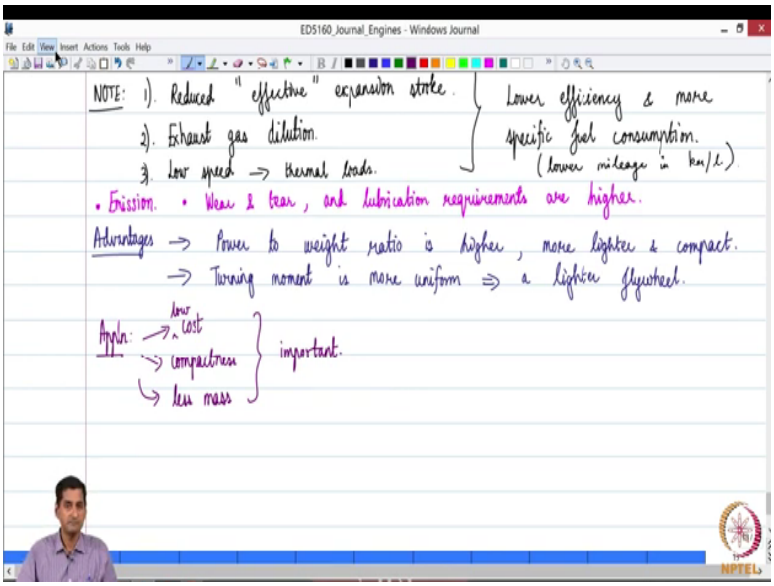


To summarize once again there is a there are only 2 strokes an upward stroke and a downward slope and all the processes of an you know compression intake exhaust transfer and distributed between these 2 stroke okay. So, you can immediately observe that there are a few differences between the way a 4 stroke engine works and the 2 stroke engine works. Now, if I have a comparable 4 stroke engine and a 2 stroke engine you know like things being the same.

And they are operated under similar conditions you know like similar loads, similar speeds and so on. When you compare it to a 4 stroke engine, a 2 stroke engine will have twice the number of power strokes would it not. Then, theoretically I should get twice the power output from a 2 stroke engine. Do you agree right, because everything remains the same right You keep everything else the same theoretically we should get twice the power output.

For the same operating conditions due to the simple fact that a 2 stroke engine has one power stroke per revolution of the crankshaft, but that is something which rarely happens in practice. Of

course, the flip side is that the 2 stroke and then also we will have twice of power fuel consumption because fuel is also taken that many times right more okay, so we will come to that shortly.

So, why do we not get twice the power output even if you have comparable 2 stroke and 4 stroke engines. There are multiple reasons for that. The first reason foremost reason is that if you look at how a 2 stroke engine operates during the down stroke, you have high pressure gases right that are products of combustion, and they are going to push the piston down and the exhaust port is opened when the piston starts to travel to the down stroke.

So, even before the down stroke is completed, what do I mean by that the piston moves from that top dead center to the bottom dead center the exhaust port is open. So, the expansion process itself does not take place over a complete stroke of the piston okay what do I mean by expansion effect to expansion right I could have converted more thermal energy into kinetic energy had a not open the exhaust code earlier.

In a 4 stroke engine we wait right we wait till the piston reaches the bottom dead center then on the way up we when it reaches a bottom dead center we open the exhaust valve and the exhaust gases are pushed out but not in a 2 stroke engine. So the first limitation which prevents this what to say lack of twice the power output from a typical 4 stroke engine is the reduced effective expansion stroke okay.

So, that is something which we need to remember, can there be some other effects in a 2 stroke engine yes there are right. So, 2 stroke engines also can even though we designed it very carefully the way it operates, we can also have what is called an exhaust gas dilution. What do I mean by this because then fresh charged for the next cycle and the exhaust gas from the previous cycle are presented the same chamber for an extended period of time right during the down stroke and part of the upstroke.

So there is a good chance that even though we may design the piston head and the ports and the other assemblies carefully, there is still a good chance for them to mix together. And exhaust gas

dilution is the term given to the phenomenon by which exhaust gases mixed with the fresh fuel air mixture and that is going to reduce the chances of effective combustion, right. So, even combustion please remember it is a process of converting chemical energy to thermal energy, it has its own efficiency.

So if I mix with exhaust gases, the efficiency of that energy conversion process also will go down right. So that is another limitation okay. And even if we are able to overcome these issues, please note that since 1 power stroke takes place every revolution by enlarge, 2 stroke engines, their speeds are limited, because otherwise the thermal load will increase imagine, you know, like, if you keep everything the same.

And you are burning fuel once in every revolution, right, it is going to become extremely hot is a not. So, how do you ensure the thermal loads are reasonable. You reduce the number of power strokes, if we reduce the number of strokes what we are effectively doing, we are reducing the design speeds themselves, right. So, the 2 stroke engines are relatively designed to be lower speed engines because of the restriction on the thermal loads that come in.

Now what do I mean thermal load the heat energy that the engine needs to dissipate right, it is going to get very hot, okay. So we can immediately observe that these effects are going to read to lower efficiency and more we will introduce this term later what is called as specific fuel consumption. So, what do I mean by specific fuel consumption it is the mass of fuel consumed per unit power delivered by the engine we will did it, what is a define it carefully when you come to engine performance.

But when you compare it to 4 stroke engines, you know, like 2 stroke engines are going to have lower efficiency and more specific fuel consumption that means, like lower mileage, right, so, more specific fuel consumption means, you know, like, the mileage that you get in terms of kilometers per litre of fuel, right, that is going to drop okay. So, low mileage okay, in terms of kilometers per litre, or miles per litre, right depending on the units that we use fine.

So, those are all what to say typical limitations of 2 stroke engines. Now, there is also another word to say issue which comes in, in 2 stroke engines as you can see, the crankcase is not used as a sum for lubricating oil, there is no separate channel for circulating the what to say coolant, the lubricating oil and so on. So, as you would have seen from experience right if we have a 2 wheeler or an auto rickshaw, you know with a 2 stroke engine.

When we go to a fuel station, the engine oil is mixed with petrol. So, the lubricant is mixed with the fuel and burns along with the fuel and the lubricant is different from fuel in chemical composition. So, that is going to bring in it is own emission issues right. So, it is going to affect the performance of the 2 stroke engine. And more importantly, in the current scenario, it is going to result in increased tailpipe emissions right.

So, that is one significant issue with 2 stroke engines. So, these are all some limitations. Why 2 stroke engines are also we can slowly observe that on roads, you know like we do not have so many 2 stroke engines today right. So, they are slowly being faced on, but what are the advantages obviously, they have advantages right. So, the main advantages are although it does not give you twice the power right for twice the fuel consumption with everything remaining the same.

Still, the power to mass ratio or what is called power to weight ratio of 2 stroke engines is higher than 4 stroke engines multiple reasons for that. Of course, you will get more than what a 4 stroke engine delivers for the same configuration. But as we already seen even the initial mass of a 2 stroke engine is small why because there is no the cylinder head is very thin, there are no valve assemblies, no camshafts right, no you know like timing gears or timing belts.

And other mechanisms right for that okay, no lubrication, separate lubrication circuits, right engine oil pumps and so on right. So, all those are not present. So, if you take the engine as a unit. So the power to weight ratio or power to mass ratio is higher in a 2 stroke engine. That means that if you look at it from another perspective, 2 stroke engines can be made compact for the same power, right if you want, let us say x kilowatt of power output from a 2 stroke engine and a 4 stroke.

Then 2 stroke engines are going to be more compact and light if you compare them right. So, that is a good advantage. And another what to say aspect which contributes to this reduce mass is it since in a 2 stroke engine you have 1 power stroke per revolution the turning moment what do I mean by turning moment the torque okay which is available at the output of the crankshaft is more uniform and this implies a lighter flywheel because we are going to have energy conversion every revolution of the crankshaft right.

So, why do we use a flywheel we want to dampen out the torque fluctuations but the torque fluctuations themselves are smaller in a 2 stroke engine. So, I consequently you know like we go for lighter flywheel. Of course, one more these are some good points about 2 stroke engines 1 more limitation is that since 1 power stroke or 1 combustion happens in every revision of the crankshaft right.

So, the wear and tear and the lubrication requirements are also higher okay. So, were and tear of the engine and lubrication requirements are higher in a 2 stroke engine. So, where do we use 2 stroke in typical application domains, typically used were you know like the application domains of 2 stroke engine you know traditionally has been were in on a cost I would say low cost, right. compactness okay, less mass okay which are these are important okay.

Applications where we need to reduce these attributes right or meet these attributes. That is where the 2 stroke engine is traditionally used, of course in road vehicle application. Now, the main reason why 2 stroke engines are the presence is reducing is due to emission alright, so that is a pressing concern okay, that is a broad worry of 2 stroke engines.