Thermal Engineering: Basic and Applied
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Lecture - 44
Comparison of 2 - stroke and 4 - stroke Engines

I welcome to the session of thermal engineering basic and applied and today we shall discuss about the comparison of 2 stroke and 4 stroke engines. In fact in the last class we have started our discussion on this particular module that is the internal combustion engine and we have seen different parts of an internal combustion engine. And we have also discussed the requirement of a few parts for the SI engine.

Which in fact we have discussed that, those parts are not needed for the operation of the CI engine. And finally we had discussed about the classification of the internal combustion engine. So, now we had seen that internal combustion engine can be classified depending on the types of combustion that is SI and CI engine. And we have briefly discussed about the initiation of combustion.

Whether it is initiated by an external agent like spark plug or the combustion process is initiated by utilizing the pressure and temperature of the compressed air that is when fuel auto ignites. And finally we had seen that another classification is based on the number of stroke that is 2 stroke and 4 stroke engine, so let us now briefly discuss about the several strokes then we can have the comparison of 2 stroke and 4 stroke engine.

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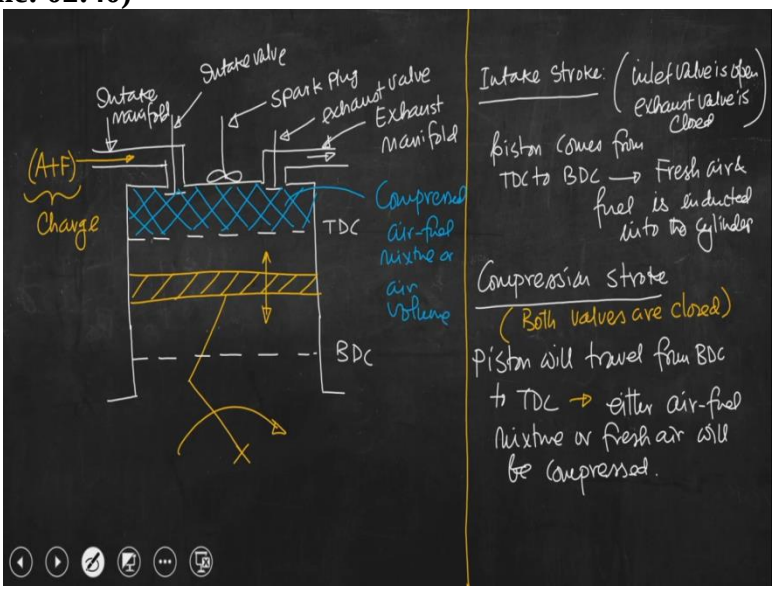

So if we try to draw the schematic of an internal combustion engine, so this is top dead center. And if we say this is the piston and this piston connected to this crank using this connecting rod. And piston is having to and fro movement inside the cylinder, so this is engine cylinder, say this is the bottom dead center. So we had seen this is intake manifold, this is intake valve.

This is spark plug and this is exhaust manifold, of course there is a valve which is attached here. So, this is exhaust valve, now this spark plug will not be there if it is CI engine and so this is air fuel mixture, charge and this will be taken to the cylinder by fixing another important device, that is carburettor essentially to provide homogeneous mixture of air and fuel.

But if it is the CI engine then only through this intake manifold fresh air will be inducted into the engine cylinder. And spark plug will not be there instead of the spark plug there will be a fuel nozzle. Now let us identify different strokes, first stroke is intake.

Intake stroke: inlet valve is open, exhaust valve is closed, piston comes from TDC to BDC and consequence is fresh air and fuel is inducted into the cylinder. Let me tell you again if it is CI engine only fresh air should be inducted into this cylinder in intake stroke. But what we had drawn here is the schematic of a spark ignition engine and spark plug is there. So, definitely intake manifold is there to supply air fuel mixture rather homogeneous mixture of air and fuel.

So, piston is travelling from TDC to BDC during the stroke and that is essentially when we start our engine, we start using electric motor, so the motor will try to rotate the crank shaft. And as a result of which piston will be taken from TDC to BDC and while piston is coming from TDC to BDC, this exhaust valve is closed, we are creating vacuum inside the cylinder and the pressure difference between intake manifold and a point inside the cylinder is the driving force to have a continuous flow of air fuel mixture. And that is how air fuel mixture will be inducted into the cylinder, next stroke is you know a compression stroke.

Compression Stroke: In the beginning of the compression stroke piston is at BDC, so naturally piston will travel from BDC to TDC. In this stroke both intake and exhaust valve are closed. You can understand in the beginning of the compression stroke entire space is filled with air fuel mixture if it is SI engine or it is filled with only fresh air if it is a CI engine.

So whether the substance is air fuel mixture or fresh air, that substance will be compressed during the compression stroke. And that is why the name is compression stroke, so basically the amount of air fuel mixture that is air inside the cylinder or if it is the CI engine then only fresh air that air fuel mixture or fresh air will be compressed as piston travels from BDC to TDC.

So that is why this known as compression stroke consequence is either air fuel mixture or fresh air will be compressed. So, basically what we can see that at the end of the compression stroke, piston is at TDC and entire charge or fresh air will be compressed and that particular air fuel mixture or air would be residing in this particular volume.

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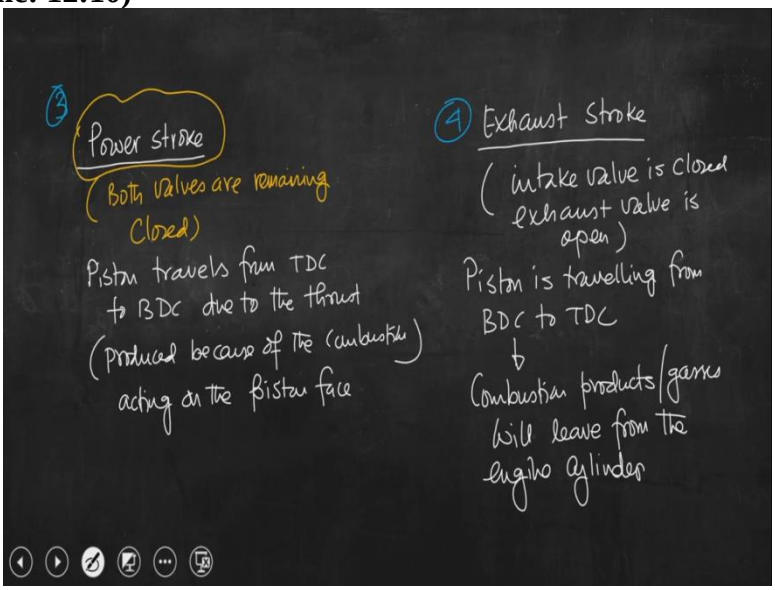

Power Stroke: Here also both valves are remaining closed. Now when the compressed air fuel mixture or compressed air is occupying in this space and that is known as clearance volume. At the end of the compression stroke so when piston is approaching towards TDC, we need to switch on the spark plug if it is the SI engine in and if it is the CI engine, as I told you that the thermodynamic state of the compressed air will be utilized to initiate combustion. So if it is the SI engine when piston is towards the TDC at the end of the compression stroke, we need to have some arrangement so that spark plug switch should be on and the spark which will generate over here. That will try to initiate combustion and the entire charge will be combusted and chemical reaction of hydrocarbon fuel will happen. The chemical reaction is exothermic reaction and because of which we will be having high temperature and pressure and that high pressure and temperature will create a thrust on the piston face.

And thrust that will be produced will allow piston to go back from TDC to BDC and that is the power stroke. So that means we are getting power. So in power stroke piston travels from TDC to BDC due to the thrust produced because of the combustion acting on the piston face. And resultant effect is piston will travel from TDC to BDC and that is the power stroke. So this is very important stroke and that is only the stroke from where we are getting power.

If it is SI engine combustion will be initiated ignition by using spark plug so we need to ignite the compressed fuel air mixture by this spark which is produced by the spark plug. And initial ignition will try to ignite the total charge and entire combustion will be completed and as a result of which we can say that the piston will travel from TDC to BDC. If it is this CI engine as I told you we need to design the engine in such a way that the pressure and temperature of fresh air which is developed at the end of the compression stroke is good enough to initiate combustion of the fuel when fuel is spread by using a fuel nozzle here.

So in a CI engine instead of a spark plug will have a fuel nozzle and that nozzle will allow fuel to spray. So basically fuel nozzle will be designed in such way that we will be getting fuel in the form of a spray. So when the fuel is sprayed inside this engine cylinder and to be precise in this particular space where compressed air is there. And that compressed air temperature and pressure is so high that the moment when fuel is sprayed it will ignite.

And it is because of this auto ignition, entire combustion will be completed. And as a result of which the thrust that will produce, that will allow piston to go back from TDC to BDC and that is related to the CI engine. But what we can understand at the end of the power stroke piston is again at BDC and both valves are remaining closed, entire cylinder space is now filled with combustion products.

Because when piston is travelling from TDC to BDC we have to ensure that total combustion will be completed. And entire space is now filled with the combustion products now we need to remove all these gases which is produced because of the combustion from the engine cylinder and next cycle that is intake process again will start so when piston is at BDC at the end of the power stroke we need to have some arrangements so that intake valve will remain closed exhaust valve will open.

Exhaust Stroke: Intake valve is closed, exhaust valve is open and piston is traveling from BDC to TDC consequence is combustion products gases will leave from the engine cylinder. So, that

movement of the piston will allow combustion gases or products to go out through the exhaust manifold. Because exhaust valve is open now and when piston is near to TDC you can see that it is not possible to remove all the combustion products. Because these combustion products that will be there within the clearance volume that will remain there but 80% or 90% of the combustion product will leave because of the movement of the piston from BDC to TDC and that is the end of the exhaust stroke.

So this is one cycle. So we have identified 4 different strokes and these 4 strokes constitute one cycle. So what we can understand in a 4 stroke engine, we will be having 2 revolution of the crankshaft and for such an 4 stroke engine to complete 1 cycle, there will be 2 revolution of the crankshaft and we are getting only one power stroke. Intake, compression, power and exhaust, there are 4 different strokes that we have identified but out of this 4 different strokes only 1 stroke is the power stroke remaining other 3 strokes are the idle strokes. So power we are getting from the power stroke will remain stored in the flywheel.

Flywheel will store the power and will supply power to execute remaining 3 other idle strokes. So we have identified the processes and the events are repeated to complete several other cycles. So basically the process is spontaneous and per one cycle there will be 2 revolutions, 1 power stroke vis-a-vis 3 idle strokes and the power that we are getting that will remain stored. So power we are getting at the crankshaft and this crank shaft is connected to the flywheel.

So, a part of that power will be utilized to execute 3 other idle strokes and these sequences we can understand that intake, compression, power and exhaust. So this events will be repeated to complete several other cycles and this is what is the 4 stroke engine. Let me tell you once again making use of this particular schematic, we have discussed about 4 different strokes for a SI engine. These 4 strokes are same even for the CI engine provided spark plug is replaced by a fuel nozzle and this intake manifold will supply only fresh air.

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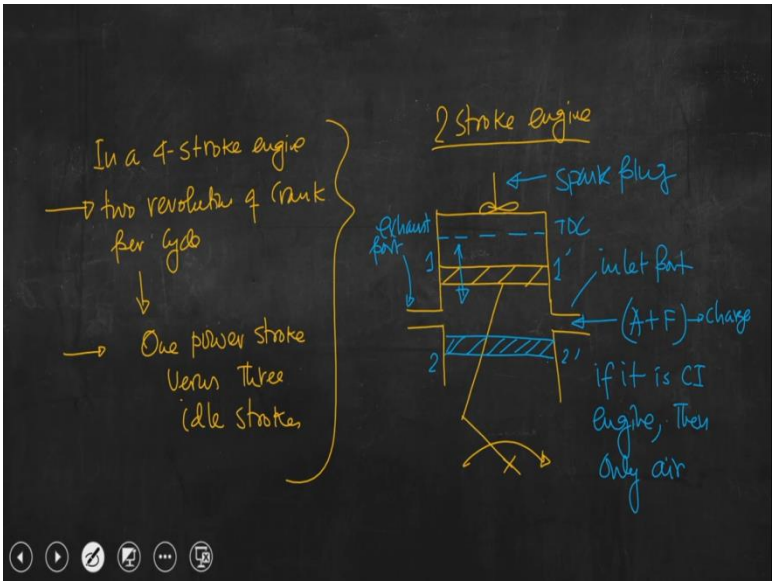

So what we can understand from this analysis is that in a 4 stroke engine, we have identified 2 revolution of crank per cycle and we have also identified 1 power stroke versus 3 idle strokes. Now question is what about 2 stroke engine, you can understand that only 2 strokes will be there.

Let us now draw the engine cylinder, so this is exhaust port and this is inlet port this is spark plug. So we are going to discuss about 2 stroke SI engine; so, you need to know the occurrence of 2 different strokes. So if we need to have to and fro movement of the piston inside the cylinder and that reciprocating motion will be converted by the rotary one using this crank and connecting the mechanism, we need to take fresh air during intake stroke. We also need to have compression as well as combustion and finally exhaust so by making use of only 2 different strokes, how it is possible to execute all these processes in a 2 stroke engine that is what we need to understand. So this is inlet port through which air plus fuel mixture will be there so that is charge, if it is CI engine then only air.

The piston is having to and fro movement and when piston is here in this location, this inlet and exhaust port are closed. When piston is coming from $1-1'$ to $2-2'$ intake port is uncovered. So when piston is coming from TDC to BDC during power stroke, the moment when piston just uncovers the inlet port, inlet port opens also exhaust port opens. So these 2 ports are closed when piston is at $1-1'$,when piston is coming from $1-1'$ to $2-2'$ during power stroke these 2 ports opened. So somehow we can have some pressurized system to supply charge or only air through this inlet port to the engine cylinder.

So when piston is coming from TDC to BDC during power stroke entire space is now filled with combustion products that we have seen when it uncovers this inlet port. Inlet port will open, exhaust port also will open and if we supply air fuel mixture by a pressurizing system then air fuel mixture will try to remove all the combustion gases that is air inside the cylinder through this exhaust port.

So what we can understand by a pressurized mechanism air fuel mixture will be inducted into the cylinder. That air fuel mixture simultaneously will remove the combustion gases that are there inside the cylinder. So combustion gases those are there inside the cylinder will go out from the cylinder with a simultaneous induction of air fuel mixture through this intake manifold.

So that means we can understand intake and exhaust, these 2 processes are occurring simultaneously. So we are taking air fuel mixture through this intake manifold using a pressurizing system and pressurized air fuel mixture will allow combustion gases to leave from the cylinder through this exhaust port.

So, now entire space is filled with air fuel mixture or air if it is the CI engine. And then when piston is again coming from $2 - 2'$ to $1 - 1'$ that is BDC to TDC, the moment when piston crosses this inlet and exhaust port these 2 valves are closed. And as if the piston is compressing the fresh air fuel mixture or fresh air and when it is coming towards TDC, we switch on the spark plug and ignite the fuel.

So we can understand the compression process when piston is coming from $2 - 2'$ to $1 - 1'$ that is BDC to TDC, when piston just crosses these 2 ports, these two valves are getting closed and the inducted fresh air mixture will be compressed. When the piston is at TDC that means compressed air is occupying in this clearance volume by using this spark plug if it is SI engine, or by utilizing the temperature and pressure of the compressed air itself for the CI engine, we can complete the combustion.

And it is because of this combustion, the thrust that will produce will allow the piston to go back from TDC to BDC that is the power stroke. So we have identified power stroke and compression stroke but when the piston is crossing this inlet port and exhaust port during the

power stroke these 2 ports will open. And simultaneous induction of air fuel mixture by making use of a pressurizing system will allow combustion gases to go out from the engine cylinder.

So induction of air fuel mixture is good enough to remove all the combustion gases those are there inside the cylinder through this exhaust port. And then we can identify the compression stroke and the power stroke, so these are 2 different strokes we have identified in the context of 2 stroke engine.

When air fuel mixture is coming through this inlet port maybe we are supplying using any pump and that fuel air mixture will allow combustion gases to go out. So to ensure that combustion products those are there in the remote corner should leave. Otherwise what will happen that residue of combustion gases will mix with fresh air fuel mixture and the combustion efficiency will drop. So, to ensure that the combustion gases from the remote corners will go out with a simultaneous induction of air fuel mixture or fresh air special arrangement is done and what is the special arrangement?

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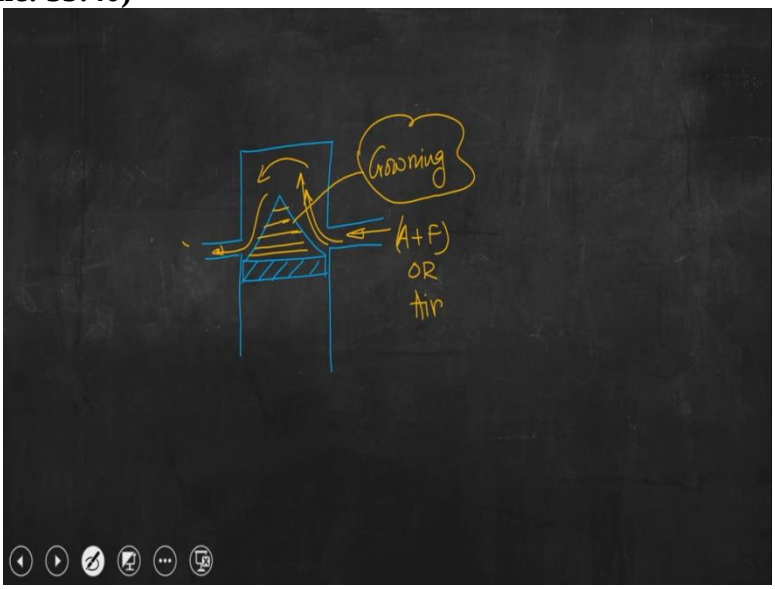

If that is the engine, this is the piston, and so this is basically like this, so this is known as crowning, so this special geometrical arrangement is done. So that when fresh air fuel mixture is coming if it is the CI engine or fresh air that fresh air fuel mixture or air will be allowed to move in this direction. And while it is moving in this direction, this particular geometrical configuration will allow the combustion gases which are there in the remote corner to go out from the engine cylinder.

This arrangement is necessary because in that case we can remove the combustion gases from the remote corners. And we also can reduce the possibility of the reduction of the combustion efficiency because of the dilution of the fresh air fuel mixture with the residue. So this is special arrangement and this arrangement is known as crowning. So this special arrangement is necessary to remove the combustion gases from the remote corners of the engine cylinder.

If we cannot remove, combustion efficiency will drop because the residue will try to dilute the fresh air fuel mixture or fresh air. So this is what is the operation of this 2 stroke engine, so instead of 4 different strokes we could identify 2 different strokes. And the cycle will be completed. So what we can understand, 1 power stroke per cycle and we have only 1 revolution of the crankshaft in 1 cycle.

So what we have understood that for 4-stroke engine, there are 2 revolution of the crank per cycle, for 2-stroke engine there is only 1 revolution of the crank per cycle and we have only 1 power stroke. So in this particular arrangement the number of occurrence of per stroke consequently the power output is expected to be double that of a 4 stroke engine.

Because 1 power stroke versus 1 idle stroke and that too in a 1 revolution of the crank. So in this case you understand that for in a 4 stroke engine 2 revolution of the crank per cycle and 1 per stroke. So engine is getting sufficient time to cool down so here we are having 3 idle strokes for 1 power stroke. So power which is produced inside the cylinder will definitely increase the temperature of different parts of the engine cylinder or engine.

And since in this case we can understand there are 3 other idle strokes so engine is getting enough time to cool down. But here it is not a case, so what we need to do we can understand that 1 power stroke is having 1 idle stroke. So the occurrence of power stroke is also very high and consequently the power output is also very high. And if power output is very high then the components will be more prone to high temperature and that is why the speed of these 2 stroke engine is reduced.

When air fuel mixture is you know drawn into the engine cylinder using a pressurizing system combustion gases are leaving. But we cannot really eliminate the possibility of loss of some amount of air fuel mixture with the combustion gases. So though we are doing this particular arrangement in this arrangement we are trying to remove the combustion gases from the remote

corner. But some amount of fresh air or fresh air fuel mixture will also go out with the combustion gases from the engine cylinder. And that is why it is not economically viable. So from the perspective of the fuel economy 2 stroke engines are not suitable. Because somehow there will be certain amount of loss of air fuel mixture or fresh air when that fresh air fuel mixture or fresh air is used to eliminate remove the combustion gases from the cylinder. So while the combustion gases are leaving that combustion gases also will carry certain amount of fresh air fuel mixture or fresh air. And that is how engine efficiency will reduce so these two are very important points. So if we try to summarize what we have discussed? We have discussed today different strokes of a 4 stroke engine whether it is a SI or CI engine.

If it is SI engine we have discussed that spark plug will be there and carburettor will be there for the CI engine carburettor will not be there. And instead of a spark plug will have a fuel nozzle then we have also identified 2 different strokes in a 2 stroke engine, the difference between 4 stroke and 2 stroke engine is that. In a 4 stroke engine there are 4 different strokes 1 power stroke versus there are 3 idle strokes so engine is getting sufficient time to reduce the temperature of several components.

Because during power stroke the power which is produced that excessive rise in temperature will increase the temperature of several components of the engine. So that is why we had seen in the last class there is a cooling system so to reduce the temperature of the engine cylinder. But for the 2 stroke engine expected rise of the temperature of several components of engine is very high.

Because only 1 power stroke vis-a-vis 1 idle stroke and also we had seen that here there is 1 revolution per cycle and in 1 cycle there is 1 power stroke. So power stroke and consequently the power output is theoretically appears to be double to that of a 4 stroke engine. That is why the speed of a 2 stroke engine is reduced and also we had discussed that there is a possibility of the removal of fresh air fuel mixture or fresh air depending on the type of engine whether it is SI or CI engine with the combustion gases during this simultaneous induction as well as removal process and that will lead to a reduction in the engine efficiency. So with this I stop here today and we shall continue our discuss in the next class. Thank you.