MARINE ENGINEERING

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Lecture40

Fuel Injection/Scavenging

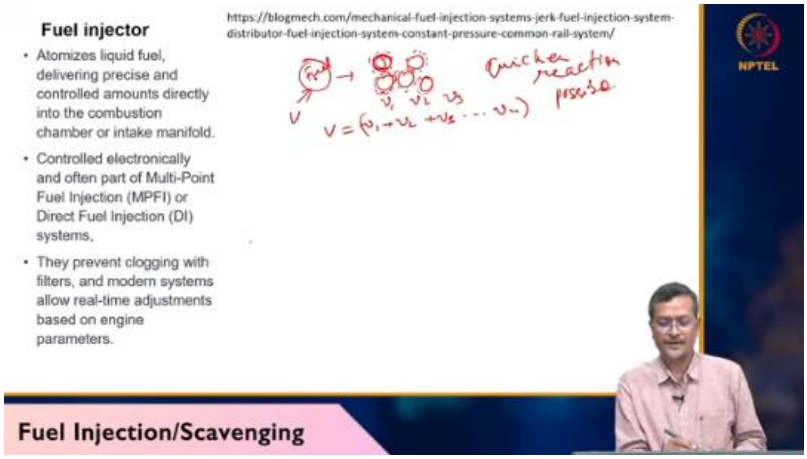
good morning everybody today i will start the topic on fuel injector scavenging and see related some topic like cam mechanism so this mechanism of fuel injection scavenging and cam is very much important for an ic engine to run smoothly otherwise the system will not function properly or it will not be giving higher efficiency or performance as per required for our engineering application previously we have seen the carburetor And we have seen this fuel compression system. Previously, we have seen the carburetor.

We have seen how to compress air and how to inject into the system. So, we have seen the turbocharging system and many other systems also. Now, today's discussion will be basically based on fuel injection, scavenging, cam mechanism. So, in fuel injector system, fuel injector will be atomizing liquid fuel, atomizing means like you have larger particle and you have to make smaller particle. Smaller many particles you make, so what is happening like larger particle volume V and small particle volume let us say V1, V2, V3, so total volume V equals V1 plus V2 plus V3

vn okay so total volume will be same but if you see mathematically this volume same but surface area actually increased this surface area increased okay because of surface area increase the oxygen particle this is fuel fuel particle and oxygen all around this one it will get more chance to re to attach with this fuel particles okay So, more surface area means more reaction, quicker reaction be possible. So, quicker reaction possible. And because these particles are small, so heat transfer rate will be very high. Let us say a bigger particle to reach higher temperature to the center, it will take certain time.

But if you have a very small particle, the time will be very small. So, combustion will be very much quick. so it will be atomizing atomizing making a small small particle like this okay and fuel injector will be controlling fuel amount how much fuel you are injecting into

the cylinder or combustion chamber through intake manifold control by electronically many fuel injector will be controlled by electronically modern engine especially previously the older engine you will have only cam mechanism to control the fuel injection these days there are concept of multi-pile fuel injection dual fuel injection in direct fuel injection system in multiple fuel injection also possible in a single cylinder so modern technologies are based on more on electronical electronic control prevent clogging with five filters and modern systems allow real-time adjustment based on engine parameters engine parameters may be your load condition changing your temperature changing pressure changing or some other different parameter changing based on that fuel injection rate also will be changing and fuel air ratio also will be changing actually so



now let's see how the fluid fuel injector looks like so fuel injector will have one cam cam i'll discuss later cam mechanism mechanism means like if you have circle wheel will have your axle at the center and when rotating it will not be no eccentric movement but cam will have a centric movement let's see if you rotate this one along this axis center okay this is circle okay this is cam cam will be eccentric or specific shape Now, if I have one stylus here, stylus, follower, this is called follower. So, if you rotate the wheel, the follower will be moving up and down. Now, this shaft, shaft is here, camshaft or cam shaft. This camshaft will be rotated by your engine shaft, main shaft.

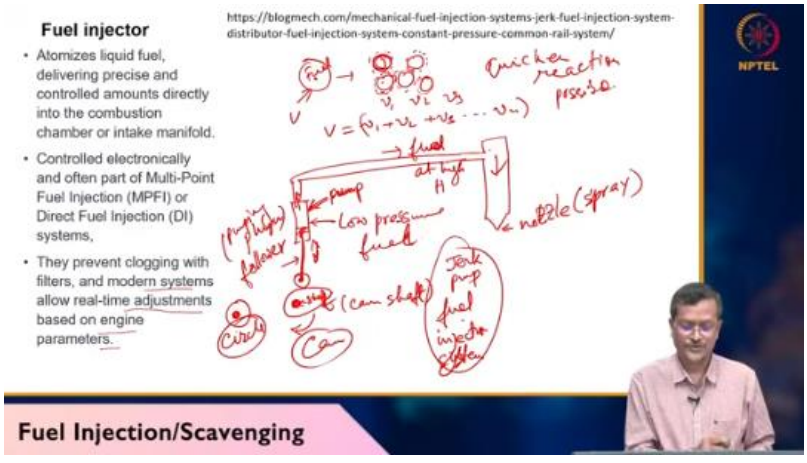
So, main shaft is rotating. this will be connected to your fuel line. how it will look like? There will be one pumping system. Assume this is a pumping system.

It will take low pressure fluid. fuel F U E L okay then it will be delivering at higher speed higher pressure okay through this pipe and it will go to fuel injector system nozzle system okay this is nozzle What is the purpose of nozzle? Nozzle will be creating spray. Spray means it will be breaking bigger particle into smaller particle.

But it will not create steam or vaporization. It will create only liquid particle in liquid form. But it will be particles will be suspended in or it will create very small small particles actually. So, it will create spray. this is nozzle fuel injector is here so this is called jar pump fuel injection system so one there are many types of fuel injection system this is one type is jar pump jar pump fuel injection okay so cam will be moving up and down because of your shaft rotation main engine main shaft or crank shaft

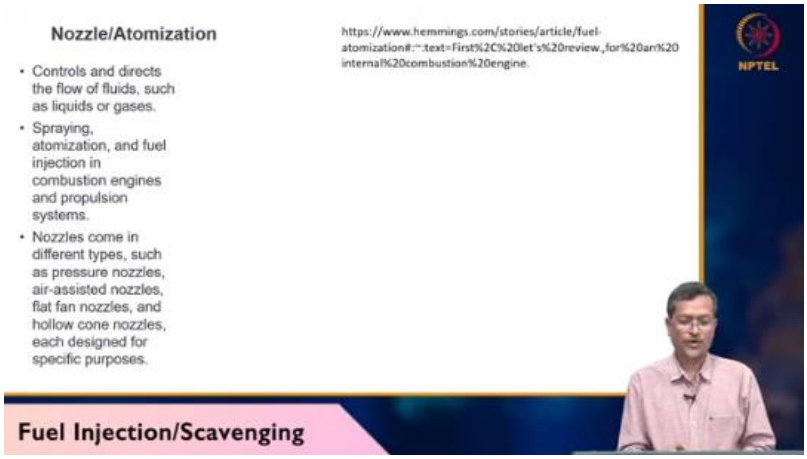
will be connected to your camshaft so camshaft is rotating because of that your follower is moving up and down follower or you can say plunger pumping okay so one pump you are creating here this is pump actually okay p u m p so pump is giving high pressure flow of fuel fuel at high pressure. That high pressure fluid is passing through on a small nozzle. So, because of high pressure and small nozzle creation, fluid will be having very high velocity. At high velocity, fluid particle will be broken and it will be creating small, small particle that is called atomization.

this is the basic principle of fuel injector system with cam and nozzle mechanism if you have electronic control system then cam mechanism may or may not be there so the electronically sign solenoid valve will be controlling your system so basically this injector system will be controlling injection timing so it will be controlling injection timing timing okay normally it will be used in this diesel engine In two-stroke spark ignition engine, two-stroke engine you have seen there will be carburetor, carburetor will be mixing and it will be injecting inside cylinder. But in diesel engine fuel injector system, fuel you are injecting separately and air you are injecting separately. So, air when entering it is getting compressed, after compression the fuel will be injected.



So, if you, so the three functions are there, injection timing, atomization, timing control, atomization and quality control. So, these three things will be done by your fuel injector. And if you see the PV diagram, let us see this one. 1, 2, 3, 4 PV.

So, at point 2, your fuel must be injected. Just before point 2, just slightly before point 2, your fuel will be injected and already 1 to 2, you compress the gas. Gas is having higher temperature, injected fuel, fuel and gas that at higher temperature, it will be burning quickly. Nozzle, I discussed already, this nozzle will be creating small small particle. So, nozzle controls and directs the flow of fluid such as liquid and gas, it will create spray and it will create small small particle that is called atomization.



and fuel injection be happening inside combustion chamber. Nozzle come up in different shapes and sizes for different applications. For our case, it will be like convergent divergent, convergent nozzle. And if you have a very high pressure, pressure high, let us say this is 0.1, this is 0.2. So, what happens?

The 0.1 pressure is P1, velocity is V1. and temperature is Tu1 and flow rate is Q1, Q is flow rate. So, at point 2 what will happen? At point 2, I will have pressure P2, velocity will fluid velocity will be changing and flow rate is not going to change, Q is not changing. Same, we are assuming incompressible fluid.

Because you are pumping liquid fuel, diesel they say. So, this is incompressible. So, flow rate will be same because mass equals rho Q. Rho is constant. So, your mass also constant. So, mass you cannot destroy.

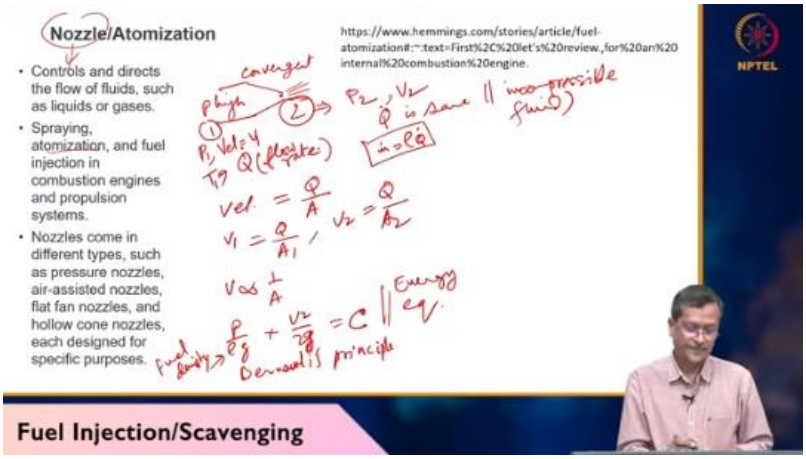
So, whatever mass is there at point 1, same mass will be at point 2, mass flow rate. So, I can say dot. Dot means flow rate. Derivation with respect to T. Now, what is happening at 2? You see this diameter is changed.

So, velocity equals flow rate divided by area. Now, V1 equals Q1 by area 1. V2 equals Q by area 2. You see the Q is same. So, area and velocity inversely proportional.

So, V proportionality 1 by A. Now, At point 2, because velocity increased, because velocity increased, the pressure will be dropping. How? P by rho g plus v square by 2 g equals constant Bernoulli's principle. Bernoulli's

principle says that p by rho g plus v square by 2g should be constant if we are assuming it is on same height z is constant okay c means constant g means acceleration due to gravity rho means density of fluid density okay fluid density of fuel density and p is pressure v is fluid velocity now if v is increasing p must be reduced then total term will be constant term means this is actually energy so total energy must be this is actually energy equation okay so total mass flow rate constant energy also constant when you are keeping energy constant velocity increase that means pressure must be dropping okay so here pressure is dropping okay and velocity increasing When velocity is increased, the particle will try to break because surface tension will be changing. Surface tension, what does it do? Surface tension will try to create a low surface area.

A flat particle you take, because of surface tension, it will try to minimize this surface area. it will be completely spherical shaped. now because of high velocity it will not be able to hold this spherical shape it will be breaking to smaller shape smaller particles and it will create a small spherical shape okay so breaking liquid of small droplet is called atomization so vaporization of liquid into gas will be done will be inside the cylinder okay so vaporization and atomization is different thing atomization means particle will be liquid vaporization means particle vapor or steam form in a non-premixed combustion system fuel is atomized in air before being burned the fuel droplets then vaporized in the high temperature environment in the combustion chamber vaporized fuel takes larger space



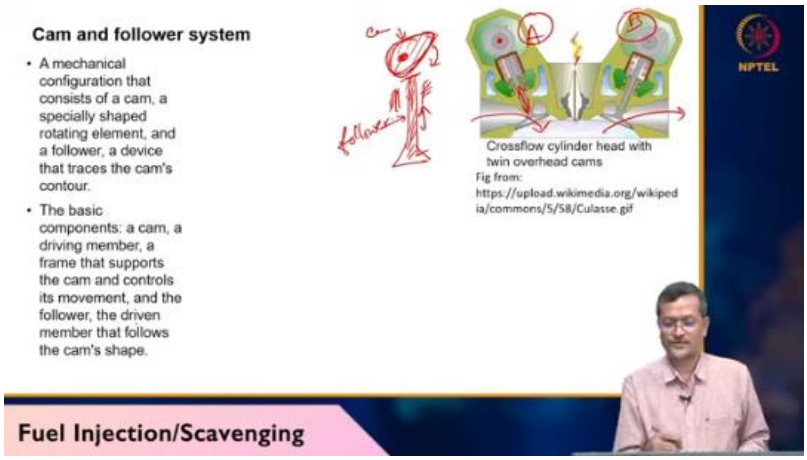
ok atomized fuel will take lower space because it is still liquid vapor vaporized fuel will take larger space because vapor will be expanding ok then atomized this displaced air dilutes the air fuel mixture for gasoline or petrol to be burnt in an engine three things need to occur it must be atomized gasoline gasoline or petrol or diesel also must be atomized broken into small small pieces then mixed with air then vaporization should be happening so carburetor will be preparing gasoline to make the phase change okay but in my diesel engine or diesel cycle i don't have carburetor i have direct fuel injection into the cylinder now you see this cam mechanism here cam is rotating you see the cam shaft is here cam is rotating cam shape is like this oval shaped almost like egg one side little bit thicker one side little bit thinner this is your center okay it is rotating and this is connected to your my cam sorry my inlet port and exhaust port so if cam is rotating it will be moving up and down you can see this one rotating moving up and down A, B. A is connected to your inlet port, B is connected to your exhaust port. So, fluid is entering here, fluid is exiting here.

So, both will not work together. One will be working first, then after that second one will be working. For example, when intake is happening, the exhaust should be closed. When exhaust is happening, intake should be closed actually. But in two-stroke engine, normally it will be almost overlapping.

That is a problem for two-stroke engine. So, CAM, so this is called CAM, this is called follower. A mechanical configuration that consists of a CAM, especially shaped rotating element, especially shaped, you can see this one, especially like egg-like shaped rotating element and a follower, a device that traces the CAM contour. So, this is follower, this is tracing the CAM contour. The basic components are CAM,

A driving member, a frame that supports. So, one frame must be there. This will be supporting the system. And it will be controlling movement also. And the driven member follows the cam shape.

So, cam will be the eccentric shape. So, driven member will be following the cam. So, disc and plate cam. This is a picture of disc and plate. So, this is plate.



You can see this one plate. So, disk and plate cam and here these are spring actually and these are guide. Now, I will go to scavenging. Scavenging means replacing the exhaust gas with fresh air-fuel mixture. charging supercharging in that case you injected air at higher normal pressure or higher pressure but it's convincing you're removing the burn gas replacing the exhaust gas with fresh air or mixture or fresh air in the case of direct injection engine for the next session so direct injection engine means like a diesel cycle you'll have fresh air but carburetor if you have then mixture air fuel will be entering

into the cylinder remaining exhaust gas can cause in proper combustion for the next cycle reducing power output for both two stroke and four stroke engine okay let's say this is my one engine two three four now if you're you are not doing scavenging some gas is remaining so the gas will not allow to enter fresh air into the cylinder so then your system is running, you are not getting sufficient amount of air and fuel mixture, so your total power amount will be reduced. Remaining exhaust gas can cause improper combustion. Most modern four-stroke engines use cross-flow cylinder head, so I will explain that one. Modern two-stroke engines use either Schuller scavenging, loop scavenging or uniform scavenging.

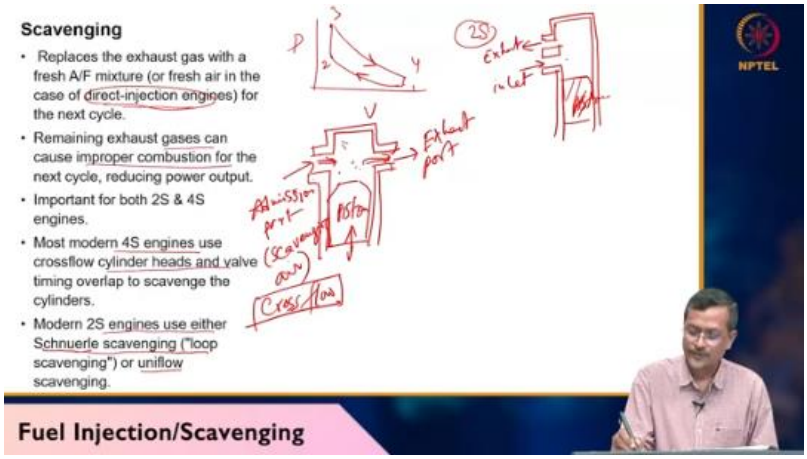
I think the pronunciation is surely. So, scavenging the term normally used for two-stroke engine. Four-stroke engine we have separate idle stroke. So, there burnt gas will be removed, but in two-stroke we do not have separate stroke. That is why this scavenging very much important for two-stroke engine.

Cross flow, there are three type of scavenging system in mechanical design. Cross flow system, loop scavenging and inflow scavenging. So, let us see one by one. So, one is like this. Piston head will be like this.

This is piston. Admission port. Scavenging air. And exhaust port. Piston will be moving up and down.

So, from admission port, air will be entering and it will be exiting. So, at the same time, air exiting and your burnt gas, fresh air entering, fresh air or air-filled mixture entering and burnt gas exiting. So, this is called cross-flow scavenging. Cross-flow scavenging system. So, another is loop scavenging system.

What is the loop scavenging system? It is like this. it is like this and piston is here okay piston is here piston and fluid will be entering like this entering inlet exhaust so fluid will be following this circular path okay uh so whatever fluid will be there inlet will be pushing this burnt gas towards exhaust okay this is called loop scavenging another is your uni flow scavenging in flow scavenging picture will be like this okay piston will be here maybe this is piston this time shading so that you can understand properly then inlet port inlet this is also inlet inlet and this is exhaust okay



So, inlet exhaust port will allow fresh air or air-fuel mixture into the cylinder and that will be pushing this burnt gas out of the cylinder to the exhaust port. This is called uniflow scavenging. Thank you very much for today's lecture.