MARINE ENGINEERING

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Lecture38

Components of IC engines - Part 1

Now, today's lecture is based on different component of IC engine. So, components can be your valves, your piston, your crank, your air system, air fuel system. Okay, so different component we will discuss one by one. so IC engine already you have seen its internal combustion engines combustion is happening inside okay so I have one system I already told that this is cylinder this is piston there will be one crank okay so this crankcase this is crankcase will be here actually okay piston part will be here and crank to piston there be connecting rod and connecting rod will be there okay this will there is one flywheel I think I was already spoken flywheel okay and shaft is here

okay and this is actually air cooled engine so air cool means one fan is there so fan is cooling the engine so later we'll discuss in details how to cool the engine if temperature is very high the system will not work so you have to reduce temperature so that system will be working safely because combustion temperature will go more than 2000 degree centigrade but your metal melting point temperature may be 1200 or less okay so then how will it sustain at 2000 degree centigrade you have to reduce temperature immediately combustion will be happening temperature will be going up immediately you have to reduce temperature otherwise your whole system will fail okay so to reduce temperature you will have cooling mechanism so combustion happening Okay, the detonation or burst will be happening. Immediately, pressure and temperature will be very high, more than 2000 degree centigrade. And there will be cooling water circulating or cooling air circulating all around the cylinder.

So, that will be taking away the heat. Now, you have seen the SI engine and CI engine. CI means compression ignition. okay so you should not forget you should not get confused with IC and CI IC means internal combustion CI means compression ignition so IC will contain CI plus SI okay internal combustion engine will contain both spark ignition engine

this is spark ignition okay so SI means spark ignition engine CI means compression ignition engine spark ignition means you are compressing certain amount of fluid or air-fuel mixture then you are giving one spark here okay then combustion will be occurring here lots of burning will be happening then you are expanding and you are getting power okay one two three four you have seen so spark will be happening around two that location in SI engine okay but in CI engine normally it will happen like this

compress it then burning will be happening no spark you are giving separately because of compression temperature will be very high that high temperature it will be auto ignition will be happening auto ignition means temperature very high automatically reaction will be happening so fuel air mixture you are giving into your cylinder so ic engine will have all this fuel burnt here okay then expansion then exhaust one two three So, this is CI engine. This is SI engine. So, you got the difference. In SI engine, you are giving spark.

Instead of compressing at very high rate, SI engine compression ratio will be 7-8 around. Low compression ratio, temperature rise will not be so high. So, it will not be auto ignited. So, you have to assist with spark. You give spark, it will generate heat.

So, that will be burning whole fuel. But in compression ignition engine, you don't have spark plug. If you see roadside vendors, lots of that sugarcane juice makers, all these things. Initially, when they are starting, they will be manually, they will be rotating the one shaft. So, those are basically compression ignition engine.

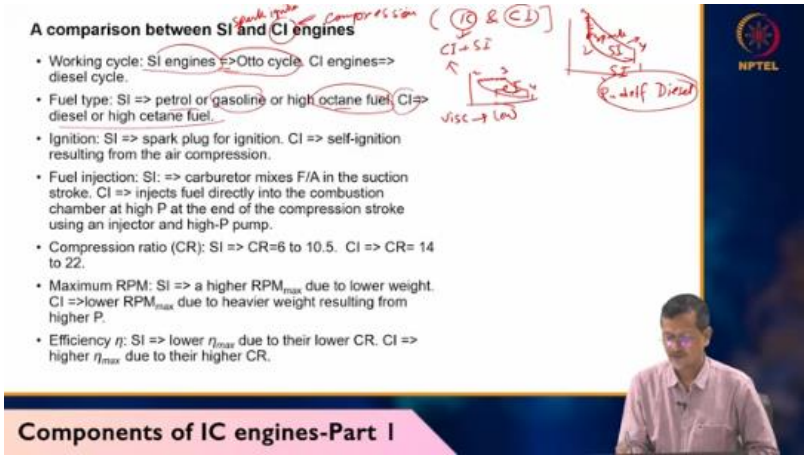
Compression, even older autos also. Chennai autos, if you see, sometime they will be taking one handle and they will be making like this. Okay. Those may be compression ignition engine. so initial compression they will be makes they will make making so that compression will be increasing lots of heat so that heat will give lots of energy okay

but my bike i have my scooter and i have auto ignition that spark plug okay electric start so actually they have spark plug okay so that spark plug will give initial ignition so that compression ratio will be lower okay but if it's a heavy engine truck bus or they will have larger compression ratio so normally they will be having diesel engine okay in some cases diesel plus spark also possible fine so si engine auto cycle okay this is linked as ci engine diesel cycle so you should remember so diesel cycle so diesel cycle may not be diesel fuel so this is diesel cycle because name rudolph diesel the scientist name i hope i'm correct correcting spelling okay and so this this person he developed this compression ignition engine when he was developing actually there was a big bust and it was supposed that he would be dying because of this bust so lots of disaster happened because of this one okay

in si engine fuel type normally petrol in America they say gasoline in india we say petrol okay

or high octane fuel. Later we will discuss what is octane, octane number. Many times you hear the term octane, cetane number. So later we will explain. Compression ignition engine, diesel or high cetane fuel.

Diesel or thicker fluid, viscosity will be higher. So petrol if you see, petrol is very light fuel. Light means viscosity will be low. very light density also i mean gravity also low but diesel fuel will have higher gravity higher viscosity so ignition si engine will have spark plug for ignition and ci engine will have compression okay so the difference you should know so si engine compression will be happening but spark also have to give okay without compression are possible if you see this figures pv diagram



okay so SI engine diagram also you see this one to two compression happening CI also one to two compression happening okay but CI compression happening plus temperature also increasing at very high rate so no need of spark plug fuel injection in SI engine carburetor will be there that carburetor will be mixing fuel and air and it will be injecting the fuel air mixture will be injected into cylinder okay so you have cylinder piston cylinder the cylinder mixture of air and fuel you are giving into cylinder okay f by a here i am writing this term fuel air mixture okay carburetor will be mixing fuel and air it will take fuel and air it will mix so inside cylinder it is not mixing rather before entering the cylinder mixing will be happening but ci engine what happening initially you take air compress it then when compression almost complete you give fuel okay inside cylinder so inside cylinder mixing will be happening okay so SI unit carburetor is there carburetor will be mixing it will be injecting your cylinders but CI engine take air compress it temperature very high then inject your fuel okay so injection method also we'll discuss later injects fuel directly into the

combustion chamber at high pressure at the end of the compression stroke so end of the compression stroke you are getting fuel in ci engine fine compression ratio here you can see si engine 6 to 10.5 so low compression ratio but you see ci engine compression ratio

14 to 22 so higher so temperature also will be higher almost double you can see six more than double okay so temperature also will be higher in ci engine okay in si engine because of spark you are creating fire maximum rpm assign it higher rpm possible and normally small engines will be two-stroke engine or si engine okay but heavy engines normally it will be ci engines like big generator set or like said gated communities are there for specific power application for high amount of power is required grid connection not there in that case normally gen set will be there big generator diesel generator set will be there those will be compression ignition engine okay those can be assisted by spark also but those will be compression ignition basically okay so compression ignition engine will be heavier because compression ratio is very high so compression is very high means it is producing very high pressure when high pressure is getting created then your mass cylinder and everything must be strong enough okay so it will be heavier engine but compression is lower in si engine that means you can make lightweight engine okay so efficiency si unit SI engine lower due to their lower compression ratio CI higher so efficiency lower because of another reason many cases it will be like two stroke engine will be there so two stroke engine will be smaller size and lots of fuel will be unburned so in that case also losses possible but if it is four stroke engine then fuel will be completely complete combustion will be there so efficiency performance will be increasing

So, this is the basic difference of CI and SI engine or auto cycle and diesel cycle. This diesel does not mean the diesel fuel. This diesel is a cycle. Cycle means 1 to 2. When point 2 is reaching, you can see in diesel cycle, it is getting maximum pressure and combustion will be occurring at constant isobaric process combustion.

But in SI unit, combustion is isochoric. Its volume is constant. okay so but other processes are almost same okay compression isentropic process expansion isentropic process exhaust we are assuming iso volume isochoric process okay only the combustion process si unit vertical this is isochoric process in ci engine it is isobaric process so engine governor engine governor means in flywheel what you have seen in flywheel if it is flywheel a very heavy mass heavy metal now flywheel the purpose is to reduce fluctuation every cycle right we already explained that flywheel when it is rotating shaft is connected here okay and shaft is rotating this flywheel heavy mass so heavy mass will be storing energy so that storing energy

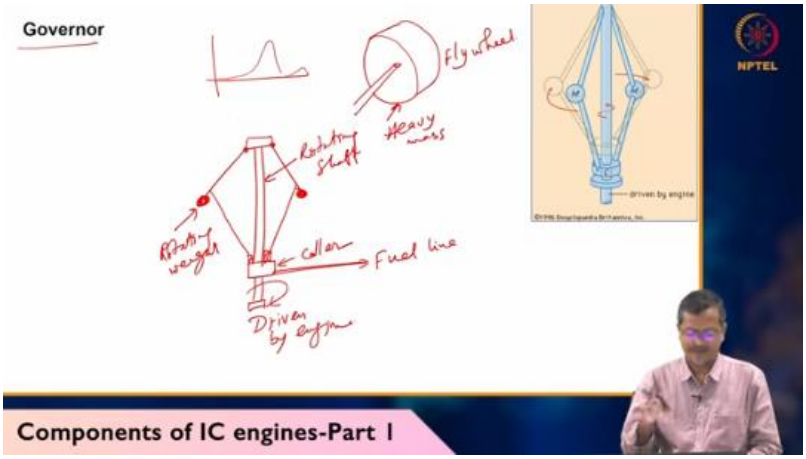
when piston getting power stroke it will be storing when it is not getting power stroke rather it will be doing idling stroke or compression stroke it will be supplying energy okay so each cycle it is supplying energy okay it is not related to your let's say overloading scooter or car or truck overloading so that whether that overloading happening or not happening flywheel does not care its purpose basically to reduce fluctuation in every cycle ok 70 degree for CI and 360 degree for two stroke engine so every cycle it will be reducing your power fluctuations ok or torque fluctuations but governor governor say you are driving your vehicle 60 km actually few years back Maharashtra government put one rule for commercial vehicles like say every vehicle must have one governor why so their purpose is that high speeding to reduce the high speeding vehicle okay if driver is trying to put vehicle let's say more than 100 kilometer or 200 kilometer so automatically fuel supply will be cut because of engine design because of governor say governor then what will happen engine power supply cut fuel supply cut so i say engine is not getting fuel so speed will be dropping

okay so maximum speed can be limited using this mechanical or electrical governor system so governor is not controlling power in every cycle every pv diagram that cycle right but governor will be helping when you are having overloading or you are having very high speed so that time it will say don't run at that speed so it will cut fuel supply done okay so how does it work so governor will have one two balls like this okay and one stem stem will have okay so there will be one stem here one rod here it will be connected here okay now this is rotating weight and this is rotating shaft this is rotating mass okay this is rotating shaft this is a drivetrain and driven by engine and this is called collar now this will be connected to fuel line so what happens this shaft if you rotate this vertical this rotating shaft is there if you rotate vertically the two balls are there one ball is here

it will be going apart from this central shaft okay when it is going apart from shaft so you see this collar will be lifted up because of you are rotating at very high speed collar will be lifted up when collar is getting lifted up it is connected to your fuel supply okay so this fuel supply will be cut automatically so when if your engine driven by engine so engine speed is increasing this means your balls will be moving further away okay when it is moving away collar will be lifted up your fuel supply will be cut if your engine is rotating at lower speed you are speeding high speeding at lower speed then fuel supply will not be cut So your system will be moving smoothly. So this is called engine governor. So this governor can be used here for steam turbine or other high speed machinery where you feel that at higher speed there will be problem of failure and safety aspect also will be there.

At very high speed something can be broken. It can be dangerous. So that's why engine should be fitted with governor. So this is called engine governor. So difference between flywheel and governor is that flywheel will be controlling every cycle.

But when you are going for over speeding vehicle or anything, so flywheel will not take any action. It will ask governor you do this work. Piston and piston rings. So every time I told that there is one piston and cylinder. So here is one piston.

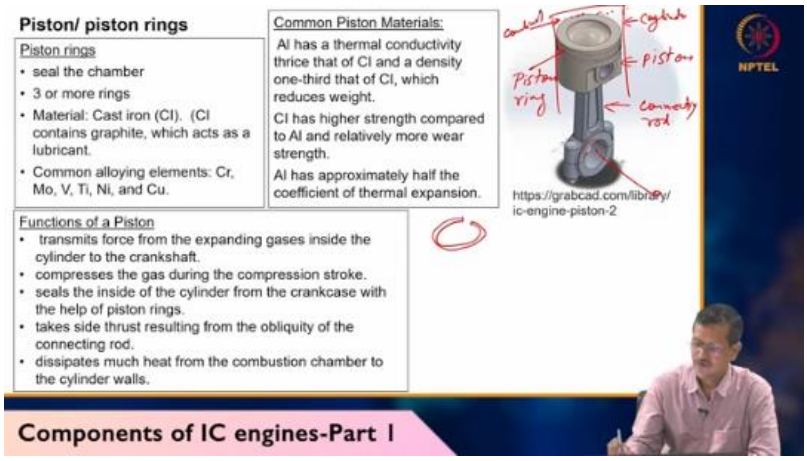


This is called piston. This is connecting rod. so there will be ample videos and youtube videos will be there just you can watch how ice engine working okay lots of animation videos will be there and these are called piston rings okay piston rings are like this metal ring okay it will be metal ring and your cylinder is here so if and this one connected to your crank actually if you rotating if you are rotating crank piston will be moving up okay crank rotating piston moving up and down

and this is cylinder okay and okay so piston seals the chamber so combustion will be happening here combustion or reaction will be happening here it will be creating very high pressure so high pressure gas should not enter into your this lubricating oil chamber or crankcase okay so high pressure the burn gas should not enter into the crankcase through this leakage area okay so the purpose of piston it will be sealing properly okay and three or more rings will be there So purpose of ring. Purpose of ring is that when piston is moving up and down, it will be having friction. Because of friction, piston will get wear and tear because of high temperature.

And your casing also will have, not casing, you can say cylinder. Cylinder also will have wear and tear. So what piston ring will be doing? Piston ring will be separating this piston and cylinder because small amount of gap. So, the ring will be sliding over this cylinder.

So, if after long time, let us say 2 years, 3 years, 4 years operation, ring will be wet out, ring can be changed, but your piston may be more expensive, you should not change. And your cylinder also, cylinder inside there will be one liner. I will discuss later. So cylinder is there. So inside there will be one metal sheet inside.



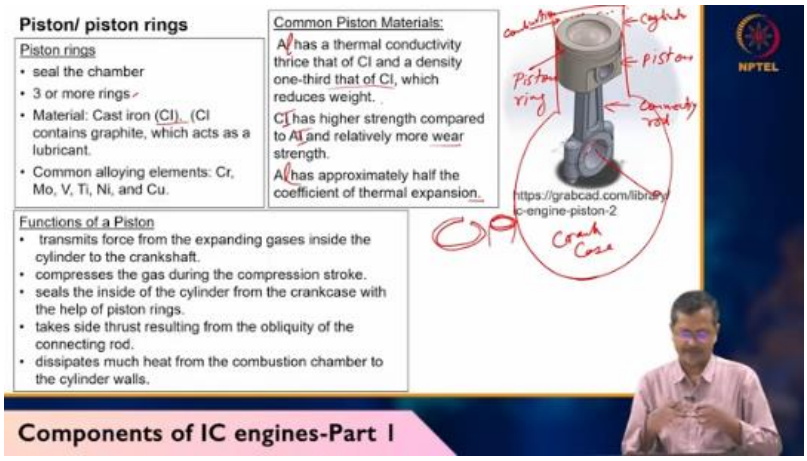
They will be press fitting. They will be taking the sheet with hammer. They will be inserting inside this cylinder. So ring will be touching one side piston, another side your liner. Actual cylinder will not be touched.

Because after 2 years, 4 years, 5 years your liner can be replaced your ring can be replaced your cylinder you are not changing cylinder will be more extensive okay you are not changing cylinder and your ring more cheaper change it piston don't touch okay that's why they'll be putting piston ring and that liner inside cylinder liner will be there okay so normally this piston rings will be cast iron based okay or maybe some alloy also possible cast iron normally they will be using because graphite will be there and when piston is having that up and down motion there will be friction if there is a wear out of piston ring also gradual small amount of so that will having that graphite graphite can work as a lubricant okay you know lubricant lubricant means it will be reducing your friction between two surfaces when two sliding surfaces are there to reduce friction

so you can use graphite or any oil long chain hydrocarbon you can use so the friction will be reduced your energy loss will be reduced so graphite also can act as a lubricant okay that's why they will be using cast iron cast iron means it will be having higher amount of carbon if you go to steel steel will have lower amount of carbon okay common alloying element chromium molybdenum okay this you can remember piston material aluminum it is not ai it is al these days ai is very common so you should not assume this ai this is aluminum so aluminum has thermal conductivity thrice as ci so and density one third which

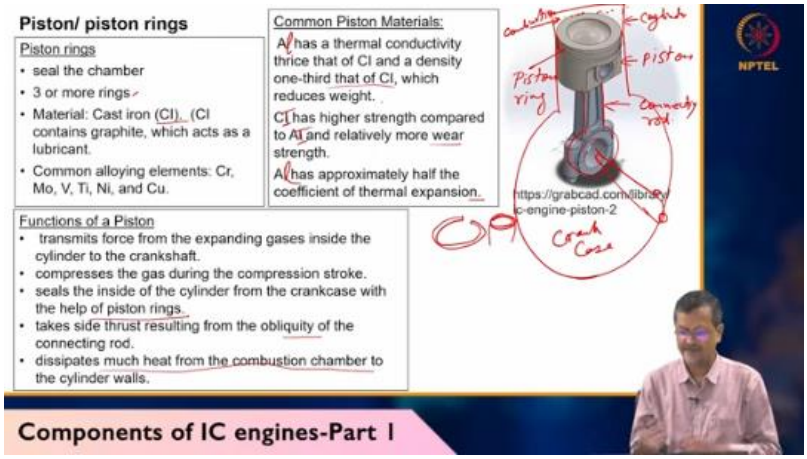
reduces weight so piston weight will be reduced if you are using aluminum but its melting point is lower that is one issue so cast iron CI, cast iron has higher strength compared to aluminium and relatively more wear strength. Aluminium has approximately half the coefficient of thermal expansion. Why thermal expansion is important?

If you have different thermal expansion and too high thermal expansion will be there, so certain uh size piston you select and if it is expanding too high then it will be rubbing too much okay so you are not allowing that excessive rubbing okay you design certain way and that is working properly that's fine but because of temperature changes if your piston size or any dimension changing the rubbing action will be more so energy loss will be more okay why rubbing will be creating more energy loss because if you know if you remember the friction formula mu n n means force mu is friction factor right n means amount of force if you are increasing then your friction force will be increasing f equals to mu n right the function of a piston transmit force from expanding gas inside the cylinder to the crankshaft so this is connecting rod below of the piston whatever i have shown here this is connecting rod okay and crankshaft is not shown here crankshaft will be like this okay somewhere it will be rotating compresses gas during compression stroke seals the inside of the cylinder from the crankcase with the help of piston rings okay so piston ring will be helping you to seal properly



take side thrust resulting from oblique connecting rod okay when connecting crank is rotating so connecting rod will have side motion okay because of side motion piston should not give extra force to your cylinder so that force also should piston will be holding actually dissipate much heat from the combustion chamber to the cylinder wall so as much as possible if it is transferring heat it is better if it is not heating then heat accumulation will be there so when heat is getting accumulated temperature rise also will be higher so higher

temperature rise means again melting point will be issue so you when combustion is happening the t3 p3 point if you see this one two three four so third point actually maximum temperature point right so maximum temperature when occurring it should not burn so immediately you have to remove that gas or you have to cool it otherwise it will be a problem okay cylinder and liner cylinder material it should be strong enough because cylinder will be holding inside liner will be there so liner like this type of thing okay so piston cylinder you have so this liner you fit inside here okay tight fit maybe with hammer you press inside okay it's a liner uh so it'll be strong enough cylinder will be strong enough to instant high gas pressure should also be strong enough to instant thermal stresses should be hard enough resist wear



due to piston movement so hard here hardness term comes actually hardness term is hardness is the resistance to localize plastic deformation caused by pressing or abrasion so whenever we say hard material hard material actually because in material science the definition is that it will be resisting plastic deformation they say the complete screen is there if i put it if it is not denting anything this is a harder material if it is denting this is not harder okay So, surface finish should be good to reduce friction during the piston movement. So, surface finish means normal surface will have some roughness. So, if you make avery good surface finish, and low roughness, then friction will be lower.

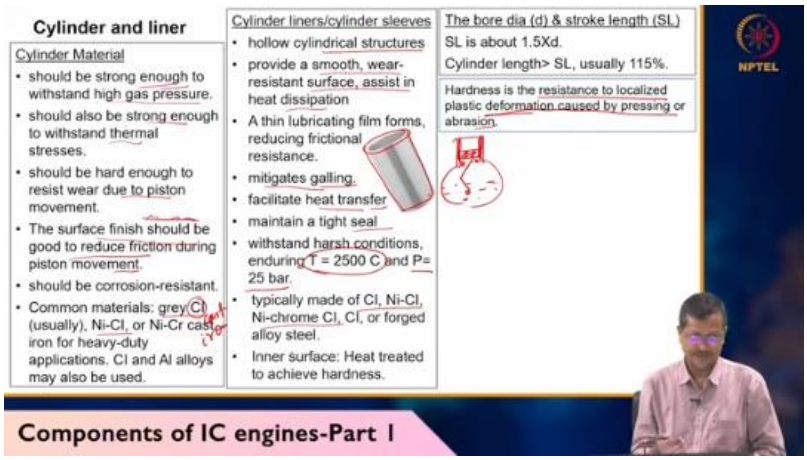
So, especially your liner surface roughness should be lower. Common material, you can see, you should remember all this gray cast iron, nickel cast iron, nickel chromium. This is cast iron actually. you should not confuse with compression ignition okay cylinder liners it is called cylinder sleeve also okay hollow cylindrical structure provide a smooth wear resistance surface assessing heat dissipation so whatever heat will be generated must be dissipating as soon as possible so thin lubricating film will form reducing friction resistance

so how it is getting lubrication so when piston is moving up and down you see piston and crank is here it is filled with lubricating oil because of high crank rotation the lubricating oil will be getting splashed okay when it is getting splashed this wall will be soaked below the piston area wall will be soaked when piston is moving up and down the soaked lubricating oil will also be reaching the surface of the liner so it will be reducing friction actually it will take some heat also when

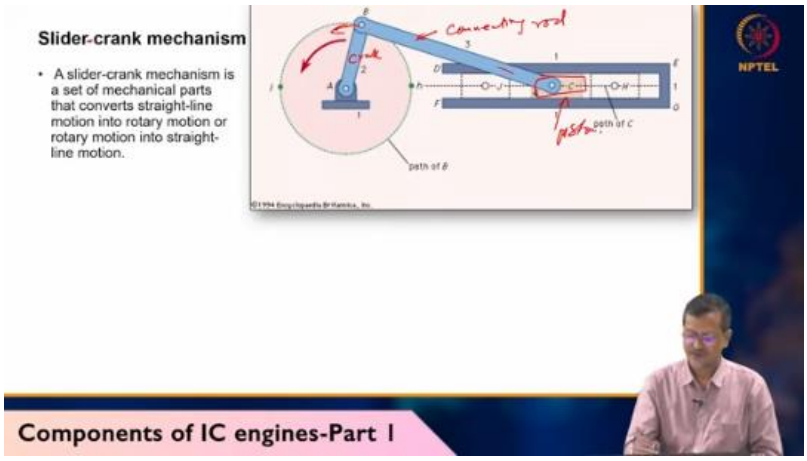
lubricating oil is getting splashed over the cylinder or liner so it will be falling down so it will be washing away some heat and it will not allow higher friction okay friction means heat generation so the final form of any energy is heat generation so friction is happening means you are generating extra heat so our purpose is not to produce more heat already using combustion we got lots of heat so we have to dissipate now as soon as possible but if you are getting more friction again there will be problem because already heat is there you are adding more heat so just you have to avoid friction as much possible okay So, a thin lubricating film forms to reduce friction. We will discuss later when we will discuss about lubrication, how thin film is getting formed. Later we will discuss.

Galling, mitigate galling. Galling means actually when two metal surfaces are sliding, if force is very high and you are sliding, one metal is sliding over another, what will happen? Because of friction, temperature is very high. because of very high temperature may be some area will be melted okay like two ice you do like this and leave it joint right similar way when two surfaces are sliding over each other at with very high force very high friction so some point this metal or this metal will be melted melted and a few second again this will be solidified so one metal or both metal got melted solidified what will happen both will be joined actually welded okay small welding possible we call galling okay so facilitating so yeah cylinder liner will be facilitating heat transfer tight sealing will be so you see this temperature temperature will be around 2500 degree centigrade very high but your aluminium or iron melting point maximum 1200 degree

600 to 1200 within that one so that means immediately you have to remove your heat from engine okay so same issue comes for your gas turbine engine also we'll discuss later when we'll discuss about gas turbine so they're also temperature will be very high so that reduce temperature you have to reduce immediately okay and pressure also 25 bar so normal pressure is 1 bar that is 25 times okay typically carbon cast iron, nickel cast iron, nickel chromium cast iron, all these things can be used for your cylinder liner. Inner surface of the cylinder liner can be heat treated to achieve hardness. So, less deformation will be happening, plastic deformation. And what is the size?



Normally bore diameter, bore diameter means this diameter. stroke length the piston will be moving up and down so that stroke length the relationship is about 1.5 times of D okay and the cylinder length more than stroke length okay usually 115 percent more than 15 percent okay so we have seen this piston is moving you can assume this one crank this one connecting rod this is your piston okay so if you want to discuss details about how much angle how much rotation so that discussion we are not doing in your class because we have limited time slot for this IC engine first you should understand how things are happening if you rotate this crank okay your connecting rod will be pushing this piston okay so piston is sliding so the mechanism called slider crank mechanism okay The slider crank mechanism is a set of mechanical parts that converts straight line motion into rotary motion. So crank is having rotary motion and piston is having straight line motion.



So the technical term is slider crank mechanism. And this is actually cylinder, combustion cylinder, rice engine cylinder.