Surface Facilities for Oil and Gas Handling

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Introduction to IC/CI Engine-01

So, piston displacement formula. So, piston displacement formula again you draw this curve piston cylinder d c diameter of cylinder ok and s will be stroke length stroke length diameter ok. Diameter of cylinder inner inner side not outside ok, but if outside diameters of cylinder is given you have to check wall thickness. If you are not checking wall thickness then things will be wrong calculation will be wrong ok. So, piston displacement is d c square s into rpm or N by 2200 single acting cylinder head and displacement ok single acting. So, what will happen yesterday I told like left side volume right side volume right.

So, in that case p d will be d c square d r square s rpm divided by 2200 ok d r is rod dia. If you are using all inch then it will be inch this will be also beinch d c rpm s will be also in inch ok. So, all your and p d this c f m cubic feet ok inch inch 2200 for unit conversion I think. So, double acting this is single acting this is also single acting double acting this double acting I will write different formula because 2 d c will be coming.

This is head end this is crank end what is head end crank end head end means this side crank end end means this side ok double acting you have making it will be this side fine. So, I am although seal there will be no gap I am showing here gap. So, that figure will be clear ok. So, this is single acting. So, double acting if we make.

So, then we have to add directly you have to add right. So, p or p d we write better p d equals 2 d c square minus d r square s rpm by 2200. So, you see this head end and crank end both are added only ok. So, unit I do not have to write again. So, one more formula is there q a f t cube per minute equals e v p d.

So, e v is volumetric efficiency if you have clearance piston and cylinder some gap is there. So, some volume will be lost ok. So, that is e v. So, volumetric efficiency is there and guess through ok. Another formula is they have given q g equals 35.

4 q a p s T s Z s ok. So, gas throughput standard condition SCFM gas throughput standard condition ok. This is suction temperature and p s the pressure and Z is compressibility this is not T s this is Z Z s compressibility. We will go to the problem simple problem actually ah. See in a reciprocating compressor the sweat volume.

So, first you have to draw the compressor and p v diagram ok. So, V s or S w you write ah, compressor volume 0.9 times maximum volume 0.9 into V 1 how what is V 1 p v and if I draw like this ok V 1 2 3 4. So, 1 to 2 compression.

So, V 1 is the maximum volume. So, total maximum volume is given V s w equals 0.9 V 1 ok. So, what is the clearance ratio this is C V c this gap ok. So, V c by V s they are asking fine.

So, V 1 equals V c plus V s w correct. So, total volume. So, V s w equals 0.9 V c plus V s ok. So, V c equals V s w minus 0.

9 V s w divided by 0.9. So, this is giving 0.1 by 0.

9 V this w. So, V c by V s w equals 1 by 9. So, equals 0.11 ok. So, this is your answer. So, simple mathematics nothing else there is no complexity actually ok.

A few minutes are there I will try to use prime mover, but so prime mover. So, prime mover this will be driving your palms compressor surface systems ok. So, there may be gas turbine system there will be reciprocating engine steam turbines also there, but normally it is not used steam turbines used to be heavier system and electric motors are

not considered also for as a prime mover. Although motor can be used, but the in the as per definition it is not included in prime mover. Now, before going through this gas turbine reciprocating engine you have to know the definition of power torque ok.

So, although you may be knowing the p equals T omega you should remember power equals torque into omega omega means rpm of the system ok. Other definition also the force power pressure load all this definition actually you should remember ok everything we may not teach, but those are basic thing you may you are learning from plus 2. So, you should remember ok. First I will start with reciprocating engine reciprocating engine actually you have seen in your cars bikes these days trains also their diesel locomotives not aircraft engine aircraft engine they use gas turbine engine actually. So, same reciprocating engine is used for your genset normal household applications or like societies they are using this very commonly used power producing system it will be requiring diesel or petrol normally in India and those will be producing torque.

So, torque will be used further ok torque will be transferred through shaft and there will be motor, motor will be converting generator will be converting electricity or may be in many cases directly that shaft torque will be used for pumping fluid or compressing fluid or many other purposes. So, reciprocating engine. So, reciprocating engine it will have piston crank case ok it is called crank case ok it will have again piston cylinder same way you have seen your compression system or pumping system it will have one ok this is called crank ok this is called connecting rod connecting rod this is called piston this is cylinder ok and there will be a valve arrangement also 1 valve 2 valve arrangements it will be giving one wave flow ok the main purpose of valve is one wave flow like in your heart also there are there will be valve right. So, those will be given one wave flow not both way and there will be may be spark plug ok. If you see any IC engine this will be the basic structure ok there will be 2 stroke engine 4 stroke engine auto cycle diesel cycle some engine or some system will be taking diesel 2 stroke ok some will be taking petrol and these days methanol operated vehicles IC engine also available ok and crank will be filled with lubricating oil ok.

Lubricating oil means long chain hydrocarbon long chain hydrocarbon already you know right long chain hydrocarbon it will give smooth operation of the system it will be reducing heat generation. So, it reduces heat generation and friction ok. So, when crank is rotating at very high speed it will be splashing everywhere inside this chamber and it will be taking away heat and it will be reducing friction. So, that will be it will be

helping. So, all the engines should have this lubricating oil chamber ok if your system is not having proper lubrication or there is some leakage or it will not change lubricating oil for long time then engine will get heated up.

So, engine may not start again or there will be some other issues ok. So, when crank is rotating let us say O A B when A is rotating in cyclic order ok in cycle. So, piston B will be moving up and down ok it will be moving from where to where T D C the same term here you can use B D C ok. So, one revolution one time up one time down ok two revolution means two time up two time down ok. So, this is the basic principle of any IC engine you see in motorcycle, truck, bus, your diesel locomotives everywhere, but not in aircraft engines because these are little bit heavier small compact you can make, but aircraft engine they need lighter ok.

So, lightweight system it will be heavier that is why they do not use they use gas turbine system ok. And piston also will be made like this it will have piston rings ok, Gaussian pin and this is connecting rod ok this sort of lots of arrangement is there. So, we will not go through the details how they are making, but we will try to see how these things working ok. So, that you should understand what is two stroke engine, four stroke engine, what is emission. So, reciprocating engine or IC engine internal IC engine means internal combustion engine.

So, all the truck, bus those are having IC engine internal combustion engine ok combustion engine, but CI engine also term used CI means compression ignition ok. What is compression ignition actually IC engine will have two part only be spark ignition only be compression ignition ok. So, another will be spark ignition engine ok engine that is spark ignition ok. I will explain what is that later ok spark ignition ok. There will be IC engine, CI engine, SI engine right spark ignition engine.

There will be two stroke engine, four stroke engine. So, many time in Chennai if you go outside some autos will be bring too much noise and lots of white smoke will be coming in from the tailpipe ok, but many autos will be there will be noise will be low and there will be no smoke or anything ok. So, that says that two stroke engine, four stroke engine. Two stroke engine will have lots of noise and lots of smoke coming out. Four stroke engine will have complete combustion.

Even I think in the in Chennai government order is there all the autos should be four stroke engine. So, that emission will be lower emission means when lots of smoke coming that means, hydrocarbon whatever fuel you are giving that is not burnt completely. Not burnt means lots of hydrocarbon will be there NOx will be there may be carbon monoxide will be there. So, incomplete oxygen supply is there that is why white smoke or hydrocarbon vapour coming out. So, hydrocarbon vapour coming out means all fuel not burnt that means, fuel did not get proper oxygen that means, some carbon will have carbon monoxide also.

Carbon carbon dioxide is not harmful actually. Although it is a green house and other thing, but all the engine designers will try to produce carbon dioxide. So, carbon dioxide will not give you a problem ok. Carbon monoxide is having severe problem. So, our target will be to produce carbon mono carbon dioxide not carbon monoxide ok.

So, carbon monoxide when you are producing that means, fuel not burning that means, all energy you are not consuming you are giving hydrocarbon in the atmosphere you are giving carbon monoxide in the atmosphere. So, all the things are wrong. So, autos and other vehicles government is saying we do not use 2 stroke engine use 4 stroke engine. 2 stroke engine has their own beauty many places people are using also 2 stroke engine will be very much compact ok. 4 stroke engine will be little bit heavier ok.

Now compression ignition and SI spark ignition engine. So, compression ignition engine actually there will be no spark plug ok no spark plug, but SI engine there will be some compression, but then you are burning fuel using one spark plug a bike and car you will have spark plug ok ah. So, because electric start is there right. So, those you are creating small spark to burn fuel. So, how the fuel will be burning you have piston cylinder arrangement right ok.

Inside you take air and you take small amount of fuel calculated amount of fuel will be injected inside cylinder ok. So, air and fuel mixture you give inside and you compress when you are compressing what will happen temperature increasing and high temperature if you increase temperature very high rate very high let us say 2000 1500

degrees automatically the fuel will be burning chemical reaction will start high temperature chemical reaction will start right. So, chemical is that is called compression ignition engine you are not giving any spark. So, compression ignition engine will have high compression ratio high compression ratio it will have compression ignition engine ok, but you are thinking about spark ignition it will have lower compression ratio ok. You compress up to certain level then you give some fire source instead of compressing and increasing temperature ok.

You have one cylinder you put air oxygen mixture now it is a compressible mixture now it needs some spark small means small amount of fire if you give it will start reacting it will give exothermic reaction exothermic reactions lots of heat will be generated that heat will be giving it will be going to another particle another particle. So, whole thing will be getting burnt ok that is spark ignition engine, but in compression ignition engine you are not giving spark you are not giving any fire you are compressing. So, high level. So, PV nRT. So, T will be increasing at very high pressure pressure increasing temperature also increasing volume compressing.

So, temperature will be very high. So, at that high temperature reaction will start ok. The hydrocarbon reaction will start and it will burn it will give power ok. So, you have to go now ok. To understand the IC engine how this is working you have to understand PV diagram again like compression system you have seen. So, PV diagram how can I draw a PV diagram and my piston cylinder arrangement will be like this ok.

So, a piston will have TDC here, TDC here, BDC here and pressure volume piston let us say my piston is here now at this moment and you are starting compressing, compressing whatever gas is there ok. So, cylinder is here cylinder this is piston ok. So, initially you take certain amount of air and fuel mixture A plus F ok. Now you start compressing 1 to 2 ok. So, once compression completes then there will be combustion.

Combustion means after compression very high temperature will be created then your burning will be happening and you reach 1 to 2, 2 to 3, 2 to 3 this is combustion process or heat addition process. Once heat addition done the piston will be moving from BDC ok. So, 1 to 2 means piston is moving BDC to TDC then 2 to 3 combustion will be

happening. So, there little bit volume also will be increased. So, piston will be moving rightward ok then your crank connected here.

So, crank will get power ok. So, the gas will be expanded 3 to 4. So, what is the process is happening? Initially it takes certain air and fuel mixture compress it to 2 then 2 to 3 combustion will be occurring or burning of the gas whatever air and fuel mixture is there inside cylinder then 3 to 4, 3 to 4 will be expansion of the gas. So, when expansion is happening that is called power stroke ok. So, one IC engine system this one cycle 1, 2, 3, 4 will have one power stroke, one compression stroke compression stroke this is heat addition heat addition this is called exhaust ok. What is happening piston is moving from BDC to TDC you are compressing to 2 when piston reaches to TDC burning will be happening.

So, burning will be happening means lots of hot gas will be created hot gas will be pushing piston towards BDC when piston is moving towards BDC complete combustion will be there at 3 from 3 to 4 piston will be pushed further towards BDC ok. So, that is called power stroke and both cases PV equals PV gamma equals constant PV equals PV per gamma equals constant adiabatic process we are assuming this is very fast process ok. Exhaust we are assuming this is isobaric process isochoric means isovolume process and heat addition process is isobaric ok PV equals constant or entropic constant entropy also constant ok. Now, ok this is this I have shown two stroke engine actually. Now, initially you take air fuel mixture you are compressing and after burning piston move backward now what will happen backward move, but it did not open any valve.

So, all the burned gas inside the cylinder then how the gas will go out. So, what will happen then you will have one port here V1. So, you have to open V1 so that all the gas will be going out. So, piston will be moving towards TDC again ok 1, 2, 3, 4 say 5 ok moving 5 all the gas will be going out again piston will be going back towards BDC when BDC is going again all air fresh air will be entering plus fuel also be entering ok.

So, what is happening OA. So, this A point when you rotating so one time it will be moving to TDC one time it will be rotating to BDC. So, what is happening you have one power stroke and piston moving from BDC to TDC compressing then TDC to BDC burning then power stroke again moving towards TDC you are removing all the burned gas from the cylinder again you are moving towards BDC you are taking air fuel mixture ok. So, this crank will be rotating two times you see this crank rotating two times one

time going one time going two time going means two time rotation. So, two time crank rotation ok but you are getting one power stroke ok. So, this is four stroke engine four stroke ok four stroke engine means one power stroke ok one power stroke means 3 to 4 one compression one one stroke compressionone exhaust one suction suction of air field ok.

So, four stroke engine crank will be rotating two times, but you are getting one time power stroke, but you can see all gas will be going out and fresh will be coming into cylinder there is no mix up of air field coming in going out ok. So, this is called four stroke engine again auto cycle, diesel cycle, auto cycle PV diagram will be like this 1 2 3 4. So, in auto cycle heat addition heat addition is constant volume ok diesel cycle diesel cycle heat addition constant pressure process ok. So, there will be many other cycles.

So, most common diesel cycle auto cycle. So, diesel cycle compression be occurring then when combustion occurring. So, that time piston be pushed backward and you will get power stroke, but in auto cycle you are compressing then at constant volume process heat addition or burning will be occurring then your piston be moving backward. So, you are getting power stroke. So, here also power stroke ok. So, power stroke and compression stroke these are not changing only the heat addition it is constant pressure or constant volume that is changing only.

And if I draw in T S diagram temperature entropy and temperature T S, S means entropy ok. T S diagram if I plot this one this PV diagram. So, it will be like this 1 2 2 is compression process compression means is an isentropic entropy constant ok. Then 2 to 3 heat addition heat addition means temperature increasing increasing increasing ok and 3 to 4 3 to 3 isentropic process again. So, entropy constant vertically down then 4 to 1 4 to 1 again heat rejection process of temperature must be going down ok.

So, 1 2 3 4 ok. So, in exam I can give draw T S diagram or from PV diagram or T S diagram is given can you draw PV diagram ok. But if I draw for auto cycles T S diagram T S the 1 2 2 is isentropic process 1 2 2 2 to 2 3 heat addition temperature increasing temperature increasing 3 3 to 4 again constant entropy 4 to 1. So, both curve almost similar ok. So, all these are 4 stroke cycles. Now I will go to 2 stroke cycle.