Surface Facilities for Oil and Gas Handling

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Horizontal and Vertical Separator: Numerical

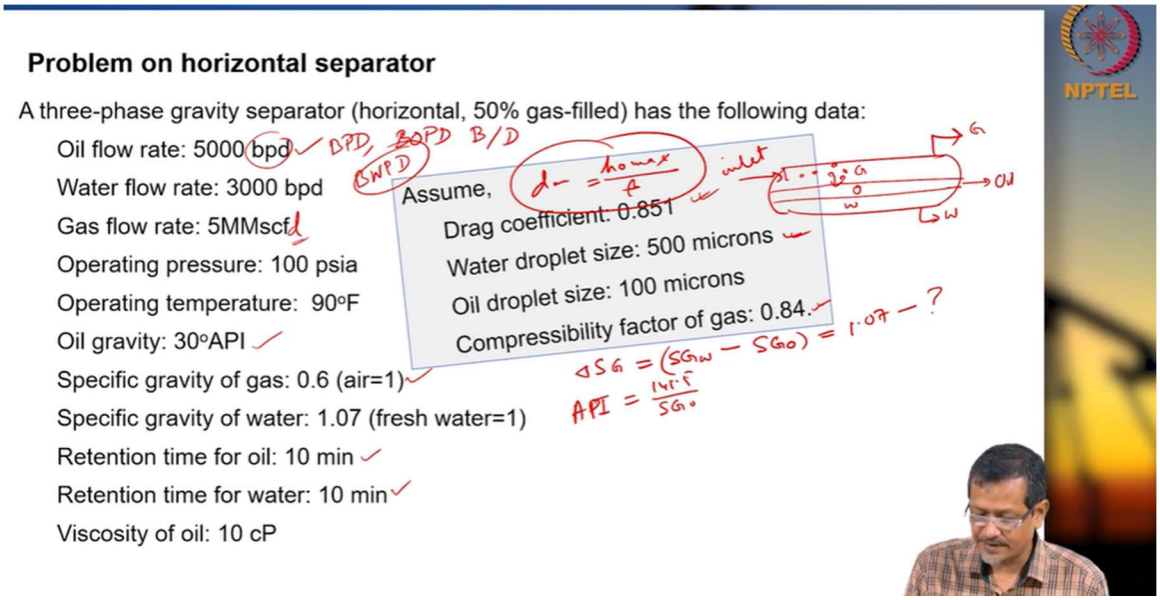
Good morning everybody, we have seen the formulation for horizontal separator and vertical separator ok. And we have done some calculation for vertical separator also. Today I will try to do some calculation on horizontal separator and I will try to formulate something which is not which is not following the specific rule whatever I followed till time like if separate is filled by lower amount of liquid or maybe higher amount of liquid then the 50 percent gas fill or 50 percent liquid fill formula will not hold. So, in that case we have to change the formula. So, how to change the formula we will discuss in this lecture ok. So, numerator for problems basically on horizontal separator because vertical separator discussion already done ok.

And it will be 50 percent gas filled or you can say 50 percent liquid filled because ok. So, if I have any separator 50 percent will be liquid 50 percent will be gas ok. And when 50 percent liquid it will have again two layers one will be oil one will be water ok. So, this way we will try to calculate some given data will be there and based on that you have to calculate separator size seem to same length and slenderness ratio ok.

50 percent liquid here liquid means oil plus gas oil plus water ok 50 percent gas we are considering ok. Let us see the problem. A three phase gravity separator horizontal we are assuming ok. We are assuming horizontal separator and this three phase three phase means I will have oil layer oil and I will have water layer also and gas and gas will be going out and oil I have to take here and water ok. And inlet will be here just I am not drawing any other specific equipment for example, wave breaker or anything.

So, just is we are assuming there is nothing it is a simple separator and we have to calculate

what will be the approximate size for diameter approximate length seem to same length and effective length of separation ok. We are assuming oil flow rate 5000 barrel per day again this unit you can write BPD BOPD or B per D or barrel per day in full form. So, anyway capital letters small letter you can write ok. Water flow rate 3000 barrel per day or BWPD also you can write ok. So, many books will be using different type of symbols.



Gas flow rate MMSEFD D should be there 5 million standard cubic feet per day, per day means we are writing D term. Operating pressure 100 psia absolute pressure operating temperature 90 degree Fahrenheit oil gravity 30 degree aps specific gravity 0.6 and we are assuming is related to air specific gravity water fresh water if we assume on then little bit higher gravity is there whatever water you are using. Retention time 10 minute and retention time 10 minute for both oil and water viscosity we are assuming oil viscosity we are assuming 10 Cp and we are assuming some more data like drag coefficient 0.

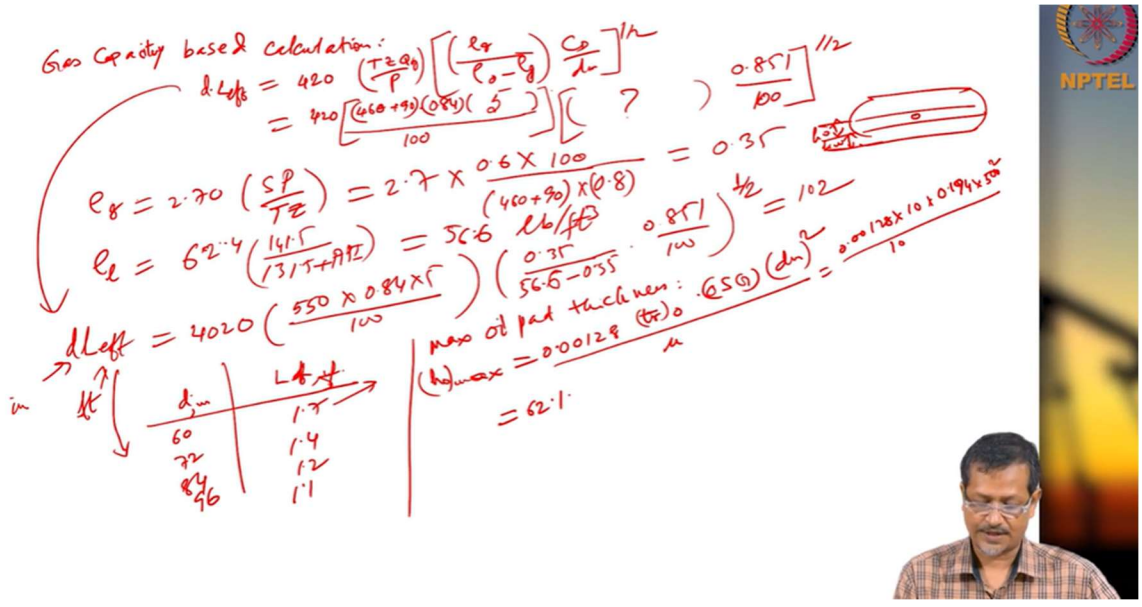
851. So, normally it will be it done calculated using iterative process, but presently just to for simplification I am giving one value drag coefficient. If we and if we ask you to calculate drag coefficient then actually you have to start CD value that coefficient of drag. So, that value 0.34 you are assuming you are calculating Reynolds number again you are calculating back to drag coefficient. So, that iterative loop will be very much longer.

So, I am not going through that route rather I am giving just drag coefficient. So, that you can do step by step calculation. So, I will assume in exam also you do step by step

calculation and solve the problem. Water droplet size 500 micron. So, we are assuming little bit bigger water droplet, but oil droplet falling when inlet fluid is there oil water droplet will be there.

So, water droplet if it is higher it will be falling quicker, but oil drop water droplet will be quicker falling, but oil droplet it will be slower. So, based on this oil droplet calculation we will do the initial gas capacity based calculation, but when we are calculating for oil and water layers. So, in that case we will assume that water particles are there in oil and it is falling down and in that case we will be assuming droplet size 500 micron little bit bigger water particle size or droplet size ok. Many time I say particle many time I say droplet. So, both are same actually oil droplet compressibility factor of gas 0.

84 we are taking and one more thing we are assuming one value beta will be there. So, later I will discuss beta HO max HO max by beta equals d max this formula will be using actually and beta value will be getting from some chart. So, later we will see. Now, try to solve the problem. So, first we have to calculate gravity API gravity is given.



So, you have to calculate del SG ok. In formula we will use this del SG or specific gravity difference between oil and water. So, del SG means del SG oil specific gravity of oil no S P. So, you get a water SG oil water will be little bit higher ok. So, the formula will be like this SG water already given 1.

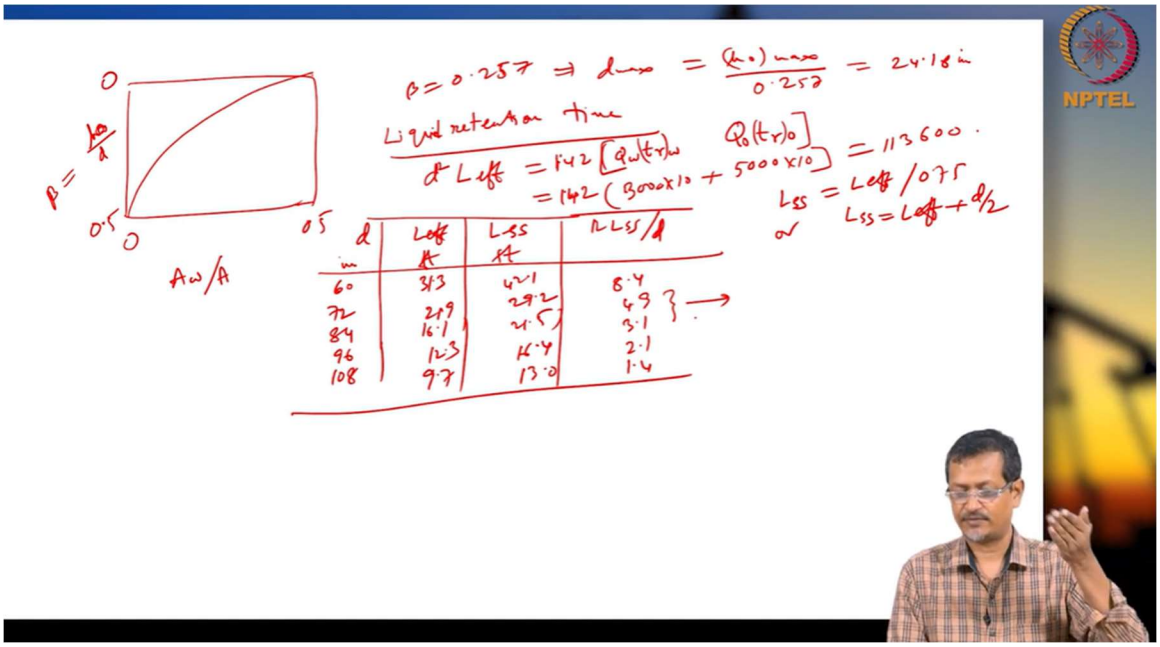
07 where SG oil you have to calculate ok. So, SG oil how to get it? So, SG oil you get from 14.141.5 divided by SG oil oh sorry this mistake API gravity equals 141.5 divided by SG oil minus 131.

5. So, this value will be coming as if I manipulate this one like this SG oil equals 131.5 plus mistake SG oil equals 141.5 divided by 30 plus 131.5 the 30 means 30 degree API already given here ok. If you see left side ok.

So, this value will be coming as a 0 del sorry SG o 0.876 ok. Now, del SG is coming SG water 1.07 this is coming here 1.

07 minus 0.876. So, it is coming as 0.194 ok, SG del SG difference. Now, we will go to gas capacity based calculation gas capacity based based calculation ok. So, in previous chapter or previous lectures we have seen this formula is that like this D effective length equals 420 I said that IPC 420. So, you can remember T z q by P rho g by rho 0 minus rho o minus rho g C D by d m d m ok.

Now, if I want to put the data 420 constant T means 460 divided by 90 plus 90 and z value I am I have already given 0.84 and q value q value you have to calculate actually. So, q I will keep it blank now and p value already given 100 psia I am putting as it is. So, I am not putting q value now first I will calculate up the report ok. Now, rho g rho g and this part I have to calculate ok.



And C D value given 0.851 and d m is given d m d m value given 100 power half. So, here the I did not put here 2 2 3 values. So, q equals ok. So, q is given 5 mm s f. So, I will be putting 5 and rho g and rho l.

So, rho g formula is like this rho g rho g equals 2.70 S p divided by T z formula we have seen before. So, 2.7 into S p is S is given 0.6 that specific gravity of gas p is pressure 100 psia given T Rankine temperature 460 60 plus 90 into z 0.

84 ok. So, this will be giving 0.35 and rho liquid again 2 points this is 62.

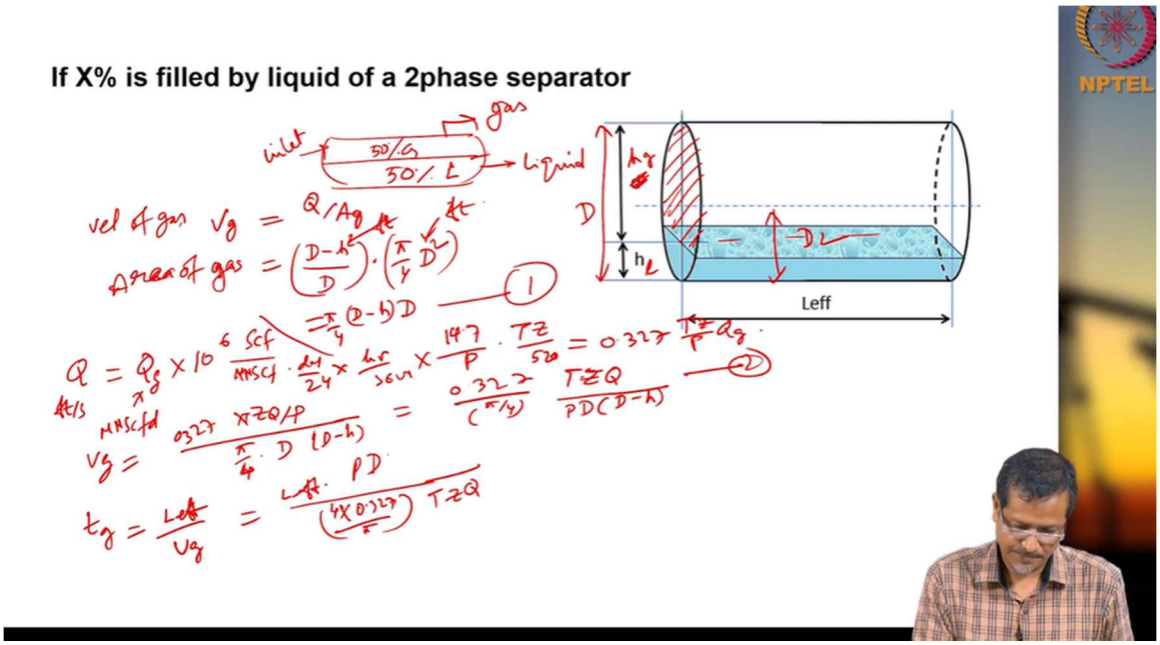
4 141.5 131.5 plus Api ok. So, this is giving 56.6 pound per ft cube ok. Now, C D value is given. So, I will be calculating d L e f f. So, here you can remember d inch and L e f f in feet ok.

4 2 0 and again I am putting digits here it is coming T means 4550 into 0.84 into 5 divided by 100 and rho g rho g value I am writing 0.35 divided by what is the value 56.

5 56.6 minus 0.35 into 0.851 by 100 per ft ok. So, this value is calculated as 102 ok. From this 102 actually you have to calculate make one table D and L effective length ok. So, D in inch and L effective length in feet ok. So, if we change D and L effect D value then L effective length will also be varying ok from this calculation.

So, they have assumed like initially you assume 60 72 84 96 then effective length also coming like 1.7 1.4 1.2 they are calculating like this ok 1. Use a low value of L effective length ok.

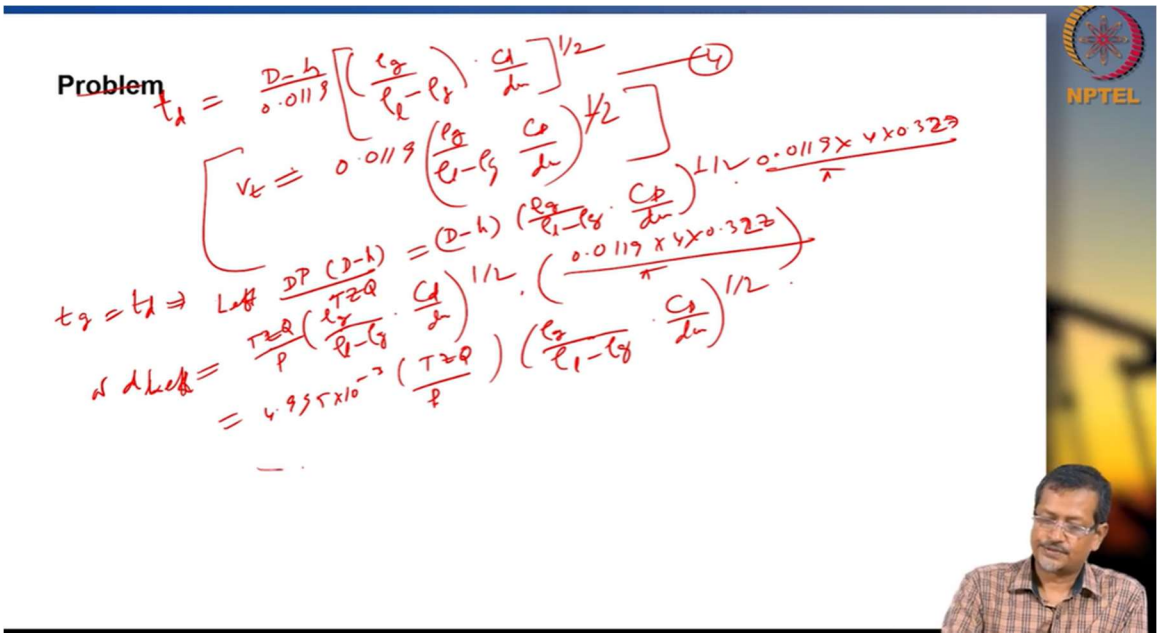
So, low effective length like 1.1 ok. So, we have to use larger value of effective length lower value if we are using then actually gas capacity equation will not hold. So, in that case you can ignore that ok. Now we have to calculate maximum oil pad thickness, max oil pad maximum oil pad thickness ok, this one h o this is h w ok. So, maximum oil pad thickness you have to calculate. So, h o max you have seen the previous lecture if you see the formula 0 I am not deriving again because in previous lecture we have derived 0.



00128 t r o del S g d m square divided by nu ok. So, this value if I put all the data. So, it will be like 0.00128 t r is 10 del S g I have already obtained 0.1994 and d m 500 square and divided by viscosity 10 10 viscosity of oil ok.

So, finally, this value will become 62.1 ok. Now, if we calculate d max from here. So, we have to go to the table sorry chart ok. In previous lecture I have shown one chart actually like this ok.

You can remember 0.520 0.5 and this is a water level area divided by total area and this is beta equals h o divided by d diameter. So, this curve was coming like this ok. So, previous lecture I have shown this graph. Now, in exam I can give the graph to find beta value or I can give the value of beta and you can calculate. So, in the present case I am giving you the value beta like 0.



257 beta equals 0.257 ok. So, if you have 0.257 then in that case we can calculate d max equals h o max already we have obtained and beta value 0.257. So, these two if we calculate.

So, d max is coming as 24.16 inch. Now, liquid retention time we have to calculate. Liquid retention time ok. If we calculate liquid retention time previous formula you remember L effective length equals 1.42 into Q water T R water plus Q oil T R oil ok.

So, this value if I put 1.42 Q water Q water is 10 sorry Q water is 3000 into 10 plus Q oil is 5000 already given the problem into 10. So, all together coming in 13600 d square L e

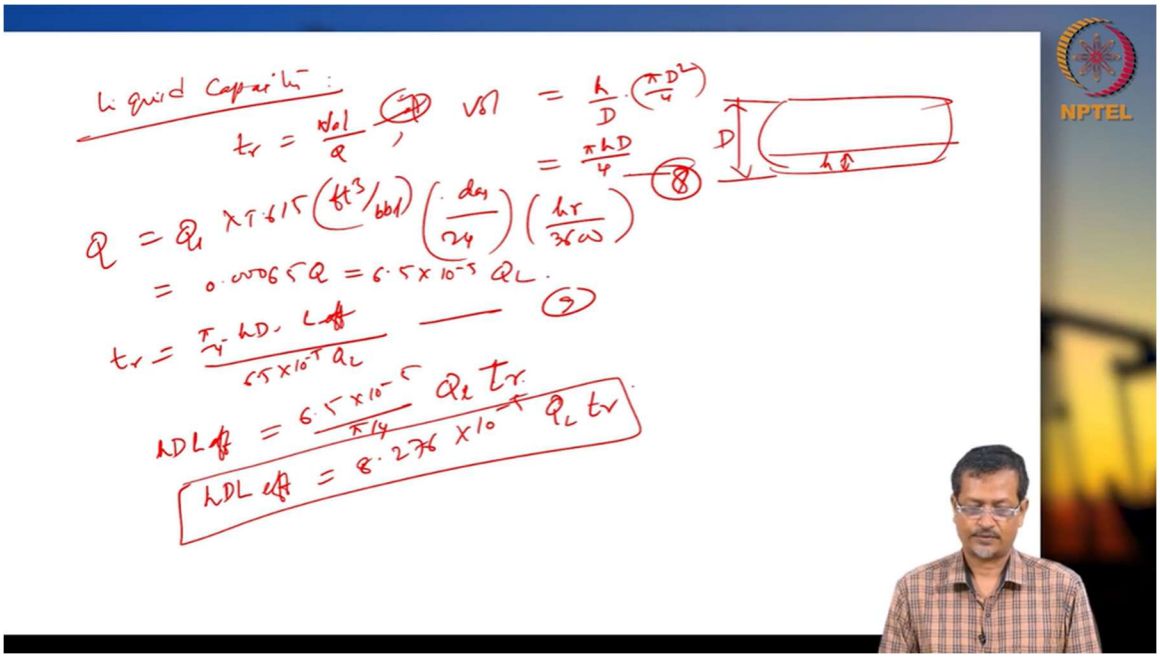
f f. Now, complete combination of d L e f f d effective length L s s 12 L s s by d ok. This table you have to prepare and you have to check unit also. This is inch, this is feet, this is also feet, this is ratio.

So, slenderness ratio is not it should not have any unit and you take the values like 60, 72, 84, 96, 108 and you get 31.

6, 21.9, then you get 16.1, 12.3, 9.7 and L s s you can calculate using the formula L e f f. So, L s s equals L e f f divided by 0.75 or L s s equals L effective length divided by d by 12 ok.

So, take the bigger one and use it. So, L s s you got 42.1, 29.

2, 21.5, 16.4, 13.0 and slenderness ratio you are getting 8.4 is too high, 4.



9 is coming down, 3.1 it will be reasonable, 2.1, 1.4. So, this value you can calculate from this table ok. So, after that you can you can select anything between 3 to 5 ok. So, 3 to 5 so within this range any one you can select and you can say this is my slenderness ratio

and respective d value this one L effective this one L s s is this one ok. This way you are calculating for horizontal separator ok. So, in exam actually I will be giving similar problem and because this is too big problem I cannot give for 2 marks or 5 marks.

So, I will break the problem like this calculate V maybe gas velocity, liquid velocity, calculate effective length and diameter d square L e f f value or I will I will ask you to calculate beta value or from beta value I will give then I will ask you to calculate d max ok. So, some data I will be giving some data I will be missing. So, if you understand the whole problem how to solve step by step then you can solve you can give answer actually, but if you try to remember memorize then it will be very difficult. So, when you are completing the course or this chapter. So, what will you do you just solve problem and vertical separator horizontal separator solve the and check how the numerical formulation was done like different formula I have developed and I have used.

So, instead of remembering the whole formula you can try to develop the formula then you can put the data. So, that you can remember steps and in exam I will give steps based calculation or data or formula or maybe I will ask what is the expression for this L e f f or the value of d square L e f f ok. Then I will give some data initial data. So, initial data you have to calculate maybe API you have to calculate maybe flow rate you have to calculate h.

So, one data will be missing and some data will be given. So, based on that you have to calculate and you can get this values. Thank you very much and I will be talking about next topic. Good morning. So, we have seen separator calculation for 50 percent field ok. So, every time we have assumed in previous lectures like separator will be 50 percent field 50 percent gas 50 percent liquid ok.

Inlet is there, outlet is here and what outlet is here liquid gas inlet ok. Now, if some case if my liquid is more than 50 percent like say 60 percent or 70 percent or maybe gas 60 percent 70 percent then what will be the formula how to calculate. So, let us see that one. So, let us assume this one capital D ok, this one maybe h gas this one h oil or h liquid let us assume is 2 phase. So, just make life simpler let us assume life is this one is 2 phase and this is like say D by 2 the center axis and this is lower than that h l or liquid.

Now, how to calculate if the gas velocity liquid velocity equal to retention time right this velocity of gas ok. So, V gas or V g will be Q by A g area of gas area of gas area of gas means this cross sectional area this portion ok, this area ok, this is gas area gas that amount of gas is being flowing. So, it will be like D total minus small h fraction of this one. So, capital D again into total area total area means pi by 4 D square ok.

So, this fraction of volume is available for gas. So, this becoming like this D minus h into D pi by 4 ok. Now gas flow rate flow rate feet per second let us say if it is given mmacf then feet per second how it will calculate Q gas this is mmacf D. So, Q gas into 10 power 6acf same formula you use for mmacf into day power 24 into hour by 3600 into 14.

7 14.7 divided by pressure into T z by 520 ok. So, this will be giving 0.327 T z p z p Q g ok. So, same way you can now you got Q value. So, V g equals 0.327 into T z Q by p divided by pi by 4 into D D minus h.

So, this value you got. So, here I can say. So, D is forget about previous notations here I am using the notation let us say D is in inch D is in feet because you are calculating a feet ok. So, let us say D in feet h also in feet instead of inch instead of creating confusion ok. So, it will be coming like 0.327 pi by 4 T z Q p D D minus h ok 2. Now, residence time of the gas T g has to be equal to the time required for the droplet to fall to the gas liquid interface to T r ok.

So, T g effective length divided by V g ok effective length L effective length and V g we have already seen here ok. So, V g value we can write here 4 into 3 2 7 4 into 0.327 by pi T z Q p D p D D minus h ok. Now, T d I will be putting next slide T d T d equals D minus h 0.

0119 rho g by rho L minus rho g into C D by d m half ok. So, we got the T d value and ok. So, this is coming for V t, V t formula we are using 0.0119 rho g by rho L minus rho g C D by d m or half ok.

We are using this formula. Now, T d and now T g equals T d. So, residence time of gas and falling time of liquid it will be same we are assuming for ideal condition. So, now, this equation will give like this L effective length p D D minus h T z Q D minus h rho g by rho L minus rho g C D by d m or half into 0.0119 into 4 into 0.327 divided by pi or D effective length is coming like T z Q rho g rho L minus rho g C D d m or half into 0.

0119 into 4 into 0.327 divided by pi ok. So, you can see the formula basically same T z Q by p ok. Basically same only the constant term is getting changed ok. So, finally, this will be giving like 4.995 into 10 power minus 3 T z Q by p rho g by rho L minus rho g C D by d m power half ok.

So, this way you can derive the formula for D effective length. Similarly, you can calculate for liquid capacity ok. Now, for liquid capacity. So, liquid capacity retention time T r equals volume by Q. So, volume is equal to h by first draw the picture ok.

This one h we have assumed this is D ok. So, h by D the fraction pi D square by 4 this volume is there. So, this is giving pi h D by 4 ok.

So, equation number will be. So, you can put equation number 7. This is 7, this is 8 ok. Now Q you can see Q equals Q L into 5.615 cubic feet by barrel ok, D by 24 into h r by 3600.

So, this will be giving 0.00065 Q L equals 6.5 into 10 power minus 5 Q L ok. Now T r equals pi by 4 h D effective length divided by 6.5 into 10 power minus 5 Q L ok. Now h D h D effective length equals 6.5 into 10 power minus 5 by pi by 4 Q L Q L T r ok T r liquid.

So, this is my formula h D L effective equals 8.276 into 10 power minus 5 Q L T r ok. So, this one approximately we have derived this one and if I give any problems using this

formula actually you can try to calculate defective length and diameter ok. So, thank you very much for this lecture. So, next lecture we will start new topic on oil separator emulsion separator that will be containing like heater to heater, it will be containing gun barrel, it will contain different emulsion separation techniques also. Thank you very much.