Surface Facilities for Oil and Gas Handling

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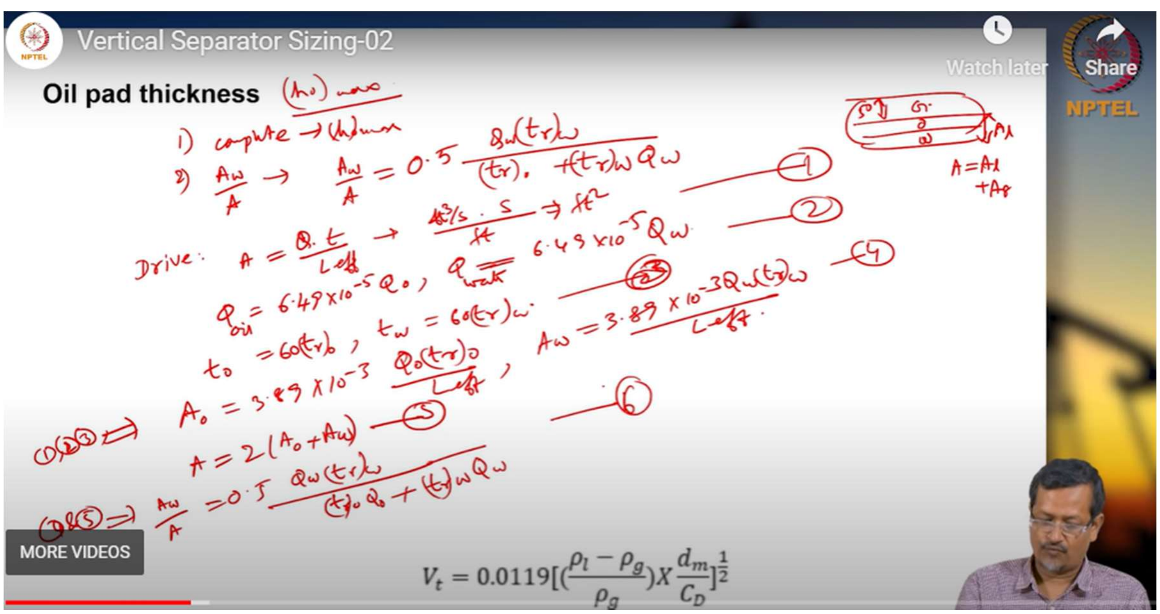
Vertical Separator Sizing-02

So, oil pad thickness you got HO max maximum. Now, how to solve it? How to solve it sequentially? So, if you want problem is given, this is some flow rate is given your separator sizing you have to do and let us say fluid viscosity, flow rate all these parameters are given. Now, solving steps will be like this first compute H max, HO max. How much oil pad thickness possible you calculate using 50 percent field gravity separator if you are not considering the 50 percent filling then equation will be different. So, presently for simplicity I am using only 50 percent field separator. And then you have to calculate fraction of the vessel cross sectional area occupied by water phase.

So, A water by A l you have to calculate. And this formula is like this A water by A l or total vessel actually not liquid total. Formula is 0.5 Q water T R water retention type of water, T R oil plus T R water Q water.

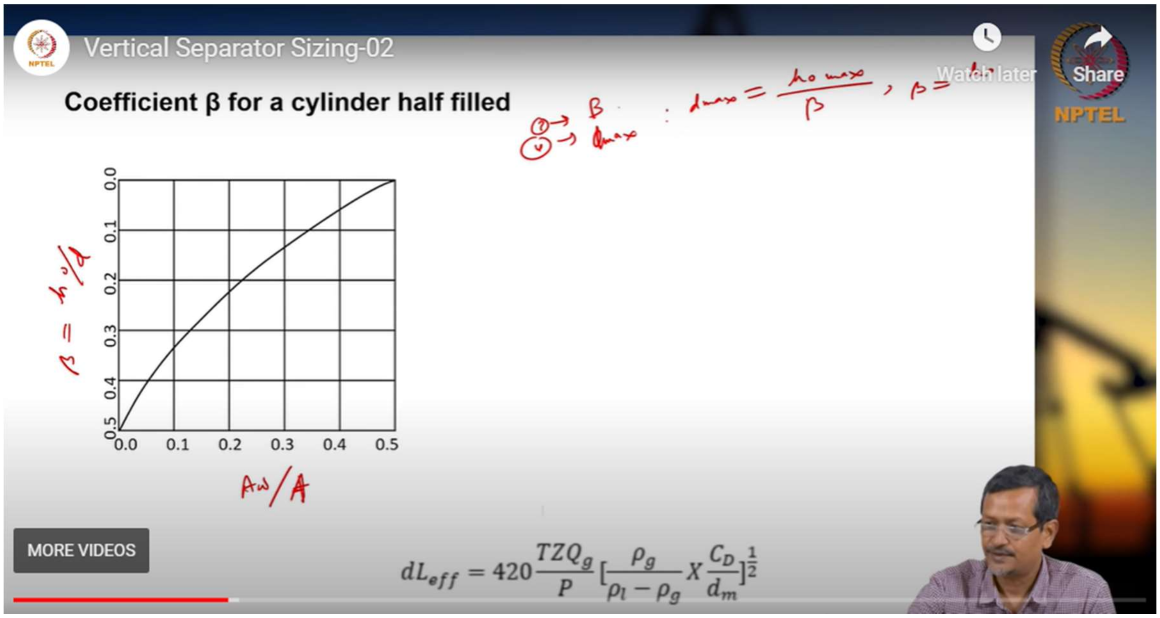


And if you have to derive this formula it is like this, derive derivation will be like this A equals area total area Q into T into effective length. Q is flow rate means cubic feet per second, T is second and so, you will like this dimension analysis cubic feet per second into second divided by feet. So, finally, second second cancelled ft. So, ft square coming. So, area is ft square.

Now, Q flow rate is equals 6.49 we have seen this constant term into 10 power minus 5 Q o, Q water case also the formula will be same equals I am putting some suffix water and oil 6.49 into 10 power minus 5 10 power minus 5 Q w. So, T oil equals 60 T R oil 60 means second you are converting into from minute to second T w equals 60 T R w. And area of oil 3.

89 10 power minus 3 into 10 power minus 3 this is important by minus 3 Q oil T R oil effective length. Similarly, for water A water 3.89 into 10 power minus 3 Q water T R water divided by effective length. And put some equation number also let us say A w this one Q t this is 1 this is Q oil this is 2 and this is 3 and this is 4. And this is coming actually from 1, 2, 3.

Now A total area is 2 into A o plus A w because 50 percent filling was there because 50 percent water oil gas. So, this was 50 percent. So, whatever area you are getting here A L total area A total area equals A A L plus A gas maybe. So, but A L and A gas is equal that is why it is coming like this 2 times of A o plus A w or A L. So, I can write this is 5.



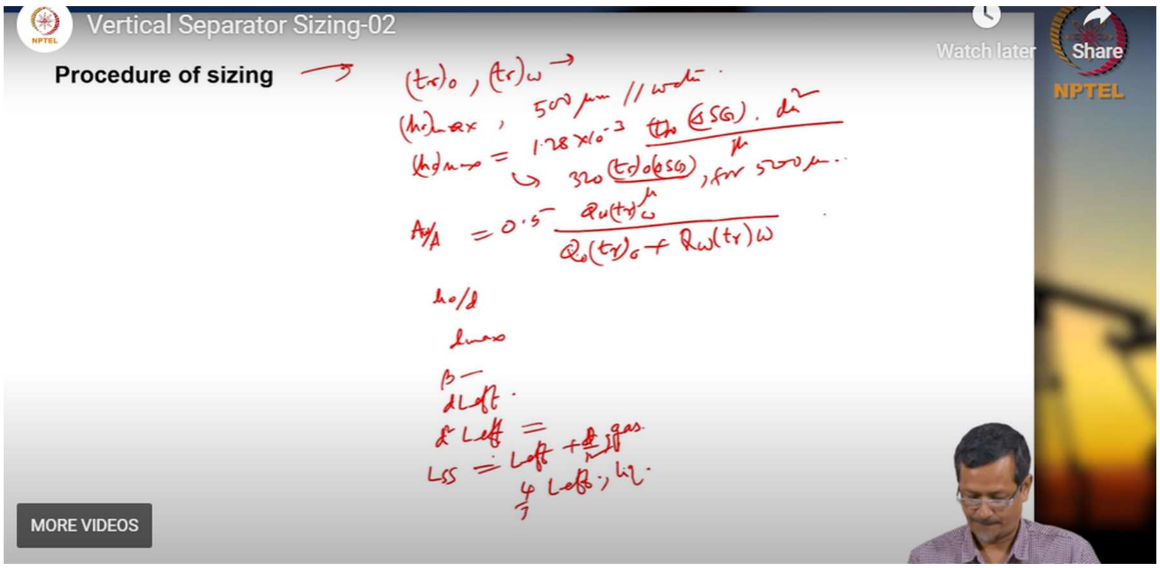
So, 4 and 5 this equation gives if I divide A w A equals 0.5 Q w T R w divided by T R o Q q o plus T R w Q w. So, this equation is 6. Now again now point 3. Now previously as you have seen this first you have to calculate h max then A w by A you are calculating then next step is that point 3 is that from figure 1 this figure is given figure is beta equals h o divided by D and this one A w by A water area divided by total area.

So, the from this figure you have to calculate beta. Then next step you have to do d max calculation. How d max will be coming d max equals h o max divided by beta, beta equals h o by D h o max by D or h o h o max by d max. Now you have to calculate any combination of D and L e f f and you have to calculate a whole you have to calculate a whole aliases D cylinder ratio or the parameter you have to calculate. So, sim to sim length in horizontal separator also you have seen L ss for formula differs actually.

So, do not use same formula L effective length plus d by 2 sim to sim length total length of separator and effectively means certain amount will not be used for separation. So, effective length will be lower than sim to sim length. So, L ss normally it will be less than 4 or 5. So, sometime it can be maximum it can go 4 or maximum 5. So, let us say 4 to prevent reentrainment to prevent reentrainment of liquid at the gas liquid interface.

If a separator is based on liquid capacity higher cylinder ratio acceptable, but still recommendation is that less than 4 L ss should be there. So, procedure of sizing is like this a first t r t r o and t r w you select. Then h o max you calculate of previous table or from formula and you can use 500 micron micron or micrometer droplet size for water. When water is moving inside oil oil pad h o formula is that h o max 1.28 into 10 power minus 3 t r o del s g d m square by mu.

For 500 micron the formula h o max will be 320 t r o del s g by mu for 500 micron. Now, you calculate A by A A w by A. So, the formula is 0.5 Q w t r w divided by Q o t r o plus Q w t r w. So, use this formula then you calculate h o by d once h o by d done again calculate h max calculate d max.



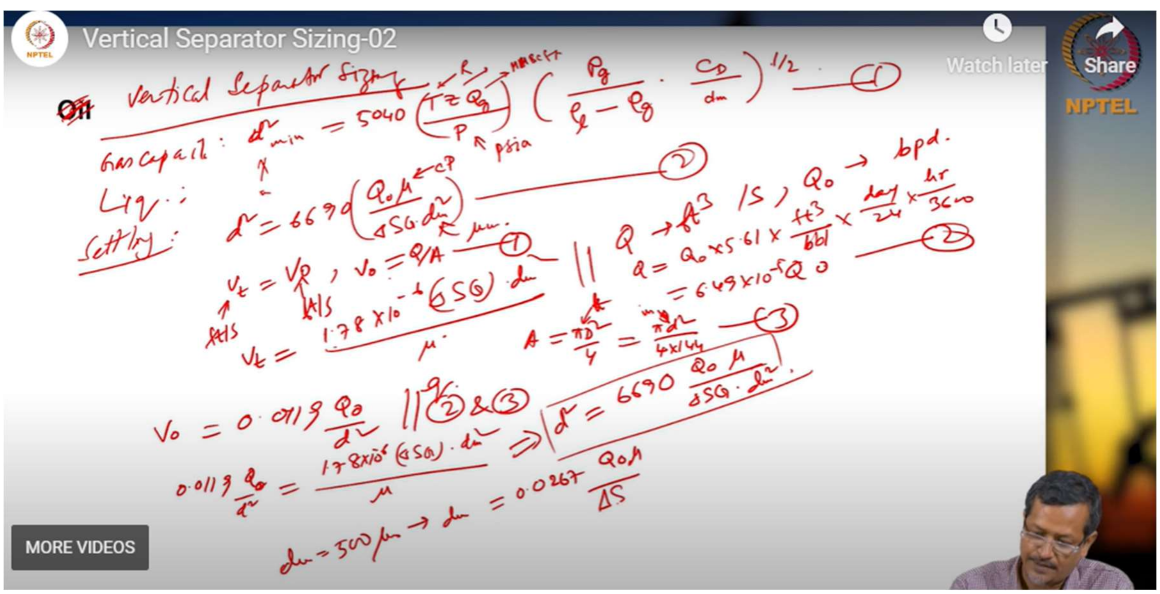
Once you get h h o by d then you can get d max actually. Then after that you can get beta from table again you can calculate. So, we will see when we will be solving problem we will see how whole procedure is going on. So, in that case also you are using d L E F F formula then after that you are calculating the retention time based diameter and L E F F relationship. Then seem to same length you are calculating L s s equals L effective plus d by 12 or 4 by 3 L effective for liquid capacity.

This is for gas capacity. So, later we will see how actual steps are going on one by one. Vertical separator sizing. So, vertical separator sizing again first you start with gas capacity and liquid capacity. So, gas capacity formula you have seen already this is 4 d square min vertical separator calculation d square min 5040 T z Q g by P rho g rho g rho L rho L the other should come negative if we do opposite way rho g into C d by d m power half.

So, this is the formula from two phase separator is coming actually as it is and units already you know d will be in inch, T will be Rankine, z unit less this is compressive factor Q g is m m s c f d c f d p is psi operating pressure rho g your density C d your drag coefficient d m is particle size. So, this is the formula you have to use for gas capacity thing. Now, we will go to settling. So, the requirement for settling water droplet from oil requires the following equation d square not q d square equals 6690 Q o mu del S g d m square. So, this formula will be there and next is V t V o.

So, V t is in feet per second and V o is feet per second because unit same and value also same and d m in micron already you know we are using mu in C p mu in C p capital P I write and d m is micron and V t V t formula is there 1.78 10 power minus 6 del S g d m square by mu. So, Q in feet per second and Q o BPD oil flow rate maybe it will be given in BPD. So, you will get the formula which is important Q.

So, Q equals Q o into 5.61 10 into feet cube BBL or barrel per day, day is 24 and hour by 3600 ok. So, finally, you are getting 6.49 into 10 power minus 5 Q oil ok. Now, A area equals pi d square by 4. So, pi d square by 4 into 144 because you are converting unit this is in feet this is in inch ok.



So, you are converting unit feet. So, small d divided by 12 equals 1 capital D ok. This is 2, this is 3 and one formula I have to write here I think V o equals Q by A flow rate 1. Now, d in inch V o equals 0.0119 Q o by d square it will be coming from 2 and 3 ok equation 2 and 3 if we if we solve properly.

So, that the constant term will be converted and it will be coming like 0.0119 Q o divided by d square. Now, V o equals V t right. So, 0.

0119 Q o by d square equals 1.78 10 power minus 6 del S g d m square by mu ok. So, it will give d square equals 6690 Q o mu del S g d m square ok. So, this formula will come finally, for 500 micron if I use 500 micrometer d m then the formula d will be 0.0267 Q o mu divided by del S g ok.

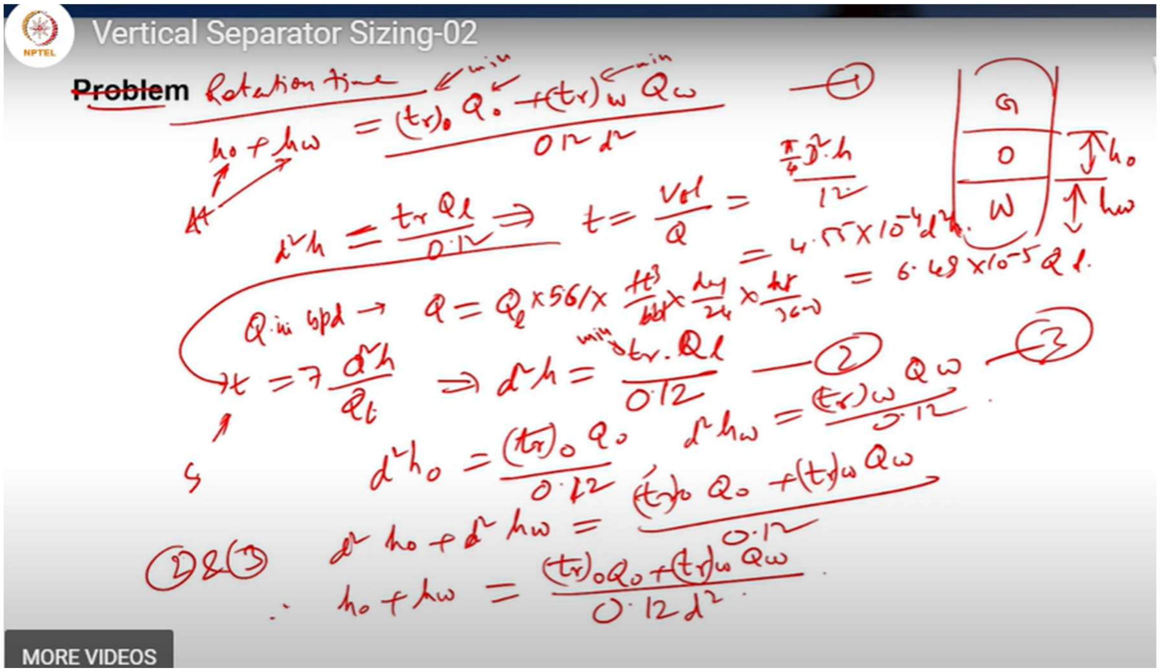
So, this will come for 500 micron. So, problem we will solve later. So, I will write retention time ok. Retention time formula is that h o plus h water T r o Q o plus T r w Q w divided by 0.12 h not h d square ok. So, this is vertical separator, this is oil, gas, water.

So, this is h o, this is h water ok. Retention time for oil is T r o, retention time of water is T r w. So, all are in minute actually this is retention time ok and Q is Q V per second. So, h is in feet for oil h o also in feet of water ok. So, d square h ok. So, in previous chapter or previous lectures I have shown that d square h equals T r Q liquid divided by 0.

12 ok. So, this one how did we derive? We did like this T equals volume volume by Q flow rate ok. So, volume we had pi by 4 d square into h height divided by 4 h you convert into feet. So, it will becoming 4 will not becoming only 12 will becoming 4 already given there. So, this will becoming like 4.

55 into 10 power minus 4 d square h ok. Now, Q in BPD in in BPD. So, it will be giving like Q equals Q liquid 5.61 into again the same thing cubic feet per barrel into BBL into a day per 24 hour by 3600. So, finally, we are getting 6.

49 into 10 power minus 5 Q L ok. And T equals d square h by Q L ok ok. So, finally, this is giving d square h equals T r Q L divided by 0.12 ok. And so, 0.12 is coming because T and T r this is the second and T r is minute ok.

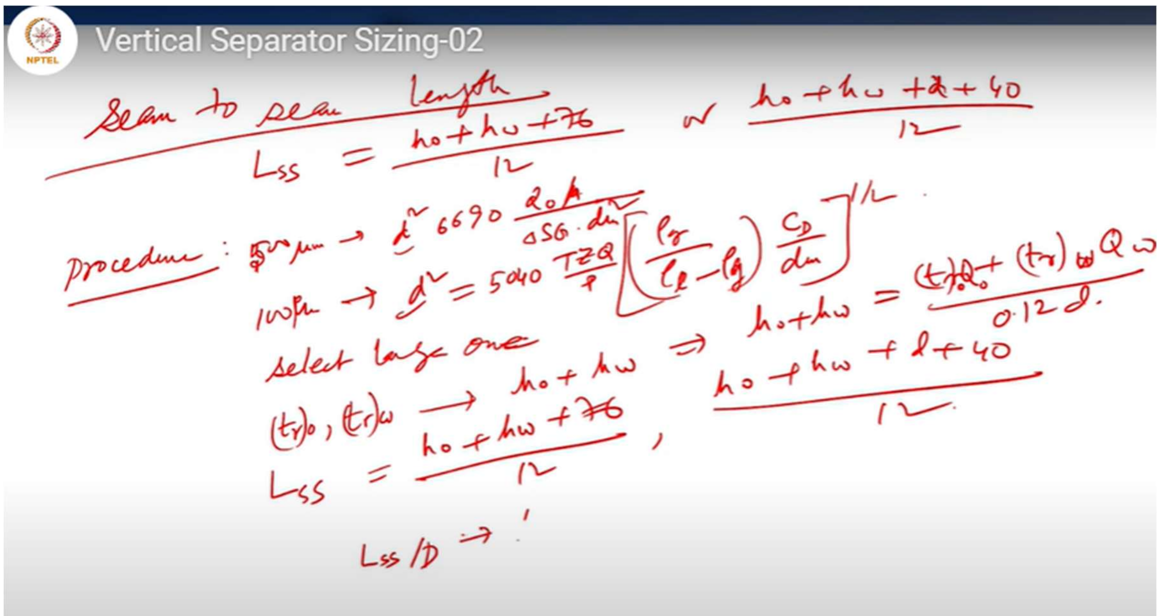


So, this formula is coming. Now, d square h for oil let us say this one equation number I can give here no number is given right 1 maybe this one 2. So, d square h oil equals T r oil Q oil 0.12 d square h water equals T r water Q water 0.12 ok. So, if we add these two if we add these two 2 and 3 here we are adding like d square h o d square h w.

So, h d square h o plus d square h w equals T r o Q o plus T r w Q w 0.12. So, therefore, h o plus h w will be T r o Q o plus T r w Q w 0.12 d square ok.

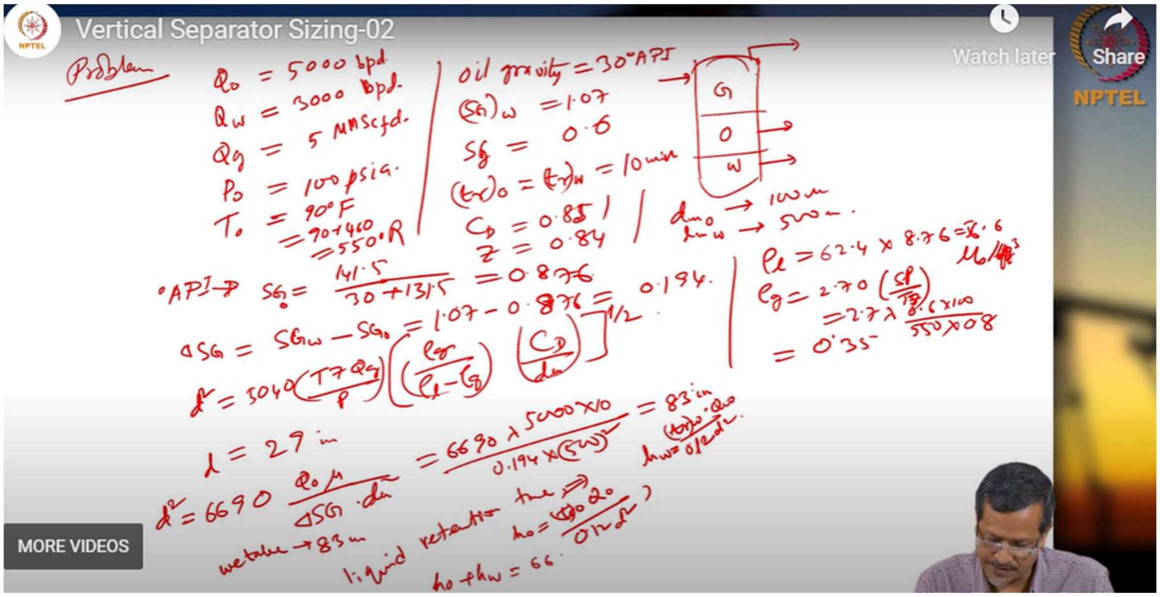
So, this formula we get same as 1. Now, seam to seam length seam to seam length ok. So, whenever whenever you are calculating seam to seam length we have to check this formula L s s equals h o plus h w plus 76 divided by 12 or h o plus h w plus d plus 40 divided by 12 ok. So, any of the formula will be used, but condition is that minimum diameter d is the minimum diameter of gas capacity. So, while we will be solving actual problem we formula to use and which value we have to use for our calculations.

So, procedure ok. In this case also you have to follow step by step for calculation for separate sizing. So, first initially calculate minimum diameter from requirement for water droplet to fall through oil layer. So, 500 micron or micrometer you are selecting for water droplet and use formula d square 6690 Q o mu by del S g d m square ok. So, mu here oil viscosity actually not water viscosity. Again next you calculate minimum diameter from requirement of oil droplet falling through gas.



So, 100 micron you are using 100 micrometer d square formula is like this d square 5040 T z z cube by p rho g rho L minus rho g rho L minus rho g C d by d m power half ok. Now, choose the larger of 2 d you are 2 in 2 d here d and d. So, select the larger one. Now, next step select larger one select larger one then next you say you get T r T rho T rw ok and you try to solve h o plus h w. So, it will be formula is already given h o plus h w equals T r o plus T r w Q o Q w divided by 0.

12 d ok. Now, now you calculate LSS h o plus h w plus 76 by 12 or h o plus h w plus d plus 40 divided by 12 ok. Select a size reasonable size and LSS LSS by d should be within the remit 0 1.5 2 3 ok within the image you are selecting LSS by d. Now, today we will solve the some problem regarding vertical and horizontal separators. So, let us see one problem flow rate of oil you have one vertical separator ok and you have 3 layers gas oil water inlet is here and you have outlet outlet gas outlet ok.

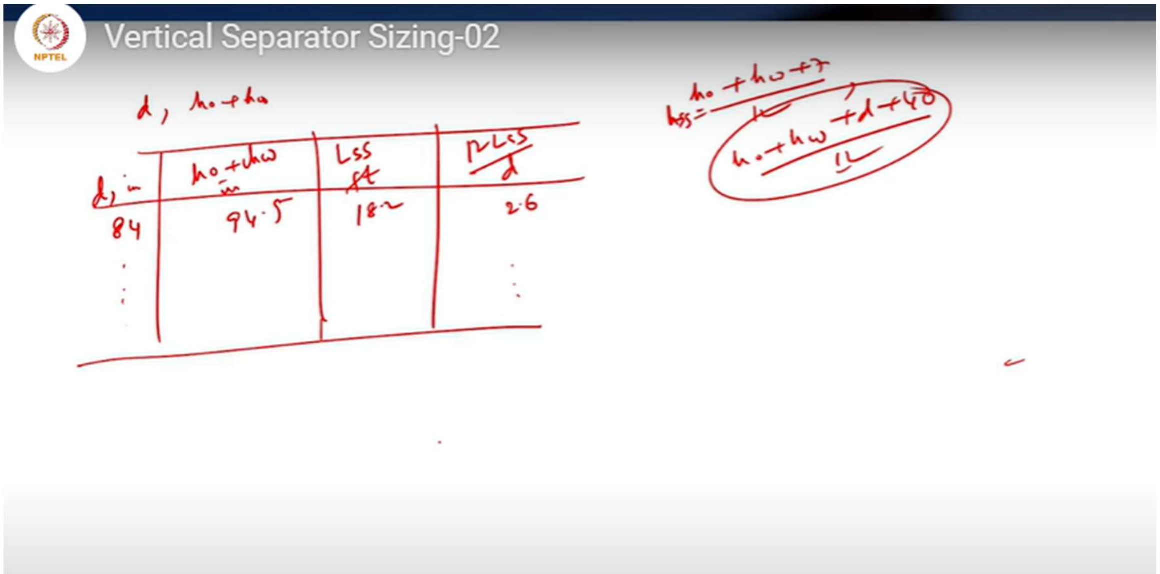


So, oil flow rate you are having 5000 BPD, you water flow rate you have 3000 BPD, you have Q g gas flow rate 5 mm SCFD. Pressure operating pressure is given 100 psi psi and T operating temperature is 90 degree Fahrenheit. Some more data are given let us copy it oil API gravity oil gravity 30 degree API specific gravity of water 1.07 specific gravity of gas 0.6 retention time both you are assuming equal 10 minute 10 minute water or oil will be staying inside the vessel and we will be assuming some values also C D you will be assuming 0.

851 Z you are assuming 0.84 ok. So, oil particle size dm oil 100 micron dm water 500 micron ok. So, degree API is given. So, from there you can calculate specific gravity ok, is specific gravity of oil 141.

5 divided by 30 plus 131.5. So, this is giving 0.876 ok. So, del SG specific gravity of oil SG water minus SG oil will be 194 0.194 better I will write all these things SG water water is given 1.

07 minus SG oil we got already 0.876 it is coming 0.194 ok. Now, we calculate d from previous formula 5040 T Z QG by P rho g by rho L minus rho g then C D by dm this is power of half ok. Now, if we put the values ok before we put values we have to calculate rho L equals 62.



4 into whatever value we got 0.876. So, it is giving 56.6 lb per cubic feet ok. Rho gas rho gas equals 2.

7 0 SP T Z this is the formula. So, 2.7 into 0.6 into 100 psi pressure T is T is given 90 degree Fahrenheit. So, it will be 90 plus 460 equals 550 degree Rankine ok.

So, 550 into Z Z is 0.84 Z we are assuming 0.84. So, finally, it is coming 0.35 ok. If we put all the values for into d we will get d equals 29 inch ok. Now, minimum diameter we have to calculate from other formula d equals that water formula 6690 Q o mu del S g into dm square ok. So, from there if we put data 6690 into 5000 oil flow rate into 10 del S g is we already calculated 0.

194 into 500 micron water particle size. So, this will be giving 0.80 only 83 inch ok. So, if you see these two values of d I can get 83 is the major one. So, we take 83 ok because we got two values of d, but we got 83 higher. So, we take 83.

Now liquid retention time calculation h o equals T ro Q o divided by 0.12 h 12 d square ok previous formula if you see h water T r water into Q water 12 d square ok. And if we add these two h o plus h water ok. So, it is coming like 667000 d square. Now, I will go to next slide. Now, we have to calculate combination of d and d h o plus h w we have combination I have to calculate and you have to prepare one table.

So, d d in inch h o plus h w inch LSS feet 12 LSS by d small d and if we take d value let us say initially we got d value 29 and 83 and we have to take the bigger one bigger one is 83. So, nearby 83 if you 84 we are taking here and h o plus h w from previous formula we can calculate 94.5 and LSS value actually you will get two LSS values you can remember the formula h o plus h w plus 76 by 12 L LSS and another formula is h o plus h w plus d plus 14 divided by 12 ok. So, if we calculate both I found that this one is giving higher value.

So, we will take the higher one. So, it is coming 18.2 and if you divide LSS and d then finally, you are getting 2.6 your cylinder ratio. So, you can calculate other parameter ok. So, finally, you are calculating LSS value and keep L this cylinder ratio 1.

5 to 3. So, any value can be taken and you can say the design parameter values. Now, because this is a very big problem. So, maybe I can break the problem into small pieces and then I can ask like say calculate specific gravity, calculate d min from liquid capacity formula, calculate d min from retention formula or water particle retention formula or I can change the dimension and I can ask you to calculate step by step ok. So, thank you very much.