Surface Facilities for Oil and Gas Handling

Prof. Abdus Samad

Department of Ocean Engineering

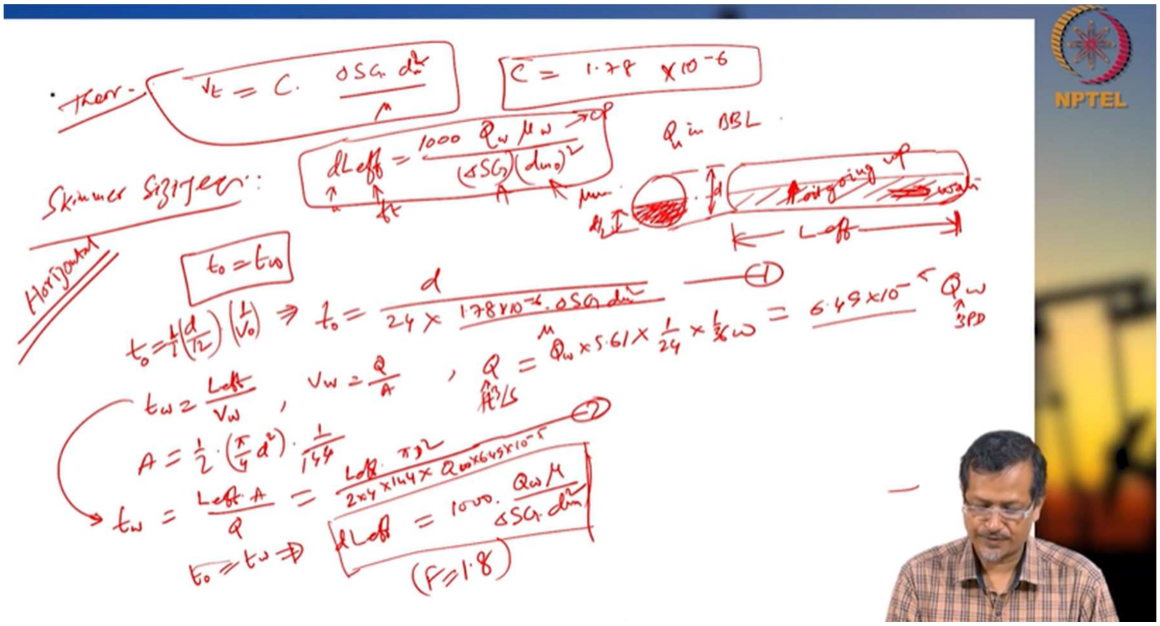
IIT Madras

Water Treatment-02

And water directly you can control using a water well, water leg, you can create one water leg here. If you are creating a water leg then actually interface level you can change. In the previous lecture, we saw this, if you are changing the water leg height then your actual interface level can change. So in this case I have not shown this water leg in this figure, but if you like you can draw also the water leg, this water leg will control your interface level. Water level if you are going up then oil because oil wear height fixed. If you change changing water level there then the oil pad thickness will change.

So oil retention time will be lower in that case. So a small amount of oil will be retained so that time will be very low. But if you are reducing this water leg height, so oil pad thickness will increase. The oil retention time will increase.

The thickness of the oil pad depends on the relative height of the oil wear and the water leg. So water leg height will be controlling that one. And the difference is the specific gravity of oil and water. Often an interface level controller is used in place of the water leg. So here I did not show any interface level controller or water leg, but it may be possible interface level or water leg will be there to control the interface level.



So, interface level controlling means you are controlling oil pad thickness and you are controlling oil retention time also. So similarly I can draw one horizontal separator. So horizontal separator, so quickly you should not take a long time to draw this. So horizontal separator means one where the simplest form of skimmer. This is oil, so oil when you are taking out, so we will have dump valve, we will have controller and oil out this is water, this is the inlet.

So here because gas is not our main purpose, so inlet we are giving in oil-water zone and we are getting very laminar flow not turbulent flow. So slowly fluid will be entering here, then water will be flowing through this and it will go out somewhere from here. And when water is going through this, oil particles will try to move vertically up. Oil particles will create one layer, which is the oil layer. So like cross-flow type, water is going horizontal, and oil particle is going vertical, vertically up.

In the vertical case, this is horizontal, this is vertical. In vertical, oil is going up, water is going down. So what is happening? Reverse, oil is trying to move up but oil is trying to pull down. But in horizontal case just cross, oil is trying to go up, water is going in horizontal direction. So horizontal separator is better then, because it will have, it will not have to resist water flow direction.

But in the vertical case, water is pulling down and oil is trying to pull up. So net upward motion will be lower. But in the horizontal case, water is going horizontally, so it is not pulling down. It may be creating some small angle but it is not pulling down. But in the vertical case, it is pulling down actually.

So horizontal separator will be better. But in some other cases, for example, sand settlement, we are saying a vertical separator will be better. If sand and debris, just sort of small sort of particles are there, solid particles. So in that case vertical separator is better. Horizontal separator, the author has written that cleaning and removing sand from the separator is very difficult.

A vertical separator easier to get separate sand. So horizontal separator is better because it does not resist oil particle movement. But the vertical separator because of the flow direction reversed, so it is resisting. Horizontal separator, sand is there, sand for sand is good, horizontal separator sand may not be good. So you got the difference.

Horizontal vessels are more efficient water-treating systems because oil droplets do not have to flow counter current to the water flow. Vertical it is happening. However, vertical separators are used by sand and other debris or particles are there. Retention time is normally 10 to 30 minutes. Normally retention time will be 10 to 30 minutes.

So 10 to 30 minutes of water is there inside the separator it will be okay. In theory, we have seen already the formula Vt, Vt constant into del Sg dM square, this is the standard formula. So the constant value is 1.78 into 10 to the power minus 6, into 10 to the power minus 6. You should remember this constant, so it should be easier to remember.

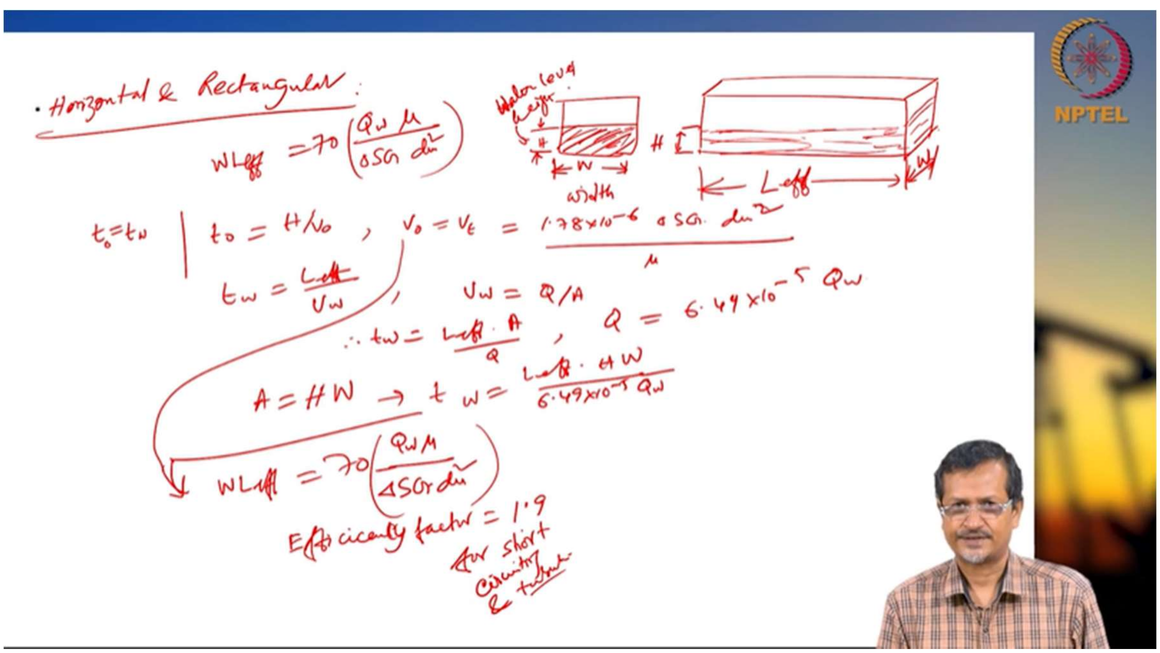
Now I said like if you are using oil droplet or water droplet accordingly mu viscosity and dM value you have to put, fine. The dispersion formula we have seen, rotations, and settling time are okay. Just wait, this will turn, this will turn, okay. Now, skimmer sizing equation. So you want to decide on a skimmer, so what will be the optimal size, we can have some formula for that, okay?

So the formula is that dL EFF, but some parameters are changed. Here 1000 terms came up, Q water mu water divided by del Sg dM, I should put oil actually, right? So this formula we should derive. So d is the vessel diameter already you know, inch, L feet, Q water flow rate, okay. If Q is in the barrel then we can convert, we will see.

Mu viscosity of water Cp and C capital P, del Sg specific gravity difference and this is micron, micrometer, okay. So the formula will start from To equals Tw, and the retention time of water equals the retention time of oil. We are assuming this is equal, okay based on that we will calculate. So To, this is for horizontal separator, okay. So horizontal separator I will draw first, L effective and this is d, d in inch and we are assuming 50 percent liquid field, okay.

And so side view if I want to see, a side view it will be like this, right? So this will be oil part, oil, and water, this will be d or I have the same d, I have already, I have already, okay this is like this. From the side, if you are seeing, you can see like this, okay. So To equals d half into d by 12 into 1 by Vo, this is 1 by 2. So d by 12 means we are converting into feet, okay half means 50 percent field, okay.

So this is d by 2, okay and Vo is velocity of oil, okay. So this To will be d by 12 into 2, 24 into Vo, Vo Vt oil velocity, terminal velocity is easy. So Vt value, how much you have seen? 1.78 into 10 to the power minus 6 del Sg, the top equation you can see, dm square divided by mu, okay. So we get To, To I should write.



So Tw, now for water. So what happens, The oil particle I said is going up, right, oil going up, right, vertically going up. Now I said like for horizontal separator, water going horizontally, water going horizontally. So oil going up, water going horizontally. So the water formula will be like this, effective length divided by water velocity, V water, okay. So now V water flow rate divided by area, okay if we know the water flow rate divided by area, which area? This area, okay this area.

And Q you know, Qw into 5.61 into 1 by 24 into 1 by 3600. So it is, it will be giving 6.49 into 10 to the power minus 5 Qw, okay? Q in B, this is Bpd, Bd this is cubic feet per second, okay. Bpd to cubic feet I converted, okay.

So you can remember directly this value 6.49 or you can convert 5.61 and this, this, this, okay. So A is half into the total cross section area divided by 2, pi by 4 d square, pi by 4 d square, right. And you have to convert it into feet, so 1 by 144, 12 into 12, 144, okay.

Now Tw equals Leff, where is Tw? Here is Tw, okay. Leff Q by A, so AQ, okay. So A going up, and Q will be its place. So it will be like Leff pi d square divided by 2 into 4 into 144 into V, into Vw, okay, Vw. Now if I equate To and Tw, so To we got here, To is here, maybe 1 and this is 2, both if you equate, both are equal, then you can get directly the formula dLeff equals 1000 Qwmu del SG dM square.

But here they have taken one formula to make this 1000, they are assuming factor F, the short circuit factor F equals 1.8 they have taken. They have assumed short circuit factor 1.8 and they are making 1000 so that it will be easier to remember, okay. So you should remember for this horizontal separator, retention time-based calculation, both retention time water and oil are equal.

So based on that, you can get, I will get d into Leff 1000 K, water flow rate divided by mu into mu divided by del SG into dM, dM square, Q will be there, right, below here, right, correct. We should have, instead of mu it is equal to W. Which one mistake again? Where, where?Here.

Okay, okay. So, Qw into 6.49 into 10 to the power minus 5. So when we are editing this to make it proper, formulate one more problem. Now you will be assuming rectangular cross-sectional, okay? So rectangular cross-section means this one horizontal and rectangular cross-sectional, okay. So in the previous case, you calculated for a cylindrical system.

Now we will have a rectangular system, a rectangular system, and again a 50 percent field. So we are assuming this is a field, okay? So this portion is the field we are assuming and this is my capital H, this is W and this is L effective length. Okay, if I take a side view it will look like this, W is here, H is here, okay.

So from a side view, we are taking. So the formula is this, W square L EFF, not W square. So the formula is that W L EFF equals 70 Q water mu del SG dm square, okay. So this is the formula, where W is the width, H is water height, H is water height, this is water level height, water level height. Now again we will start derivating this one, T o equals T w, the same formula we will be using, how much time water remaining inside, how much time oil remaining inside. So T o equals H by V o, okay, how much time does the oil stay there, okay, or how much time does the oil take to go to the oil layer, okay?

So V o formula already you know, V o equals V T, time velocity 1.78 into 10 to the power minus 6 del SG into dm square divided by mu, this is the common formula we are using. And V w, T w equals effective length divided by V w. So V w is equals Q by A, okay. And so T w equals effective length into A divided by Q.

And Q equals, we can write 6.49 into 10 to the power minus 5 Q w, okay, this formula already we know, right? So one A term is there, A equals H w, you can see this shaded area, H into w, this area, okay, also generally water is flowing, okay, so that will be the area. So w, now if we can equate T w, T w equals an effective length A H w divided by Q 6.49 into 10 to the power minus 5 Q w, okay.

Now I got T w value, I got V o value, okay. So all these two values if we equate, then finally we will get w L EFF equals 70 Q w mu del SG dm square. And this 70 term is coming, they are assuming efficiency factor. The efficiency factor equals 1.9 for short circuiting and turbulence, short-circuiting and turbulence, okay. So more than one you are assuming actually, that means you have to design more than the required size.

So whatever you are calculating, actually you are enlarging because of the short-circuiting and turbulence, so if you have more turbulence, the separation will be difficult. So you have to increase the separator sizing, okay? So that is why you are taking efficiency factor 1.9, okay? So this is a, in the book they have taken, but in the problem maybe I can change the efficiency factor to 1.

5, 1.7 something, so based on that you have to calculate, okay. Okay, thank you very much for today's lecture. Next, we will continue this water TD system.