Surface Facilities for Oil and Gas Handling

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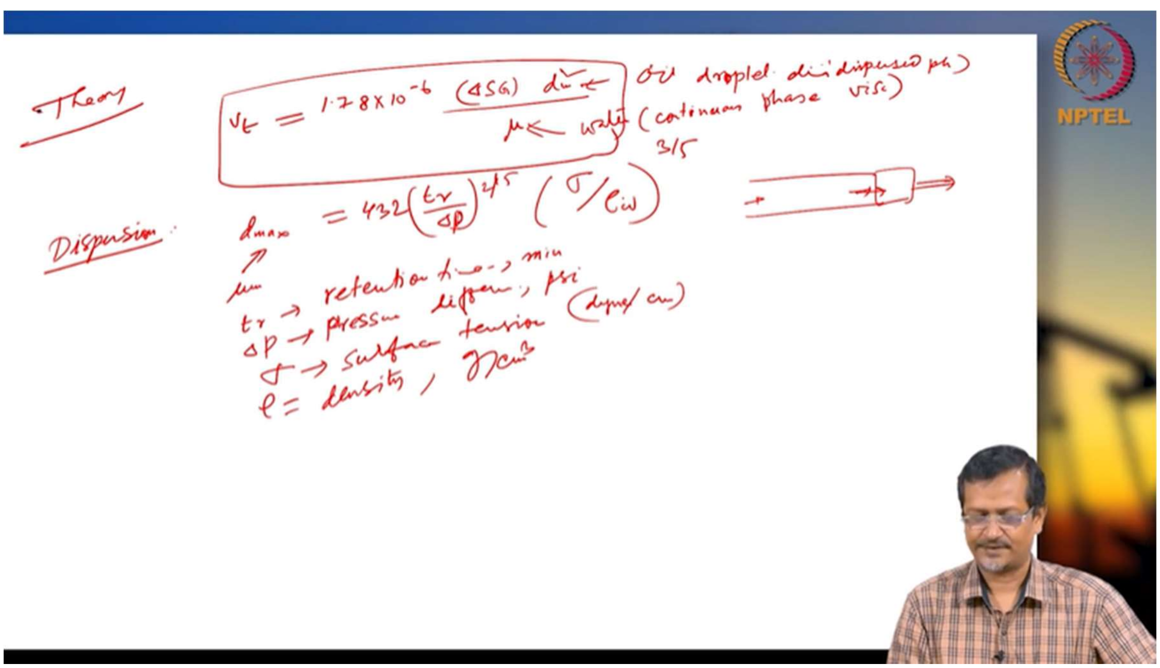
Water Treatment-01

Good morning everybody. Today we will start a lecture on Water Treatment. Previously you have seen two-phase separators, three-phase separators, gun barrels, heater heaters, electrostatic separation systems, gravity separation systems, horizontal separators, and vertical separators. Now, we separated oil and we reduced BSW, sedimentation water content up 0.5 percent. Now what oil is sold to your refineries?

For example, when this is produced it will be sold into a reliance refinery. Then you have water because any well bore whenever you are producing oil or gas maximum amount of fluid will be producing water actually because water is available. So that water you cannot dispose of anywhere, randomly. So water disposal only issue.



So before disposing, you have to reduce hydrocarbon content. So if you are not reducing hydrocarbon content what will happen? You have an aquifer zone or the surface area like say trees will be there, and your drinking water zone will be there. If you are disposing of somewhere then those trees will not survive, and your environmental pollution will be there. So you have to remove hydrocarbon content as much as possible then you can dispose. Now hydrocarbon one way is that you can create one dike maybe, you can allow evaporation and you can reduce water content, ok that way you can.

Another way is you drill a hole, you put whatever produced water is there you put inside the good bore and you dispose of it that way. But in offshore applications, there are some difficulties are there. So first we have to understand how much oil content or HC hydrocarbon content will be there in water before disposing, what is the regulations and if you are designing certain mechanical equipment or equipment. So what is the sizing, what is the basic equation, and what are the fundamental theories are there we will discuss in this lecture? So previous lecture we discussed gun barrels, right gun barrels, vertical or horizontal separators, and horizontal separators.

So basically we got gas, we got oil, we got water. Now gas we have not separated yet, we got gas but gas will have several other constituents so we will discuss it later in some other lecture, in different weeks. Oil already separated almost all BSW, so normally we try to maintain 0.5 percent BSW. So we removed salt, we removed small small water droplets, and then we tried to maintain this point.

So after the gun barrel you can store this oil in your stock tank or you can send it to your customer. Now water whatever you are getting, so that one you have to separate properly, I mean oil particle you have to remove, sand particle if it is there any way it can be disposed along with water maybe or maybe you have to separate sand separately and handle sand and water and oil because it will be having economic value, so oil you can use again. Sometimes this water separation system some gas also comes out, so the gas also you can used. So governing regulatory bodies specify hydrocarbon content, so normally 15 to 50 milligrams per liter, this will be the range, within this range government body will say okay you have to maintain within this range or less than this one, that is fine. Also, water must be disposed injected into an acceptable disposal formation or disposed of by evaporation, so maybe we can put it in a hole, inject it, or evaporate it so that it will not be spreading everywhere.

Reduce hydrocarbon content below the limit from water obtained from free water knockout or oil treaters, free water knockout will have lots of oil content even water treating equipment you have separated small particles of oil and water you separate then that water will contain some amount of oil that you have to remove that one also. To produce water treatment equipment, so this picture this table have taken from Arnold and Morris's book Arnold and Morris surface production operation, surface production operation book volume 1, volume 1 chapter 7. Again you have to see additions whether a new addition came up and several chapters changed I do not know, but this is one volume, volume 1 chapter 7 whatever I am following the book. So, there are several ways you can remove oil particles from water, one is the gravity separation method as a plate coalescer, enhanced coalescer, gas flotation, enhanced gas separation, and filtration so there are several techniques are there. So one separate system can use many of these mixes of maybe one or multiple.

So gravity separation is because of the gravitational difference gravity difference between oil and water the fluid oil particle will be floating slowly going up. So schema tank or vessel the approximate minimum droplet size is 100 to 150 millimicrons or a micrometer disposal pile. So I will discuss all these equipments later. So just you can remember at this moment if these equipments are there the particle size will be like 100 to 150 micrometer microns. Plate coalescer, parallel plate interceptor 30 to 50, corrugated plate, cross flow separator, so this is plate type things are there later we will discuss.

If you are using enhanced coalescer, precipitation, filtration, and free flow turbulent coalescer so several types of here also enhanced coalescence systems there are particle sizes will be 10 to 15, and if you go further separation then like a gas flotation device you can create hydraulic disperse medium you can create hydro cyclone you can create multimedia filtering you will create. So you can separate much smaller particles also. So this particle separation will be based on your regulator's instruction they will say will not accept more than this much hydrocarbon. So you have to confirm that one because if you are a production engineer it is your responsibility to confirm or this bias will not buy so that will be another issue. So, chemical produce water treatment system, produced water treatment systems are typical.

So I will draw one diagram so some primary treater are their primary treater from their secondary treater many types of treaters will be there so there is water you are getting so you can discharge. Secondary treater so many types of treaters in there 1, 2, and 3 stages so there are some primary treaters and secondary treaters. So from there whatever oil you are getting small amount of oil you will get so that again you have to separate. So that one you are sending to the oil recovery tank. So from water, you are getting a certain amount of oil so that oil will also contain some water you have to remove that water from the oil then again you can use that water oil.

So oil recovery tank, then oil recovery tank again you are pumping this one to production separation or oil treater. Production separator or oil treater whatever oil you have you have to separate again so you are putting that water into another separator using one pump because that other separator will have higher pressure so you have to increase pressure then you put it into that high-pressure separator again it will be regular process. So it will be like a cyclic thing then secondary treater here coming then a sump tank, sump tank, sump tank some oil will go there and if water is coming water will be drained, and water discharged. So open drain, open drain, closed drain different types of the drain will be there we will discuss later. So if you have a closed drain, then from there pressure vessel, the closed drain will be higher pressure so the pressure vessel through the pressure vessel you are adding that fluid here and you are sending it to the oil recovery tank.

An oil recovery tank separates your oil and sending to the previous separator so that water particles can be removed and whatever water is there you can separate it separately. This will be roughly one water separation system diagram. Two separation systems from here, and there are coming. Offshore production water can be piped directly on board after treatment or it can rotate through a disposal pile or skim tank. Later I will discuss what is the skim tank or disposal pile.

Deck drains must be treated for the removal of free oil. So free oil means extra oil particles are there so you have to remove them. This is normally done in a skim vessel called a sump tank. So this skim vessel is called a sump tank so whatever oil is there you have to remove it.

So sump tank is done. So water from the sump tank is either combined with produced water or rooted separately for disposal on board. So you have lots of small small particles of oil you have to separate. So the basic theory is the same actually, oil particles will be moving up because of density difference. So theory Vt terminal velocity we start from there at 1.78 you should remember this one 10 to the power minus 6 almost all chapters contain the same basic formula.

Del SG specific gravity difference, vertical diameter square, and mu viscosity. This is the basic formula you are using. Now here in the water treating system, you use the same VT but DM mu changed actually. In the water case in the previous chapter where you separated oil particles. So oil particle means dm was oil diameter.

In the previous case, you separated water particles from oil. So in that case previous chapter it was water particle diameter. Now presently we will be using it as an oil particle diameter, droplet. And what will be the viscosity? Viscosity will be water. But if you see the previous chapter it will be just the opposite.

Oil was a continuous phase in the previous chapter but here water is the continuous phase. Water continuous oil particles dispersed. So mu actually a continuous phase. Oil droplet size is dispersed phase. Disperse phase particle diameter.

So you should not get confused when you are putting the values. Maybe in one problem, I can create confusion I can give both values. So you have to select the proper one. If you say wrong viscosity wrong dm then your calculation will be completely wrong. So you should remember this one.

And dispersion. So they have given one d max formula dispersion formula 4, 3, 2. So there is no drive here. They have given just an empirical-type formula. T R del P 215 2 divided by 5 sigma rho w 3 divided by 5.

Because it is power. And this is micrometer and T R retention time. Retention time I am using the common symbol. The book also uses the same symbol. Retention time and del P is a pressure differences. And normally we use psi, the field unit we are using.

And retention time in minutes. And what are the terms? Sigma is there. Sigma is surface tension. It is oil surface tension. Dyne plus Cm. So surface tension unit also you should remember.

Rho w.So if I do not give a surface tension unit you should remember this is a standard unit right? Rho equals density. So, it is a 1.1 per centimeter cube. Now del P large then particle diameter will be small.

You can see the formula. So just inversely proportional. If a higher pressure drop is happening a smaller particle diameter will be produced. So let us say one pipe is here and oil and water mix are going on flowing through this pipe and I have one choke or valve. So choke or valve lots of pressure drop will be happening del P. So large pressure drop happening this particle will be broken, quickly.

So quickly broken means particle size will be smaller. So large particle drop, the pressure drop is there. So in that case particle diameter will be smaller. Sigma surface tension. If surface tension is higher then particle diameter will be higher.

So it will be particle will not try to break actually. Rho w density. If density is higher then d max will be lower. So I can give some problem like this. How does del P sigma rho w tr affect your particle diameter?

So based on this formula you can write the answer. So del P is large across a small distance at choke, valves or so d max will be smaller. The dispersion process theoretically is not instantaneous. For calculation purposes we will assume this is instantaneous, quickly it is happening. So in this case I can create some problems also I can give some value and I can ask what the possible value of d max is.

So you can calculate roughly. If I give exact data then you have to get, you can get exact value also. Coalescence. So you have seen the VT formula if two particles are colliding with each other then particle settlement will be quicker or oil particles will be quickly settling so your retention time will be lower. So you have low, if you want to know retention time T R then your particle size should be bigger.

So it will be settling quickly. If the droplet pair is exposed to turbulent and fluctuation pressure so in the case particle will be smaller in size. So coalescing will be difficult. Flotation. In the previous chapter, you have seen that if your gas particle is there oil droplets and water droplets from oil separation will be difficult if the gas particle is there. They will not be allowed to collide with each other, they will not be allowed to make bigger particles.

But here if you have gas particles, gas particles around the oil droplet will try to help to float. So the process of floatation improves separation. So if the gas particle is there it will improve separation. So gas assists in oil particle separation and oil droplet separation. The floatation process reduces vessel T R if we are doing it, if you have some amount of gas it will assist so it will reduce retention time.

So separators also can be smaller in size or retention time can be smaller.