Surface Facilities for Oil and Gas Handling

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Principle Of Separation-01

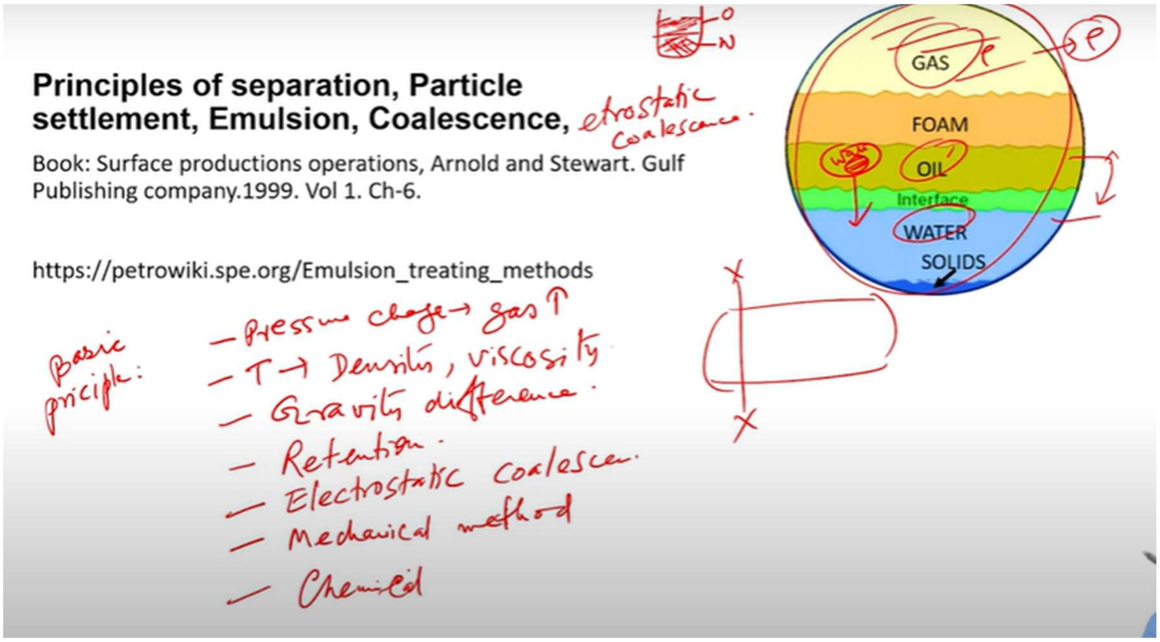
So, I will start today with the principles of Separation, Particle Settlement, Emulsion, Coalescence and Electrostatic Separation, and Electrostatic Coalescence.

Now, you can see this right side picture is just a cross-section of the separator you can say like if I take cross section here, x-x section. So, it will look like this circular section and the top layer will be gas because density will be lower or gravity will be lower than other fluids. Then there will be a foamy layer maybe, then oil, then oil-water interface and there will be like emulsion layer or mixed layer will be there, then water, then solid based on the gravity. Solid means sand may be there, sand is heavier, and the sand will settle at the bottom where gas and gas are lighter.

So, it will be creating a layer on the top of the section. So, these three layers normally we get three layers of gas, oil, and water, but if you have foam then you will get a foam layer, if you have an interface then interface means the oil-water mixture will be there because of emulsion and there will be bottom layer solid section. So, here gas density matters, and liquid density matters. So, the liquid density, and gas density difference is very high.

So anyway, gas will be creating a top layer. But if you see here oil and water case, if oil density is very much lower or gravity is very much lower and water density is very high, anyway water almost fixed density will be there, and gravity will be there, but oil gravity will be changing based on your different types of oils you are using. For example, you may have your heavy oil or light oil. So, based on that this layer will be formed quickly or it will be delayed for a longer time and the interface will be like if you have an emulsifying agent then the interface will be stabilized for a longer period. So, separation will not occur.

So, in this case how to separate this oil and gas quicker, how do not create the interface, if the interface is there then how to reduce the time of holding that particle oil particle or water particle there? So, we will discuss in this lecture solid, envious, sand. So, it will form a layer at the bottom. The basic principle of oil separation, the pressure change, the basic principle, the basic principle, the pressure change. So, pressure change causes more gas will be coming because the loss of dissolved gas will be there, so the gas will be coming out from your fluid.



So, gas or low-gravity fluid will be coming out. The temperature change, if you change temperature then your density viscosity will change. Then gravity difference will assist in separation. Let us say in let us say one oil particle is here, sorry oil particle, water particle is here, water particle is here. So, the water particle how quickly it will be settling it will be based on the density difference or gravity difference.

So gravity is the difference between two fluids, oil and water. Then some other techniques you also use to increase separation, for example, water particles from oil or oil particles from the water you want to separate. The techniques, one technique is gravity settlement, you take a certain amount of fluid in a certain bottle or any pot and give it enough time. So, automatically water will create one layer and oil will create another layer. So this will be oil, this will be water.

So time is important, so retention time is important, retention time. So retention time depends on many factors, so we will discuss it later. Then if you have a longer retention time you have an emulsifying agent, later we will discuss the emulsifying agent. So, longer retention time you can reduce the retention time or separation time using maybe electro electrical method called electrostatic violations, electrostatic method or you can use mechanical method. So using the mechanical if you can create particle collision, so mechanical method and the particle will collide and it will make a bigger particle, and the bigger particle will separate quickly.

So, smaller particle separation will be difficult, so if you have bigger particle oil, particles in water, and water particle oil it will be very easy to separate.

So using the mechanical method you can create bigger particles, you can separate them, and you can use the electrostatic violations method we will discuss. So using that one also you can create bigger particles and you can separate them, you can use some chemicals also. Let us say when you have one emulsion two particles of immiscible particles are there but they are not separating quickly, maybe some chemical is helping them not to be separated. So in that case you add some chemical and deactivate that chemical which prevents to creation of bigger particles.

Some chemical methods are also possible, so when you are separating one is gravity separation if there are no extra chemicals or any impurities the oil and water if you keep them in a bottle automatically be separated. Gas also will be separated because gas is very much lighter weight and if you change pressure gas will be automatically coming out. If you are changing temperature then viscosity changes, gravity change, viscosity gravity when changing then particle settlement rate will be changing.

Particle settlement rate means the oil particle from water, water particle from oil will be moving, oil particle will be moving up quickly, and water particle will be falling quickly,

falling because it will create bigger particles when bigger particles are forming they will fall quickly. Smaller particles take time, so retention time will be longer for smaller particles.

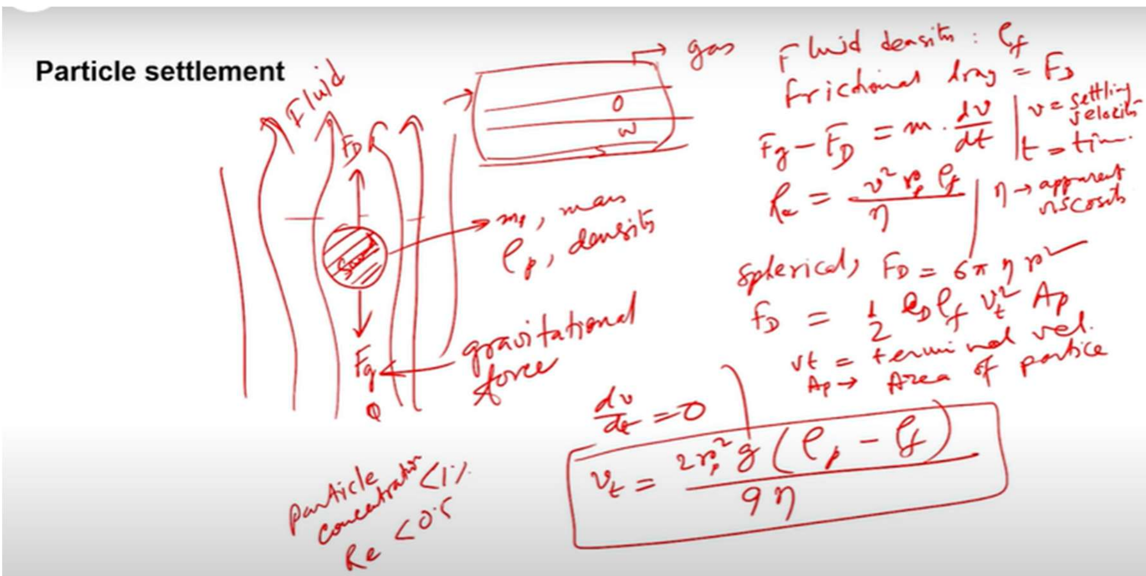
Suppose a very high-viscosity fluid particle will not try to move. For example, in a hair gel, you may have seen, lots of particles will be there, but it is not settling actually because the viscosity is so high. Electrostatic coalescence, so using electrical means you can create resonant in the fluid. So small particles will be resonating and two particles will be colliding with each other which will make a bigger particle. Then chemical method if some particle has some chemical that is preventing it from separating, so use another chemical to react then you make a bigger particle you separate.

Particle settlement, whenever you are separating oil and gas or oil, gas and water, oil, gas, water, and sand four phases or maybe three phases. Here one thing is that we say phases, liquid phase, gaseous phase, solid phase. We get three phases we know it from physics plus two physics if you can remember.

But here water and oil are two different we are saying phases, but it is not phases two components of liquid.

Single phase, liquid phase both, but in our oil and gas industry normally we use the term liquid phase and water phase and oil phase.

So we say four phases it is three phases. So gas will be going out and you are creating different layers, oil, water, maybe sand also there. So when you are creating layers you are injecting fluid if you have a certain time so because of gravity the high-density high-gravity fluid will be falling, down, down, down, down depending on settling at the bottom and low-density low-gravity particles will be moving up. So this will be controlled using a particle settlement theory. So particle settlement theory is like this.



Let us assume one particle is here and the particle is trying to fall into the liquid.

I have one liquid column, this is a liquid column and my liquid is moving up and this is maybe sand, or maybe one liquid oil is moving up and water is falling this is also possible. This is the force due to gravity, the force due to gravity because it is trying to fall and another force because this fluid is moving up maybe this is sand, just assume sand is solid. Because this fluid moving up it will be dragging up, fluid will be dragging up the particle.

So Fd is dragging up. So if my Fg is higher it will try to move down, if Fd is higher it will try to move up.

Now the mass of the particle, m mass, density rho p, m p you can write, density assume this variable. Fluid density, fluid density rho fluid, and frictional drag force, frictional drag Fd already I have given and this is, Fg is a particle gravitational force, this is the gravitational force. So Fg gravitational force opposing the drag force, Fg I have written a small letter, Fg minus Fd, Fd I have written capital. So m into dv by dt, acceleration due to gravity, sorry particle acceleration.

Now v is settling velocity, settling velocity and t is time. Reynolds number equals from Stokes law, v square r rho f, I will write, v square r into rho f divided by eta, eta is the apparent viscosity or is the particle radius and rho f is the fluid viscosity and v is the settling velocity. So spherical particle, we are assuming spherical, if we assume another shape particle then there will be some shape factor. simplicity just assume this is spherical. For spherical particles Fd equals 6 pi eta r square and frictional drag Fd half Cd, Cz drag coefficient rho f vt terminal velocity, Ap, vt is terminal velocity, vt equals terminal, Ap is the particle area, area of the particle, Ap area of a particle means projected area.

So dv by dt equals 0 when acceleration is 0. So finally this will be forming if you assemble all together vt terminal velocity will come 2 r square rp square, rp you can write better, rp square g rho p minus rho f divided by 9 eta. This is the terminal velocity formula.

Now from here what you can see, you can see viscosity increasing vt reducing, vt proportional to inverse of viscosity, fluid viscosity, and vt proportional to the radius square of the particle. So particle radius means the particle is larger particle will have more larger vt terminal velocity means quickly it will be falling down and that rho density difference if you see rho p and rho f, if density difference is very high again it is high.

So larger particle size is more important because the square term is there, in another part linearly relationship is there like rho p rho f the difference is relationship is just proportional but viscosity is inversely proportional. So whenever you are solving any problem you have to see the unit also, here it is SI unit-based calculation and this is for strokes using strokes law. So particle, we are assuming particle content is less than 1 percent particle, less than 1 percent particle, particle concentration, particle concentration, and Re less than 0.5 I think. So this condition should be there.

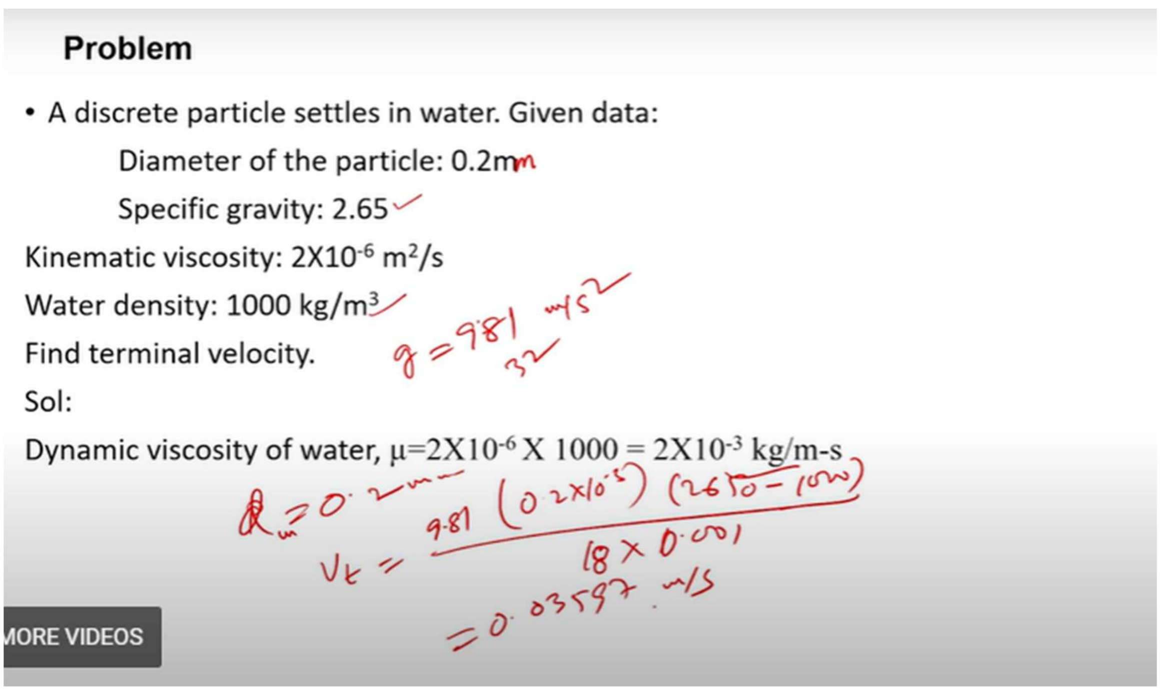
If you have changed the Re value particle concentration will increase so the formula will be changed. So we are not going into further details for that, up to this one. Now gravity settlement, so the same equation is modified by your oil and gas industry people because they want to use a field unit. The field unit this extra constant term will be coming and del SG specific gravity difference and dm is the particle diameter square and mu is the viscosity.

So vt term is unit feet per second, so you have to see the unit here.

Del SG means specific gravity anyway related to water, mu is viscosity c small c capital P. So here also you should remember small c capital P poise okay, so not both small or both capital or not opposite. dm is particle diameter okay and the unit will be micron. If I give a different unit you have to convert okay. So exponential comes same as before like vt proportional to del SG proportional to dm square proportional to 1 by mu.

So now if you want to get more quicker settlement means VT is higher, so if you want to increase VT higher means del SG has to change. So how to change, del SG is dependent on actual temperature, so you can increase temperature you can change viscosity. dm, so how to increase DM, dm actually whenever you can add one particle, one particle, or two particles together it will be a bigger particle.

So a bigger particle means DM is larger now. Now how to join these two particles, so There are techniques, so we will discuss and viscosity again will be dependent on temperature.



So we will see how to change. Now based on the simple formula whatever you discuss let us see one problem. A discrete particle settles in water okay given the data diameter of the particle is 0.2 metres just an assumption. Specific gravity 2.65, I think it is sand particle diameter specific gravity.

Gravity viscosity 2 10 to the power minus 6-meter square per second, water density is given 1000 fine terminal velocities. So here the value I think you should not forget is 9.81

right, and in in field unit will be 32 right feet per second square. So water viscosity is given right and kinematic viscosity is given, so from dynamic viscosity, we are getting this one.

So the particle diameter, diameter is 0.2, this should be 2 millimeters, not a meter. So terminal velocity V t, this is diameter dm. So V t will be 9.81, if you see the previous formula then 0.2 into 10 power minus 3 millimeters is given, so you have to convert into a meter because you are calculating SI unit and then 2.

65 is given right minus water 1000 and viscosity 0.001 and into 18 sorry 118. Why 18 is coming? If you see the previous slide actually, this 2 R p by 9. So R p if we put in diameter form, diameter means it 4 terms will be coming.

So d equals R p 2 right, so 4 terms will be coming, so 4, if you calculate again 2 and 9, is there, so finally at the bottom below 18 will come.

So altogether if you calculate your result of like 0.03597 metres per second.

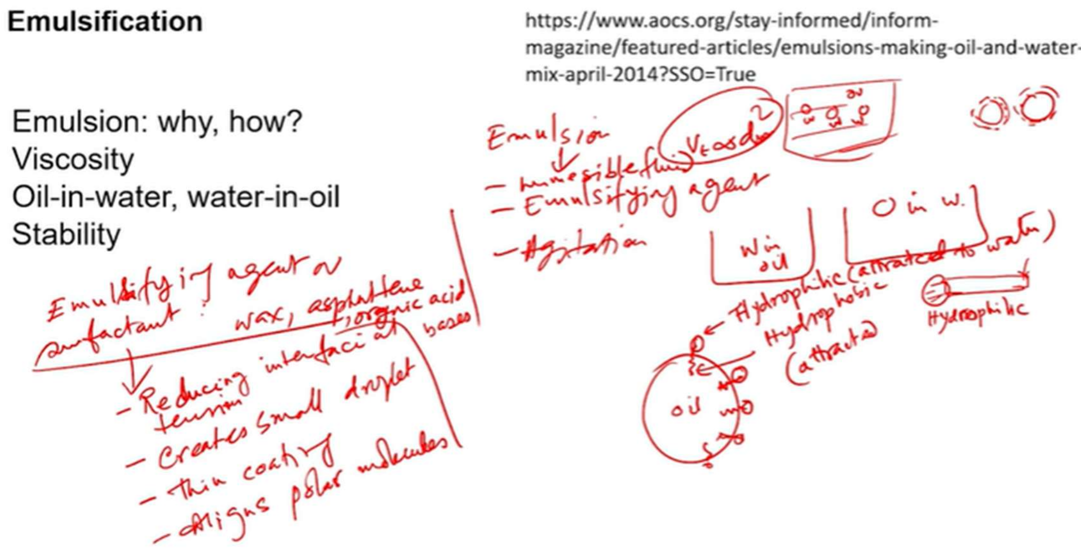
Now in the exam what I can do, I can change some parameters or I can just twist a little bit and I can give this sort of simple problem. So you should be familiar with how the particle is getting settled and what parameters are important for a particle settlement. So based on that actually, now next you will be doing research okay, how to change my diameter, how to change viscosity, how to change my density, emulsion.

So whenever we are talking about emulsion, why emulsion term is coming?

The emulsion will not allow particles to join and to make bigger particles. Let us say you have an oil and water mixture okay and water particles are like this, water, water, water particle. Now if it is creating emulsion, then water particles will not make bigger particles whatever

method you apply. So because what happens, water particles will have a certain coating around because of this coating two water particles will not mix okay, they will have one barrier.

So how to break the barrier? You have to understand now why the barrier is getting created and how to break the barrier so that you can get bigger particles.



So that your V t is proportional to d m square, d m you can increase, your purpose is to increase d m. Now two immiscible fluids, water and oil are there and it is creating emulsion okay.

So immiscible fluid is there and one particle is there, let us say an oil particle, and a water particle are there in oil and two water particles not joining together.

So it is not joining, so it is not making a bigger particle. So the particle is not moving, it is called a stable emulsion.

So particles are not moving at all very small tiny particles are there. So for that one emulsifying agent should be there to create, an emulsifying agent.

So one emulsifying agent should be there that will be coating the surface, that small particle around the barrier will be created using that emulsifying agent and two particles not mix.

Then sufficient agitation you have to give, how to create agitation? When fluid is flowing from well above to the surface, it is flowing through pipes and lots of turbulent flow will be there, it is passing through chokes, it is passing through maybe artificial lifting system, passing through different valves. So lots of agitation already you are creating, agitation when you are creating bigger particles you are breaking down to smaller particles.

When you are creating a smaller particle immediately the emulsion will say I got a small particle just coat it. Then they will be happy, they will not be allowed to mix small small particles. So lots of agitation you are creating.

So three things are there, immiscible fluid immiscible fluid, water oil in our case, and the emulsifying agent is there so that it is not allowed to mix and make bigger particles and one agitation you are creating, lots of agitation, lots of agitation and you are creating very tiny tiny particles.

So very tiny particles will not move at all, if you have high viscosity, tiny particles are.

So examples of emulsion, milk on emulsion, cream, lotion, lots of lotion you are using, those are also actually emulsion. So normally you have seen everywhere and stable emulsion if you want to make the particle must be very small, very small particle so very DEM is very small so the particle does not move actually. So emulsion is a colloid form okay, colloid means very very small particles are there in fluid and it is not moving at all. Emulsion normally it will have a specific property like it is a bigger particle and oil and water mixture in our case we are seeing emulsion. So two types of emulsion will be there, water in oil, water in oil, or oil in water. Whenever you are creating an emulsion, so you need one emulsifying agent. So normally they are called surfactants.

So emulsification will be happening because you have the emulsifying agent or surfactant, emulsifying agent or surfactant? So if you have surfactant then it will not allow you to make bigger particles. So what are the different surfactants, Surfactants like wax, it is there in oil bores, and asphaltene okay wax, asphaltene are emulsifying agents.

Sometimes I ask in the exam, give some examples okay? So what they do, will be reducing interfacial tension, reducing interfacial, interfacial tension creates small droplets, small droplets, thin coating okay, and aligns polar molecules. So any fluid particle if you say water polar molecule, if you see will try to create a smaller surface area okay if you have an emulsifying agent, it will create a smaller surface area but two particles will not be colliding and make a bigger particle. An emulsifying agent will try to create smaller particles and it will coat them so that they will not move. Asphaltene resin organic acid, here are some more examples are there organic acid, organic acid basis, and how does this emulsifying agent work? Let us say we have one water oil particle and the emulsifying agent will be like this,

it will have one end hydrophilic, hydro and another will be hydrophobic. Here you can remember the name Felix means loving, hydro water, water-loving, hydrophobic will fear right, hydrophobic it fears water, so it will be going away from water.

So the going away that end of this molecule, it will have one end like this, one end like this, so this will be hydrophilic, this will be hydrophobic end okay, hydrophilic end will be outside, it will be around water and hydrophilic, hydrophobic end will be inside oil. So lots of you are creating like this and it will be creating like coating around, so the oil will have all around water, so one oil particle all around water, another oil

particle all around water, so all around water it will be coated with water. So finally two oil particles will not meet okay, so this way they are creating separation between two particles. So this is hydrophilic or attracted to water, attracted to water okay, hydrophobic means

attracted to oil, attracted to oil, just not right this one. So emulsifying agents are partially soluble in water, and partially in oil okay, because of that

they create a coating around the particle and they do not allow it to make a bigger particle.

So it is a chemical compound, that lowers surface tension or interfacial tension between two compounds.