**MARINE ENGINEERING**

**By**

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**Lecture74**

**Oil water separation, electrical systems**

Good morning everybody. Today I will start class on oily water separation, some electrical and other background I will give and I will finish the whole lecture course. So first I will start with oily water separation. Actually this is bilge water. Bilge water means at the lowest most position of the ship there will be storage of water.

So, whenever any waste water is there, so there will be storage and finally, you have to dispose this one and disposing directly into sea will have issue because marple is there, they have some regulation, you have to follow the regulation. So once you are following the regulation that means you have to do some mechanical chemical or other arrangement so that you can remove the contaminants from water and you can dispose. In many cases you can transport to onshore also and there you can dispose with proper regulation following proper regulation. But normally, when you are having big ship or you are going for long duration from one place to another place, so the volume of water will be higher. So, via volume of water, you cannot dispose or you cannot carry.

So, you have to remove contaminants, then you can dispose in water, in ocean water. So, the build location, if you see in a ship, ship build location will be like lowest most position here. and bilge will be collecting all the waters water coming from your air conditioning system your machinery system grease may be there oil will be there so many contaminants will be there so that contaminant you have to remove then you can you dispose so if you can see this this is bilge well and this is bilge well and this is bilge water tank And this is one pump. So normally this bilge water pump will be centrifugal type pump.

Many other type of pumps also can be used but most common is centrifugal pump because it is easily available, cheaper and it can handle larger volume. Because here your target is not to produce high pressure rather just transporting water from one place to another place

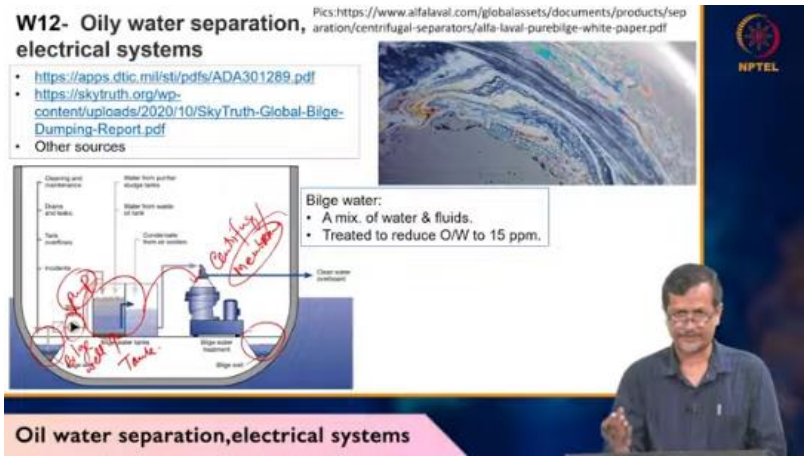
or adding certain amount of head. But in certain cases, for example, if you remember your pump lectures, if you need very high pressure development, there you need reciprocating and other type of pumps. Because in this case, your volume flow rate will be a little bit higher, but pressure development is not too high. So centrifugal pump is okay.

But other type of pumps are also used. I will discuss later. And once you get bilge water, you pump to some bilge tank. So bilge tank you will be doing some chemical dosing. Chemical dosing means you add some chemical and you try to settle some contaminant there or you try to separate the emulsion, oil and water emulsion so that other mechanical arrangement they can separate oil and water properly with proper regulation as per regulatory mechanism, regulatory instruction.

So then from there you can go direct at the end you can go to nearby bilge water treatment system maybe centrifuge or maybe you will have like reverse osmosis system you have seen your membrane system. So membrane system may be there because you have to remove the oil content to a very low level. That is why you will have several stages of separation. First maybe you just settle in tank. You store water in a tank and you give enough time.

So slowly water will create one layer at the bottom and oil will be floating on the water surface. When oil is floating on the water's surface, you just use it separately you skim out that oil. And then again you send that water, oil mixture, whatever remaining part. So, to another tank where you may have to add chemical to break the emulsion. Then once emulsion is broken, then you put to another mechanical arrangement.

For example, OWS, Oily Water Separator or centrifuge or membrane system. So, then you can separate. Once separation done, then you can dispose the water. And you can see right side one picture I have given here. So if oil spill is there, how it will look like in the ocean.




And once it is spreading over a larger area, so it will be harmful for your environment. Oil spill occurs because of many reasons one may be like say tanker overturning or leakage in tanker or maybe bilge water not treating bilge water and you are disposing in ocean. So, that sort of reason can be there for this oil spill and environmental hazard. And bilge water a mix of water and fluid that can be like oil. So, hydrocarbon basically and many aromatic aliphatic hydrocarbon will be there.

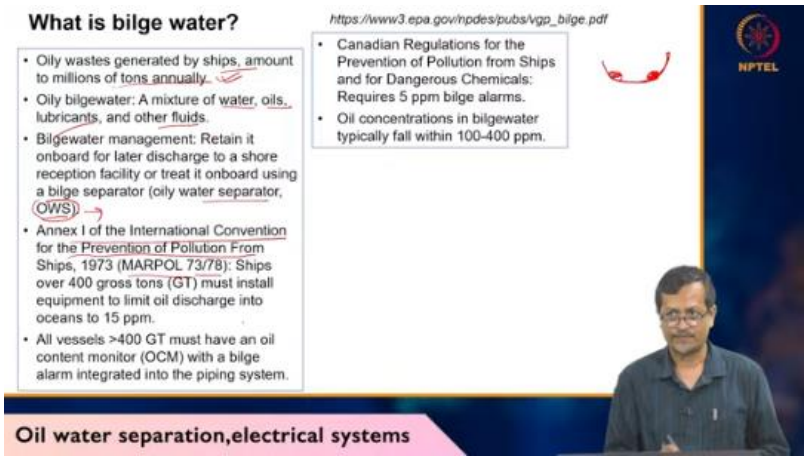
So, if it is aromatic hydrocarbon then you have some detector you can detect also how much percentage of hydrocarbon is there and your oil and water I will be using the term O for oil and W for water. So, oil and water mixture to 15 parts per million. So, this level you have to reduce. So, during desalination process you have seen this definition of ppm parts per million like seawater desalination, seawater will have ppm of 15, 35,000 to 40,000 ppm and you are reducing to 500 around ppm 500 to 1000 but here oil content you are reducing further lower 15 ppm this is as per Marple Regulation. I think you have write capital.

uh marpol regulation but if you see the canada's regulation canada they have regulation uh you have to reduce the content of oil 5 ppm okay uh canada is much stricter than international agency so a binge is there at the bottom nearby bottom of the ship you have seen here and here it is getting collected okay So this is the name term is used as a bilge water. Sometimes we are using as an oily water mixture coming from your ship. Oily waste generated by ship amount to millions of tons annually. So huge amount of oil and water mixture is being produced every year because of lots of ships are running all over the world.

So a mixture of water, oil, lubricant and other fluids. Some metals also will be there, small metal particles. Bilge water management, so retain it on board for later discharge at shore, reception facility or treat it on board using bilge separator, oily water separator or OWS. So the term OWS I will be using later stage. Annexation 1 of International Convention for

the Prevention of Pollution from Ships, so MARPOL, 1973, 73 by 78, they have regulation that if you have ship,

gross weight more than 400 gross stones or gt must must install equipment to limit oil discharge into ocean to 15 ppm okay all vessels more than for 400 gt or gross stones must have an oil content monitor ocm with the bilge alarm integrated into the piping system oil content monitor will say okay your oil content is going more than 15 ppm or 5 ppm whatever regulations you have following then your alarm signal will be working and your bills pump and other system will be working accordingly if you are not pumping out this one then everything will be over flooded in that area again the flood flooding and water can enter into engine room and other areas plus this ocean pollution will be one issue so you have to remove oil and you have to handle the water properly So, Canadian regulation for the prevention of pollution from ships and dangerous chemicals, they are saying 5 ppm, this criteria. This is very tight criteria actually. International standards, they are 15, but Canada's is 5.




Oil concentration in bilge water typically fall within 100 to 400 ppm. So, we have to reduce 100 to 400 to 15 if you are following international standard. If you are using Canadian standard, then it will be 5 ppm. So bilge pump. So when you have bilge water, so you have to transport water from one place to another place because during disposal stage or during your cleaning or removing of oil particle or contaminants, you need to pump or you need to give pressure or energy to the fluid so that fluid can be given to your centrifuge or maybe OWS or maybe your filtration system then you can pump it out.

Okay, so bilge definition is part of the hull that would rest on the ground or if the vessel were unsupported by water. The lowest compartment on a ship is on either side of the keel and in a traditional wooden vessel between the floors. Common bilge pump, centrifugal or

diaphragm pump and reciprocating pump also can be used. Okay, so centrifugal pump I already told, the centrifugal pump volume flow rate will be higher. you can remember this head and flow rate characteristics centrifugal pump will have head and flow characteristics like this and but reciprocating pump this is centrifugal


okay and diaphragm pump also one type of reciprocating pump so whenever talking about reciprocating its speed is lower so volume flow rate is lower but your pressure developmental very high but in bilge cases normally our pressure development may not be required so high so common use centrifugal pump but other pump also can be used and one bilge pump got from website geomart so like For example, purpose, I have given 1100 gallon per hour electrical bilge pump. Electrical bilge pump can be used in aquarium, fishing, many other applications also there. But this is also used for shipping applications. So, the picture also shows this is a centrifugal type pump.

So, in India, they are selling this simple plastic type pump. Reciprocating in diaphragm pump, lower capacity and cannot handle debris. While centrifugal pump can handle little bit debris also and higher flow rate can be achieved in a centrifugal pump. So bilge separator. So bilge separator or bilge water separator you can say.

A gravity OWS or oil water separator. OWS oil water separator. A gravity OWS, because of gravitational force, the separation will be done or a centrifuge can be used to separate oil and water with one or more additional unit of operation that polishes the bilge water, reduce the ppm to 15 or 5 as per requirement. Oil exists in free, dispersed and emulsified form. small amount of oil is there in water okay so oil particle will be dispersed like this okay so this is discontinuous phase or dispersed phase okay and water oil and water continuous phase because oil content is low

But in many cases, many other applications where oil content is higher and small water particle will be there. For example, oil and gas industry, they will be separating water from oil because their main target to get oil. So, water must not be there. In that case, continuous phase will be oil and discrete phase will be water. But in your bilge water application, normally water content will be higher.

So, that is continuous phase and small, small oil particle will be here and there. So, that will be discrete phase. So, descriptive oil particle will not get separated easily. So, if you can make larger particle, if you can make small small particle combined together, then separation will be quicker. So, later we will discuss how this happens.

Oil exists in free, dispersed and emulsified form. So many oil, many time oil may not be emulsified, many time it will be emulsified form. So if oil is pure and water is pure, there is no contaminant, then water and oil, let us say if you take water and oil. water and oil you take in a bottle and you shake properly and within few seconds again water will get separated because there is no contaminant for example you take petrol and oil if you mix it and if you keep for few seconds it will be separated completely oil will be creating upper layer water will be creating lower layer because water density is higher gravity is higher okay higher gravitational force and lighter oil is lighter so this is not related to viscosity this is related to whether heavier and lighter so water is heavier so it will be creating lower layer and if you have sand also for example or some heavy metal so it will create lower layer okay so sand sand will be sand will be much more denser so sand density like 2.6 water water density is one and oil density will be like point

So, oil density differs because oil will have long-chain hydrocarbon, short-chain hydrocarbon and different types of oil will be there. So, the oil density will be changing, but sand, normal sand application like around 2.6 density and water density you know already 1, 1 means 1 gram per centimeter cube or 1000 kg per meter cube. So sand will be like 2600 kg per meter cube. oil will be like 800 kg per meter cube. oil is lighter.

So oil will be already floating. Now if you have certain amount of oil in water, small particles, those particles will try to slowly floating up because of buoyancy effect and will be creating layer on the top. so layer oil layer slowly oil will be creating one layer so from the top just you remove the oil and again you give enough time the oil particle to move up so you need you have to give enough time so to separate oil with gravity separator gravity separator means you are not giving any energy just you have one tank and in tank you put all this oil water mixture what will happen oil will be trying to oil particle will be trying to

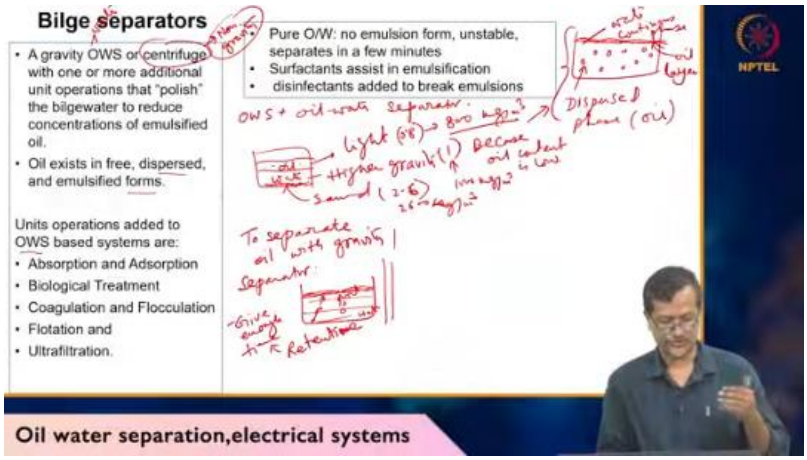
moving up okay water will be settling then oil will be creating one layer here okay so you have to give enough time give If there is no impurities or contaminant, then oil and water will be separating quickly.

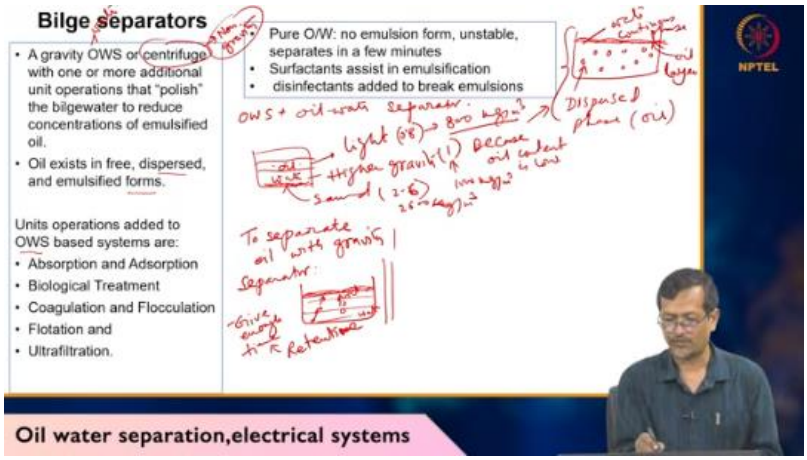
In few seconds, it will take unstable emulsion before me. But if there is any chemical, then it will be creating stable emulsion. So, oil particle will not move or will not be able to move because of certain other hindrance effect on this one. So, enough time is called retention time. So, how much time you are giving?

So, that is called retention time. So, you keep for 15 minutes. So, 15 minutes is your retention time. In 15 minutes, how much oil is getting separated? That you have to calculate.

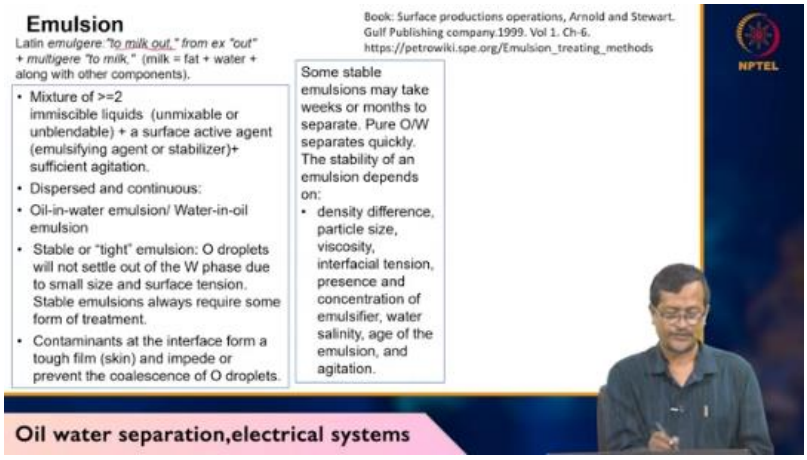
Later, we will see how to calculate this one. So, unit separation. Here, OWS, Oil Water Separator. So, I am discussing about this one, Gravity Waste Separator. And there will be some non-gravity waste separator.

For example, centrifuge. centrifuge this one you see the top center fusion non-gravity based non-gravity based or maybe gravity will be assisting okay because at high velocity you are creating the separation so the unit operations will be like absorption absorption mechanism biological treatment nuclear coagulation and flocculation flotation ultrafiltration so we'll discuss that one also in short so how to separate oil water before disposing the water into the ocean so pure oil water no emulsion form okay unstable separate in a few minutes or few seconds surface surfactant we'll discuss later surfactant means some chemical if you add then the oil particle will not try to move because of this chemical effect so surfactant will be creating emulsion and because of emulsion creation the particle not get settled then how to settle that one this some techniques are there we'll discuss disinfectant added to break the emulsion or surfactant must be neutralized using this disinfectant so this some chemicals are there if you add there then the emulsion will be broken and again oil particle will try to get separated from water so we'll discuss that one also So, the Latin term emulsion is to milk out.




So, like milk if you rotate very high speed it will create skim or butter will be separated from the milk. So, from there the term came up. So, normally emulsion will have two fluids. So, not any two fluids, two immiscible fluids. two immiscible fluids are there.




When you are trying to mix and if you are creating emulsion, that will be stable emulsion. It will not get separated again. But this oil water, pure water you are taking and both are

immiscible. But if you do not have any other chemical, then it will be separating quickly. You are not creating emulsion there.

Okay, that will be unstable emulsion you can say. So, immiscible liquids, unmixable or unblendable plus surface active agent, emulsifying agent we will discuss later. So, one liquid is here, let us say oil particle and inside water. So, oil particle will be moving because of buoyancy effect moving up. But if you have some surface active agent around, let us say called surfactant.

or surface active agent surface active surfactant surface active agent are there then this particle will try to move but it will be pulling it back so it will not be separated some cases the emulsion will be so stable several months also if you keep it will not get separated. So, dispersed and continuous phase. So, dispersed already I discussed that like continuous phase is water because larger amount is there. Dispersed phase is oil particle. The small particle here and there.

So, this is dispersed. So, oil in water. So, in our case, in our bilge water case, normally it is oil in water. So, small amount of oil is there. Bilge water.

So, in our bilge water application, it is oil in water emulsion. But in certain other cases water in oil will be there. So oil in water means our continuous phase is water. But discontinuous or discrete phase or dispersed phase is oil. But water in oil their continuous is oil.

continuous phase so here actually although we are seeing phase but technically it is not phase because water and oil both are liquid phase so it many time we say component same phase but different component okay so although we are using phase but instead of phase we can use component okay so liquid component a liquid has having two components one is oil one will be water both are immiscible okay So, stable or tight emulsion, oil droplets will not settle out from the water quickly due to small size and surface tension. So, because of water is having the surface tension and size, if particle size is very small, then water, oil particle will not try to get out of the water, oil particle. So, in that case, we say it is stable emulsion. Unstable emulsion means like pure oil-water mixture, just heat working bottle, you shake it.

So, quickly it will get settled out. Contaminant at the interface form a tough film or skin and impede or prevent coalescence of oil droplets. So, coalescence means like I have one

oil droplet, I have another oil droplet. If both are mixing together, making bigger particle, it will be better. But what happens if I have emulsion?

I have like say surface active agent. So, pure it will create bigger particle, but if you have surfactant, so surfactant what will do I have a oil particle, oil particle, so this will not make bigger particle. Why bigger particle is better? Later we will discuss particle settlement term.

So when particle is bigger, it will be sliding at higher rate. But particle is smaller, it will not slide. So our attempt will be to make bigger particle. So if I make bigger particle, that will be settling quickly. So our retention time in a tank, so if I have one settling tank, if I give enough time, let us say 15 minutes time.

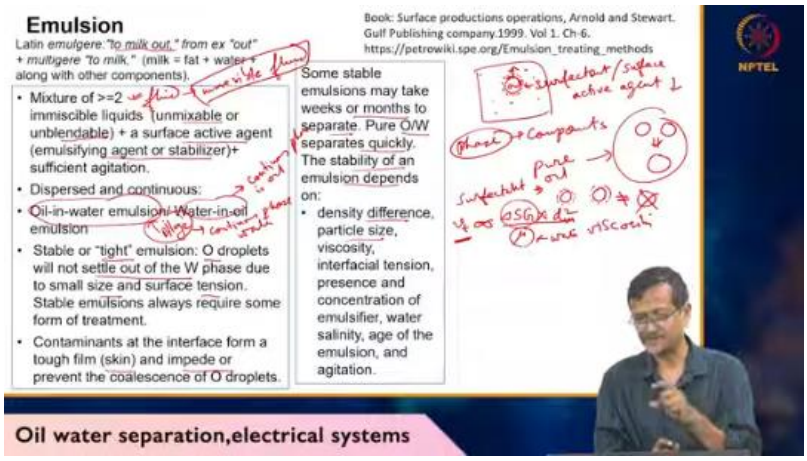
and particle very small so particle is trying to move up but before moving it again i have to remove water i have to fix it i have to put more water okay because our retention time low but particle size very low but in some cases particle size larger larger size it will be moving at higher rate so 15 minutes will be sufficient for moving water particle to the surface so that we can skim out oil water can be separate separately it can be taken out separately okay so we'll discuss it Some stable emulsion may take weeks or months to separate. Pure oil water separates quickly. The stability of an emulsion depends on density difference, particle size. So, like Vt proportional to density difference, delta specific gravity or density, particle size, viscosity.

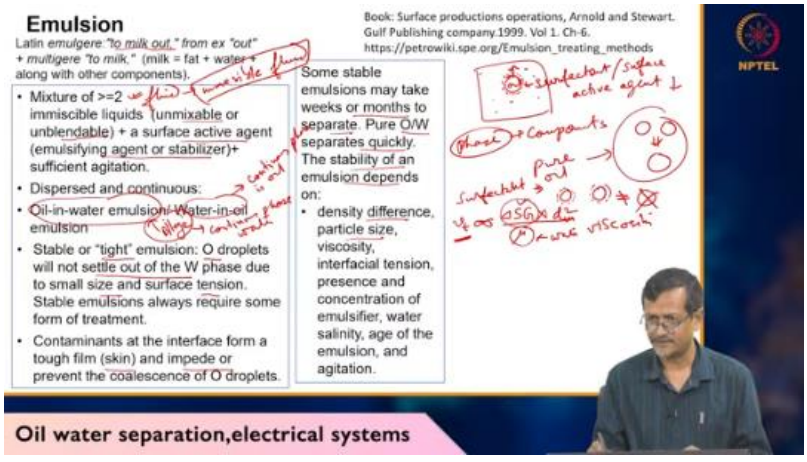
Interferential tension, presence of emulsifier, emulsifier will not allow to mix separate, water salinity, age of emulsion and agitation. Agitation means if you are stirring very high rate then actually you are creating very small particle. Very small particle will not separate quickly. You have to make bigger particles. So, if you are trying to make bigger particle, then okay.

But if some pump is working, pump will be creating very small particle or if any other machine is working, very small particle will be creating, then things will not work for gravity settlement. Gravity settlement, you have to make bigger particle. Again, if you have emulsifying agent, you have to remove that emulsifying or surface surfactant. If you are removing surfactant or neutralizing surfactant or removing emulsifying agent, using some chemical or other mechanism then again settlement rate will be very high so vt actually your settlement velocity okay if density difference high settlement velocity high is dm particle diameter which particle oil particle diameter so oil particle diameter higher

settlement is higher viscosity viscosity means fluid water viscosity here not oil viscosity water viscosity

Okay, water viscosity anyway, it is, we cannot change much. But in other case, for example, water in oil case, oil viscosity can be changed. Okay, so in that case, viscosity also plays a very good big role. But in water case, normally viscosity will not change, it is small temperature changing. okay so terminal velocity or settlement rate will be higher if you have high density difference water and oil density difference is very high settlement rate will be higher for example oil density and water density is same then both will not get settled but oil density very low and water density almost fixed then the settlement rate will be higher again particle size diameter dm or oil particle size diameter is higher is settlement rate also higher and this is for your gravity based separator




if you are having only settling tank one tank and you are putting oil water mixture and it gives a half an hour one hour time so slowly oil particles moving up it will create layer on the top okay so in that case higher larger water oil particle size better uh density difference

oil and water better and again you have to consider that no emulsifying agent should be there if emulsifying agent is there then whatever time you give it will not get settled So then in that case you have to add some other chemical to neutralize the emulsifying agent or deactivate. Then again your settlement will be starting. So emulsion breaking by four mechanism. So, emulsion yes I have one emulsion here I have oil water mixture this oil particle is here water and oil particle.

So, distributed now next is flocculation and coagulation. So, what will happen initially before separation the particle will be nearby together. this is called flocculation and coagulation from there it will happen it will make bigger particles Few particle will be joining together because you are removing you do not have maybe surfactant you neutralized then particle will be coming together it will make bigger particle. So, this is called post walled ripening.

It is making bigger particle. Then from bigger particle it will create creaming. Creaming is particle will be bigger so it will be trying to moving up. So it will try to move up. So this is called creaming or sedimentation.

sedimentation the next is making bigger particle there when particle move top so this will be making further it making one layer d so this is called making bigger particle making oil layer so finally it will create two separate layer one will be oil okay so first part is that you have to bring the small small particle nearby together then it will be colliding if there is no surfactant then collision will be occurring there will be no barrier between them and they will be joining it will be like this so one particle is here another particle is here now because of agitation or some motion the two particle will try to touch each other when it will be touching it will be creating like this finally it will be creating a sphere so normally the oil particle will create a complete circle because of surface tension sphere because of surface tension because surface tension says that particle will try to create lowest surface area. So lowest surface area means spherical shape will have the lowest surface area.

So particle will make spherical shape. So emulsion stability unstable phase separation immediately unstable phases separate immediately then it may be like few seconds okay within few seconds it will be happening but if you have stable so it can take one hour two hour days or weeks and in many cases it must be so much stable that no visible sign of phase separation after two weeks also is possible so i said like emulsifying agent or emulsifier emulsifier agent or emulsifier or surfactant okay the same thing there will be different names so surface active or surface active agent or surface active agent they will

say some some agent will be preferring oil some surface active agent will be preferring water Insoluble in one phase.

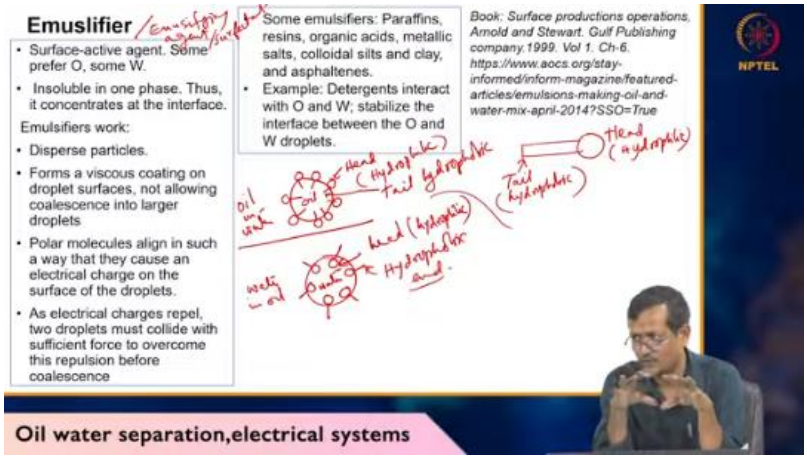
So emulsifier will have insolubility in one phase and other phase it will be soluble. Thus it concentrates at the interface. So emulsifier or surface active agent it will be interface. For example oil droplet is here and it will be concentrating. So it will be creating like this.

So many emulsifying molecules will be creating one leg, one head. So this is your head. Hydrophilic. And the tail, tail part will have hydrophobic. So emulsifying agent, it will have

two end one end is hydrophilic end head hydrophilic hydrophobic tail. So, hydrophobic part will be entering into oil molecule, oil particle and hydrophilic part it will be around the surface. So, it will be creating one almost layer around the oil particle. So, this way it will not allow two oil particles to mix each other. So, I have another oil, let us say one oil particle, one layer, another layer.

of surfactant is there so both will not allow to join together because already hydrophilic end is there okay so it will not mix together it will not make bigger particle but if I can remove that part then it will make bigger particle but in other case if I say this is oil this is oil in water okay but if I have water in oil say water in oil so in that case so head part is here this is water molecule water droplet so head part hydrophilic So hydrophilic, philic is loving, hydro loving, water loving. So water loving area will be inside droplet and outside hydrophobic this one. Those molecules will be aligned like this way.

So again two water particle will not mix if it is water in oil. So water in oil also two water particle not joining together. So settlement rate will be lower. In oil case, oil particle case, in oil in water, Two oil particles will not mix together.



They will not make bigger particles. So, settlement rate will be very low. So, polar molecules align in such a way that they cause an electrical charge on the surface of the droplet. An electrical charge repels two droplets, must collide with sufficient force to overcome this repulsive force before coalescence. Some emulsifier, so for some example emulsifier you should remember, like emulsifier or emulsifying agent, paraffin, resin, organic acid, metallic acid, salt, chloric acid, clay, asphalting, your detergent, detergent also emulsifier actually.

Detergent, example is here, detergent interacts with oil and water, stabilizes the interface between oil and water droplet, so it will create stable emulsion. So demulsifier, when you have emulsifier you know, so then you have to add certain chemical which is called de-emulsifier or emulsion breaker or demulsifying agent. It will be inactivating your surface active agent. So emulsion can be broken thermally or chemically. Demulsifier neutralize the effect of emulsifier.

Four important aspect of emulsifier, attraction, oil water interface, flocculation, coalescence, solid weighting. So these things the demulsifier will be doing. The demulsifier immediately migrates through the water to the droplet interface, attacks similar droplets, create a large cluster of droplets, neutralize emulsifier, rupture droplet interface. So droplet is there. So you have this one emulsifier.

This is emulsifier. okay so emulsifier first you have to they will neutralize remove or rupture this surface layer whatever the this emulsifier created so demulsifier will be removing neutralizing removing then they will allow to coagulate or meet each other and make bigger particles okay so first thing surface removing surface barrier barrier Demulsifier removes surface barrier make bigger particle give sufficient time to meet and separate and low agitation. Okay, so why low agitation? Because if you have large agitation again a big particle can be broken.

So if big particle broken again separation will be difficult. So give lower agitation so the particle will be moving. So give agitation maybe if needed certain amount so which can be helping you. But if you are giving too much agitation maybe some particle is trying to moving up because of water turbulence the same particle will be going below also. or the same particle would be broken because of turbulence.

So, do not give so much hesitation that particle will be broken, or that particle already moved up, same particle should not go back to the bottom. So, that you have to take care.

Thank you very much for today's lecture. Next day, we will continue this topic. Thank you very much.