MARINE ENGINEERING

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Lecture78

Membrane Technologies

good morning everybody we have started the topic on beach water separation or oily water separation so in that case we have seen that if there is no emulsifying agent then oil and water will get separate separated quickly easily with no time almost but if you have any emulsifying agent then life is difficult small particle with emulsifying agent then you have to add maybe demulsifying agent or remove the emulsifying agent or deactivate the emulsifying agent then you make bigger particle small small particle tiny tiny particles are there those will not get separate easily so you have to make bigger particle bigger particle will be settling quickly because we have seen the formula terminal velocity or settling velocity is proportional to your density difference specific gravity difference into particle diameter size and viscosity okay this formula you have seen so if density difference is higher for example water and liquid oil is having higher density difference dsg then vt or terminal velocity or separation rate will be higher in that case in the case of dm or diameter of the particle oil particle diameter if oil particle diameter is higher you can see this squared term is there so small increase in particle diameter size settlement rate will be very high so if we can combine like small particle to bigger particle settlement rate will be very high and viscosity water viscosity normally it will be unchanged because of temperature and other effect but if we have let's say

water particle in oil so in that case using temperature and other especially temperature changing your viscosity will be changing so viscosity lower viscosity will give better settlement rate because viscosity will give drag or force not to move or allow to move the oil particle in water so in our case water viscosity this is actually water viscosity not oil viscosity because we are considering oil in water So, oil small particles or dispersed particle will be there in continuous phase that is water. So, in that case continuous phase viscosity this is continuous phase viscosity. okay so continuous phase in our case water so if you know water viscosity if you know del sg if you know dm square then you can calculate actually vt or terminal velocity or settlement velocity now we have seen that ows or oil or oil and water separated

system where gravity separator where only gravity or gravitational force between the difference between gravity force in oil and water that will be separating oil from water so we have seen centrifuge centrifuge actually instead of gravitational force you are giving extra force you're rotating at very high speed so because of rotation a high density particle will be creating a larger distance from the center axis of the rotation then lower density particle then for the lower density particle in that way we can separate different density particles okay

Now, after that also separation may not be completed. So, we have to add some chemical. So, chemical dosing they call that chemical actually diversifier. Then you have to use maybe ultrafiltration or nanofiltration technique or reverse osmosis technique where you can reduce further the particles. So, here you can see this membrane technology ultrafiltration, nanofiltration and reverse osmosis.

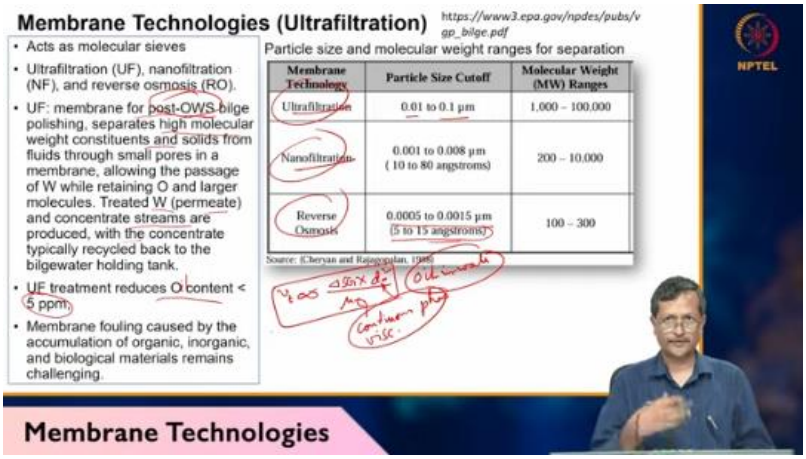
ah so in ultra filtration particle size 0.01 to 0.1 micrometer the reverse osmosis the particle size is very very small okay So, 5 to 15 angstrom. So, very small particle also can be separated if we are using reverse osmosis. If we are using reverse osmosis then actually you have to create a high pressure fluid. High pressure fluid again it will be coming from your some pumping system.

So, one pump will be pressurizing high pressure fluid like you have seen this one reverse osmosis or RO module in your desalination system so you create high pressure fluid high pressure fluid will be passing through your membrane reverse osmosis membrane so that membrane will be giving uh low density uh or low salt low salt or mineral content fluid and they'll be giving permeate and high brine or high salt oil oil content solution and low oil content solution they'll be separating So, ultrafiltration membrane for post OWS or oil water separator system binge polishing this separate high molecular weight constituent. So, first you are doing this basic gravity based OWS. So, this is first one because higher amount of oil and higher amount of solids and other particles are there which will get settled there.

So, this is you are getting laminar flow inside a chamber or you are settling chamber and you are separating. Then after that you are applying UEF and centrifuge or other techniques. treated water or permeate and concentrate streams are produced within the concentrate typically recycled back to the beach water holding tank. UF or ultra filtration

treatment reduces oil content up to 5 ppm, less than 5 ppm. So, membrane fouling causes by accumulation of organic and inorganic biological materials.

So, regularly you have to remove or you have to replace the membranes. so ocm or oil content monitor or many times they say binge alarm or binge monitor so you separate oil water but water may contain some more percentage or more amount of oil particles or droplets so how to know how much it is there so there are several oil content monitor instrumentations are there so those if you put in in the oil stream then it will give the percentage or ppm or amount of oil content is still there in the fluid so it will be integrated part of OWF system scattered light so there are types like scattered light type absorbance type fluorescence type microscope type so there are different types of OCMs are there so let's discuss one by one So, scattered light, scattered light like you have oil and water mixture here. They say oil droplets are like this.



You see the right side circle. Oil droplets are here and you are giving LED, light emitting diode is creating light and it is passing through lens and you are creating a convergence of light. It will be detected using some detector. So, this is called transmitted light. This is T for transmitted light.

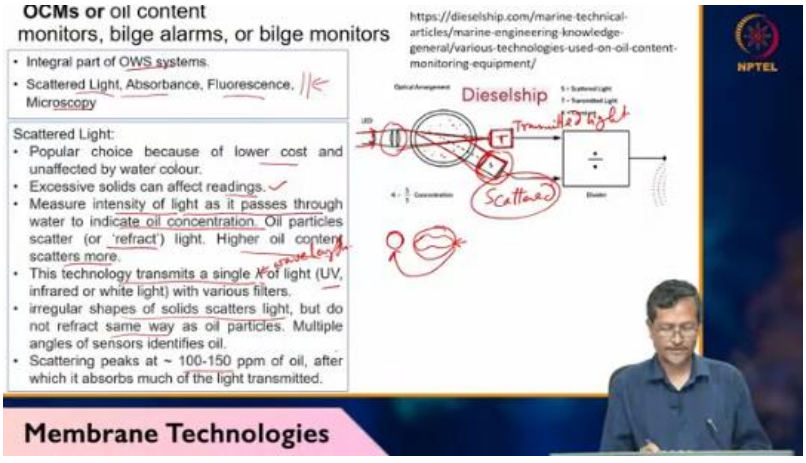
directly it will be going okay it will not be scattering light but if there is any oil particles so that oil particle will be scattering or refracting the light and it will be creating going to another path and you have another lens here so this lens will converge and it will be detecting your scattered light amount So, scattered light amount will say how much percentage of oil or what is the ppm of oil is there in the mixture. So, popular choice of this scattered light technique because it is cheaper cost and water color and other thing will not affect because the refraction will be happening because of oil particle. Excessive solid can affect the reading. So, if lots of solids are there, so you cannot use actually.

Measure intensity. So, to reduce solid like settling tank or initial OWS will be helping you. So, that time you reduce solid content. So, measure intensity of light as it is possible through water to indicate oil concentration. Oil particles scatter or refract

So, you can remember the light theory is reflection, refraction. So, here refraction means light will not go in right straight direction if you have refractory material, it will be diverting this path. Higher oil content will have higher scattering. This technology transmit a single wavelength of light, this is wavelength. or ultraviolet or infrared or white light with various filters.

Irregular shapes of solid scatter light but do not refract the same way oil particle. Multiple angles of sensors identifies the oil. So, now solid can have irregular shape but oil particle in water it will have completely spherical shape because I already discussed that if you have because of surface tension any liquid particle will try to get minimum surface area because of the surface tension if it is having irregular surface area then total surface area is higher but surface tension does not like that surface tension will try to make minimum surface area so that's why this oil particle or any liquid particle in air or in water it will be purely spherical okay but solid because it's solid that surface tension will not be affected Irregular shapes of solid scatter light but do not refract the same way oil particle.

Scattering peaks at 150 ppm of oil after which it absorbs much more of the light transmitted. So, here S is scattered light, S is scattered light, T for transmitted light and K, the ratio of S by T is called constant. So, microscope or microscopy, micro means very small, scope means that seeing something. So, microscope using, microscope you can see that Oil particle, how much oil particle is there?

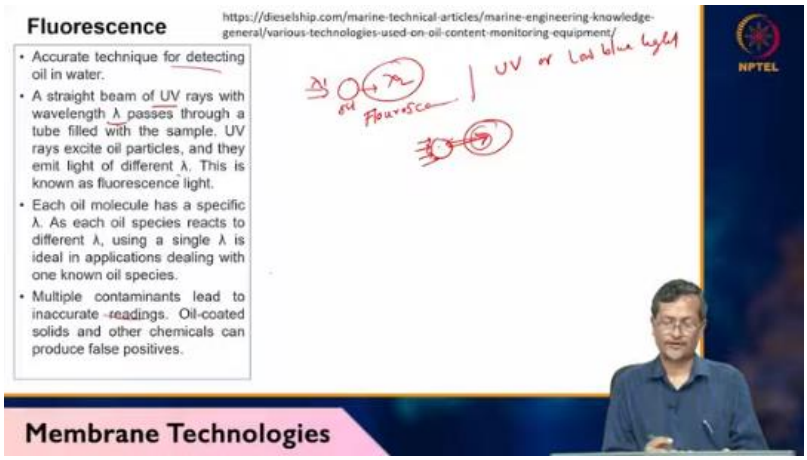


You can measure also, you can find the size of the particle also. It detects gas bubbles or oil particles in water. So, it determines oil concentration and droplet size also here. You are calculating size also, not only concentration. Gas particle forms a circle with a dark edge and bright center.

Solid have irregular shapes. Calibrates the image unaffected by the intensity of wavelength of light. oil species and solid particle size limitation affected by fouling of the optical monitor blurred lens this sort of things will create a problem absorbance so commonly not used due to high cost okay accuracy high higher than scattered light mechanism okay different particle observed light of different wavelength hydrocarbons absorb wavelength of 3.4 micrometer and the amount of energy absorbed is proportional to the amount of hydrocarbon present in the liquid or in the sample advantage it can be used oil field chemicals however measuring fluorescent with uv light can lead to false positive in dirty water so if this water and oil mixture is very much clean then it will give better result but if dirty then it will not give measuring absorb light at the right wavelength reduces the risk So, another technique is the fluorescence.

So, fluorescence accurately measure or detect oil in water. Straight beam of UV light rays with wavelength lambda passes through the tube of filled with sample UV rays excite oil particle and they emit light of different. So, one wavelength you give, but when it passing through oil droplets, different wavelength you will get so this is known as fluorescence light flow each oil molecule has specific wavelength and each specific react with reacts different wavelength using a single wavelength is ideal in application dealing with one known species Multiple contaminants lead to inaccurate readings.

So, many type of contaminants are there it will be giving a false reading. Oil coated solids and other chemicals also will create a problem. So, use of ultraviolet light or low blue light UV or low blue light to measure amount of oil in water technique expose around hydrocarbon to light okay hydrocarbon you give lots of light your fixed wavelength then they will be absorbing and they will be radiating their own light they will be giving okay so then now you check what type of wavelength is there in that accordingly you can decide okay this sort of hydrocarbon is there in your sample and this is for aromatic this is especially it will be working for aromatic aromatic hydrocarbon for aliphatic i think it is not working aliphatic it may not work okay but it will be working good for aromatic hydrocarbon so first see the settling tank settling tank can be rectangular shaped or maybe cylindrical shaped okay so you put lots of fluid here



It may be partial filled or completely filled and let us say inlet is here and exit is here. Inlet oil water mixture, exit also oil water will be there because this is gravity settlement system. So, oil content will be reduced, but still oil will be there, oil lower, lower amount of oil will be there. and similarly rectangular system or any other shape of systems are there it still it will be giving the similar mechanism so it can be vertical or your cylinder can be vertical cylinder so any type of thing you can design okay now let us say diameter of this cylinder is d and this is l and volume equals volume V pi by 4 d square L, this is obvious.

So, flow rate Q equals, flow rate equals Q, the retention time, let us say certain volume flow rate is there, and total volume of the cylinder is this one v but your flow rate is q that means this fluid is staying certain time inside the cylinder how much time is it staying there so capital v divided by q retention time t okay now if x percent if x percent by volume of the by volume the cylinder is filled then now volume is x into v volume was total volume was capital v now it become x v okay now retention time t equals x v by q okay now tank shape can be anything rectangular cylinder okay vertical horizontal So, tank shape, cylindrical, vertical, horizontal or rectangular different types of shapes possible. Now, oil particle motion.

say assume oil particle is moving from P to Q because oil particle will be floating. So, from P to Q if it is moving, so what is the velocity of oil particle? Velocity of oil particle v oil equals r by t. So, r or you can say d by t if completely filled. If it is not completely filled, partially filled, then accordingly your velocity of oil will be changing.

So, some particle will be there nearby top, some particle with nearby bottom. So, whenever you are sizing or calculating size of the cylinder, how much time it is staying, how much time it will take. So, then if you calculate the maximum distance one particle traveling. So, one particle will be traveling from P to Q actually. So, bottom to top.

and this time the time taken from reached bottom to top and retention time both time must be same. So, retention time equals time taken a particle oil particle. then an oil particle moving from P to Q or bottom to top. Now, if I have, now if I have a cylinder like this and my entry is here, exit is here, maybe this is oil layer, this is water.

So, in that case V volume equals pi by 4 D square into L same formula I am using, L means this length of this one. Now, to calculate velocity of fluid inside settling tank V equals Q by pi by 4 d square. Let us assume this inlet is nearby bottom. So, fluid is flowing from bottom to top.

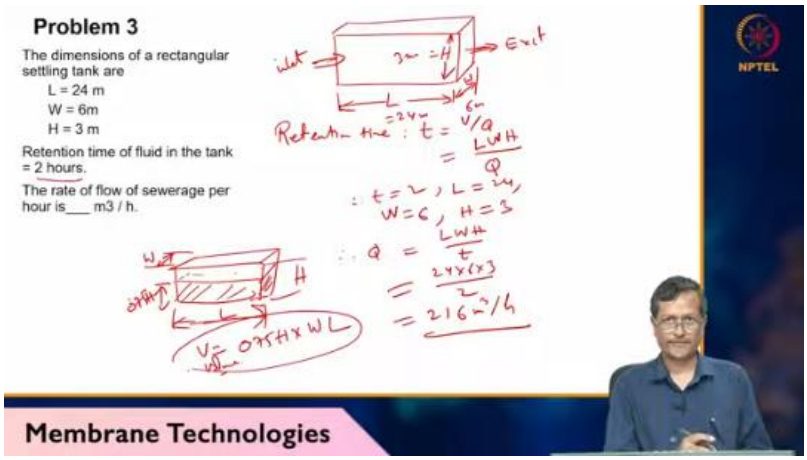
So, your velocity will be Q pi by 4 d square because total area is your cross section area of the cylinder. Now, let us see another problem. Okay. Let us see one cylinder. Height H. Length L. And width.

Okay. L equals 24 meter. Width 6 meter. Height equals 3 meter. Okay.

Let us say fluid is entering here. Exit. So retention time. t equals v by q so v is the volume so v equals total volume of fluid l w h of volume fluid q now in the problem it is given retention time 2 hours so that means t equals 2 l equals 24 v w equals 6 h equals 3 so q equals LWH by T equals 24 into 6 into 3 by 2 equals 216 meter cube per H. But in many cases, the cylinder may not be filled completely.

For example, if the cylinder is filled, let us say 75 percent. Let us say we are assuming 75 percent filled. let us say this is 0.75 height is h this is total height is h width w l so in that case your total volume will be changing so volume will be like h H will be 0.75 H, then W, then L. So, V is change, volume, volume of liquid. So, accordingly your flow rate also will be changing.

So, if you have partially filled cylindrical tank instead of rectangular, tank will be cylindrical also. So, in that case also you can calculate the partially filled. okay uh if let's say any satellite tank is there you are not feeling completely otherwise there will be splashing so there will be like little bit lower uh you are feeling so maybe 50 or 75 percent you are feeling so in that case your flow rate will change your fluid velocity your other parameter also will change so thank you very much for today's lecture next i will start a different topic thank you



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