MARINE ENGINEERING

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Lecture66

Numerical problems

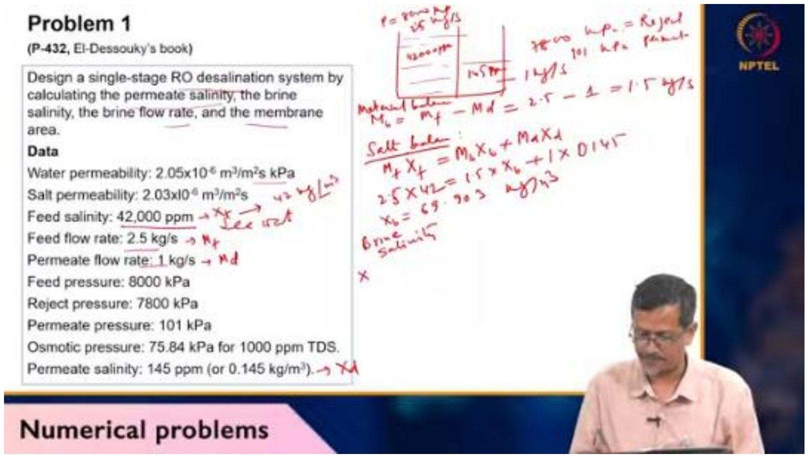
Now, let us try to solve one problem on RO based system. Design a single stage RO desalination system, reverse osmosis based desalination system by calculating permeate salinity, brine salinity, brine flow rate and the membrane area. So, data given water permeability 2 meter cube meter square per second, salt permeability given, feed salinity given, this seawater. Feed water rate given 2.5 kg per second. Permeate flow rate.

So I have one pot here. Here I have this one given 42,000 ppm and my target ppm 145 ppm and osmotic pressure feed rate 2.5 kg per second and permeate flow you are getting permeate this is 1 kg per second feed pressure also given 8000 kPa reject pressure is given 78.00 kPa permeate pressure is given permeate pressure 101 kPa permeate pressure. Now we have to calculate different parameters.

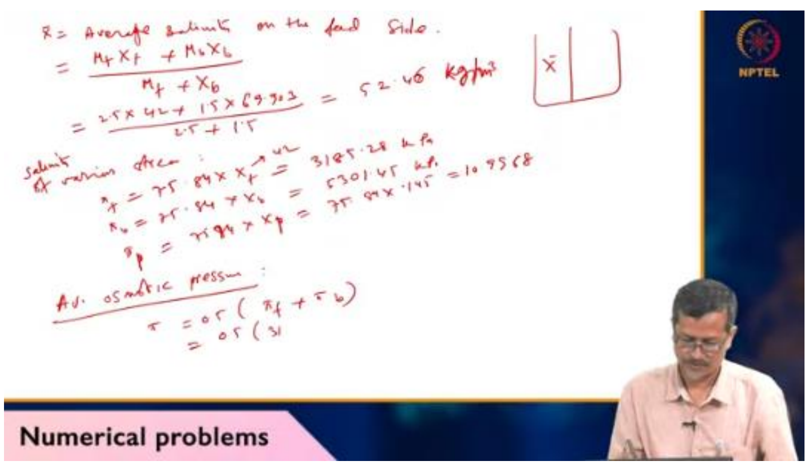
So first do material balance MB equals MF minus MD. Now MF is feed mass flow rate. So feed mass flow rate it is given MF MD permeate flow rate. MD and XF feed salinity, XF MB 1.5. Now, this is giving now 2.5 minus 1 equals 1.5.

kg per second this is mass flow rate now salt balance this is a this is water material balance material balance balance and salt salt balance how much salt was there how much salt you are separating MF, the formula is MF XF equals MB XB plus MD XD. Okay, MF is given 2.5 into XF. XF is given 42. So, this is 42,000.

actually it is 42 kg per meter cube now equals equals 1.5 mb you already got into xb xb value i don't know plus md md value 1 into xd 0.145 this is given Now if we calculate XB is coming 69.903 kg per meter cube. This is brine salinity. Now X bar equals average salinity. average salinity on the field side okay so x bar average salinity on the field side so equals m f x f plus m b x b divided by m f plus x

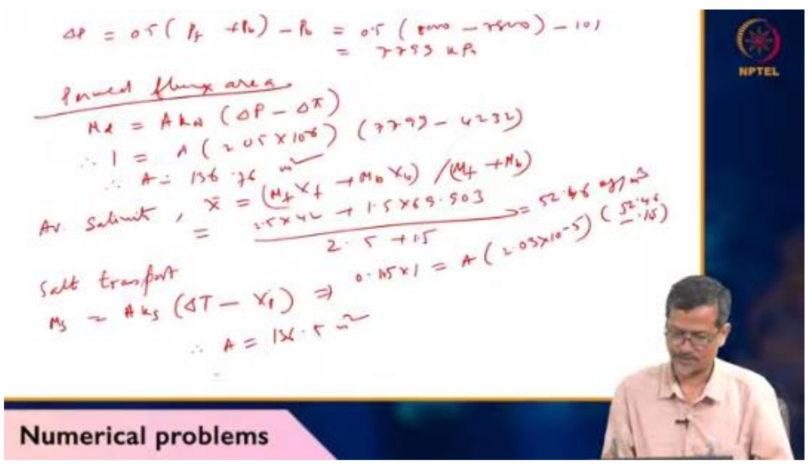


xb this formula you have to remember so this coming like 2.5 into 42 plus 1.5 into we just calculated 69.903 69.903 and mf value 2.5 plus xb value 1.5 so it is coming 52.46 kg per meter cube Now salinity of various stream, so pi f salinity of the stream to calculate osmotic pressure, so pi f equals 75.84, already told that we can approximate like this, xf equals 70, so xf value 42, so it is coming eight five point two eight kpa pi b is coming seventy five point eight four into xb it is coming five three zero one point four five kpa pi p equals seventy five point eight four into xp equals uh so seventy five 0.84 into 0.145 equals 10.9968 okay so average small osmotic pressure osmotic average osmotic pressure so pi equals 0.5 pi f plus pi b so this is giving 0.53185.28 plus 5301.45 equals 42.43.366 kPa and net osmotic pressure del Pi net equals



pi bar minus pi p equals four two four three point three six six one zero nine nine six eight equals four two three two point three kpa now del p 0.5 p f plus p b minus pb equals it is coming 0.5 8000 minus 7800 minus 101 is giving 7799 kpa so permeate flux area permeate flux area MD discharge AKW permeability del P minus del Pi so 1 equals A 2.05 10 to the power minus 6 7799 minus 4232 so this is given A equals 136.76 meter square so average salinity x bar equals mf xf plus mb xb mf plus mb equals 2.5 into 42 plus 1.5 into 69.903 divided 2.5 plus 1.5 this is giving 52.4 6 kg per meter cube so the salt transport ms equals a ks del x minus xp xp 0.145 into 1 equals a

2.03 10 power minus 5 52.46 minus 0.145 so this is giving a equals 136.5 meter square so this is your area good morning everybody today i'll start uh some problem then later i'll discuss some other thing also so already we have discussed uh that fire fighting system will have one fire hose then it will be nozzle and you have to direct the nozzle towards fire and it will be extinguished and for that you need pump also so pump will be creating very high pressure the pressure pressurized fluid will be passing through let's say one pump is here then high pressure fluid will be passing through this hose or pipe or soft or pipe normally it will be there then there will be nozzle so nozzle will be creating a very high velocity jet okay so jet will be directed towards your fire then fire will be extinguished so now uh what is the nozzle size what is the whole size we should know then accordingly we can take action uh if fire is there so here one problem you can see a fire hose uses in a major structural fire has an inside diameter 6.4 centimeter so hose diameter 6.4 4 centimeter and the hose carries water flow rate 40 real q is given 40 liter per second starting at a gauge pressure 1.6 so p gauge 1.62 into 10 power 6 Newton per meter square.



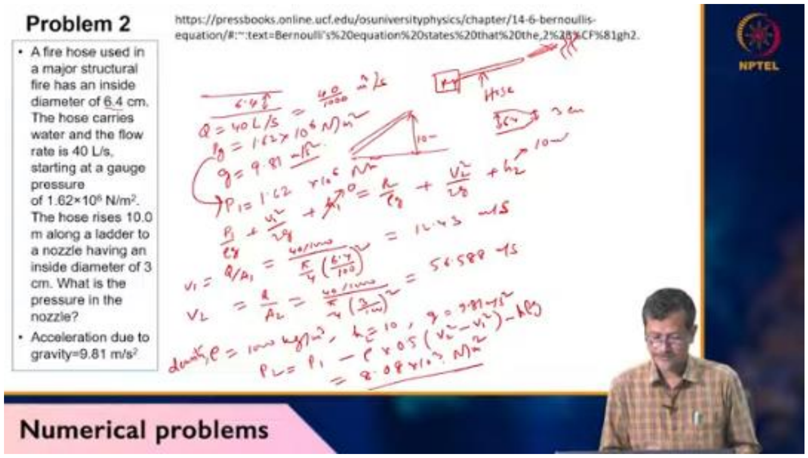
The hose rises 10 meter. So, hose actually it will be slanted. Then nozzle is there. So, hose rises 10 meter. This is 10 meter along the ladder.

Okay, then inside of a nozzle inside diameter. So nozzle is like this. So this nozzle diameter is given 3 centimeter. Okay, then it is going to go. So this is 6.4.

Acceleration g value also given so that we will get unique solution. Everyone should get 9.81 meter per second square. Now to solve this problem. so the what is the pressure inside the nozzle so you have to calculate the pressure here so pressure will be converted into velocity okay so q is given 40 liter per second so 40 liter means 40 divided by 1000 meter cube per second okay so liter into meter conversion is there now pressure p1 equals 1.6 uh 1.62 okay 1.62 into 10 power 6 Newton per meter square okay you are already given now you have to apply Bernoulli's equation Bernoulli's theorem says p1 by rho g plus v1 square by 2g plus h1 equals p2 by rho g plus v2 square by 2g plus h2

so here we are assuming friction losses are not there other losses are not there and we are assuming that at initial stage of the pipe the elevation is h1 and at the end elevation is h2 so if we assume at initial stage there is no elevation so h1 is 0 h2 will be value will be having value 10 meter per yeah 10 meter only now v1 equals flow rate divided by area So, flow rate is 40 divided by 1000 already you have seen and area, area is pi by 4 d square. d means we have given 6.4, 6.4 and you have to convert into meter, so 100 square. So, it is giving 12.43. meter per second now v2 equals same way we have to calculate q flow rate you are not changing because you are not destroying mass and we are assuming water is an incompressible flow so flow rate is same flow rate like volume flow rate or mass flow rate is same and area

let us say first one A1 second one A2 so area is changed so in that case formula will be like 40 divided by 1000 divided by pi by 4 6.4 it is not 6.4 it is 3.3 3.3 centimeter 3 by 100 square okay so this is giving 56.588 meter per second now road density density of water is 1000 kg per meter cube we are assuming h is given already 10 meter h2 actually g is given 9.81 meter per second square so p2 equals p1 minus rho into 0.5 v1 by v2 square by 2 v2 square minus v1 square minus h rho g so this gives 8.08 into 10 power 3 neutron per meter square so this is your solution so whenever you're solving this type of problem you should look at the units also here centimeter meter mix units are there so i converted into meter and i solved so Whatever unit you use, same unit should use so that there will be no calculation error or decimal error. Now, see the next problem.



A fire hose nozzle directs a steady state water of velocity 50 meter. Fire hose nozzle is here and velocity is here. Velocity equals 50 meter per second at an angle 45 degree. So, this is 45 degree. 45 I will make horizontal line this is 45 degree above the horizontal the stream rises initially okay it will be reaching to maximum height then again it will be falling down right if stream rises initially but then again falls to ground so definitely assume the water is incompressible and inviscid

Consider density of air and air friction negligible. Assume that acceleration due to gravity 9.81. So all other losses are ignored here. So maximum height in round of two decimal places. Maximum height means this one you have to calculate.

H max. Now this velocity component will have two values. One will be Vy. One will be Vx. So Vy will be giving the fluid to maximum height.

Vx will be maximum reach. ah g value already given 9.81 so v y equals v 1 sine theta so if it is theta so v y is v 1 sine theta so 50 into sine 45 degree so this is giving 50 by root 2 meter per second and v x this is v1 or vy this is vx v1 cos theta so it is going 50 by again root 2 positive value root 2 root over meter per second now maximum height 50 by root 2 divided by 2g okay now v at v at y max so it velocity at y max the vertical velocity will be zero now h max will drive like this this formula v o equals v y minus g t g means acceleration to gravity vo means maximum velocity at h max velocity at h max okay now vy equals g t because velocity h max equals zero actually so vy equals gt now t becomes vy by g so h max

because v y t minus half g t square you can remember the plus two formula a is equals u t plus half f t square f means friction sorry acceleration due to gravity or acceleration so this will begin v y square by g minus half g v y square by g square okay because we are putting this value this value here now h max becomes half v y square by g so then h max becomes 50 square by 2 into 2 into 9.81 50 square 50 is having root okay so this is giving 63.71 meter so this is your solution