MARINE ENGINEERING

By

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Lecture65

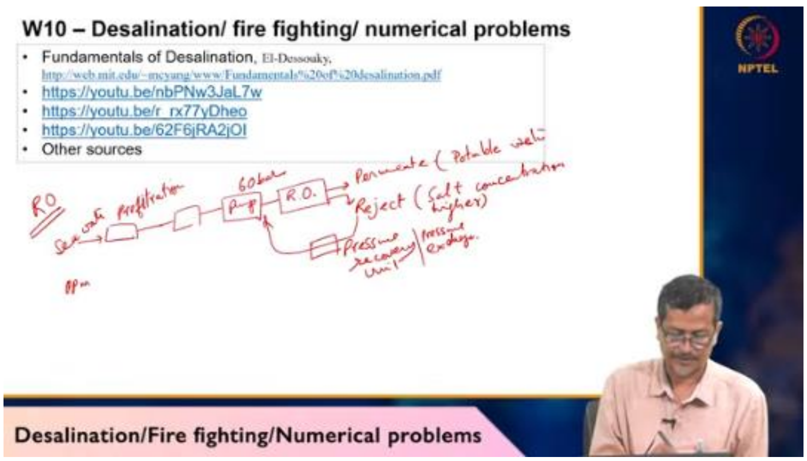
Desalination/Fire fighting/Numerical problems

Good morning everybody. Today I will start the topic on desalination firefighting numerical problems. So, we will give some basic about desalination already we have given, but some more details we will discuss in desalination part and firefighting already we discussed in another lecture and we will try to solve some problem in this lecture. Now, in desalination we have seen like we have seawater intake let us say you take seawater so seawater will go to your pre-filtration system.

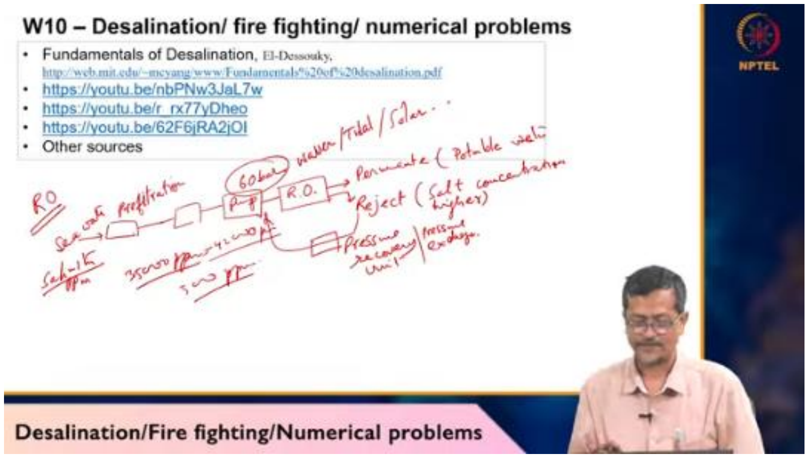
so like small debris or fissures or anything should not enter. Then after that there will be several sedimented filter and other filters. Then there will be one pump. we said that pump will be like very high pressure pump. Normally seawater distillation will be requiring about 60 bar pressure.

and then this pump will be delivering the fluid to your RO module reverse osmosis module so RO module when you have it will be taking it will be taking seawater then it will be giving permeate or it is portable water maybe water and there will be another part will be reject reject will have higher salt concentration salt concentration higher so many people say this is actually brine because high salt concentration is there now in many cases especially salt sea water salt removal process or desalination process in that case after RO there will be sufficient amount of pressure so that pressure also can be recovered and it can be fed that pump will be working less. So there will be one pressure recovery system, unit or system or sometimes a pressure exchanger. So this is actually RO based system.

Reverse osmosis is the same, one membrane is there, so membrane, one side high pressure you create and salts will not get transmitted through this porous membrane, rather only water will be, you will get in another side. Some small amount of salt can be there, but if you increase RO quality or number of RO module, then you will reduce further salt concentration. And salt concentration is in terms of ppm per square median. this is called salinity salinity of sea water normally it will be like 35 000 ppm and it depends on different area location wise also for example density salinity very high while somewhere sea water uh is mixing with river water so say salinity can be lower so but normally it will be like 35 000 to 42 000 ppm okay within that range but our portable drinking water will be like about 500 ppm and brackish water and other water those will be ppm maybe one thousand two thousand that range so because of high ppm or high salt concentration you need a very large amount of energy to be consumed by the system energy where energy getting consumed basically the pump pump will be taking majority part of your energy now pump if you want to replace then i already told that wave energy can be one source maybe alternative source or maybe tidal energy



for your marine systems or may be solar or many other sources also you can use. For example, battery operated also possible, battery but anyway battery will be getting energy from somewhere else to get charged. So, pump if you can use I mean if you can use renewable and other sources energy then your electric consumption or fossil fuel based power requirement will be lower. But if you have normal water, let us say river water or other brackish water, so in that case power consumption is lower. in that case, let us say normal domestic RO plants, they are using very small amount of power.



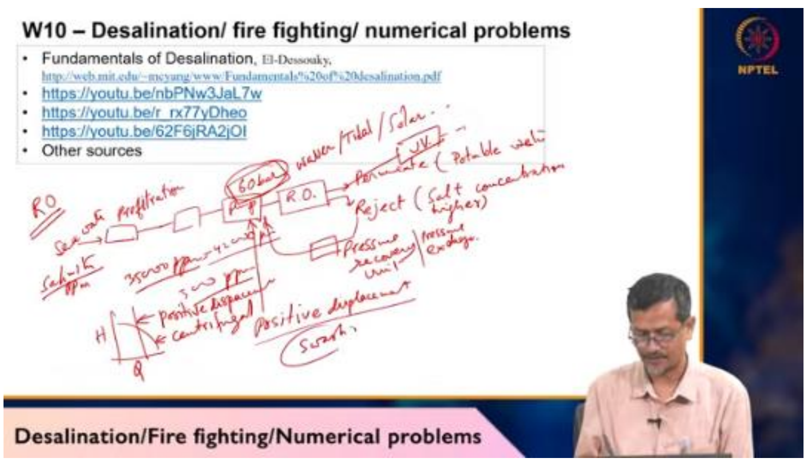
and now this when you are having RO plant on your ship or in optional machinery so it is only not pump and RO it is having pre-treatment systems like sand removal process there will be bacterial bacteria cleaning process ultraviolet UV filter will be there maybe somewhere there is a permeative guard then you pass through UV filter ultraviolet filter so ultraviolet filter means ultraviolet rays if you it is falling on viruses or bacteria those virus will get disinfected Or the water will be get disinfected, bacteria will be killed and there will be charcoal filter. just to remove all the odors, many other filters will be there. major part is that pump and aero module. This is a major part and major energy will be consumed by the pump.

There will be different RO modules and lots of new research are going on. New materials are coming up. For example, nanoparticle-based RO module and other modules are also available these days. if you are interested, then you can go through this available literature for latest RO module and latest pumping systems. And what are the pumps?

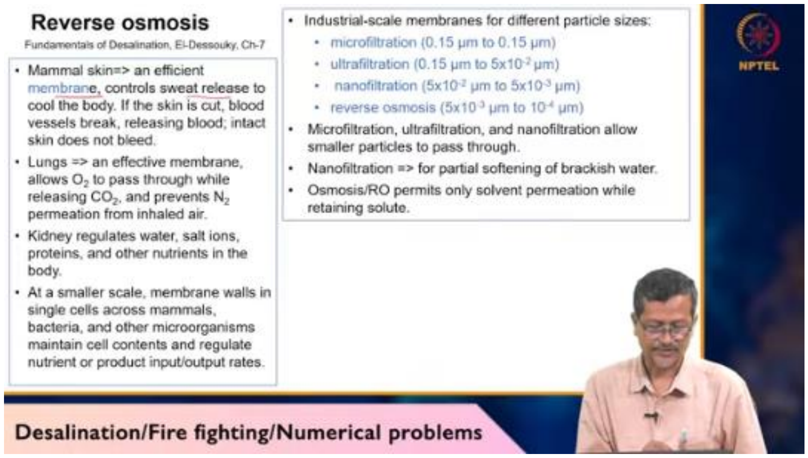
What are the different pumps you can use? Because this is very high pressure pump and low flow rate normally. normally positive displacement type you use. Positive displacement type. okay centrifugal pump if you want to use you can remember that characteristic of centrifugal pump like this h q like you can get maximum head but if you are having this is centrifugal this is positive displacement positive displacement

So positive displacement pump can be like reciprocating pump, your screw pump, your diaphragm pump. Those are positive displacement pump. I even gave the example that the human heart also has a positive displacement pump. it will be taking certain amount of fluid and it will be delivering. And if you can supply the power so it can deliver any amount of pressure.

So positive displacement pump reciprocating type can be used. one type of reciprocating pump is called swash pump. swash pump or multi-cylinder pump can be used for giving smooth pressure or smooth flow rate to your RO module because RO module needs smooth pressure 60 bar about minimum and if you have more pressure also it will be okay but normally you have to maintain that bar if you are not maintaining then actually your water will not get pushed through the membranes and for more information you can go through the youtube videos for basic simple diagram and simple animation videos will be there and i have taken uh content from the book fundamental of dissemination and it is given already uploaded in the mit website you can download there from there okay now reverse assumption we will already discuss but let's see some more details so mammal skin is an efficient membrane so it controls sweat for example our uh body will be releasing water and it body will be cooled but blood will not go out of the body okay so this is also one membrane system similarly our lungs is there our uh kidney is there so those are also having like membrane system okay



So kidney regulates water, salt, iron, proteins and other nutrients but it does not allow blood to go out. It will be allowing only water to go out So at a smaller scale, membrane walls single cell across the mammals, bacteria and other microorganisms. It maintains cell content like cell, if you have cell, nucleus and mucology bodies and other things, the cell wall also on membrane. So it will allow certain amount of salts and other nutrients to enter into the system.



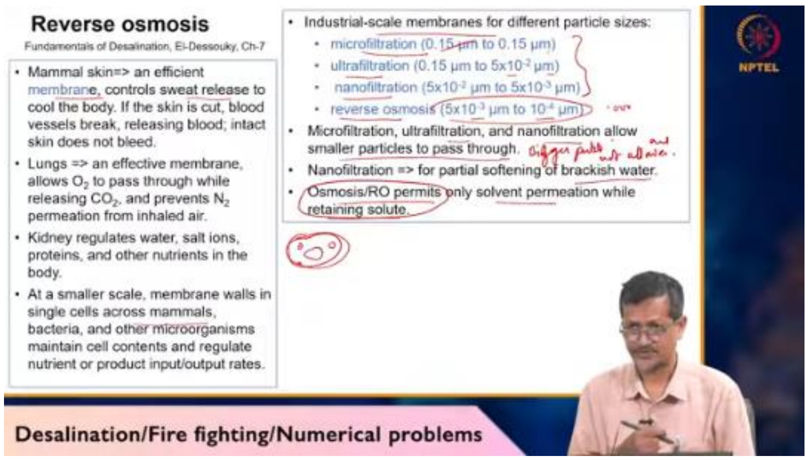
Now industrial scale membrane for different particles. these are the natural and industrial scale they have developed different types of membranes. One is microfiltration, ultrafiltration, nanofiltration, reverse osmosis. you can see this particle size. microfiltration it can separate particle 0.15 to 0.1 micrometer.

There is some mistake possibly. so up to 0.15 more than 0.15 millimeter micrometer it can filtrate by more than 0.15 millimeter micrometer can be filtered by micro filtration ultra filtration will be 0.15 to 5 into 10 to the power minus 2 so much smaller particle size nano filtration further smaller and reverse osmosis you can see the smallest particle 5 10 to the power minus 3 to 10 minus 4 so 0.000 that range particle can be separated using reverse osmosis membranes so microfiltration ultrafiltration and nanofiltration allow smaller particles to be passing through but bigger part icle bigger particles are not allowed are

particles are not allowed okay nano filtration for partial softening of brackish water so brackish water purpose nano filtration you can use but osmosis and eosmosis it will be like something in solvent in solvent solid form they it will be separating okay so that's why this reverse osmosis this membrane is used for your salt separation you see what a salt you are taking you are separating salt and you are taking pure water or less salt content okay and whenever you are disseminating normally the people will not go to zero salt thing zero salt means you have to give lots of separation unit or lots of osmosis reverse osmosis that candles That will be increasing your cost.

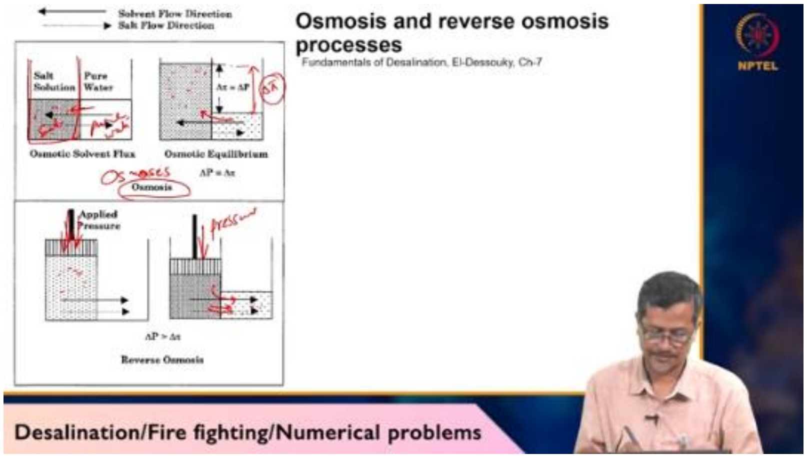
Again you are removing all the salts. Salts also required for your body. So certain amount of salts should be there in your water so that it will be good for health. But not more than certain, crossing certain amount. For example, if more than 1000 ppm salt is there, that may not be good for your health.

But again, if certain chemical is not good for health, that sort of salt also is there in water, that will be problem. For example, arsenic is there in some part in West Bengal. So that may be, that is very much problematic for the human health. so even IIT Madras professor also has developed some technology to remove arsenic from water then they are giving to the people so how osmosis reverse osmosis working you see first this one osmosis part okay see in osmosis you can see this one salt solvent is there so lots of salt is there and pure water is this pure water okay so the salt will



not pass through this one rather water will be passing through this high density area okay this is normal osmosis case okay and in this case when low density or low salt concentration water entering this level of salt concentrated area it will be increasing okay now this osmotic pressure del pi the difference del pi is not del p del pi so osmotic pressure you can see this one this liquid column increased okay and this time del p equals del pi because your atmospheric pressure or outside pressure and your osmotic pressure become equal till it is not equal the fluid will be flowing through this one and it will be maintaining one eq uilibrium finally no

w another case you apply lots of pressure although salt concentration is there and you are applying pressure just you are pushing water in opposite way that's why it is reverse osmosis so finally what will happen you are applying pressure or force because of that you are pushi ng water towards this o ne okay so in this case your applied pressure is higher so applied pressure more than your osmotic pressure so del p more than del pi okay pi is your osmotic pressure uh now see the some formula uh pi your osmotic pressure and unit is kpa so pi equals r t summation of xi what is r r is your universal gas constant T is your temperature in K and summation of Xi is concentration of all constituents in solution kg mol per meter cube. And pi value normally it is taken about 0.75.84 kPa for 1000 ppm of total dissolved solids.

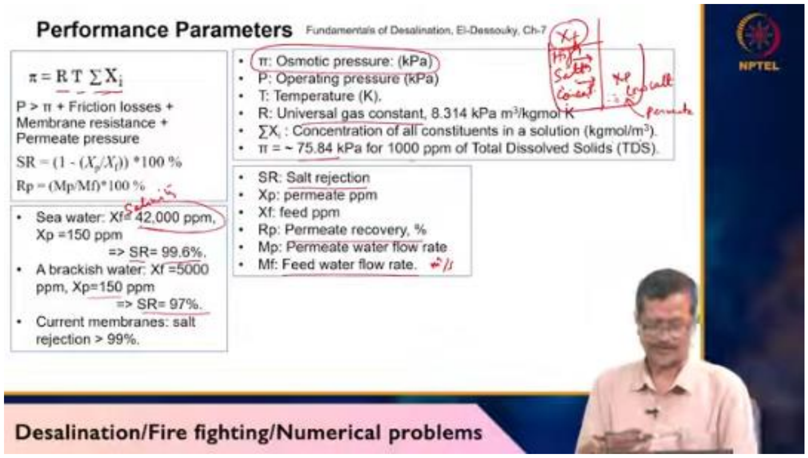


So total solids dissolved how much is there. So if 1000 ppm is there so pi value you can take 75.84 kPa. If no value is given, if you can assume, then you use this value. Now, Sr. Sr is a salt rejection. you have one membrane.

High-pressure fluid you are giving. The higher salt concentration is here. high salt concentration and low salt concentration is here. Sr is salt rejected. rejected how much salt will be remaining after removal of water so the formula is 1 minus xp by xf into 100 rp rp means permeable recovery permeate recovery means this water whatever you are getting here this is called permeate low salt content this is permeate low salt okay so

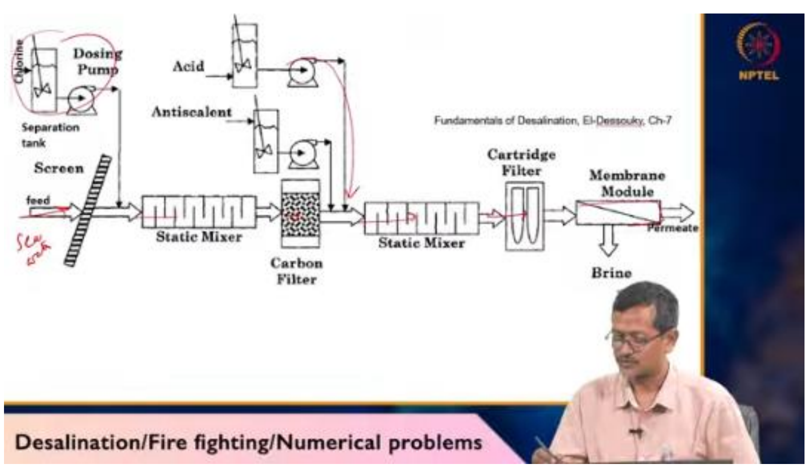
rp formalizer mp divided by mf mp mf mp means permeate water flow rate mf feed water flow rate so meter cube per second okay flow rate so see water xf this is your ppm of salinity 42 it is assumed 42 000 ppm sanity is there xp value xp means your permeate XP and this one XF. F means feed water. XP means permeate. permeate is having 150 ppm and feed water is having serenity 42,000.

your SR, SR means salt rejection is becoming 99.6%. brackish water, if you take XF is 5000 and XP 150. SR becoming 97%. currently the membranes can separate Salt about 99 per cent so it's very highh-performancemembranes are there now how this whole system in RO based system is there RO based system has one chlorine dosing pump where you have to add chlorine and you have to remove a certain amount of salt using chlorine feed coming from here seawater



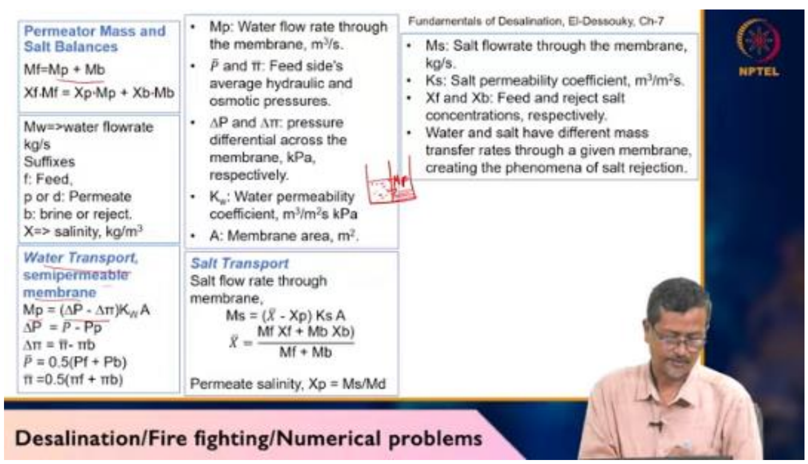
Then it will be going through one mixture because you are adding chlorine and you are adding seawater and mixing. After mixing you are passing through carbon filter. So carbon filter also will be removing certain amount of solids. Then again it is going to starting mixture because you are adding certain amount of acid. So basicity you are removing and you are adding small amount of pH.

Now it will be going through cartilage filter then membrane. so before membrane there will be one high pressure pump then membrane module will be removing brine and it will give your permeate permeates portable water and brine means you have a higher amount of salt basically sodium and chlorine ions will be more so whenever you are this you are separating salt majority portion will be sodium and chlorine sodium chloride now some formula so permeated mass and salt balance mf equals mb plus mb xf mf and equals xp mb xb mb so you can see this mp is water flow rate through the membrane p bar and pi bar is feed side average hydraulic osmotic pressure so you can draw this one This is a high salt concentration area.

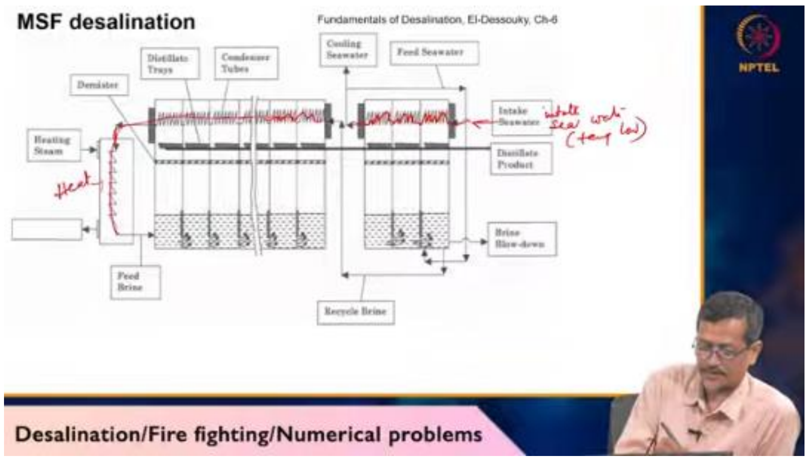


This is low salt concentration area. So water flow rate through the membrane MP. that means is permeate. P means permeate. Pi means the osmotic pressure. P is your average hydraulic pressure.

kW water permeability constant meter cube per meter square second kPa so when you have membrane so it will have some constant water permeability constant A is a membrane area so how much area is there in a membrane so that is A now water transport semi-permeable membrane through so Mp formula is there Mp is del P minus del Pi kW A just you should reme mbe r this formula so del p equals p bar minus pp del pi equals pi bar minus pi b and p bar and pi bar also calculated using formula like 0.5 pf plus pb and in both cases pi f plus pi b now for salt transportation you have one formula ms equals x bar minus xp ksa x bar formula is this one okay so permeate salinity xp equals ms into md md means actually discharge or permit amount now we have seen the formula for ro base system now we will see msf or multi-stage filtration system so here you have intake sea water you are taking from here intake sea water so it is intact sea water is in lower temperature so this lower temperature you are it is going through this like this okay then again coming like this it is coming like this now another water you are taking the intake water same water you are heating here it is coming through this one and you are giving heat



you are giving heat means you are increasing probability of creating steam then that hot hot water will be passing through this boxes okay one two three four many boxes are there it will be passing okay what is passing what will happen actually it is low pressure zone when low pressure is there this hot water will be releasing lots of steam so lots of steam will be uh that steam will be going through this one and here we have cold coil okay so cold coil will be condensing certain amount of water so that water will be collected here you see this one collection part and you are getting distilled or distillate product okay now whenever this steam is moving uh from low pressure liquid layer to steam zone so there is one demister okay demister means like one mesh will be there like mesh is like this okay when what vapor is going and if any liquid particle is there it will be caught and the liquid particle will be forming liquid droplet and it will be falling down and other steam part your steam will be moving up it will be getting pulled down here it will be falling and you are collecting distillate product Now first stage will be giving certain amount of water. Again you push towards second stage.

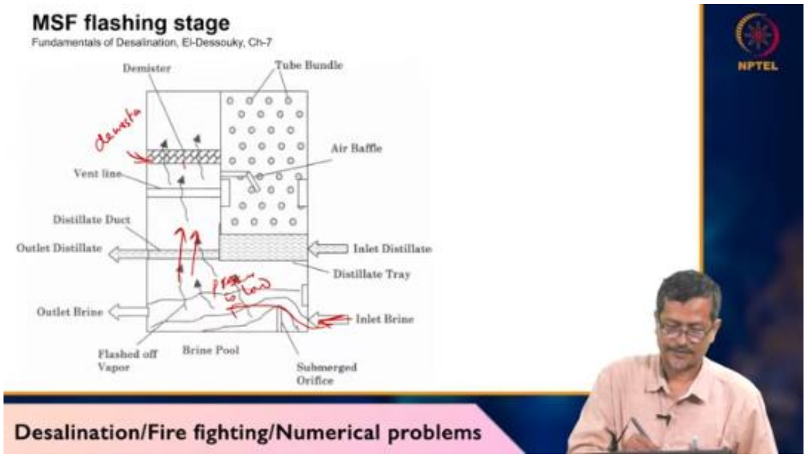


The water will be moving to second stage. This one, two, three, four. many stages are there. second stage again it will be getting certain amount of water. Third stage again it will be entering.

Again you are getting certain water. you may have 30-40 stages. Again finally you are getting distillate product. But in this case you are using limited amount of power because any waste heat also can be given to increase your brine or this heater or heat here in heat exchanger this is heat exchanger okay and finally whenever you are getting water so that water you can see this last stage last stage it will have higher brine higher salt

that salt again you can put into your system again recycle the whole water and some salt if salt is very high you can reject this one and you can take fresh water from sea and again recycle the whole system so ms flushing stage you can see the single stage of flushing how it is working okay let's say inlet brine you are taking here okay Then you are putting this one inside this and pressure is lower here. Pressure is low. When pressure is low, lots of steam will be coming up, lots of vapor will be coming up and passing through this one. And it will be going through demister.

This is demister. Then this steam will be passed through this cold tube bundle. and when coal tube bundles are there steam will be condensed and will be creating one layer here so that steam you take distillate okay this is one single stage and if a multiple stage then again you can create another stage another stage you take distillate and whatever remaining brine is there so that brine you send to another stage another stage so that way you collect lots of amount of water now we have seen that RO module this flush distillation system you have flash distillator one two three system like brine high temperature high temperature brine entering then demister is there okay then you have cold coils okay now pressure



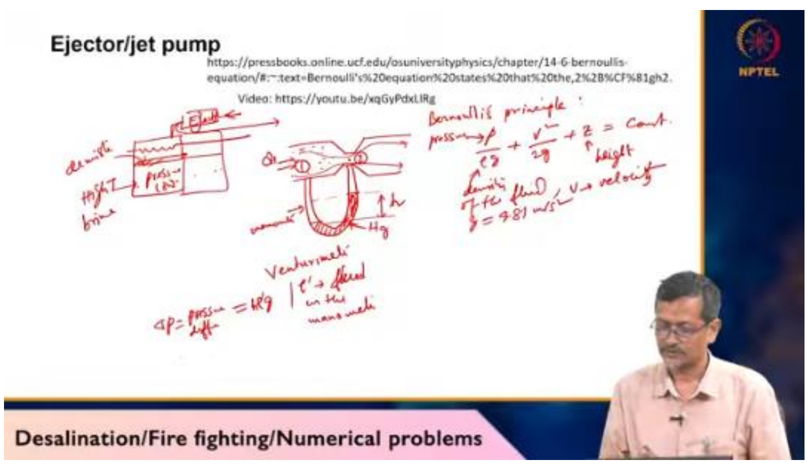
low this pressure for the lower for the lower so when pressure is low how to create the low pressure so previous lecture we have seen that we have one ejector ejector system so ejector system will take water it will create low pressure then water will go back but that low pressure will be used to handle your uh high volume of uh sting so how this ejector is working so ejector principle is just it will be working basically based on venturi principle okay so venturi meter you may have seen your undergrad class laboratory venturi meter will have like two pipe and one manometer will be there this is manometer it's called venturi meter venturi meter okay this is flow rate Q1 this is location 1 maybe this is location 2 this neck location and I have here one mercury column okay so maybe Hg or anything any suitable fluid here now because fluid is passing through this one at very high velocity this narrow area is created so velocity will be increasing so velocity when increasing pressure will be dropping so that is called Bernoulli's principle principle p 1 by rho g plus v1 square by 2g plus rho plus z equals constant.

z means height. p is pressure, rho density of the fluid, I will remove one. I will make general equation first. Density of the fluid and V is the velocity.

And G already you know 9.81 meter per second square. Z is height or height of the pipe. Now, I have 2.1 and 2, one pipe diameter larger, two pipe diameter smaller and narrow section. it is creating venturi. at 2, because of high velocity creation, the pressure will be lower.

when pressure is lower, if mercury column is there, it will create this difference H. Now, how much pressure loss is there or pressure difference is there? H rho g, this will be pressure difference. Or del P. Del P is created like h rho g. And if we know rho means rho dash equals fluid in the this main pipe fluid will be different and manometer fluid will be different. manometer fluid is say mercury then it will be 13.6 gram per centimeter cube.

Now, this laboratory setup will be there all over majority of the engineering colleges. This is basic test how this venturi creates low pressure. and this is this calculation this pressure how much pressure drop will be there the calculation can be obtained from your Bernoulli's principle Bernoulli's principle nothing but this is an energy equation okay and we are assuming that there is no energy loss because of friction and heat transfer and other losses so we are assuming no energy concept and there is no other loss then you can calculate directly from this formula p by rho g plus v square by 2g plus z equals constant now ejector is created based on your venturi meter principle okay ejector will have like this the one design then it will have design like this so 0.1 this is 0.2, this is 0.3, this is 0.4, this is 4, maybe this is 5.

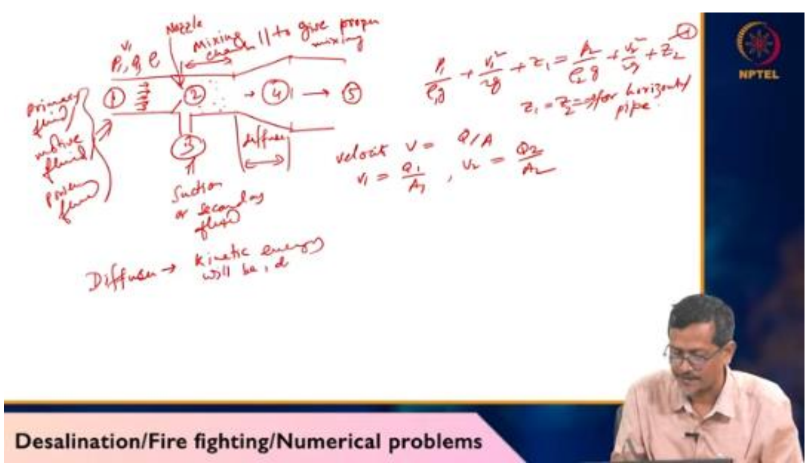


Let us say fluid is moving from 0.1 to 0.2, again 0.2 to 3, 3 to 4, 4 to 5, 2 to 3, 3 to 4, 3 is below, 2 to 3, 3 to 4, 2 to 4, 4 to 5. now how we are creating vacuum say high velocity fluid is having p1 q1 flow rate and density let us say constant density rho and velocity v1 then what is the velocity of 2 so 2 at point 2 p1 by rho 1 g plus v1 square by 2 g plus z equals P2 by rho 2g plus V2 square by 2g plus Z2 whatever you say. Because let us assume the pipe is horizontal. Z1 equals Z2 for equals 0 for horizontal pipe.

Now P1 pressure at 1 and pressure at 2 we can calculate and what is the velocity? velocity V equals Q by A flow rate divided by area. V1 equals Q1 by area 1 and V2 equals Q2 by area 2. Now area 2 means the diameter changed so area changed. Now I can calculate

velocity from this equation maybe I can put number one from equation one I can calculate if I give you pressure you can calculate velocity or if flow rate is some if some parameter is missing even calculate other parameters okay and now this main fluid is called primary fluid or suction fluid primary fluid or motive fluid or power fluid okay main pipe is having primary fluid motive fluid power fluid and this one three at three it will be like this is called suction fluid or secondary now after venturi this this area is called mixing chamber mixing chamber and this area called diffuser this is called nozzle this is called nozzle nozzle will have loss lesser diameter than main pipe now mixing chamber is the purpose mixing chamber actually to be mixing primary fluid and secondary fluid so fluid coming from one fluid coming from two it will be mixed up properly in mixing chamber if mixing is not proper your performance will be decreasing so proper mixing is important in mixing chamber so to give proper mixing And what is the purpose of diffuser?

I have written like you can see this diffuser I have written that wider section. wider section actually it will be reducing fluid velocity and it will be increasing static head. The kinetic head will be converted into static head at diffuser. the purpose of diffuser kinetic kinetic energy will be reduced and pressure energy okay kinetic energy will be reduced and static energy will be increased mixing chamber is mixing only it is not changing velocity and pressure but diffuser is changing that one okay nozzle is nozzles main work is to change pressure to velocity or velocity to pressure



Now you should remember the terms because whenever you are talking about creating low pressure, so the suction fluid, this is creating vacuum. This is creating vacuum or low pressure in your MSF system. In MS system you are creating low pressure and because of low pressure you are creating lots of steam or vapor. So that low pressure is giving you the distilled water.