MARINE ENGINEERING

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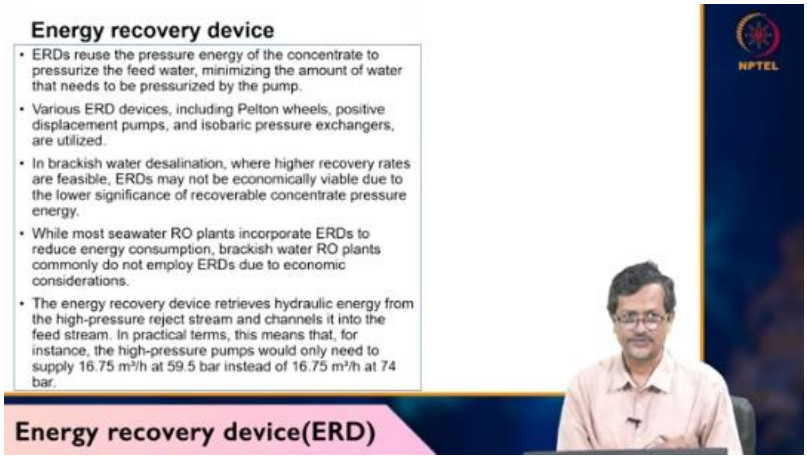
Lecture64

Energy recovery device(ERD)

energy recovery device. Now, what is happening? So, you have RO system reverse osmosis let us say this is RO membrane. Now, RO membrane is getting high pressure water high pressure water from where it is coming? It is coming from several filtration intake sea water then several filters like sand filter sand filter and scale anti-scaling agent all these things will be there then it is going to RO member membrane then pressure is becoming lower let us say this is 60 bar pressure is required about and sea water concentration 35,000 ppm okay and sand filter other filter there will be there will be some pressure loss let us say as initially you ignore the pressure loss



Main pressure loss is coming in RO membrane. Then after RO membrane also there will be certain amount of pressure. It is not becoming directly to atmospheric pressure. So what is happening? You are getting your permeate and you are getting your reject.

So reject is having higher pressure. what is happening this pressure then it is getting wasted especially energy what is having pressure so they make certain arrangement energy recovery device okay then that energy will be supplied to here also okay so here will be

pump okay so this high pressure So reject will be giving certain amount to energy recovery device and this energy will be given to this system. certain amount of energy you are recovering using that mechanism. In brackish water where pressure requirement is very low, it is not 60 bar, it will be much lower than 60 bar.

in that case this energy exchange system is not required. But if you are using for sea water desalination, so in that case you are giving huge amount of energy to generate the high pressure. you want to recover certain amount of energy in that case you are using energy recovery device or ERD. While most seawater RO plants incorporate ERDs to reduce energy consumption, brackish water RO plants commonly do not employ ERD due to economic consideration. you can use also you can, but that will be increasing cost actually, increasing maintenance other cost.

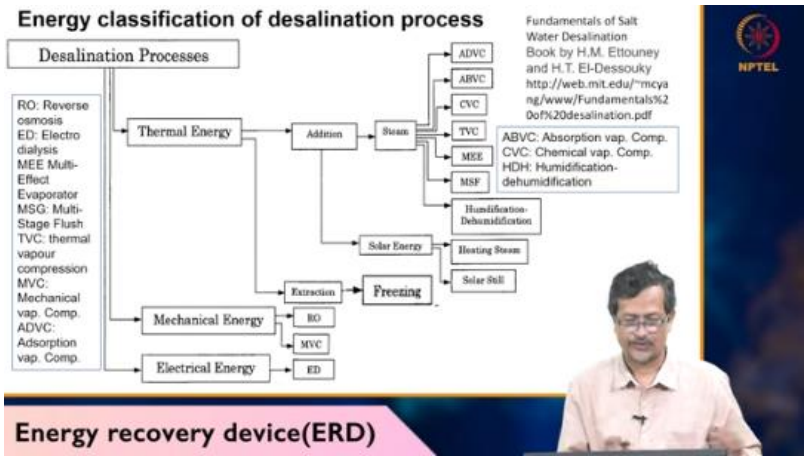
Because energy recovery device, I was reading certain document and they are saying like energy recovery device is there, but still those systems are not efficient. again you are using for brackish water where pressure requirement already low and so it will be you are putting extra money you are not getting that much of benefit that's why normally people will be avoiding the energy recovery device retrieve hydraulic energy from the high pressure reject steam stream and channels it into the feed stream okay so this is from reject how much pressure is there that one you are recovering this means that for instance the high pressure pumps would only need to supply 16.75 meter cube per hour and this some data you can remember okay now deceleration i said like ro system is there but there are several other destination systems okay what are the several most widely used systems are there here one membrane system already we explained membranes one will be rov system and will be ED. ED means you see left side full form is written there. Electrodialysis system also there.

We are not discussing in details of all these things. we will be focusing on RO and some one thermal systems. What you should know? What are the different mechanism available? One is membrane system.

Another is thermal system. Thermal system is increase temperature, evaporate and you cool down or reduce pressure and again you can create concentration or evaporation. That way you can get. So, from thermal you can get MEE, MEE means like multi effective evaporator will be there Then, multi-effect parallel feed, forward feed, vertical stack.

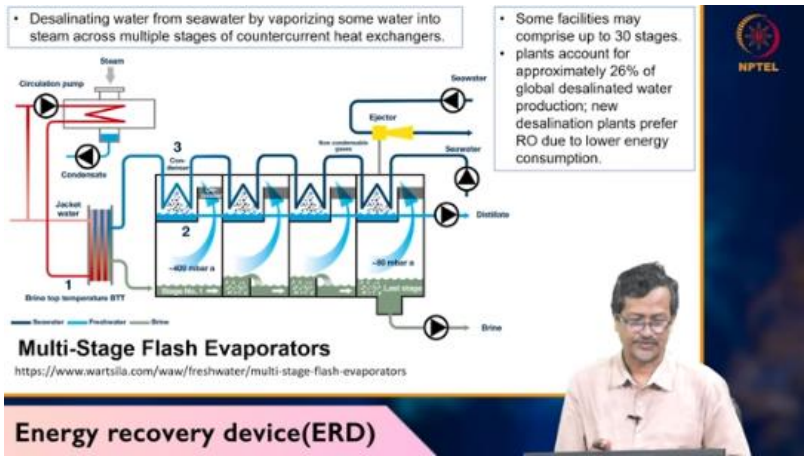
many types are there. many types again TBC, MBC. So, many different types are there. Here, MSF, SE, freezing, solar steel is there, SDH is there. for your course, we are not discussing everything, but you should know that there are many other types.

But we should discuss only membrane and only evaporative type, mechanical type. Two types I will discuss. whenever you are giving energy, so there will be thermal energy you are giving, in some cases mechanical energy you are giving, mechanical energy you are giving means actually basically one pump is working in mechanical energy system, then you are getting RO, reverse osmosis based system and you are purifying water. In thermal energy system like distillation you have seen already, you increase temperature, you boil water, you cool down, you get water, right? In some cases, you are giving electricity directly. electro-dialysis system is there.



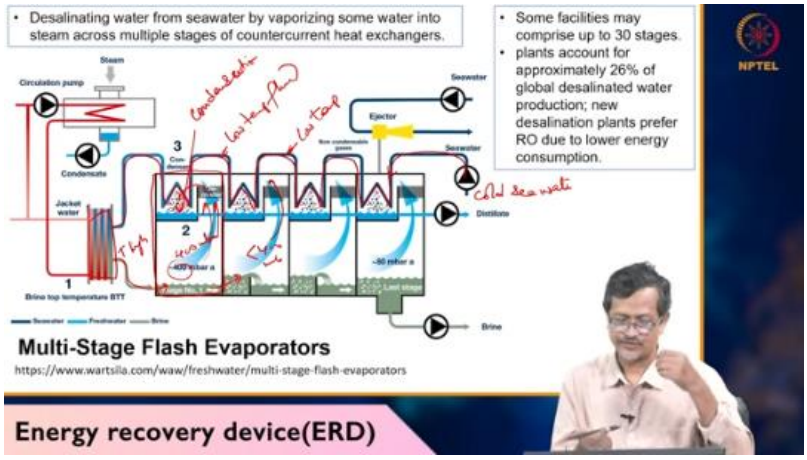
you can get directly electricity, directly water from electro-dialysis systems. And if you go further thermal energy system, so they will have different options also. So, descending water with multi-stage flash evaporator. So, this is not ROV system. This is just evaporation and condensation system.

how it is working? First you have to understand. So, you are taking seawater. Seawater is taken and it is going through this one. This is cold seawater actually.



cold seawater taking and it is going through like this then there will be brine system so higher temperature this temperature is high okay so you're increasing temperature then this high-temperature fluid it is coming through this and your pressure is 400 millibar okay now because 400 millibars and here this pipe is getting low-temperature fluid first chamber it is coming this you see this chamber ok some fluid coming to the first chamber after heating the here pressure is lower 400 millibar and upper part some cooling pipe also there when it will be giving lots of vapour so vapour will be getting cooled down it will be collected here So, here vapor is cooled condensation condensation condensation happening. So, you got certain filtered water. Now, this water will go further into this chamber their pressure will be lower less than 400 millibars, but still it will be giving ofa certain amount of vapour.

Because this pipe temperature is lower, this seawater pipe, low a temperature pipe. And the pressure will be lower. Because of lower pressure, again certain amount of vapor you are getting. From water surface, if you are reducing pressure, you are getting more vapor. vapor, when it is going top, cold pipe is there.



Cold pipe will be reducing temperature. You are getting concentrated water or condensed water. then again this water is going to this again further pressure down finally it is going to 80 millibar so 400 to 80 millibar gradually you reduce pressure and every step every step you are reducing pressure is going down and your cold pipe is there because of low pressure you are getting more vapor vapor is condensed by the cold pipe okay so that way the condensed water you collect That is your portable water. So, indirectly you are evaporating and cooling.

Like if you boil water, you are getting directly steam and a cooling. But here instead of doing that boiling option, you are reducing pressure using seabed cold temperature. Seabed temperature will be around 4 degree. that temperature you are using and you are making

flash evaporation system. this is called multi stage means first stage 400 millibar, second stage may be 300 millibar, 200, 100.

you see right side text some facility may comprise up to 30 stages. bigger unit will have lots of stages so you will get more water. Efficiency will be increasing. plants account for approximately 26 per cent of global destination water production but newer systems they prefer rov system because rov system is lower in low energy consumption and easy to handle very simpler system this is having more bulkier heavier system okay so here are some more things are there so last stage you can see brine is going to water again because uh it is ocean anyway so brine will be going to ocean so sometime brine can be used for some other commercial purpose also But normally it will be going to the ocean.

A small amount of brine if it is there then just spreads in the ocean. And here seawater intake ejector is there. what is that purpose? what happens? Seawater you take from surface and seawater.

Then ejector. What is ejector? Ejector is like this. Ejector means one nozzle is here. And high pressure fluid water is coming seawater. okay sea water coming through this pipe and like this so what is happening this ejector is getting sea water and there is the system i'll draw like this okay then this system is there this system is there okay So, what happens when fluid is flowing through pipe and if suddenly reduce pipe size because of Bernoulli's law, pressure will be reduced.

How? P by rho g plus V square by 2 g equals constant, right? You know the Bernoulli's equation. So, let us say 0.1, 0.2 you create. So, 0.1 pressure and velocity you got. point two you reduce diameter and reduce diameter fluid velocity increase actually because same flow rate you have to maintain it is water incompressible fluid same velocity same flow rate you are maintaining and velocity will be flow rate divided by area okay now point two area is changed okay i'll explain like this area a2 area a1 okay so a1 velocity v1 equals

q by a1 and a2 velocity v2 is q by a2 okay you see this area reduced so area reduced means velocity 2 is increased so when velocity to increase you go to again Bernoulli's equation velocity increase so pressure must be reduced this is energy equation so you are not destroying energy or not creating so when velocity reduced velocity increase pressure must be reducing so at point two your velocity got down when velocity got down your this pressure become lower okay so this is low pressure the system is like this. I have pipe, then size reduced, then design is like this. There will be intake pipe.

1, 2, 0.2 your pressure reduced. 0.2 is connected to this one, 3. From 3, fluid will be sucked or it will create low pressure. whatever low pressure you are creating because of this ejector effect. okay you have one pump you are pumping high pressure fluid high pressure fluid passing through a nozzle nozzle increasing low pressure that low pressure is connected to your stages okay so you are getting

sea water cold temperature you are getting low pressure from sea water again even pump will be running and another temperature source must be there left side the brine temperature source so that temperature how the temperature will be generated you have loss of waste sheet so you can generate temperature and you can increase temperature ok where the other applications of in offshore area where you can generate desalinated water luxury area NIOT National Institute of Ocean Technology in Chennai they design low temperature thermal destination system using ocean thermal energy how ah you have sea surface you have sea bed sea bed temperature already you know about 4 degree and sea surface temperature in chennai nearby it will be around 30 degree 28 30 degree right so you have temperature difference 4 degree and 30 degree. Using that one actually they are trying to they are running their low temperature distillation system. So, at low temperature and they are creating low pressure because of that they are generating lots of water for Lakshadwe people.

So, water evaporated at low temperature under reduced pressure. In previous slide you have seen. vacuum pump creates a low pressure, low temperature environment facilitating water evaporation despite the modest temperature difference of 8 degree. about 8 degree temperature also it can create certain water. cold water from 600 meter depth, NIOT collecting cold water from 600 meter water depth. So, that water depth is not 4 degree rather nearby 4 degree.

maybe 8 degree ah so they installed this one at kabaratti island you can see for one lakh million liter per day water they are producing and deep sea water temperature rising 7 to 15 degree. So, within that temperature range they are collecting water and surface the temperatures at surface different sea bed temperature difference using the temperature difference they are running this flash evaporation system. Ocean thermal energy conversion, again this NIOT working and sometime IIT Madras also will be involved in this case. So, many professors were involved.

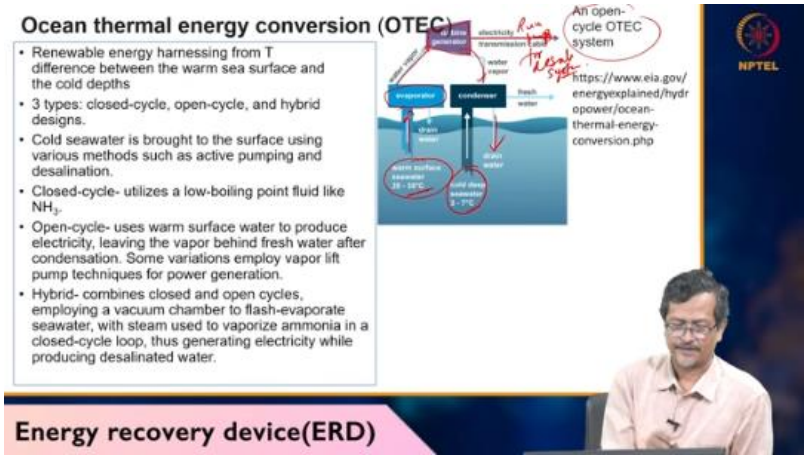
Ocean thermal energy, how you harness energy from there? let us say it is open cycle. Open cycle, what will do? You take this warm water, surface water 25 to 30 degree centigrade temperature. and it will go to low pressure evaporation water vapor will be going it will be running it going through turbine turbine will be giving electricity that electricity use for running pump for your desalination system then run pump for desalination system then turbine again you condense again you can

you can put that water into the sea. And how to condense? You are having sea bed temperature around 3 to 7 degree, 4 to 7 degree actually. So, this cycle will be running continuously and you are getting certain amount of electricity. The thermal performance is very low, but still people are trying to develop this technology because the cost involved, only initial cost is involved.

After that energy free. Because you put in the ocean and you are not giving any fuel or any other thing. Only the installation cost is required. Another thing, there is no money required. So, that is why still lots of research is going on.

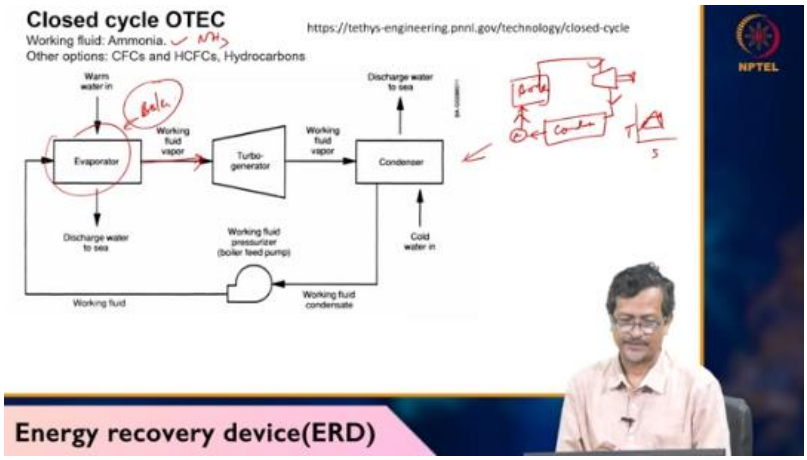
NIOT is working and US and many other countries are also working. Japan. So, renewable energy is harnessed from temperature difference. Three types of systems may be there closed system open system hybrid system this ian s open system so water taking from the ocean again thrown into the ocean so the same water is not circulating that's why it's open okay then another system is a closed cycle I'll explain later closed system will be using ammonia then how it will work I'll explain so open cycle uses warm surface water to produce electricity leaving vapor behind freshwater fresh water after condensation some variation of employees vapor lift pump techniques for power generation hybrid also there so open and closed system both coupled together they will make hybrid system so what is closed cycle closed cycle actually you can remember your thermal power plant okay rankine cycle how so evaporator you can assume that one for your boiler okay you can

remember it is boiler And boiler you are getting high temperature high pressure steam is going to a turbine ok.



I can draw like this every time I am drawing same way I will draw right. Turbine then you have one condenser then pump ok. You can remember the same cycle actually left side this is they are saying closed cycle for ocean thermal energy conversion, but same actually this is Rankine cycle ok. So, this thing also you can draw in T-S diagram right. It will be like this pump will be working then like this and working fluid normally it will be ammonia.

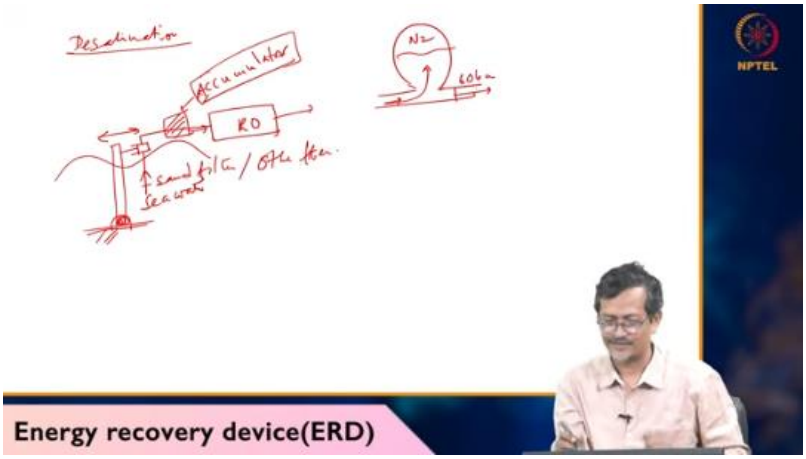
Other options are there, CFC, HFC, hydrocarbons, so many other options also there. But ammonia normally used by the OTEC scientists or OTEC research units. Another desalination work, we are working with Department of Energy, USA. So, our system was wave energy based desalination. how did you arrive the idea?



We have one flat charge converter wave energy converter so wave energy converter wave will be passing over this one it will be moving forward backward motion will be there when forward backward motion is there actually you can create one reciprocating pump here

okay so reciprocating pump will take water from sea water then this water you send to your ro module okay RO module when you are sending you are getting pure water. that was our concept, but I am showing direct picture it is not the work is not like. simple we will have like sand filter and many other filters other filters then we will have one accumulator.

why one accumulator will be required because supporting pump giving pressure to pass form okay like when surge converter this will have one okay so it's going to move forward backwards because of wave will be moving over this flat plate so when wave is moving over this one it will be moving like this when now you have one rod connect as a piston cylinder so you are pumping but fluid will be flowing like this pulsed right when it is moving fluid flowing this side no flowing so flowing flowing flowing like this so that way your RO system will not work so what you do you put one accumulator what you do accumulator actually it will be absorbing all the pulsed water and it will be giving uniform water to RO module how accumulators work accumulator is like this I have input output and this is actually nitrogen filled dome and when water is coming it will be entering and nitrogen will be getting compressed and we will have one valve actually it will not open normally when 60 bar pressure will be coming this valve will be opening. So, initially you pump continuously . that will be compressed, compressed, compressed.



So, all the pulses will be absorbed. When 60 bar will be reached, this valve will be opening. So, this valve when it is opening, our output pressure will be almost smooth, about 60 bar constant. But input pressure will be like this, output pressure will be like this. So, this concept actually we presented, we did some research work for Department of Energy.

So, we are working further to develop this technology. directly wave energy can be converted, can be used for your desalination purpose and that can be used for your local

offshore community or coastal communities. So, thank you very much for listening to this lecture. Next, we will come with new topics. Thank you.