Module #6 - EMR

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010 – Ocean Thermal Energy Conversion OTEC

OTEC

- Sun on oceans ->
  - the water at the surface is warmer
  - the water at a deeper location is cooler.
  - tropical climates :
    - Surface temperatures can reach 28°C
    - Deeps temperature : 4°C about 1 km below water.
- Ocean is a heat engine
  - Carnot efficiency (max possible efficiency)

$$\eta_{\text{th,max}} = 1 - \frac{T_L}{T_H} = 1 - \frac{(4+273)\ \text{K}}{(28+273)\ \text{K}} = 0.080 \text{ or } 8.0\%$$

  - Actual OTEC system : 3%

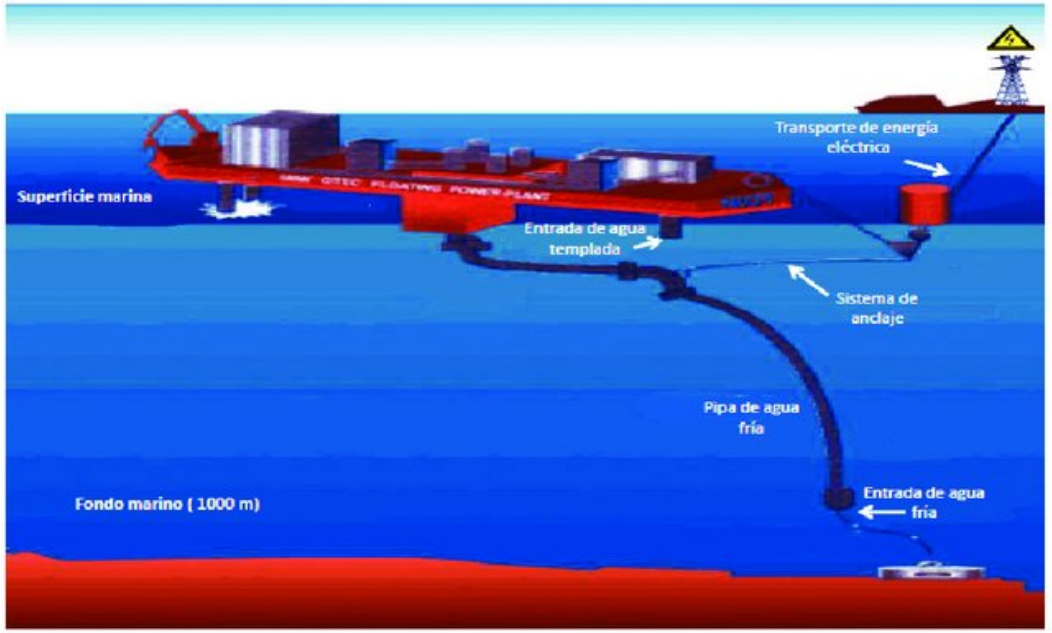
j:r

OTEC

- OTEC systems involve very large devices
- Example
  - If you want a power output of 100 kW
  - For a 3% efficiency, the heat transfer in the cycle must be up to 3300 kW
  - With a classical heat exchanger, an exchange surface of 440 m^2 is necessary.
- Two basic design can be used for OTEC sytems
  - Open system : Claude cycle
  - Closed system : Anderson cycle

OTEC

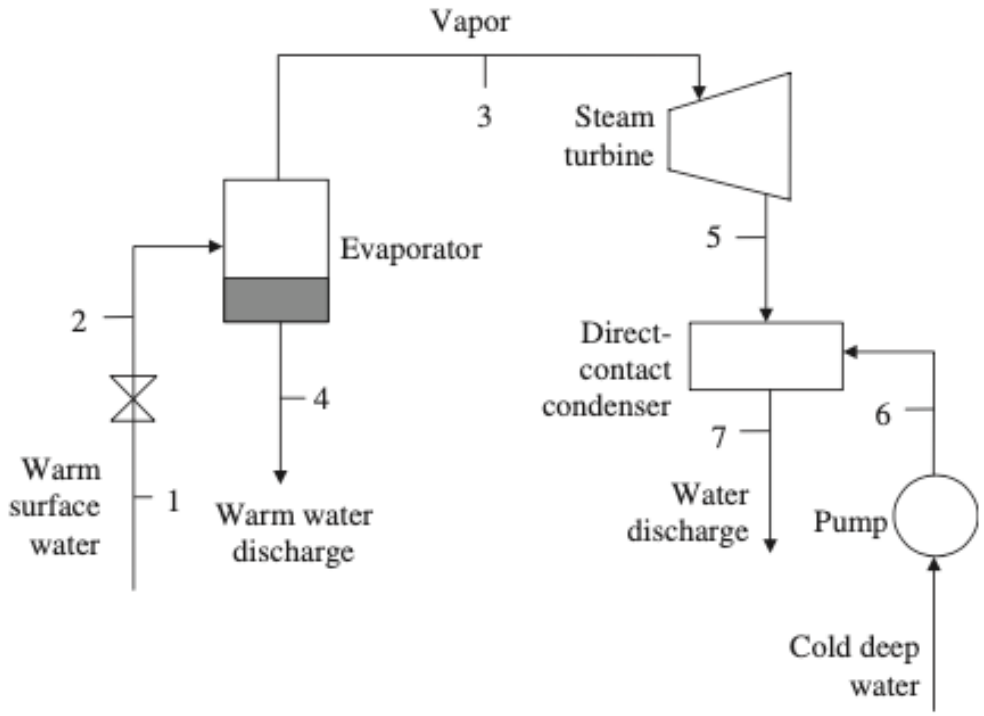
- Open system – Claude cycle

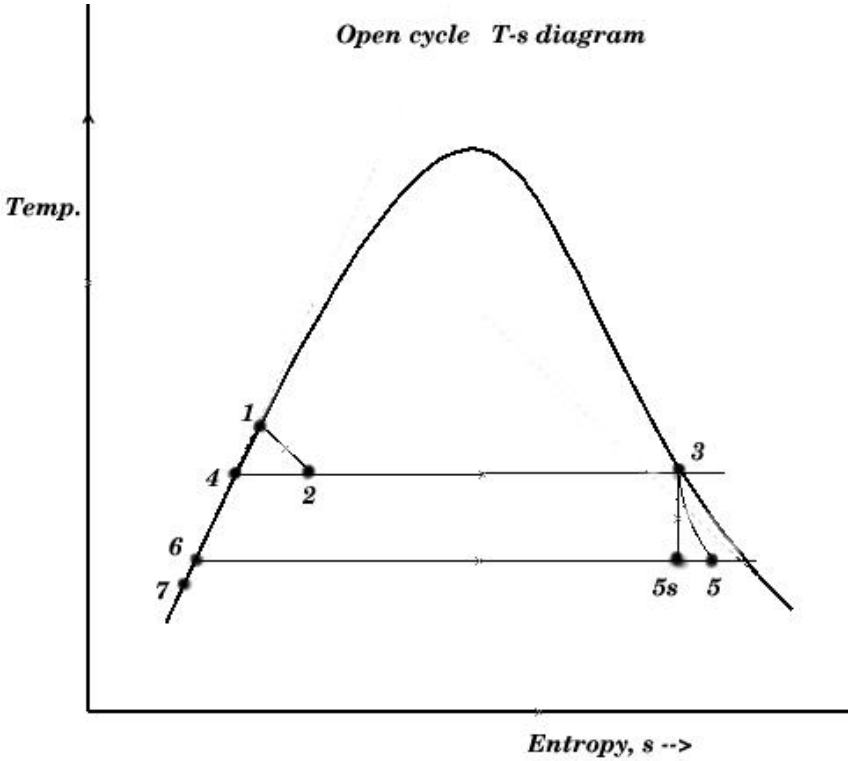


https://www.researchgate.net/publication/323458934_Conversion_de_Energia_Termica_Oceanica_otec_Estado_del_Arte/figures?lo=1

OTEC

- Open system – Claude cycle



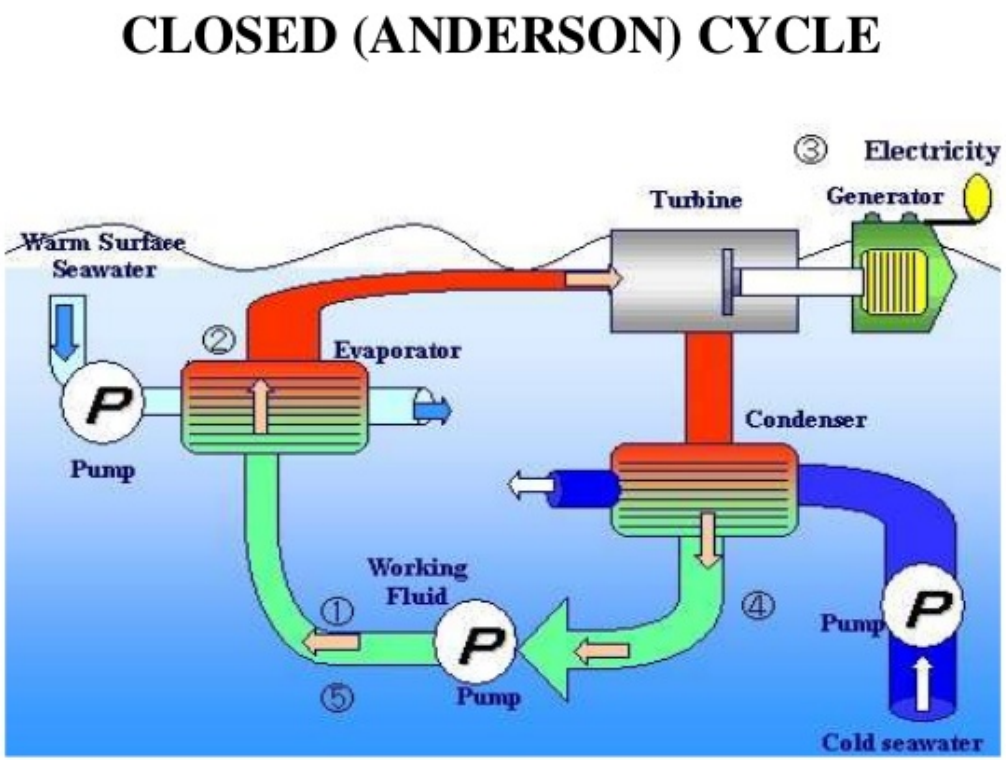


OTEC

- Open system – Claude cycle
  - warm surface water at around 27 °C enters the system (1) at saturation pressure (X1=0).
  - A valve allows to diminish the pressure down to the evaporator pressure, below the saturation pressures causing a partial vaporization of the water.
  - The evaporator now contains a mixture of water and steam of very low vapor quality (0<X2<1), X2<<1.
  - The steam is separated from the water as saturated vapor (X3=1).
  - The remaining water is saturated (X4=0) and is discharged to the ocean.
  - The saturated steam expands in a special low pressure turbine.
  - Since the turbine exhaust is to be discharged back into the ocean, a direct contact condenser is used to mix the exhaust with cold water (drem the deeps), which results in a near-saturated water (X7=0).
  - That water is now discharged back to the ocean.

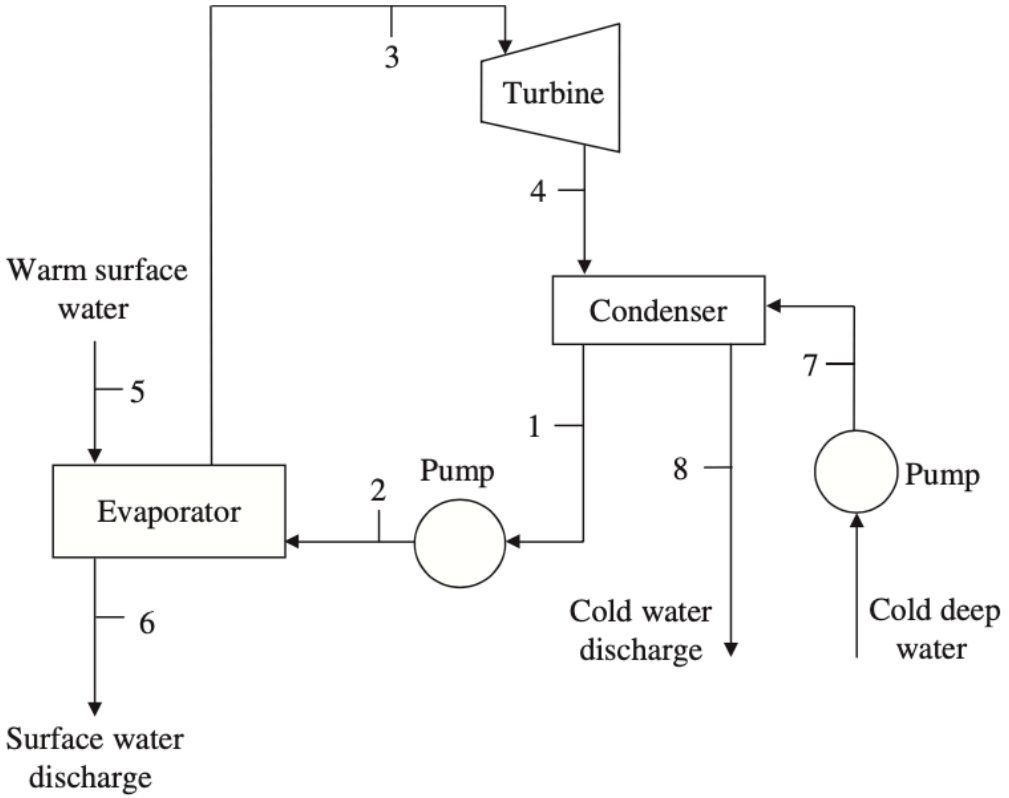
OTEC

- Closed system – Anderson cycle



OTEC

- Closed system – Anderson cycle



OTEC

- Closed system – Anderson cycle
  - Closed-cycle plants operate on a closed Rankine cycle with a fluid that has a low boiling temperature.
  - The working fluid is fully vaporized (evaporator) by the warm surface water.
  - The vapor expands in the turbine before condensing by transferring its heat to the cool deep water flowing through the condenser
  - The condensed working fluid is pumped to the evaporator to complete the closed cycle.