ATME College of Engineering

Module-5
OCEAN THERMAL ENERGY

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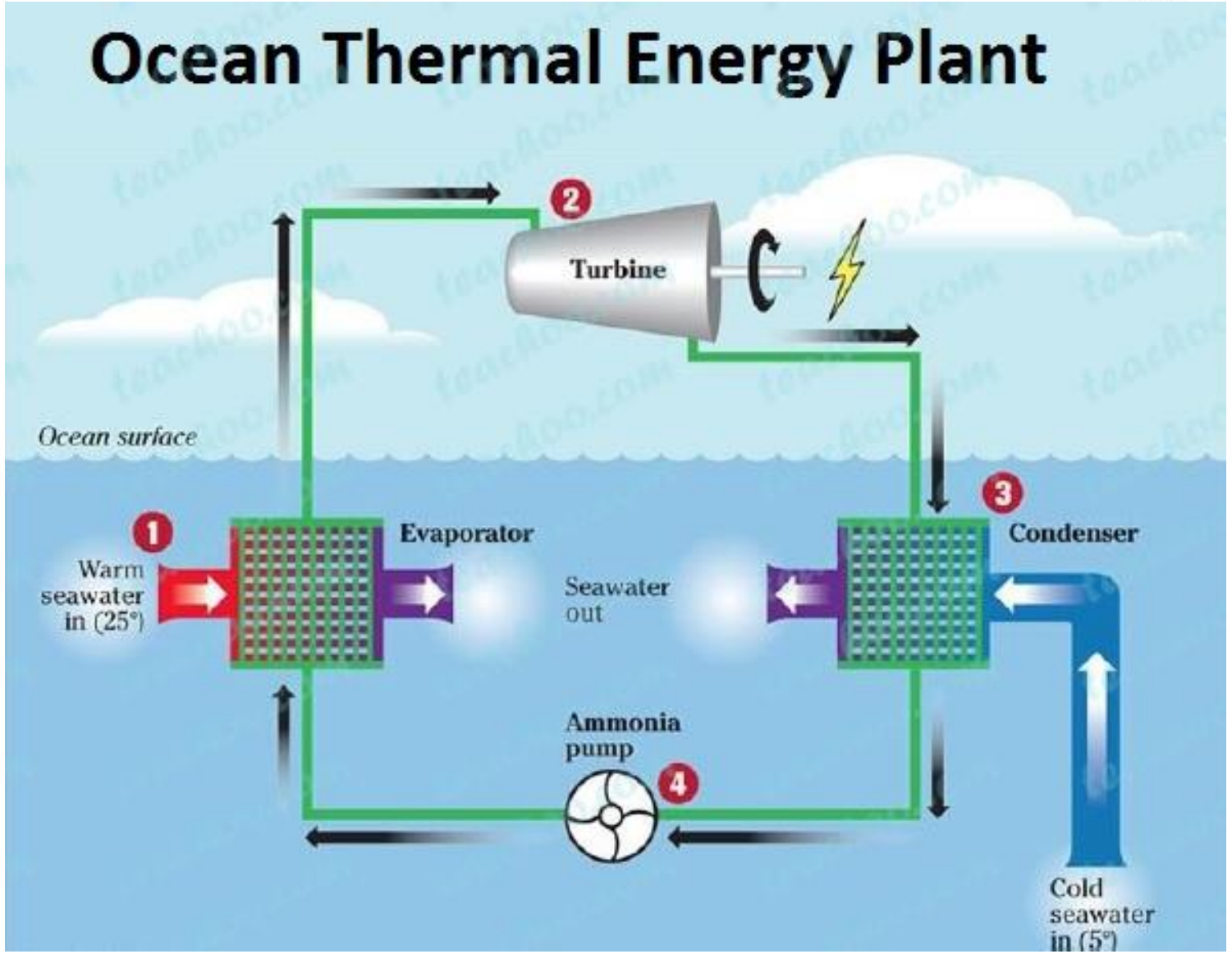
About 70% of earth's surface is covered by ocean which is continuously heated by solar heat.

Solar heat is stored as uneven distribution of heat between warm surface water and cold deep ocean water (called gradient) from where it is harnessed as ocean thermal energy.



- Ocean Thermal Energy Conversion (OTEC) is a process that can produce electricity by using the temperature difference between deep cold ocean water and warm tropical surface water.

- The ocean contains enough energy to power all of the world's electrical needs.

- Oceans cover more than 70% of Earth's surface, making them the world's largest solar collectors.

- OTEC is a renewable energy technology that converts solar radiation into electric power by use of world oceans.

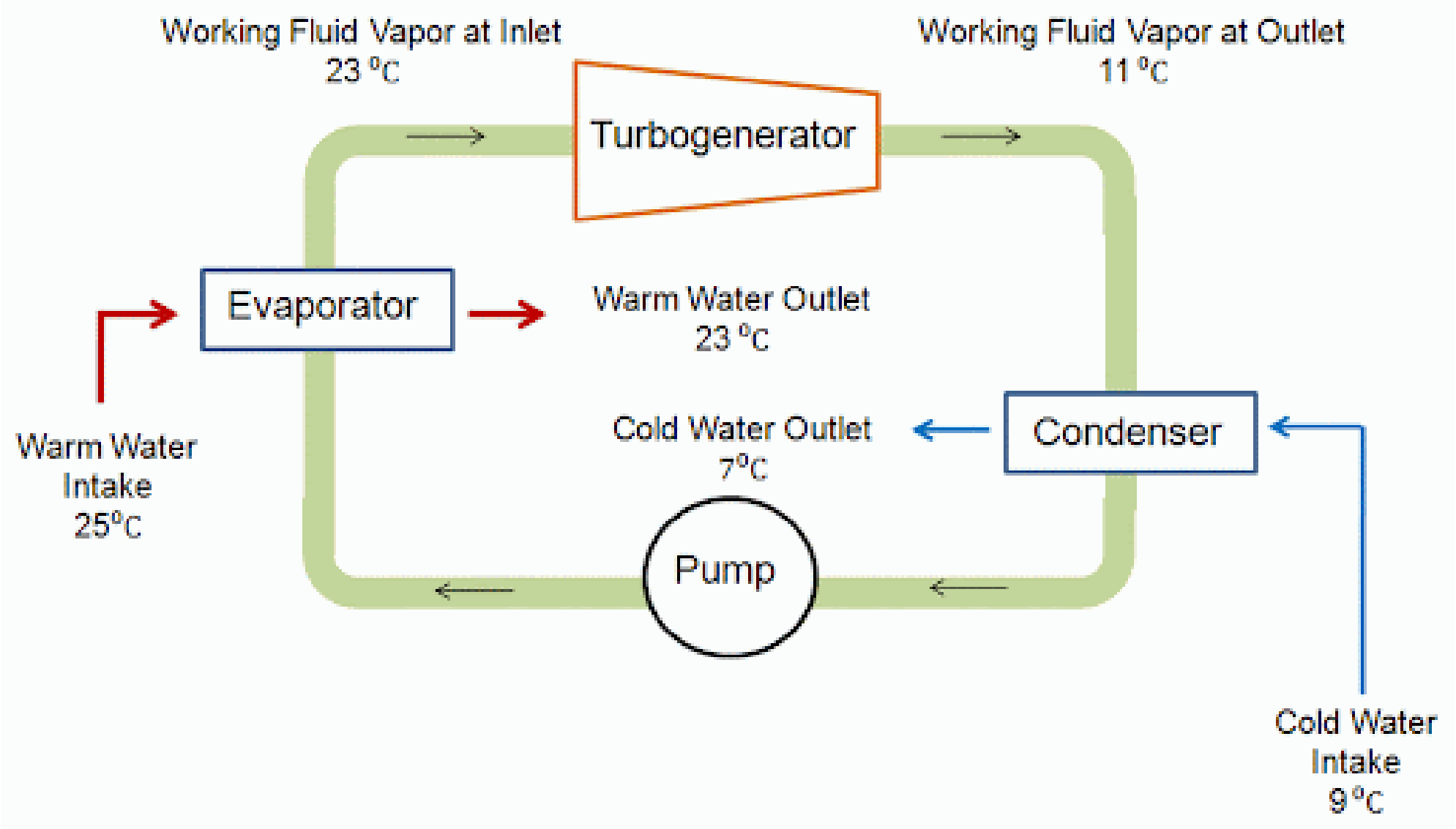
- OTEC process uses temperature difference between cold deep water (5 ℃) & warm surface water (27 ℃) to power a turbine to generate electricity.

PRINCIPLE OF WORKING

The basic principle of ocean thermal energy conversion (OTEC) is explained as follows:

1) Closed cycle OTEC

- The warm water from the ocean surface is collected and pumped through the heat exchanger to heat and vaporize a working fluid.
- The fluid develops pressure in a secondary cycle.
- The vaporized working fluid expands through a heat engine (similar to a turbine).
- Working fluid vapor coming out of heat engine is condensed back into liquid by a condenser.
- Cold deep ocean water is pumped through condenser where the vapor is cooled and returns to liquid state.
- The liquid (working fluid) is pumped again through heat exchanger and cycle repeats. This is known as closed-cycle OTEC.


Working Fluid Vapor at Inlet
23 °C
Working Fluid Vapor at Outlet
11 °C
Turbogenerator
Evaporator
Warm Water Outlet
23 °C
Warm Water
Intake
25°C
Cold Water Outlet
7°C
Condenser
Pump
Cold Water
Intake
9 °C

2) Open cycle OTEC

- If ocean surface water is high, enough propane or similar material is used as working fluid.

- Otherwise, for low-temperature surface water, fluid such as ammonia with low boiling point is used.

- In an open-cycle OTEC, warm ocean surface water is pumped into a low-pressure boiler to boil and produce steam.

- Then, the steam is used in steam turbine to drive an electrical generator for producing electrical power.

- The cold deep sea water is used in condenser to condense steam.

- Electrical power generated by OTEC plants are used for feeding to energy consumers.

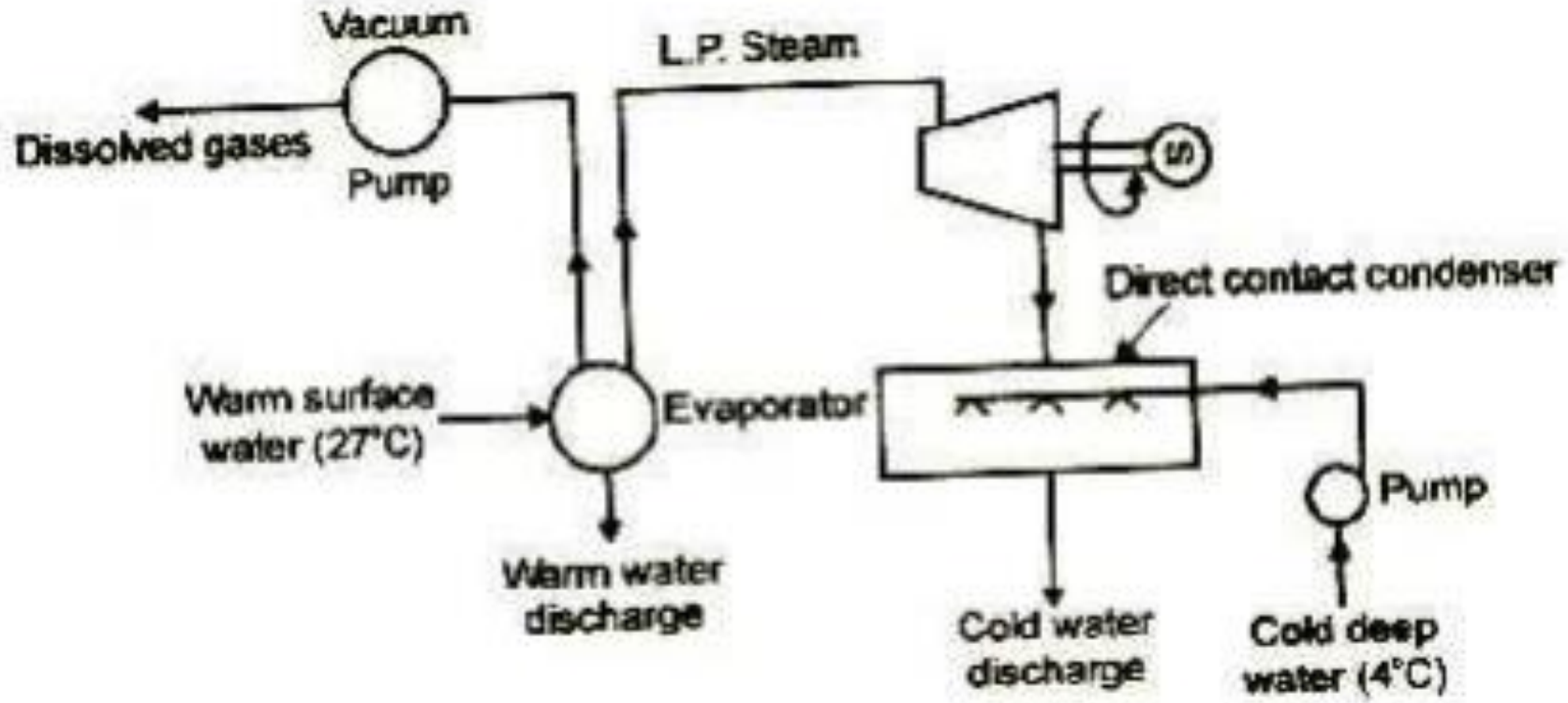


Figure: OTEC – open cycle.

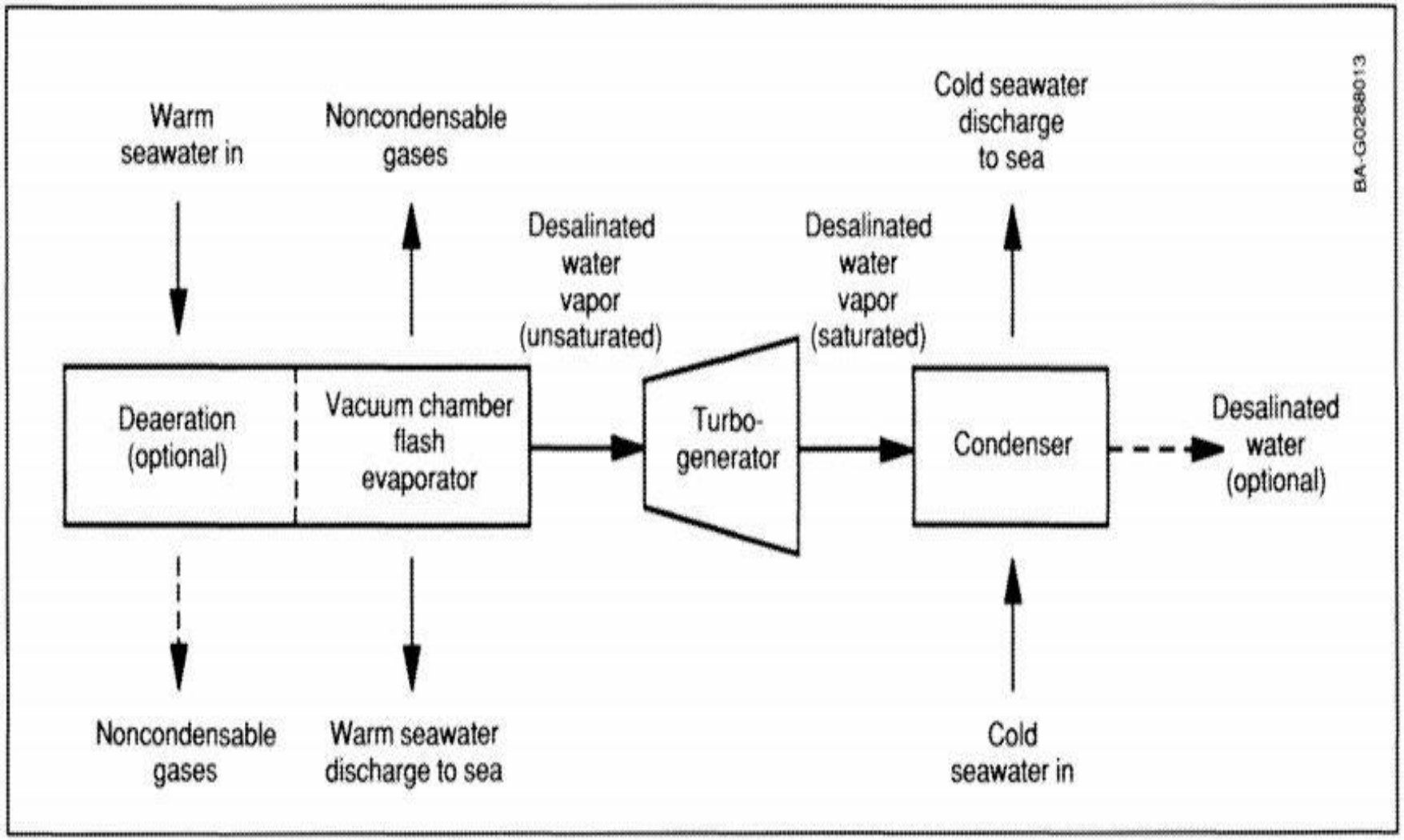


Fig: Ocean thermal energy conversion – open cycle system

OTEC POWER STATIONS IN THE WORLD

• Makai Ocean Engineering's ocean thermal energy conversion (OTEC) power plant in the US is the world's biggest operational facility of its kind with an annual power generation capacity of 100kW, which is sufficient to power 120 homes in Hawaii.

• OTEC plant in Japan overseen by Saga University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RANKINE CYCLE

The basic Rankine cycle shown in the Figure consists of an evaporator, a turbine expander, a condenser, a pump, a working fluid

• In open-cycle OTEC, warm sea water is used as working fluid, whereas in closed-cycle type, low-boiling point ammonia or propane is used.

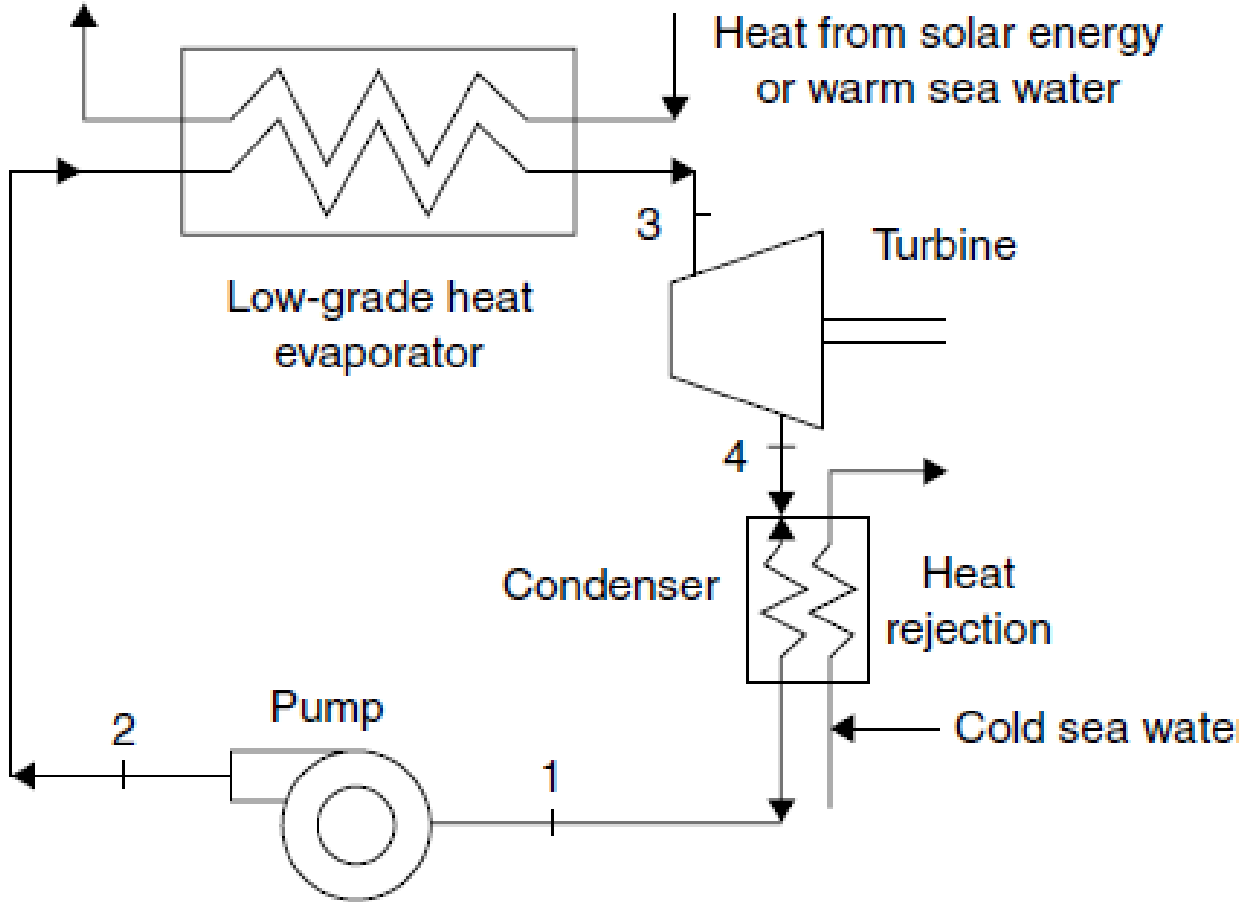

Fig: OTEC Rankine Cycle

• Warm ocean surface water flows into the evaporator which is the high-temperature heat source.

• A fluid pump is utilized to force the fluid in a heat evaporator where liquid fluid vaporizes.

• Then, the vapor of boiling fluid enters the turbine expander coupled with an electrical generator to generate electrical power.

• The vapor released from the turbine enters into condenser where it condenses.
• The cold deep sea water is pumped through the condenser for heat rejection from vapor fluid and condenses it as liquid fluid.
• The liquid fluid is again pumped through evaporator and cycle repeats.
• As temperature difference between high- and low-temperature ends is large enough, the cycle will continue to operate and generate power.

PROBLEMS ASSOCIATED WITH OTEC

• **High cost**: Electricity generated by OTEC plants is more expensive than electricity produced by chemical and nuclear fuels.

• **Complexity**: OTEC plants must be located where a difference of about 20°C occurs year round. Ocean depths must be available fairly close to shore-based facilities.

• **Acceptability:** For the large-scale production of electricity, OTEC plants are poorly acceptable due to their high costs.

• **Ecosystem damage**: It is obvious by setting OTEC plants.

• **Lower efficiency**: A higher temperature difference between ocean surface warm water and cold deep ocean water is required for highly efficient operation of plant.

END OF SLIDE SHOW