

Parametric study of working conditions of an Organic Rankine Cycle applied to Ocean Thermal Energy Conversion

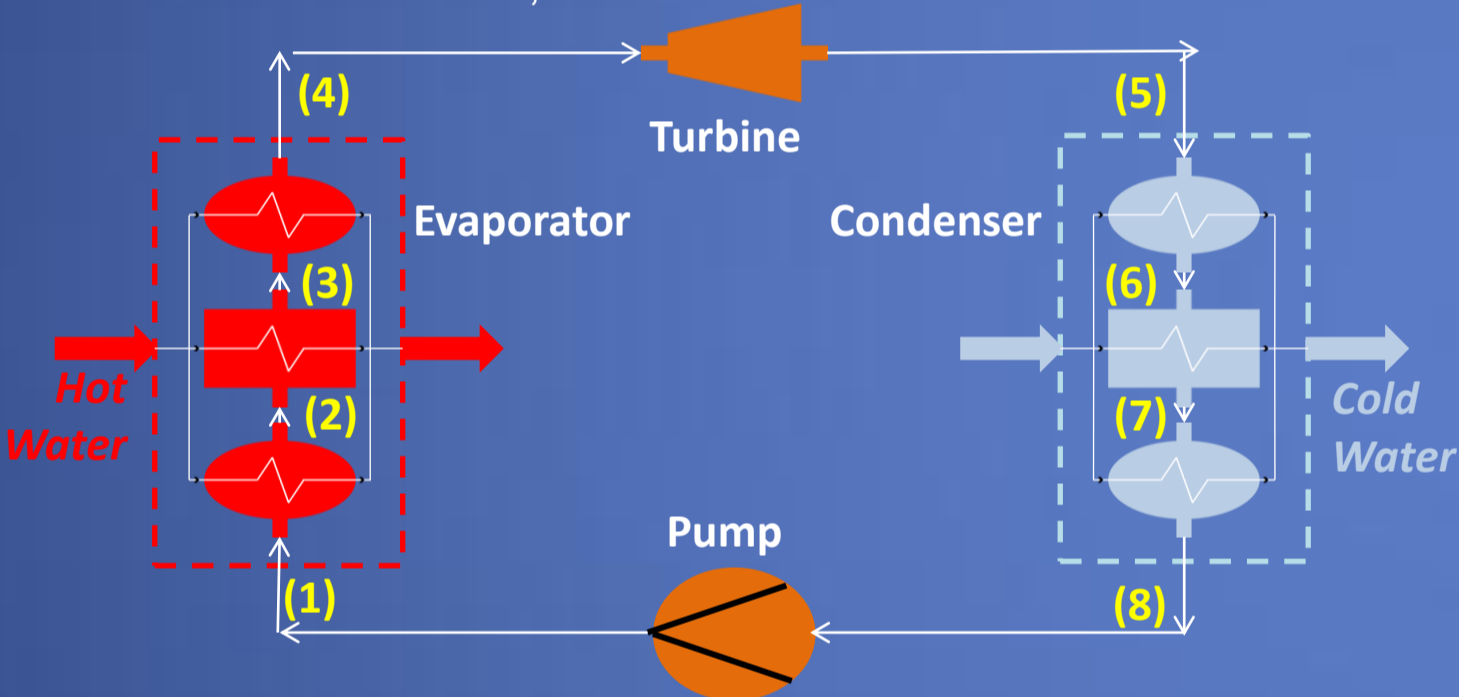
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Introduction

Ocean Thermal Energy Conversion (OTEC) is an elegant way to provide renewable and non-fluctuating energy. The temperature difference between the cold deepwater and the hot shallow water in tropical areas allows to drive a thermodynamic cycle. However, the range of temperature is very small compared to that of conventional cycles. The Organic Rankine Cycle (ORC) is employed in order to take full advantage of the low temperature difference, because of its simplicity and reliability. The purpose of this study is to show how to achieve the best performance of the ORC considering various objective parameters.

Model of the ORC

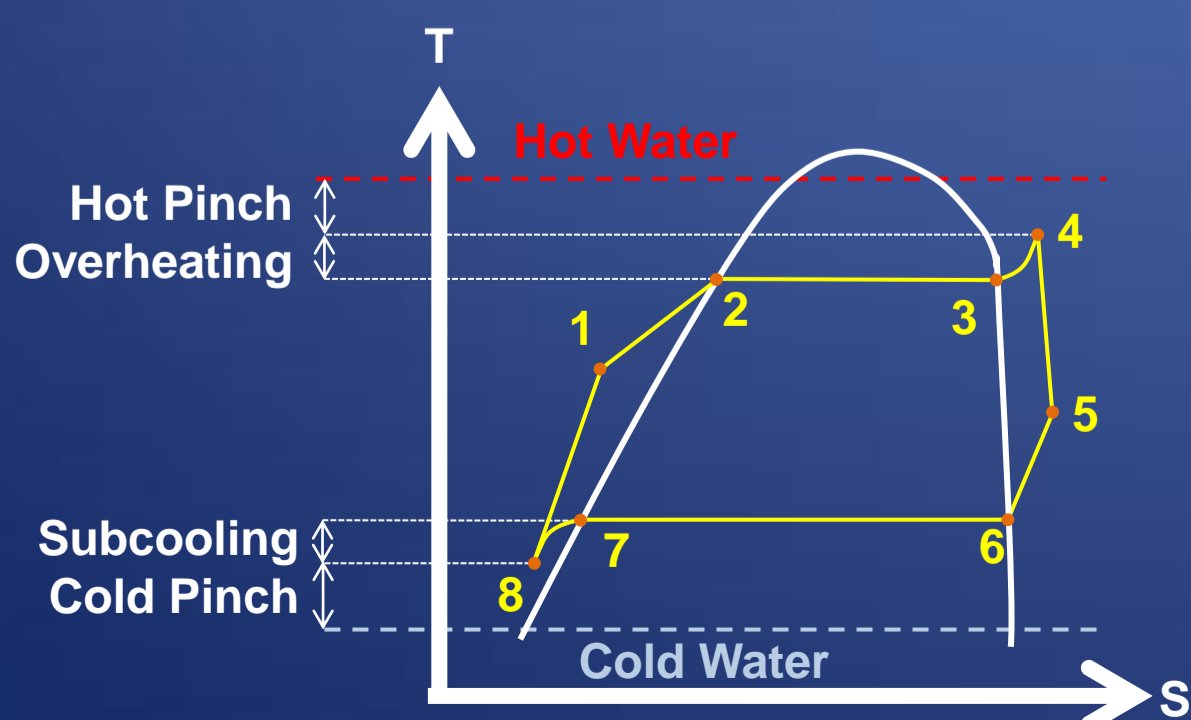
The ORC contains four components : a pump, an evaporator, a turbine and a condenser, as shown below :



Point of the cycle	State	Pressure	Transformations
(1)	Liquid	High	(1) to (2) Isobar heating
(2)	Liquid	High	(2) to (3) Evaporation
(3)	Gas	High	(3) to (4) Isobar superheating
(4)	Gas	High	(4) to (5) Expanding
(5)	Gas*	Low	(5) to (6) Isobar cooling*
(6)	Gas*	Low	(6) to (7) Condensation
(7)	Liquid	Low	(7) to (8) Isobar sub cooling
(8)	Liquid	Low	(8) to (1) Compression

* For some kinds of fluids, the state at the leaving of the turbine is biphasic, so the cooling phase doesn't happen, and we have (5)=(6).

Temperature-Entropy Diagram



Simulation results

The inputs are taken from experimental results of the OTEC onshore prototype situated at the IUT of Saint-Pierre, Reunion Island.



3. OTEC onshore prototype

Inputs

External Conditions

Hot sea water temperature : 27°C -
Cold sea water temperature : 4,9°C -

Evaporator

Overheating : 0,08°C -
Hot pinch : 5,6°C -

Condenser

Subcooling : 0,17°C -
Cold pinch : 5,2°C -

Pump and Turbine characteristics

Pump isentropic efficiency : 0,7 -
Turbine isentropic efficiency : 0,85 -

Working fluid

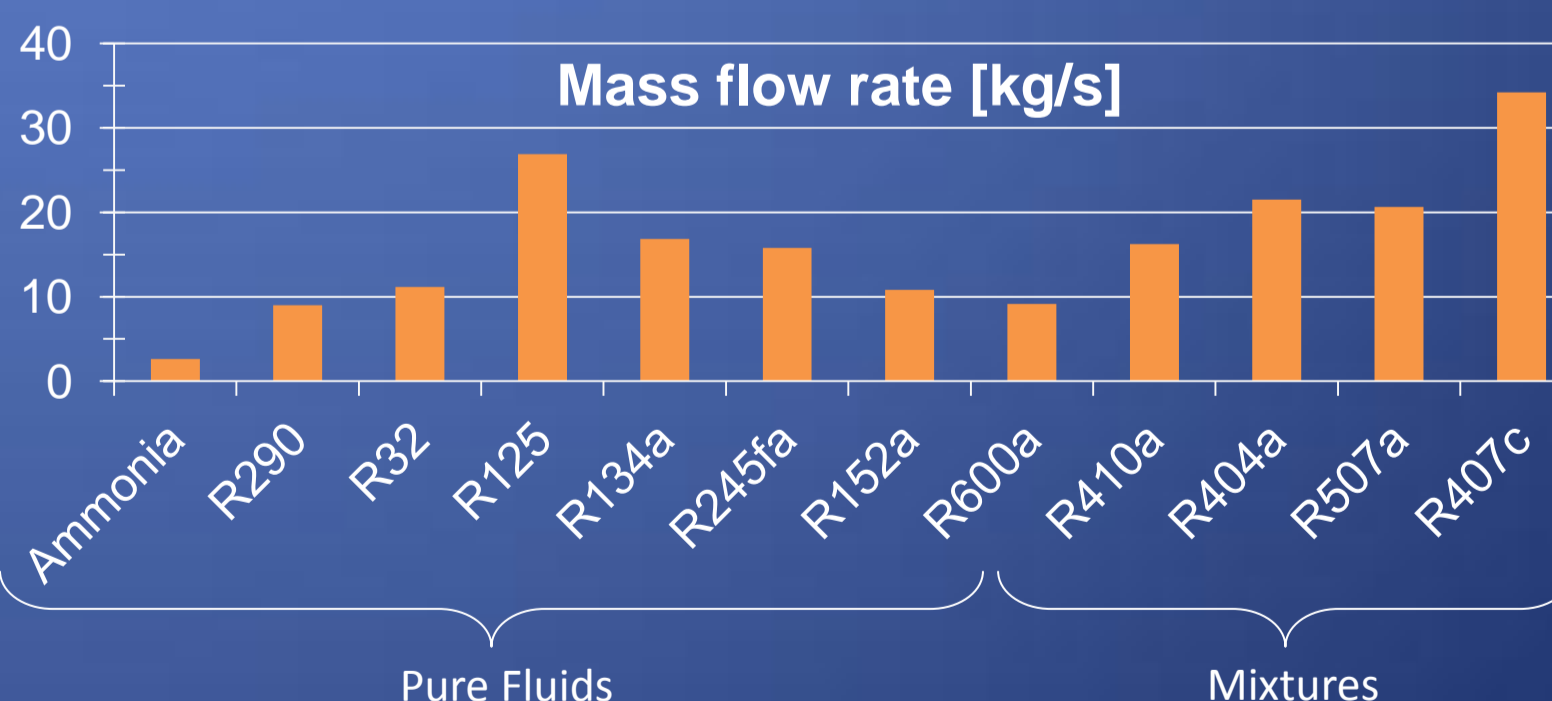
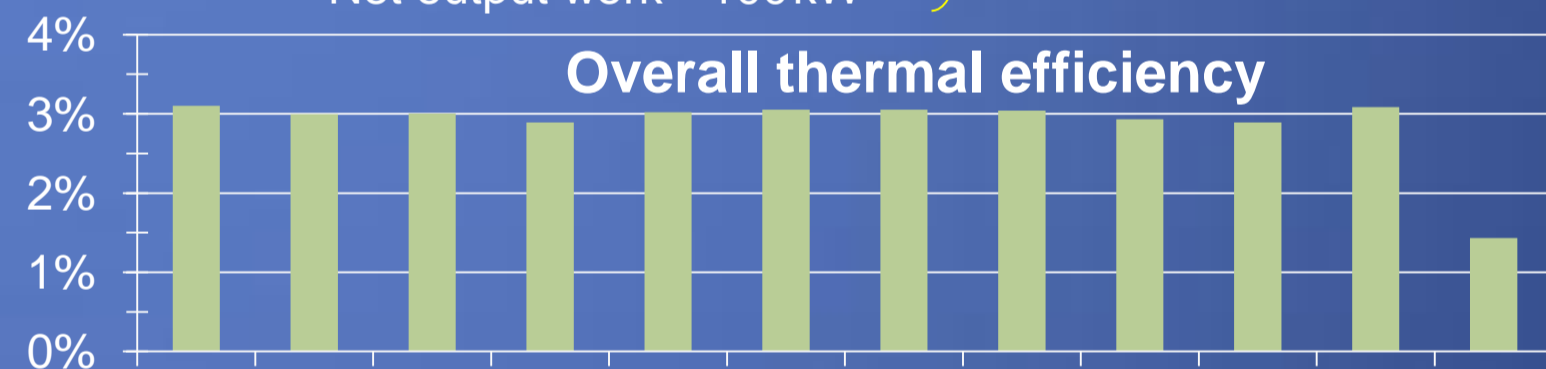
Choice of the working fluid -

Production needs

Net output work 100kW -

Outputs :

- State variables at each point (Temperature, Pressure, Specific enthalpy, Specific entropy)
- Mass flow rate
- Heat transfer rate inside the exchangers
- Work in the pump and the turbine
- Overall thermal efficiency



Conclusion and perspectives

The results show that, considering the needed mass flow rate to reach the net output work, ammonia is clearly the most performing working fluid. However, when considering the thermal efficiency, the differences between the working fluids aren't significant. In order to compare this working fluids, we can also take account of the working pressures or the environmental impacts of each fluids. So, a study have to be completed to show witch objective or multi-objective parameter best fits to the characterization of the performance of ORC applied to OTEC.