Cycle Analysis on Ocean Geothermal Power Generation using Multi-staged Turbine

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Background and Object

- ## Background

  - **The use of fossil fuel and rapid development of technologies**
    - improved the quality of human lives.. depletion of usable fossil fuels and problems on the global environment

      → **Interest for alternative energy**

  - **Geothermal heat and deep seawater**
    - Renewable energy.. Geothermal heat, Ocean energy, etc..
    - Geothermal heat..
      - one of the humankind's oldest energy resources
      - the usage is globally increased but in Korea the importance is relatively underestimated.
      - Need for research of proper geothermal power generation cycle
    - Deep seawater
      - The use of deep seawater as cooling water of geothermal cycle
      - In East Sea.. there is the deep sea water comparatively close to the seashore

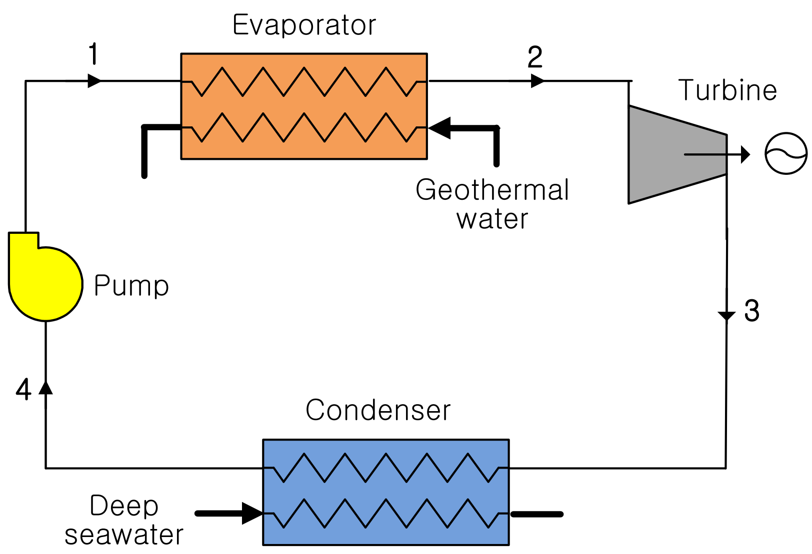
      → **Improvement of cycle efficiency**

- ## Object

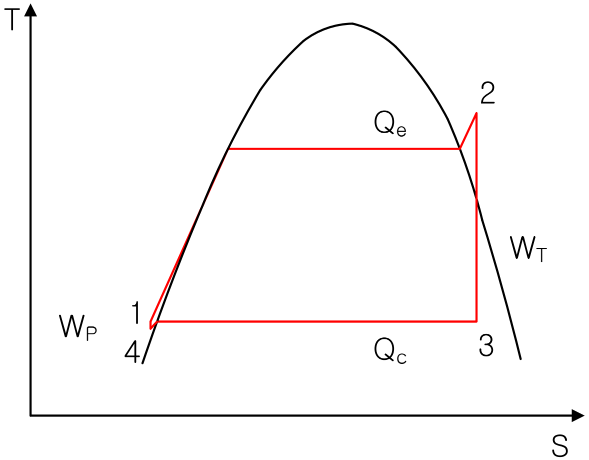
  The cycle performance of the multistage cycle and the multistage regeneration cycle was analyzed and compared with that of the existing ORC

Cycle simulation

- Cycle simulation
  - **Basic thermodynamic model : Rankine cycle**
  - **Solver : HYSYS**



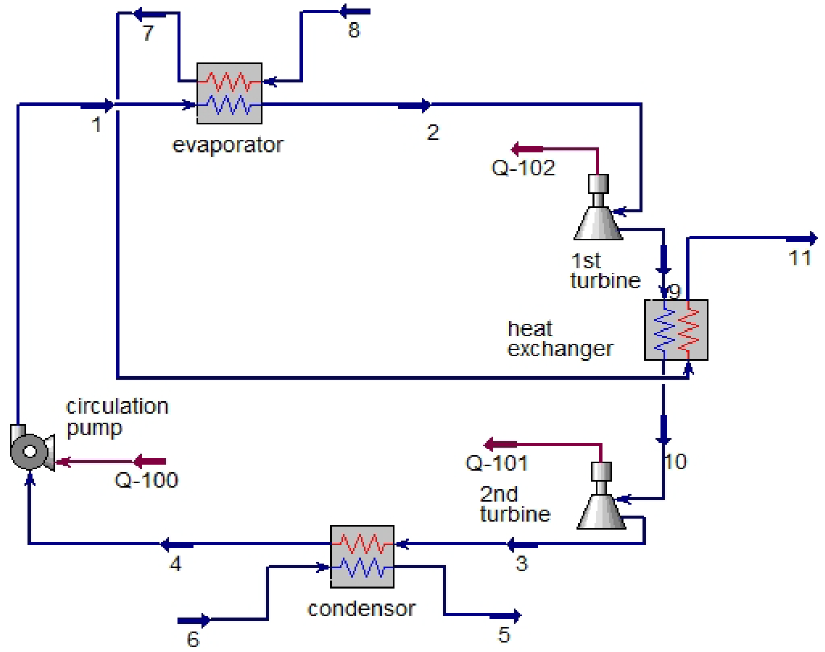
Basic simulation design



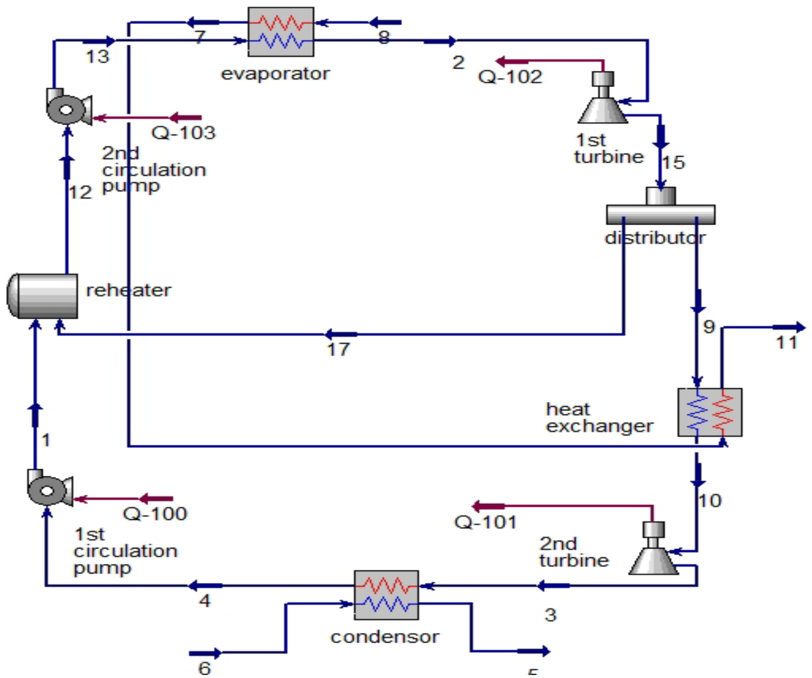
T-S diagram

Cycle simulation

- Cycle simulation
  - **Performance improvement cycles: multistage cycle, multistage regeneration cycle**



MR cycle



MSR cycle

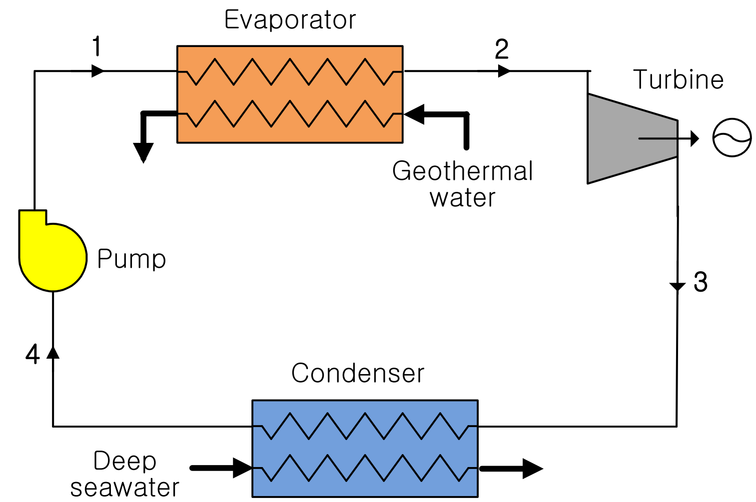
Cycle simulation

▪ Cycle simulation

- **Design condition of simulation**

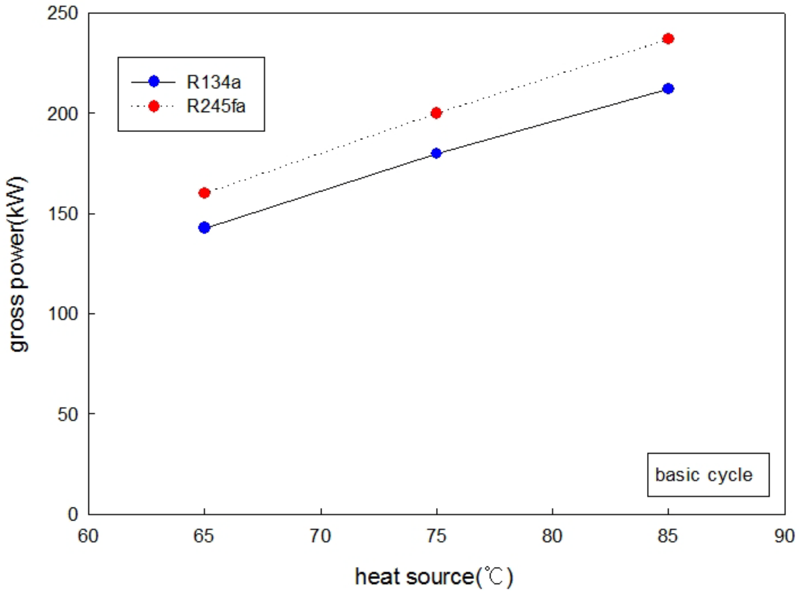
Parameter	Value
Gross power (kW)	200, open
Cycle type	ORC, MS, MSR
Warm water inlet temperature (℃)	65, 75, 85
Cold water inlet temperature (℃)	5
Heat Exchanger LMTD	3.5
Working fluid mass flow (kg/s)	9.495
Flow rate ratio	1:1
Isentropic turbine efficiency (%)	80
Isentropic pump efficiency(%)	65
working fluid	R134a, R245fa

- **Design of each component**
  - Evaporator : Heating, phase change process
  - Condenser : phase change process
  - Pump & turbine : iso-entropic process

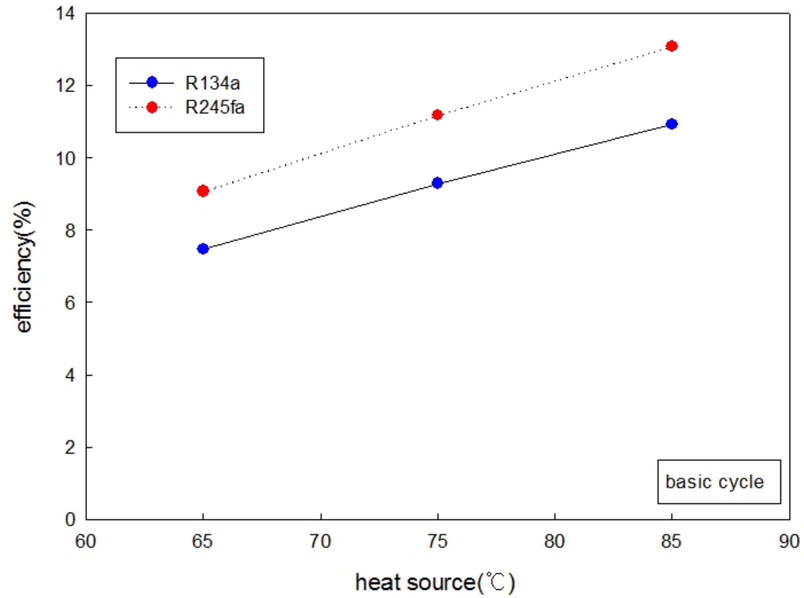


Results

- Heat source variation
  - **Cycle : basic cycle**



Power



Efficiency

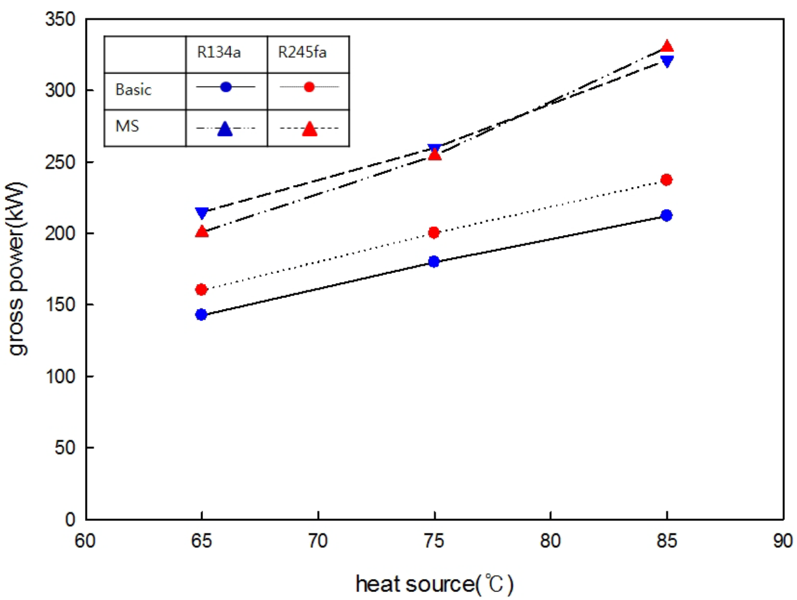
WFP : R134a, 16.33kW (at 75℃)
(basic) R245fa, 4.56kW (at 75℃)

Maximum value	Gross Power	Efficiency
ORC	R245fa (236.9kW)	R245fa (13.06%)

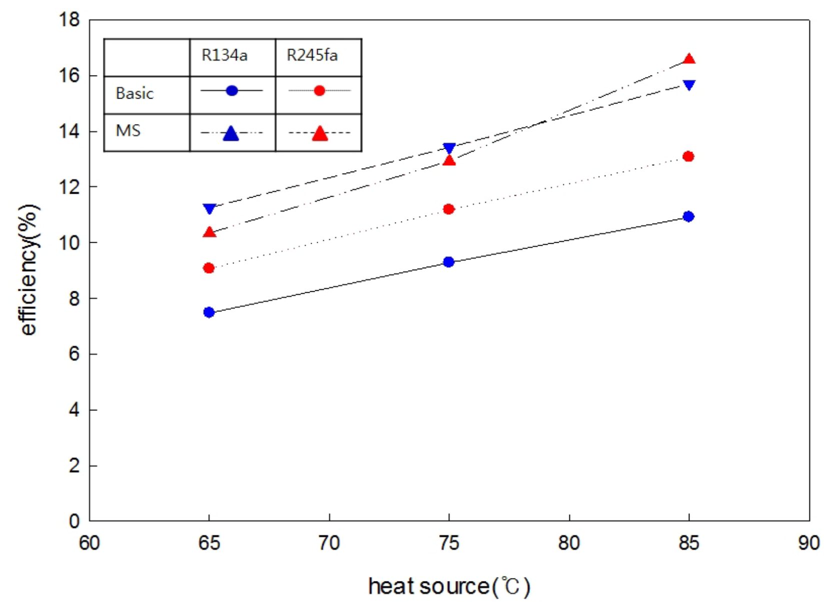
Results

■ Heat source variation

- **Cycle : basic/MS cycle**



Gross power



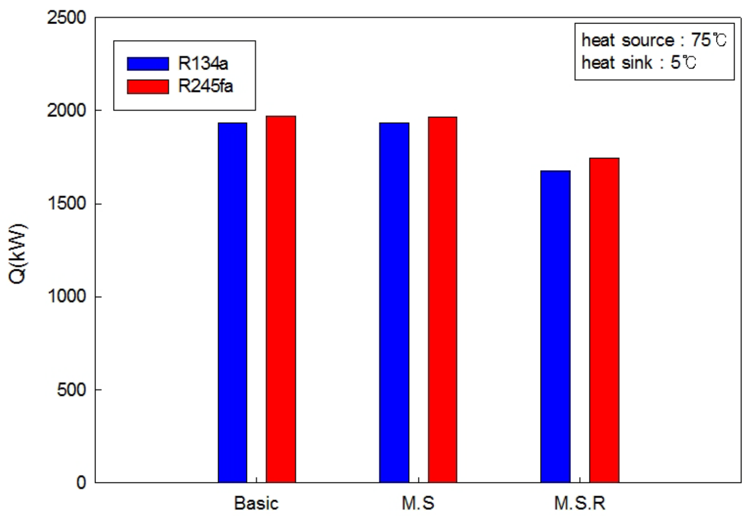
Efficiency

WFP： R134a, 16.33kW (at 75℃)
(MS)　R245fa, 4.55kW (at 75℃)

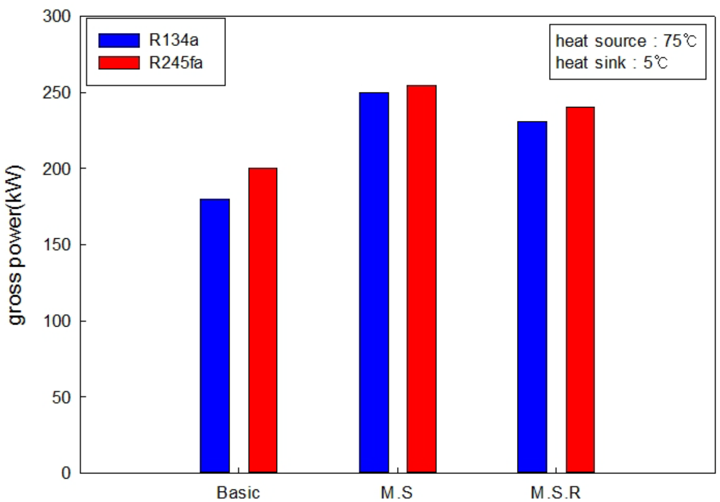
Maximum value	Gross power	Efficiency
MS	R245fa (330.0kW)	R245fa (16.56%)
BS	R245fa (236.9kW)	R245fa (13.06%)

Results

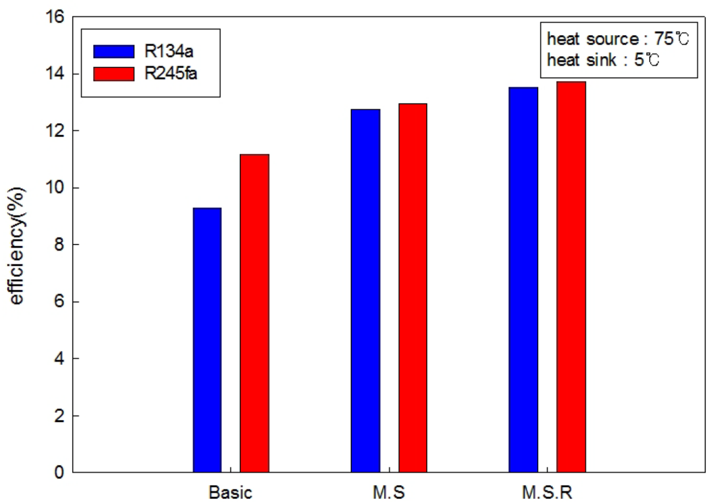
- Cycle comparison
  - **Cycle : basic, MS cycle**



HX capacity



Gross power



Efficiency

Maximum value	Gross power	Efficiency
	MS (259.65kW)	MSR cycle (13.7%)

Conclusion

- In the basic cycle, R245fa had a 10.51% higher output and a 16.44% higher efficiency level than R134a. The MS cycle had a 21.32% higher output and a 13.5% higher cycle efficiency level than the basic cycle.

- The comparison of the characteristics of the working fluids showed that R134a had a higher output and efficiency level when the heat source temperature was below 75°C, and that R245fa had a higher output and efficiency level when the heat source temperature was above 75°C.

- The comparison of the MS cycle and the MSR cycle showed that their performance was superior to that of the existing basic cycle, and that the MS cycle had a higher output whereas the MSR cycle had a slightly higher cycle efficiency level.