COMBINED POWER AND REFRIGERATION CYCLE FOR GEOTHERMAL HEAT SOURCES

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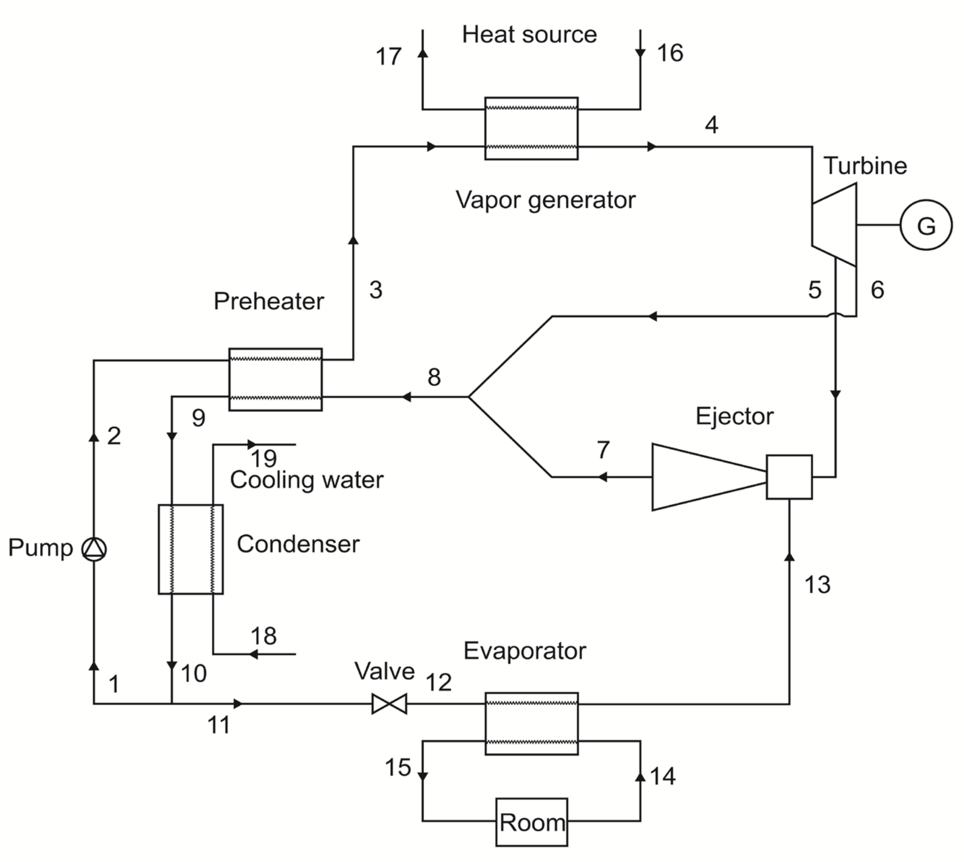
Int. Seminar on ORC Power Systems
22-23 September 2011, TU Delft

1. Introduction

A power and cooling cycle which combines the organic Rankine cycle (ORC) and the ejector refrigeration cycle supplied by geothermal heat energy sources is presented. The thermodynamic and physical properties of thirteen working fluids -including one wet (R152a), eight dry (R123, R227ea, R236fa, R245fa, R600, R600a, R601a and RC318) and four isentropic (R124, R134a, R141b and R142b) fluids- are investigated in the proposed combined cycle and their performances are compared. With a waste heat source temperature between 373 and 433K, an evaporator temperature between 368 and 408K and with a fixed power/refrigeration ratio, the effects of the various operating conditions on the cycle performance are examined. The proposed model is validated with the results of the combined power and ejector refrigeration cycle using R245fa as the working fluid presented by Zheng et al. [1] and Hasan et al. [2]. Also it is validated with the results of Dai et al. [3] in which R123 was selected as the working fluid.

2. Assumptions and Model



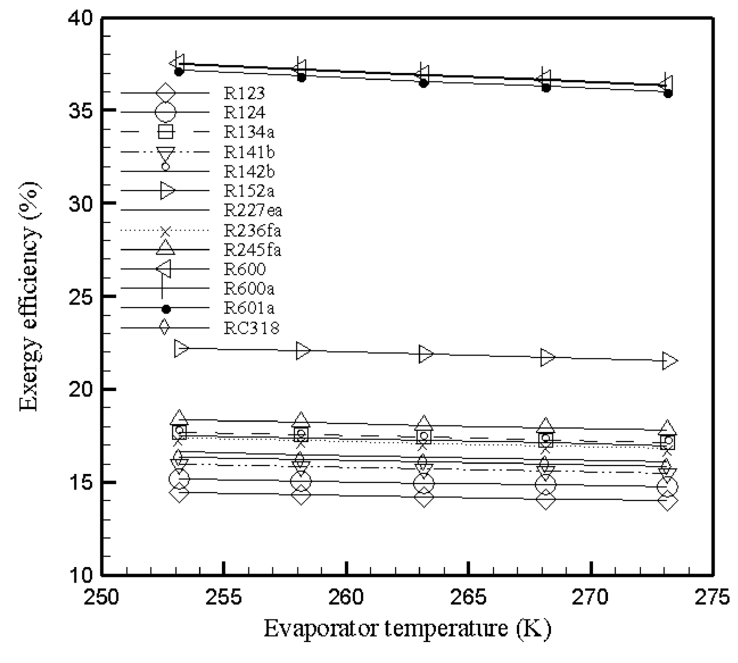
2.1 Assumptions:

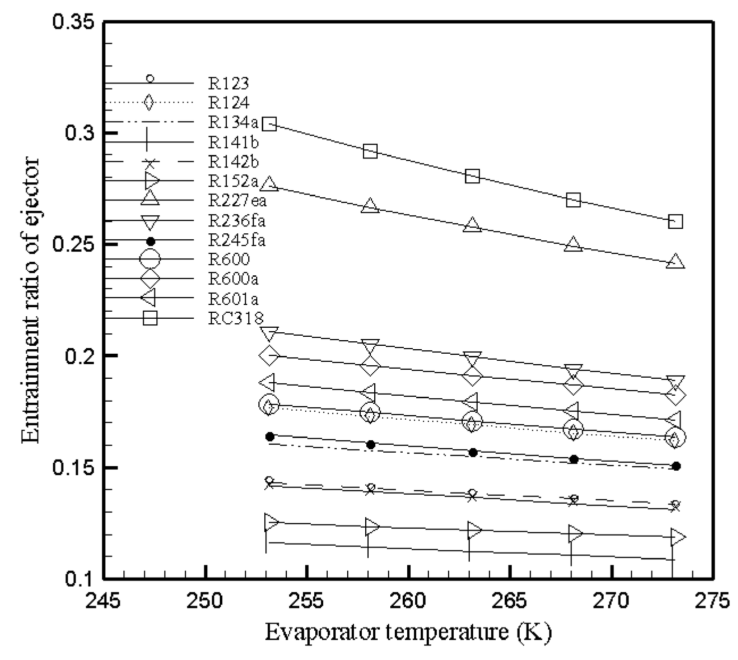
- The system runs in a steady state.
- The kinetic and potential energies as well as friction losses are neglected.
- Generator, evaporator, turbine, ejector and condenser are assumed adiabatic.
- The expansion valve process is at constant enthalpy.
- The working fluid at the evaporator outlet is saturated vapor.
- The outlet state from the condenser is saturated liquid.

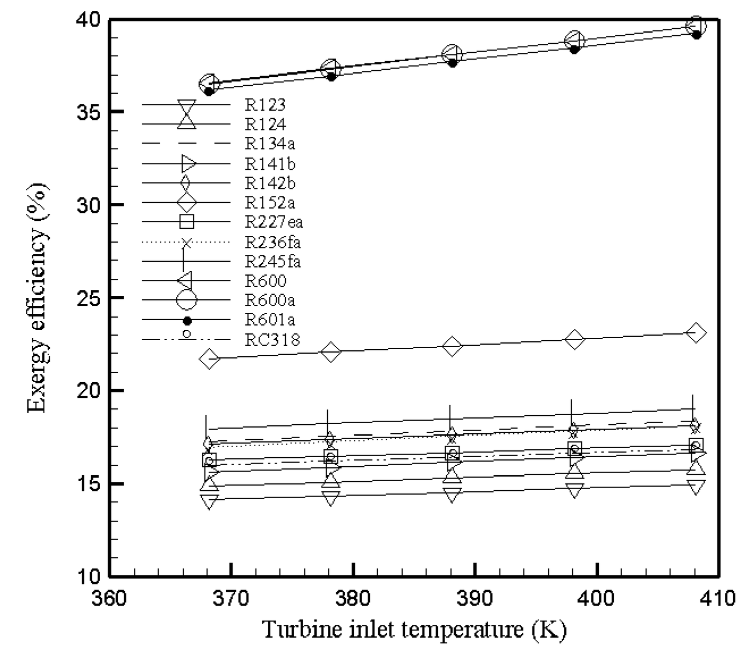
2.2 Equations:

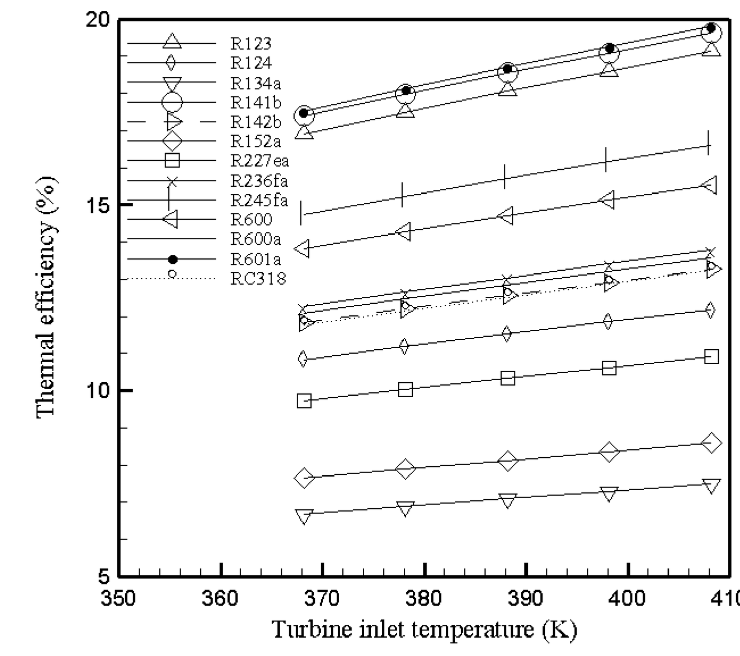
- Conservation of mass and energy for each component
- Relations between thermodynamic properties
- Exergy analysis of each component
- Definition of turbine and pump efficiencies

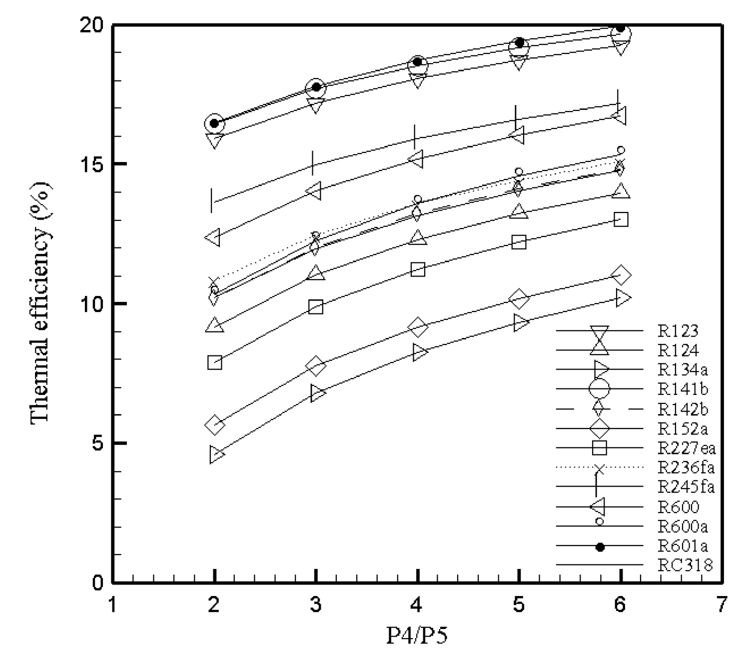
3. Results

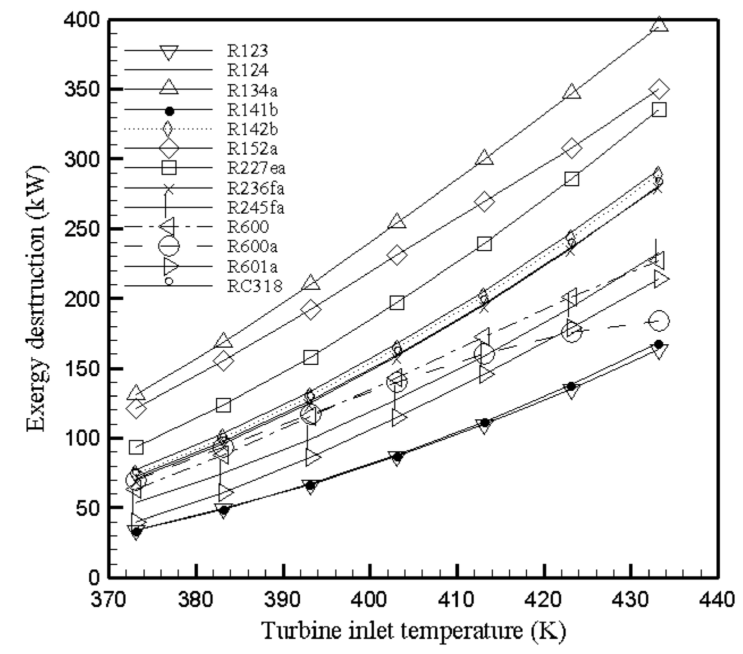












4. Conclusions

The main conclusions from this study are as follows:

- The results confirm the thermodynamic superiority of dry and isentropic ORC fluids over the wet fluids.
- Exergy efficiency decreases with increasing evaporator temperature but increases with decreasing turbine inlet temperature.
- Thermal efficiency increases with the increase in the turbine inlet temperature and expansion ratio of the turbine.
- Entrainment ratio of the ejector decreases as the evaporator temperature rises.
- Exergy destruction rate of the cycle for all working fluids increases with the increasing turbine inlet temperature.

5. References

[1] B. Zheng, Y.W. Weng, “A combined power and ejector refrigeration cycle for low temperature heat sources”, Sol. Energy, Vol 84, pp. 784–79, (2010).
[2] A.A. Hasan, G.Y. Goswami and S. Vijayaraghavan, “First and second law analysis of a new power and refrigeration thermodynamic cycle using a solar heat source”, Sol. Energy, Vol 73, pp. 385-393, (2002).
[3] Y. Dai, J. Wang, L. Gao, “Exergy analysis, parametric analysis and optimization for a novel combined power and ejector refrigeration cycle”, Applied Thermal Engineering, Vol 29, pp. 1983–1990, (2009).