OPTIMIZATION OF A COMBINED POWER AND EJECTOR REFRIGERATION CYCLE USING LOW TEMPERATURE WASTE HEAT

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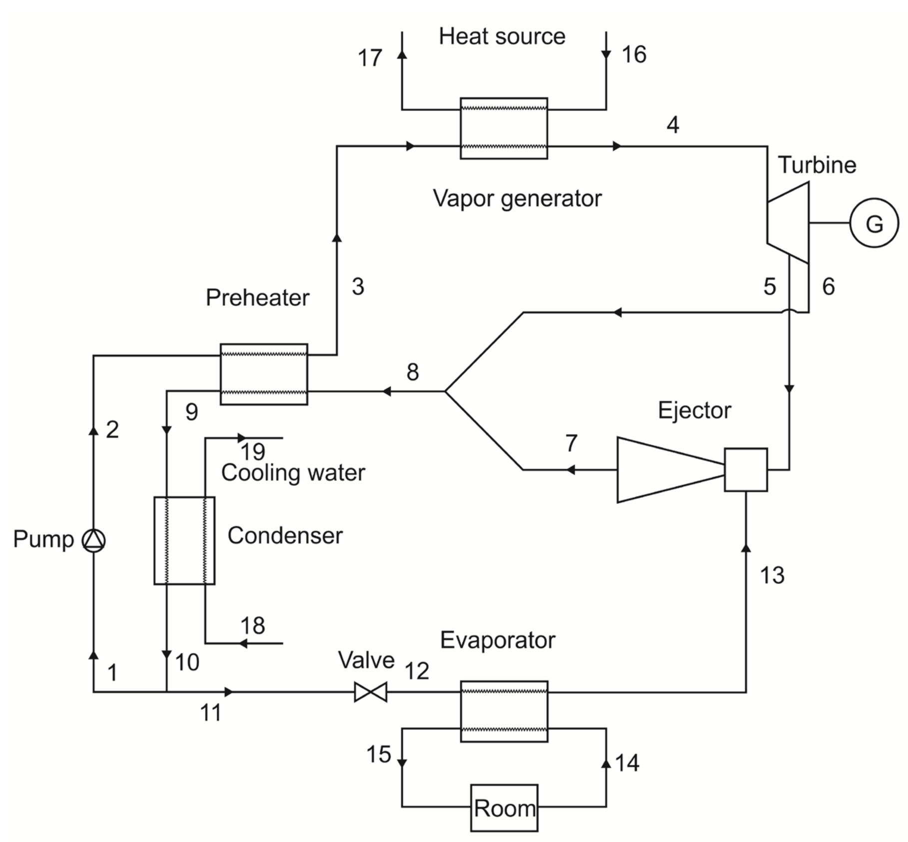
Int. Seminar on ORC Power Systems
22-23 September 2011, TU Delft

1. Introduction

Recently there is a strong interest toward exploiting renewable energies and waste heat instead of fossil fuel sources. The main reason is that the renewable energy sources are environment friendly, cheap and abundant. Furthermore the use of waste heat improves energy efficiency. Several studies have investigated the performance of cycles using low temperature heat sources [1, 2].
The present paper presents a thermodynamic study and optimization of a combined organic Rankine cycle (ORC) and ejector refrigeration cycle driven by low-temperature waste heat. The performance of different working fluids (R123, R141b, R245fa, R600a, R601a) was investigated. The analysis has been performed for a case for which the power/refrigeration ratio is 2, the pinch point temperature difference is fixed, the waste heat source temperature varies between 393 and 443 K, and the evaporator temperature varies between 258 and 278K. Results show that the inlet pressure of the pump and inlet pressure of the turbine can be optimized to get a minimum total thermal conductance.

2. Assumptions and Model



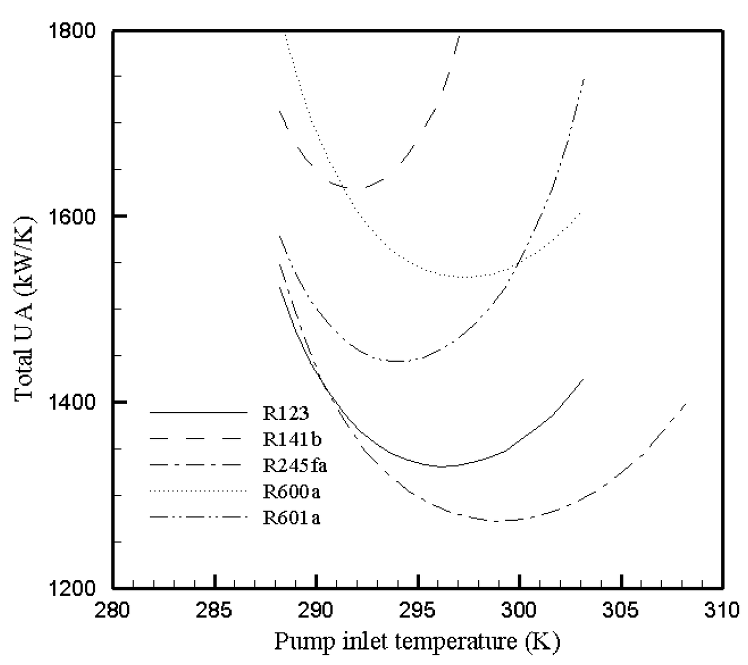
2.1 Assumptions:

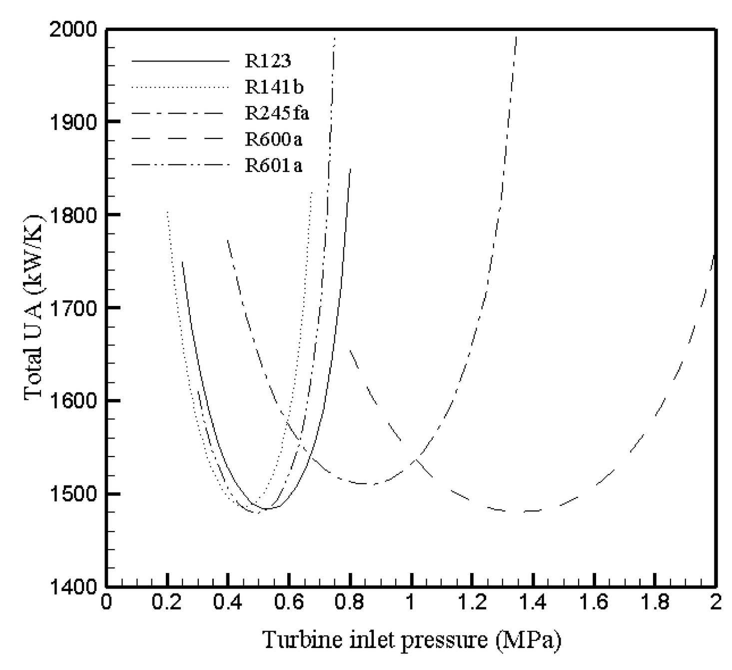
- The system runs in a steady state.
- The kinetic and potential energies as well as friction losses are neglected.
- Generator, evaporator, turbine, ejector and condenser are assumed adiabatic.
- The expansion valve process is at constant enthalpy.
- The working fluid at the evaporator outlet is saturated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

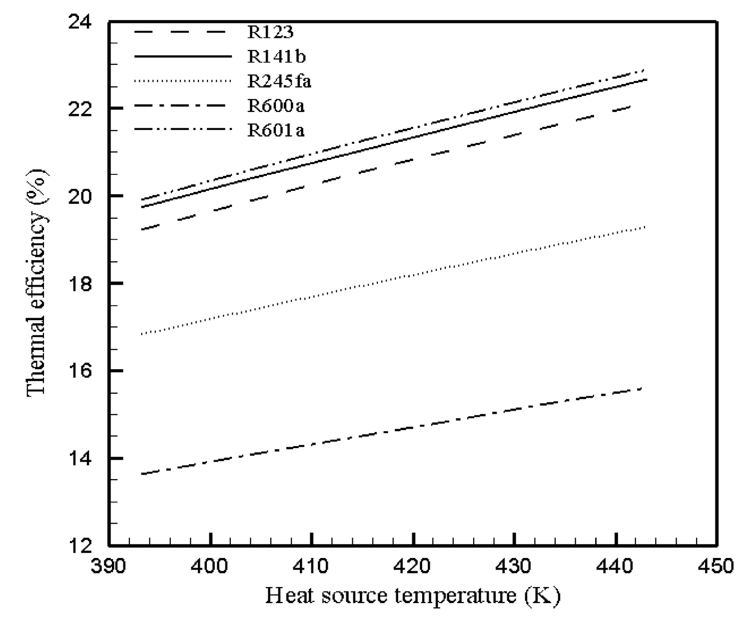
2.2 Equations:

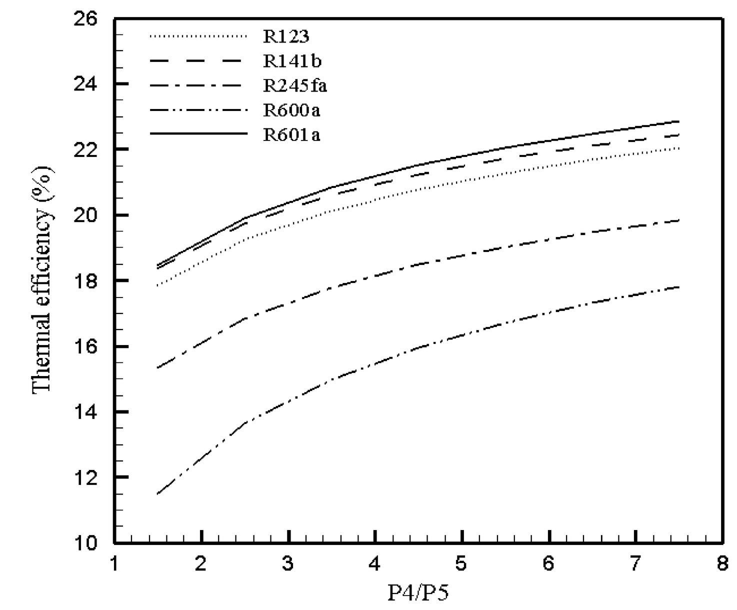
- Conservation of mass and energy for each component
- Relations between thermodynamic properties
- Exergy analysis of each component
- Definition of turbine and pump efficiencies

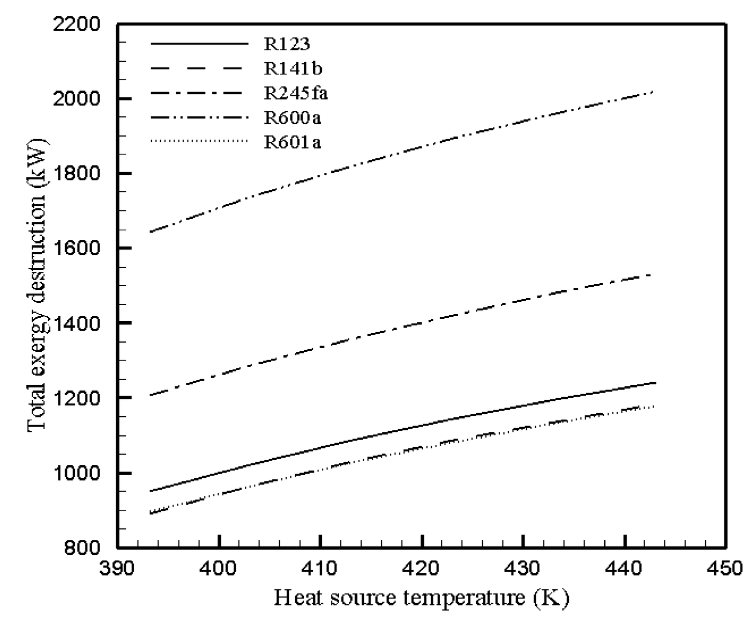
3. Results

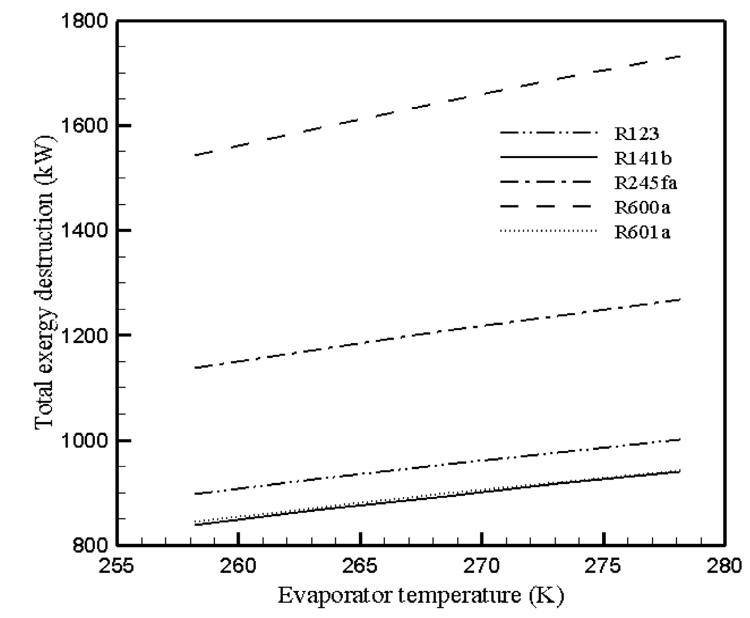


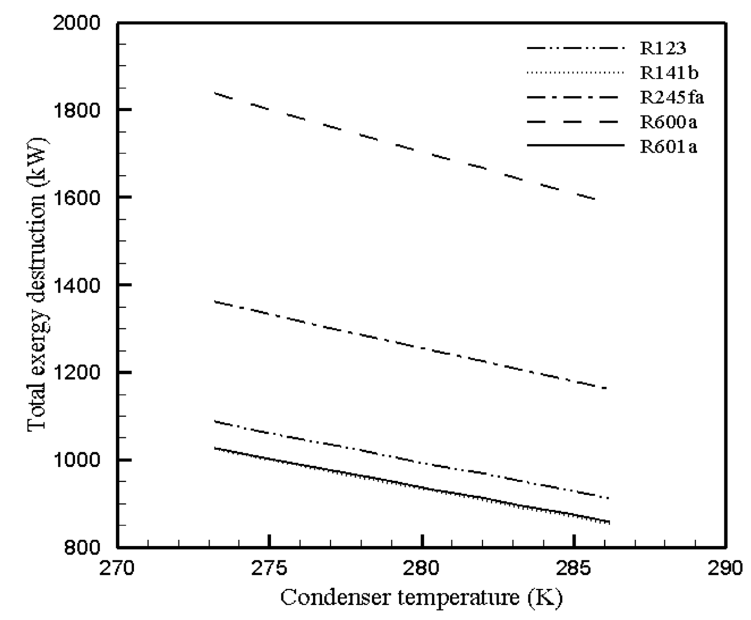


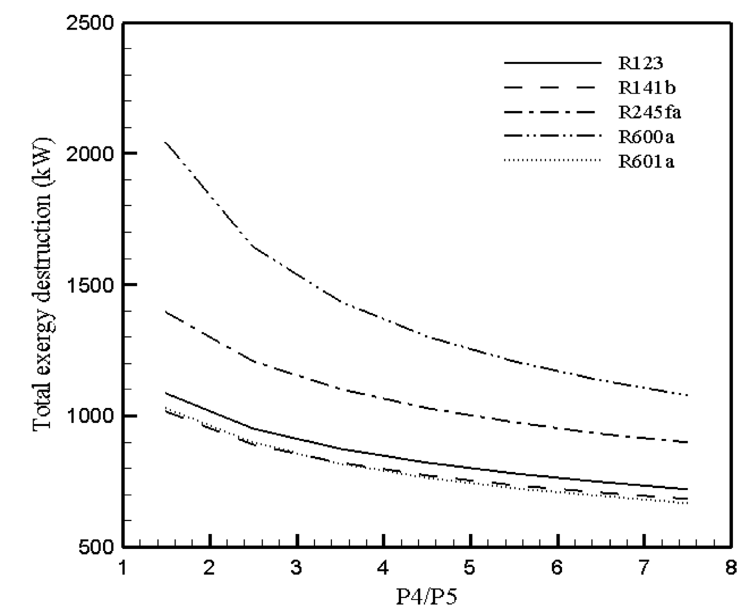












4. Conclusions

The main results from this study at the defined ranges are as follows:

- Inlet temperature of the pump and inlet pressure of the turbine can be optimized to get a minimum total thermal conductance.
- Working fluid R601a is the suitable working fluid if the cycle is optimized according to the turbine inlet pressure, because it has the highest thermal efficiency (18.67%) and the lowest total thermal conductance (1479 kW/K). On the other hand, if the cycle is optimized according to the pump inlet temperature, R141b is the best choice because it has the lowest exergy destruction rate (911.8 kW) and the highest thermal efficiency (19.02 %).
- Total exergy destruction of the proposed cycle increases as the heat source temperature and evaporator temperature increase but decreases as the condenser temperature and turbine expansion ratio increase.
- Thermal efficiency for all the working fluids increases as the heat source temperature and the expansion ratio P4/P5 go up.

5. References

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[2] E.Cayer, N. Galanis, M. Desilets, H. Nesreddine, and P. Roy, “Analysis of a carbon dioxide transcritical power cycle using a low temperature source”, Applied Energy, Vol 86, pp. 1055–1063, (2009).