

ANALYSIS OF USING DIFFERENT REFRIGERANTS AND OPERATING CONDITIONS IN STEAM GENERATING HEAT PUMP

RESEARCH GROUP

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Introduction

The investigated configuration consists of a closed-cycle, cascade high temperature heat pump with a steam compression cycle on top. All the compressors are centrifugal. The goals of this Master's thesis are to test the performance with different refrigerants, HTHP temperature lifts and steam outlet pressures, and to create an automatized Microsoft Excel based calculation tool. Fig 1 . presents the investigated configuration.

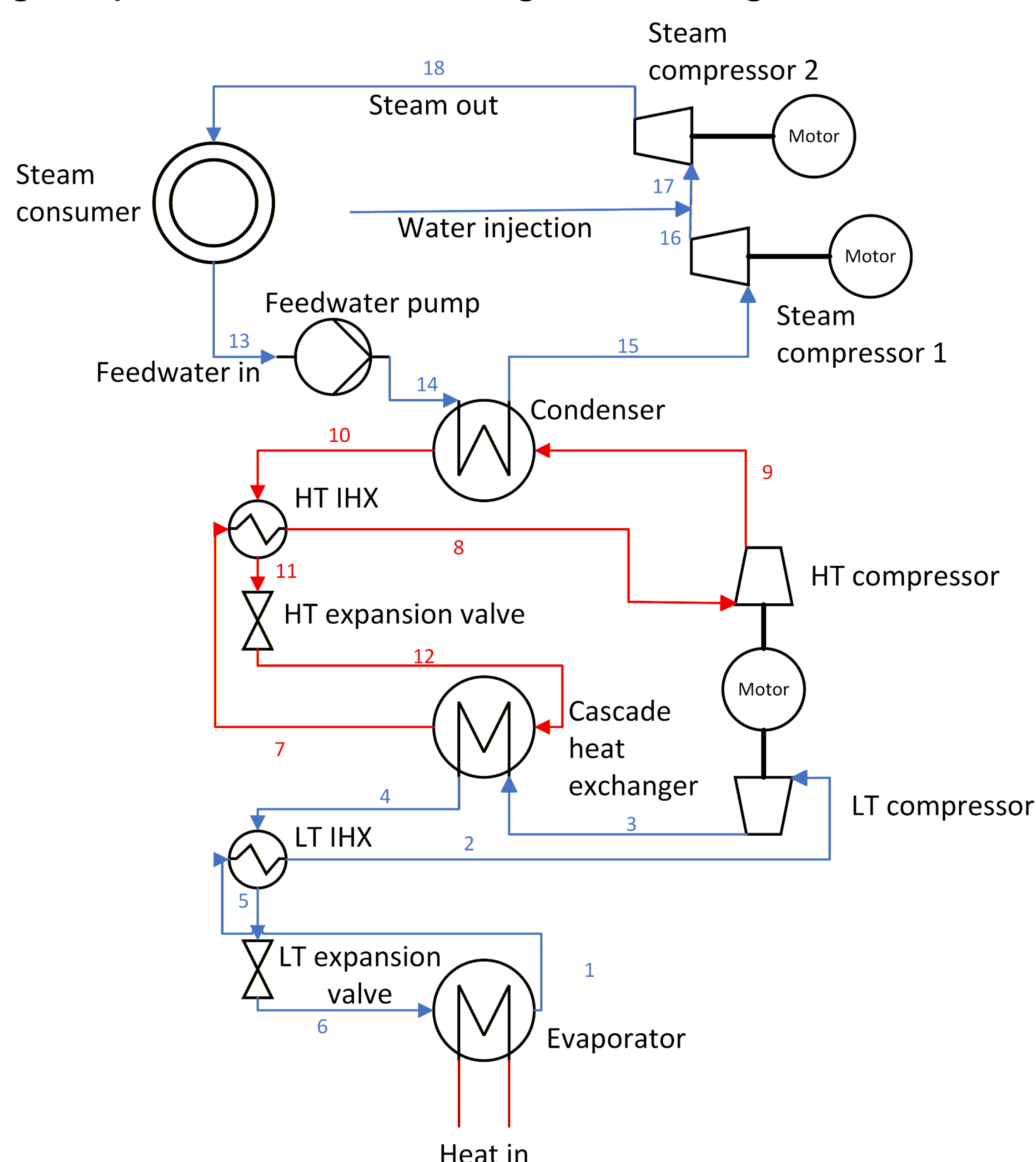


Figure 1. Configuration for the examined steam generating heat pump.

Methods

Investigated refrigerants are hydrocarbons: butane, isobutane, pentane, isopentane and cyclopentane. Temperature lifts vary between 50 °C to 110 °C, with condensation temperatures of 110-130 °C and evaporation temperatures of 20-60 °C. Steam outlet pressures (2.7 bar-7.9 bar) are determined by saturation temperatures (130-170 °C).

Results

Table 1 and Fig 2 present the preliminary results of the study. The biggest factors affecting the COP seem to be HTHP temperature lift and steam outlet pressure.

Table 1. Highest combined COP (HTHP and steam compression) for each refrigerant with different steam outlet pressures.

| Refrigerant | COP [-] ($p = 2.7$ bar) | COP [-] ($p = 3.6$ bar) | COP [-] ($p = 4.8$ bar) | COP [-] ($p = 6.2$ bar) | COP [-] ($p = 7.9$ bar) |
|--------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| R600 | 4.10 | 3.74 | 3.45 | 3.21 | 3.01 |
| R600a | 3.96 | 3.63 | 3.36 | 3.14 | 2.95 |
| R601 | 4.25 | 3.86 | 3.55 | 3.30 | 3.09 |
| R601a | 4.22 | 3.84 | 3.54 | 3.28 | 3.07 |
| Cyclopentane | 4.30 | 3.90 | 3.59 | 3.33 | 3.11 |

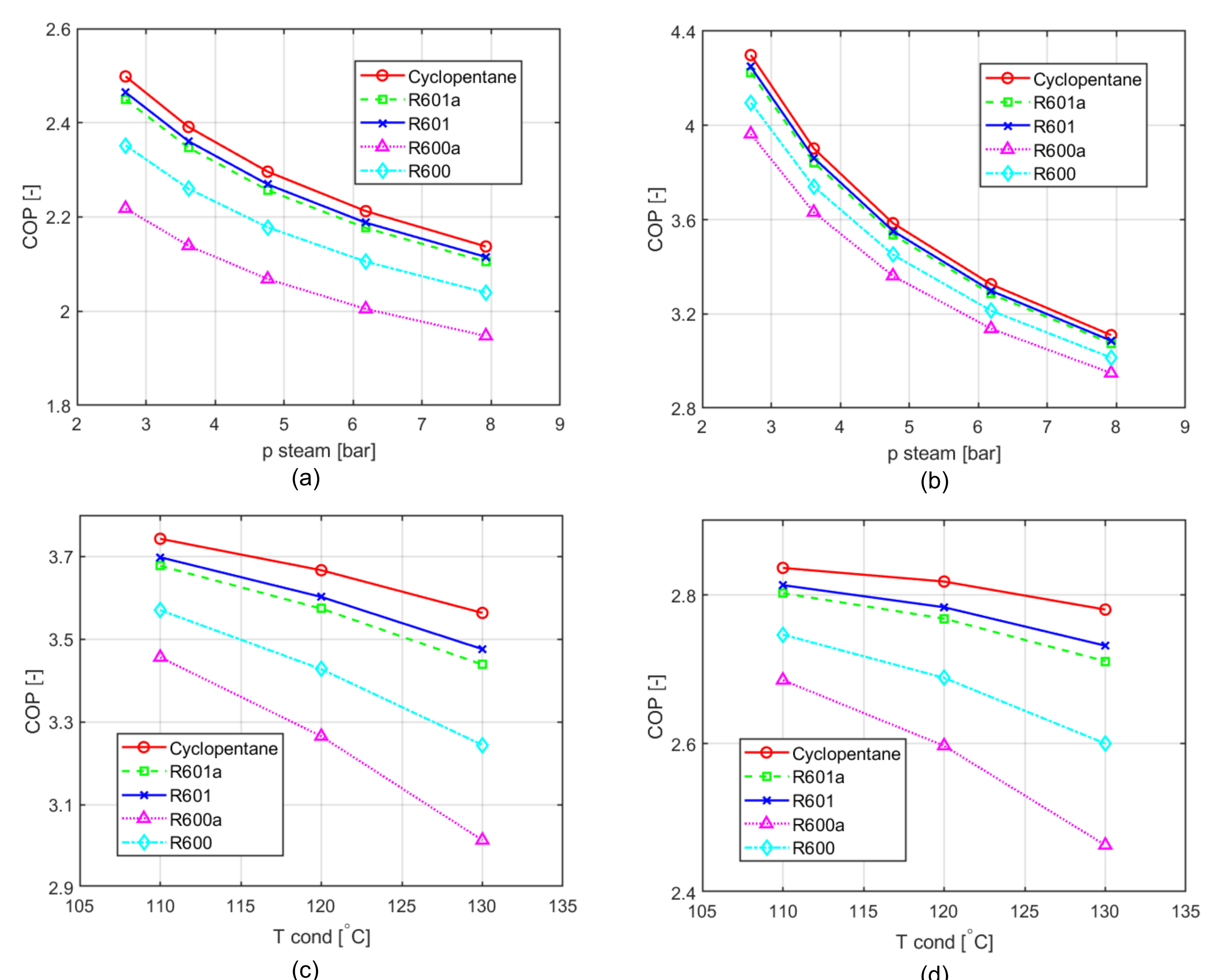


Figure 2. Overall COP as a function of condenser temperature with steam outlet pressure of 2.7 bar (a), with steam outlet pressure of 7.9 bar (b), overall COP as a function of steam outlet pressure with a heat pump temperature lift of 50 °C (c), and with a temperature lift of 110 °C (d).

Conclusion

The first results present cyclopentane as the most promising refrigerant, when comparing COP values.