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Performance Analysis of High Temperature Heat Pump Cycle for Industrial Process

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Abstract : High-temperature heat pumps (HTHP) that can supply heat at temperatures above 200°C can enhance the energy efficiency of industrial processes and reduce the CO_2 emissions connected with the heat supply of these processes. In the current work, the thermodynamic performance of 3 different vapor compression cycles, which use R-718 (water) as a working medium, have been evaluated by using a commercial process simulation tool (EBSILON Professional). All considered cycles use two-stage vapor compression with intercooling between stages. The main aim of the study is to compare different intercooling strategies and study possible heat recovery scenarios within the intercooling process. This comparison has been carried out by computing the coefficient of performance (COP), the heat supply temperature level, and the respective mass flow rate of water for all cycle architectures. With increasing temperature difference between the heat source and heat sink, ΔT, the COP values decreased as expected, and the highest COP value was found for the cycle configurations where both compressors have the same pressure ratio (PR). The investigation on the HTHP capacities with optimized PR and exergy analysis has also been carried out. The internal heat exchanger cycle with the inward direction of secondary flow (IHX-in) showed a higher temperature level and exergy efficiency compared to other cycles. Moreover, the available operating range was estimated by considering mechanical limitations.

Keywords : high temperature heat pump, industrial process, vapor compression cycle, R-718 (water), thermodynamic analysis
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