The Misselhorn cycle: Batch-evaporation process for efficient low temperature waste heat recovery

Abstract:
The concept of the Misselhorn-cycle is introduced as a power cycle that aims for efficient waste heat recovery of temperature sources below 100 °C. The basic idea shows advantages over a standard Organic Rankine Cycle (ORC) in overall efficiency and utilization of the heat source. The main characteristic of this cycle is the use of at least three parallel batch evaporators instead of continuous heat exchangers. The operational phases of the evaporators are shifted so that there is always one vaporizer in discharge mode. In an isochoric batch-evaporation, the pressure and the corresponding boiling temperature rise over time. With a gradually increasing boiling temperature no pinch point limitation occurs. Furthermore, the heat source medium is passed through the evaporators in serial order to obtain a quasi-counter flow setup. These features offer the possibility to gain both high thermal efficiencies and an enhanced utilization of the heat source at the same time. A transient Matlab model is used to simulate the achievable performance of the Misselhorn Cycle. The calculations of the thermodynamic states of the system are based on the heat flux, the equations for energy conservation and the REFPROP [1]
equations of state. A basic model with a fixed heat transfer coefficient promises a possible system exergy efficiency of 42.8%, which is an increase of over 50% compared to a basic ORC with a system exergy efficiency of only 27.4%. In addition to this purely thermodynamic evaluation of the process, a more detailed shell-and-tube model was developed. This advanced model includes heat transfer calculations based on the fluid flow and the shell-side liquid level. A finite differencing method is implemented to solve the partial differential equations of state and 1-D flow in the tubes. Early results of the detailed model also show a significant improvement over a common ORC.

Stichworte: Waste heat recovery, Low temperature, Batch evaporation, Transient simulation

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