SIMULTANEOUS WORKING MEDIUM SELECTION, PROCESS AND CONTROL SYSTEM DESIGN FOR ORGANIC RANKINE CYCLES

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ABSTRACT

The present work addresses the integrated ORC process design and control for a set of potentially promising working media under a unified framework. The proposed work aims to investigate the optimal combination of the working mixture with the ORC configuration that satisfy an economic criterion under steady-state and closed loop conditions. Therefore, for a selected working mixture the steady-state design of the ORC is performed based on economic optimization, where the optimal configuration and sizing of the equipment is obtained. In addition, a set of disturbance scenarios is constructed that are representative of the most commonly occurring operating conditions for the process. A model predictive control (MPC) scheme is employed for the satisfaction of the process goals under process variability and disturbance influence. The use of a MPC enables the best handling of the interactions among the various processes in the cyclic process. The integrated design framework enables the determination of the most suitable input-output structure for the controller by allowing the selection of the controlled and manipulated variables from a pool of screened options. The performance of the MPC under the specified disturbance scenarios is calculated through dynamic simulations for the selected working medium and process flowsheet configuration, in each optimization iteration. The dynamic performance is converted to an economic equivalent term so that it can be combined with the steady-state design economic term to generate the overall objective function value.

Novel and conventional hydrocarbon- and halogenated hydrocarbon-based mixtures are considered for the integrated ORC process and control system design under the proposed unified framework. Variation in the hot and cold source streams is considered in the system where the employed MPC aims to maintain the evaporator temperature at the desired level and achieve the maximum work in the expander. The simultaneous problem of working mixture selection and process design under static and closed loop conditions is solved using a stochastic optimization technique. The results provide significant insights in the behavior of the ORC system under closed loop conditions. The ability of the ORC system with the MPC to maintain a high performance under variability is found to be influenced by the sensitivity of the working medium physical properties within the range of variation that is transferred through the system.