INTEGRATING WORKING FLUID DESIGN INTO DYNAMIC ORC PROCESS DESIGN FOR MOBILE ORC APPLICATIONS

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ABSTRACT

Organic Rankine Cycles (ORC) generate power from low temperature heat sources. To maximize the generated power, both the ORC working fluid and process have to be tailored to the specific application. The resulting integrated design problem for ORC working fluid and process has been studied intensively for steady-state applications [1,2]. However, recently, ORCs are increasingly used in applications with transient conditions such as exhaust gas waste-heat recovery on heavy-duty vehicles [3]. For such transient applications, steady-state design approaches can result in suboptimal solutions due to the neglect of the dynamic process behavior.

In this work, we integrate working fluid design into ORC process design while considering the dynamic process behavior in transient applications. The resulting integrated design approach is based on the Continuous-Molecular Targeting−Computer-aided Molecular Design (CoMT-CAMD) framework [2,4]. Herein, the physically-based Perturbed-Chain Statistical Associating Fluid Theory (PC-SAFT) [5] is used to calculate the thermodynamic properties of the working fluid. In PC-SAFT, a working fluid is characterized by pure component parameters, which are directly considered as degree of freedom during process optimization in CoMT-CAMD. So far, CoMT-CAMD has been limited to one steady-state design point. To consider transient applications, dynamic models for the ORC equipment are integrated into the CoMT-CAMD formulation resulting in a dynamic mixed-integer optimal control problem. For a given transient input, the resulting dynamic CoMT-CAMD approach provides the optimal working fluid and the corresponding optimal design and control of the ORC process.

The resulting dynamic CoMT-CAMD approach is applied to tailor an ORC for waste-heat recovery on a heavy-duty vehicle. Dynamic CoMT-CAMD reliably identifies the optimal working fluid jointly with the optimally controlled ORC process that best exploit the transient exhaust gas of heavy-duty vehicles.

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References

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