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Title

Characterisation of thermal management specific heat rejection for electric propulsion architectures

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Abstract

To limit the climate impact of aviation, electrified aircraft propulsion concepts are investigated. Such electrified propulsion architectures introduce new components to the propulsion system which reject heat. In the absence of conventional heat sinks such as kerosene and the engine bypass flow, the introduction of an actively managed Thermal Management System (TMS) imposes further challenges as the TMS leads to additional mass, power and drag penalties within the overall aircraft design process.

To account for the TMS mass penalty within the design process, the rejected heat managed by the TMS is correlated to the TMS mass. This introduces the specific heat rejection as a characterising parameter. For several studies, such values have been derived as a result based on detailed described thermal management system architectures. However, the stated specific heat rejection parameter values are not necessarily transferable between different propulsion architectures as different electrical components require different TMS solutions due to their individual operating conditions such as heat flows and temperatures. Additionally, there remain deviations in the modelling assumptions of TMS components within literature. This complicates comparability of the available specific heat rejection parameters across different propulsion architectures and sizes.

The presented investigation addresses a study across a variety of TMS sizing relevant input parameters to establish correlations to characterise the TMS specific heat rejection. The assessed TMS architecture considers a liquid cooled TMS with subsequent heat rejection to ambient air. Key TMS components are identified with models for the individual TMS mass contributors taken either from literature or derived analytically. Initially, the TMS component models will cover the effects of coolant, heat exchanger, coolant pump, pipes and compressor for air supply if applicable. The variation parameters include the rejected heat flow, the coolant fluid type and associated specific heat capacity, the temperature differences for heat pickup of the coolant as well as the temperature difference between coolant and air for the heat exchanger, and potential pipe lengths.

For the assessed TMS architecture, input parameter ranges are defined to reflect typical electrified propulsion architectures and aviation application requirements. This feeds into a multi-dimensional parameter variation to characterise the specific heat rejection for a range of different systems while also establishing the robustness of the specific heat rejection based on the input assumptions. The assessment enables comparisons of the achievable specific heat rejection across different propulsion architectures and components. This enables preliminary design calculations to consider TMS mass penalties with increased accuracy while offering a significant reduction in the modelling effort by the derived correlations.