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Conceptual Design, Optimisation and Qualification of Highly Efficient Brazed Plates and Fins Heat Exchangers for Heat Removal sCO₂ Brayton Cycle to Increase the Safety of Nuclear Power Plants

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The sCO₂-4-NPP european project aims to develop an innovative technology based on supercritical CO₂ (sCO₂) for heat removal to improve the safety of current and future nuclear power plants. The heat removal from the reactor core will be achieved with multiple highly compact self-propellant, self-launching, and self sustaining cooling system modules, powered by a sCO₂ Brayton cycle.

Heat exchangers are one of the key components required for advanced Brayton cycles using supercritical CO₂. To this end, two compact and highly efficient brazed plates and fins heat exchangers are designed :

- a main heat recovery heat exchanger (CHX), which allows the heat transfer directly from the steam generator to the sCO₂-4-NPP cycle,
- a heat sink exchanger (DUHS), which evacuate the remaining heat to the atmosphere.

An important work has been achieved in the frame of this project to conceive the preliminary design of these components, in close collaboration between Fives Cryo, a French brazed plates and fins heat exchangers manufacturer, the Institut für Kernenergetik und Energiesysteme (IKE) of University of Stuttgart and KSG/GfS Institute, a simulator center, both in Germany.

In fact, several constraints needed to be taken into account, mainly for CHX, the small size of available space in the reactor building to install the heat exchanger and the very high pinch between steam and sCO₂ which is responsible for thermal and mechanical stress inside the matrix. For DUHS, the low fans power available for the cycle and the necessary air flow for efficient heat exchange implies considering almost inexistent pressure drops on the air side.

To this end, several fins geometries and new design ideas has been adressed to meet the desired thermal duty.

Also, this project benefits from the recent results achieved among the european project sCO₂-flex, related to the mechanical resistance of heat exchanger components, the assembly process and their thermal and hydraulic performances, along with Fives Cryo expertise and background. Both design configurations for CHX and DUHS are submitted to off-design cases to simulate their operation under different weather configurations and during start-ups, leading to cover a wide performance map.

A second challenge of the sCO₂-4-NPP project is to qualify the designed plates and fins heat exchangers mechanical resistance, at cycle operating conditions, in order to meet with pressure vessels codes and regulations according to nuclear requirements.

Heat Transfer 1990 Abstracts

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