

# **Numerical modeling and design of supercritical CO<sub>2</sub> pre-cooler for fusion nuclear reactors**

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## **Abstract-**

One of the key issues of fusion technology is the efficient recovery of the fusion power extracted by heat transfer fluids in the breeding blanket. The Spanish National Program TECNO FUS is exploring a dual-coolant breeding blanket design concept and its plant auxiliary systems for a future power reactor (DEMO), with liquid lead&ndash;lithium as main primary nuclear power recovering fluid. Supercritical CO<sub>2</sub> is chosen for the secondary circuit, since its high efficiency at significantly lower required temperatures than for the Brayton helium cycle, due to low compression work near the critical point and also because its additional major benefits in terms of tritium control. Use of printed circuit heat exchangers (PCHE) is suggested in literature due to its highly compact design and robustness for the high pressures found. This work deals with the heat exchanger devoted to release the thermal energy of the power cycle to the thermal sink. The aim of this work is analyzing how the nearness of the CO<sub>2</sub> to its critical point affects the performance of the heat exchanger. Computer Fluid Dynamics (CFD) simulations that include the complex thermal behavior of CO<sub>2</sub> properties at supercritical conditions are used in order to achieve an accurate approach to the design of this heat exchanger. These results are compared with others obtained through correlations found in the open literature. The behavior of CO<sub>2</sub> close to its critical point results in an inefficient use of the exchange area, giving a temperature profile in CO<sub>2</sub> which remembers a condensation process and an overall heat transfer coefficient 1.4 times higher than the one achieved with literature correlations design.

**Index Terms-** Feher cycle, PCHE, supercritical CO<sub>2</sub>

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