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Parametric analysis of pressure drop and heat transfer in the meander-flow heat exchanger of HTS current leads for fusion applications

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The Karlsruhe Institute of Technology is responsible for the design, construction and testing of the high temperature superconductor (HTS) current leads (CL) for the stellarator Wendelstein 7-X and for the tokamak JT-60SA. The HTS CL consists basically of an HTS module, carrying the current in the temperature range from 4.5 K to 60 K in series with a Cu bar provided with transverse circular fins, working as a heat exchanger (HX), covering the range from 60 K to 300 K. The HTS module is cooled by heat conduction, whereas the Cu bar and the fins are actively cooled by helium. The HX is of the meander-flow type. Helium flows between the fins and is forced to a cross flow with respect to the central bar. An important issue in the operation of the HTS CL is the optimization of the cooling power consumption, i.e. the minimization of the helium mass flow rate inside the HX that allows a stable operation in steady state conditions. For this purpose, the knowledge of the helium thermal-hydraulics in such meander geometry becomes rather important.
In this paper the procedure introduced and validated in [1-2] is extended to a systematic computational fluid dynamics (CFD) analysis of the helium thermal-fluid dynamics inside this kind of HX. The aim is to obtain a complete picture of the flow regime in a wide range of operative conditions and the dependence of pressure drop and heat transfer on the geometrical parameters of the HX.
In the paper it is shown that the He flow inside the HX changes from laminar to turbulent and that the variation of geometrical parameters affects differently the pressure drop and the heat transfer process inside the HX.

[1] L. Savoldi Richard et al., IEEE Trans. on Appl. Supercond., Vol. 20, No. 3 (2010), pp.1733-1736
[2] E. Rizzo et al., presented at SOFT-21, Porto, PT, accepted for publication in Fus. Eng. Des.

Author: Mr RIZZO, Enrico (Karlsruhe Institute of Technology)

Co-authors: Dr SAVOLDI RICHARD, Laura (Politecnico di Torino); Dr HELLER, Reinhard (Karlsruhe Institute of Technology); Prof. ZANINO, Roberto (Politecnico di Torino)

Presenter: Mr RIZZO, Enrico (Karlsruhe Institute of Technology)

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