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Flow Characteristics in HyperVapotron Elements Operating with Nanofluids

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HyperVapotrons (HVs) are highly robust and efficient heat exchangers able to transfer high heat fluxes of the order of 10-20MW/m2. They employ the Vapotron effect, a complex two phase heat transfer mechanism, which is strongly linked to the hydrodynamic structures present in the coolant flow inside the devices. HVs are currently used in the Joined European Torus (JET) and the Mega Amp Spherical Tokamak (MAST) fusion experiments and are planned to be used extensively in ITER. The efficiency of heat transfer and the reliability of the components of a fusion power plant are important factors to ensure its longevity and economical sustainability. Optimisation of the heat transfer performance of these devices by the use of nanofluids is investigated in this paper. Nanofluids are advanced two phase coolants that exhibit heat transfer augmentation phenomena. A cold isothermal nanofluid flow is established inside two HV models representing the geometries used at JET and MAST. A hybrid particle image velocimetry method is then employed to map in high spatial resolution (30μm) the flow fields inside each replica. The instantaneous and mean flow structures of a nanofluid are compared to those present during the use of a traditional coolant (water) in order to detect any departure from the hydrodynamic design operational regime of the device. It was discovered that the flow field of the JET model is considerably affected when using nanofluids, while the flow in the MAST geometry does not change significantly by the introduction of nanofluids. This signifies a possible presence of a viscosity change mechanism inside nanofluids that is dominant for the JET geometry and insignificant for the MAST geometry. The finding goes against Einstein's effective viscosity equation derived for spherical micron sized suspensions that is widely used in such applications.

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Author: Dr SERGIS, Antonis (Imperial College London, CCFE)

Co-authors: Prof. YANNIS, Hardalupas (Imperial College London); Dr BARRETT, Thomas (EURATOM/CCFE)

Presenter: Dr SERGIS, Antonis (Imperial College London, CCFE)

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