Seminar

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Institute for Plasma Research

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Title: Thermo-hydraulic performance characterization and development of straight and curved hydroformed panel experimental test set-up

Speaker: Dr. Manoj Kumar
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Date: 22nd May 2025 (Thursday)

Time: 11.00 AM

Venue: Seminar Hall, IPR

Online - Join the talk: https://meet.ipr.res.in/viewer/9758384204?be_auth=NTI5ODY1

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Abstract

The hydroformed panel is used as a plate-type heat exchanger (PPHE) characterized by its wavy profile, and parallel plates and fabricated using hydroformed technique. While adjustments to geometrical parameters have been extensively explored to improve the heat transfer performance of PPHEs, the design optimization, thermo-hydraulic features, and entropy generation of fluid flow especially at cryogenic temperature received limited attention. The designed hydroformed panel has been used in Tokamak, superconducting accelerators for its cryogenic shielding. These shields are strategically positioned between plasma containment (4 K) and ambient temperature to minimize the heat loads.

The design includes the development of a graphical user interface (GUI) for thermo-performance characterization followed by an artificial intelligence-based optimization of thermo-hydraulic parameters to obtain an optimal hydroformed panel geometrical configuration. The off-design performance mapping of the panel is also analysed. Based on the optimal geometrical specifications, a three-dimensional model of straight and curved panels has been developed in CATIA V 5®.

Finally, the commercial computational tool ANSYS CFX® has been used to simulate turbulent flow and heat transfer in inner channels of hydroformed panels using helium as a working fluid at various working pressures (4−16 bar) and cryogenic temperature (80 K) with a heat load of 1 kW uniformly distributed on the surface of the panel. A comparative thermo-hydraulic performance characterization between straight and curved panels is also investigated in detail. The local entropy generation caused by the thermal effects and friction is also computed. This study analyses how the geometrical parameters such as inflation height (δ), weld spot diameter (dsp), arrangement of spot welds (longitudinal (S_l) and transversal (S_t) pitch, and first weld spot distance from the edge (Ww) influence the thermo-hydraulic performance of the hydroformed panel in general, and overall entropy generation (losses) in particular. The results indicate that increasing the channel height increases thermal entropy generation. Furthermore, increasing the spot weld diameter leads to a higher frictional loss in the hydroformed channels, but the effect of spot weld size on thermal entropy generation is negligible. Also, the arrangement of spot welds significantly affects the thermal and hydraulic characteristics of the hydroformed panel. In addition, to ensuring an adequate level of operational safety, the regulatory standards require experimental proof of burst pressure as per ASME code B 31.3. This pressure is computed and verified with the regulatory standards.

The experimental test facility for straight and curved panel using liquid nitrogen (for curved panel) and gaseous nitrogen (for straight panel) is under developing phase.