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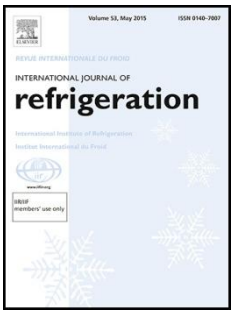

Title: Effect of rotation on the flow behaviour in a high-speed cryogenic microturbine used in helium applications

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EFFECT OF ROTATION ON THE FLOW BEHAVIOUR IN A HIGH-SPEED CRYOGENIC MICROTURBINE USED IN HELIUM APPLICATIONS

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Highlights

- Effects of rotation on the flow field in a cryogenic helium turbine are analysed.
- Study of vortex cores to understand the various loss generation mechanisms.
- Variations in the flow characteristics observed with change in rotational speeds.
- Balje's chart needs to be modified for the design of cryogenic helium turbines.

Abstract

The complex flow characteristics in a high-speed helium microturbine used in cryogenic refrigeration and liquefaction cycles are highly influenced by the effects of rotation. In order to enhance the turbine performance and to improve the preliminary design process of the turboexpander, the flow characteristics within the turbine blade passage needs investigation at different rotational speeds. Here, three-dimensional unsteady flow analysis of a high speed cryogenic microturbine used in helium applications was carried out using Ansys CFX®. The loss generated by the various secondary and vortical flows for the different cases were quantified in terms of entropy loss coefficient. The loss generating mechanism was also assessed by analysing the velocity vectors, entropy contours and the behaviour of the vortex cores. With change in speed the influence of scraping flow due to relative casing motion and the blade loading on the flow characteristics was found to vary significantly. At lower speeds, the scraping flow decreases and thus augments the tip leakage flow which in turn interacts with the suction side leg of the leading edge vortex to form a single large vortex. This combined vortex increases the velocity defect and thus leads to increased loss generation. The analysis of the vortex core velocity and the blade loading diagram revealed the need for modifications in blade profile for improved turbine performance. Furthermore, the comparison of the CFD results with the Balje's $n_s d_s$ chart showed remarkable variations, the results of which can be used to modify the chart for the design of efficient cryogenic microturbines for helium applications.

Keywords: Cryogenic turboexpander, microturbine, computational fluid dynamics, rotational effects, loss.