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Master Thesis Defense

Entitled

A PARAMETRIC NUMERICAL ANALYSIS INVESTIGATION TO OPTIMIZE THE PERFORMANCE OF THE RANQUE-HILSCH VORTEX TUBE

by

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Date & Venue

Wednesday, 26 April 2023

3:30-5:30 pm

F1-Room 1045 (ME meeting room)

Abstract

The vortex tube is widely used in various industrial applications for cooling and heating purposes, owing to its compact size, affordability, and safety. This study investigates multiple parameters' effects on a vortex tube's energy separation efficiency. The parameters examined in this study include internal tapering angles, length-to-diameter ratio, inlet pressure, and cold mass fraction. First, computational fluid dynamics (CFD) simulations are employed to investigate the Ranque-Hilsch vortex tube (RHVT) by utilizing the shear stress transport (SST) k- ω turbulence model with viscous heating to analyze the flow structure of the vortex tube. The results are validated by comparing them with the experimental data reported in the literature. Next, the energy separation performance of the vortex tube is analyzed by varying the internal tapering angles RHVT, including convergent angles (2°, 1.75°, 1.5°, 1.25°, 1°, 0.75°, and 0.5°), straight angles (0°), and divergent angles (0.5°, 1°, 2°, 4°, and 6°) while maintaining a constant cold mass fraction. Subsequently, the length-to-diameter ratio is examined for the optimal case to determine the highest energy separation. Then, input pressures under a constant cold mass fraction for the optimal length-to-diameter study are studied. Finally, the cold mass fraction study is performed for the optimal case. The results indicate that the optimal energy separation occurs at a convergent angle of 1.75°, a length-to-diameter ratio of 3, an inlet pressure of 6 bar, and a cold mass fraction of 0.56. The internal flow structure of the vortex tube is found to comprise a forced vortex, a transition region, and a free vortex, as shown in the static temperature radial distribution. The findings of this study provide valuable insights into optimizing vortex tube design parameters for efficient energy separation.