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CFD analysis of straight and flared vortex tube

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Vortex tube (VT) is a simple low refrigeration producing device having no moving part. However, the flow inside it is very complex. Recent studies show that the performance of VT improves with the increase in the divergence angle of a flared VT. To explore the temperature separation phenomenon in the VT, a three dimensional computational fluid dynamics (CFD) analysis of VT was carried out. For the present work, a VT having diameter of 12 mm, length of 120 mm, cold outlet diameter of 7 mm and hot outlet annulus of 0.4 mm with 6 straight rectangular nozzles having area of 0.5 sq. mm each is considered. The turbulence in the flow field of the VT is modeled by standard k-ε turbulence model with Redlich-Kwong real gas model. The effect of variation of divergence angle of hot tube in the VT is studied and compared with the experimental results available in the literature. The temperature separation between the hot outlet and cold outlet, in both straight and 2 degree divergent tube is studied. Analysis results indicate that for a hot mass fraction above 0.5, the divergent tube have better cold production capacity compared to the straight tube. Some parameters like temperature gradient, velocities (axial, radial and tangential), velocity gradients, effective thermal conductivity and viscosity of fluid etc., have been investigated for heat transfer and shear work transfer in the VT. To understand the temperature separation mechanism, heat transfer and work transfer along the axial direction have been evaluated in both straight and divergent tubes. The isentropic efficiency and COP as refrigerator as well as heat pump of straight tube and divergent tube have been computed.

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