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CFD study on the effects of viscous shear in a hot cascade Ranque-Hilsch vortex tube

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Ranque -Hilsch vortex tube is a device that is capable of splitting the highly compressed inlet gas into two streams of lower pressure gases, namely, central zone of cold fluid generated near the axis and peripheral zone of hot fluid around the inner wall of the tube. Though, vortex tube has many benefits over the conventional heating and cooling devices, low efficiency is the biggest drawback of it. Therefore, the method of hot cascading is an endeavor to make the use of the cold gas for cooling purposes while improving the heating capacity of the hot gas. Thus, the method of hot cascading enhances the overall efficiency of the whole system. The hot cascade vortex tube consists of two vortex tubes connected in series in such a way that, the hot gas emerging out of the first stage of vortex tube serves as the inlet fluid for the second stage vortex tube.

This paper presents two predominant parameters which are utmost concern in the process of thermal separation, namely heat transfer and work transfer due to viscous shear along the radial, axial and tangential directions per unit length are studied. The Computational Fluid Dynamics (CFD) study has been carried out using RANS standard k-epsilon turbulence model with a two dimensional axi-symmetric structure mesh geometrical domain and air as working fluid. The CFD results reveal that the work transfer due to the action of viscous shear along the tangential direction increases considerably with hot cascading. However, the work transfer due to viscous shear along the axial direction degrades the performance of the device, as the heat transfer takes place from cold zone to the hot zone. The effect of radial shear stress is negligible due to low value of radial velocity gradient.

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