An Investigation on the Effect of the Hot End Plugs on the Efficiency of the Ranque-Hilsch Vortex Tube

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Abstract

The phenomenon of temperature distribution in confined steady rotating gas flows is called as Ranque-Hilsch effect. The simple counter-flow vortex tube consists of a long hollow cylinder with tangential nozzles at one end for injecting compressed air. Rotating air escapes the tube through two different outlets—a central orifice diaphragm placed near the inlet (cold end) and a ring shaped peripheral outlet at the opposite end of the tube (hot end).

Figure: Vortex tube and air flow in the vortex

This work focuses on the influence of the dimension of the plugs placed at the hot end of the vortex tube. To ignore the influence of the shape of hot-end plugs, all the plugs used in the tests have similar shapes, but differ in diameter. In some works, plugs were replaced by conical valves to control the cold mass fraction, as in the Gao's [1] and Pongjet's [2]. Thus, the shape of the conical valve at the hot nozzle changed when it was moved to adjust the balance of the mass flow rate. In this experiment, plugs with different diameters are used where shape and all other parameters of the tube are kept the same, and the efficiencies of the vortex tube are calculated according to the different sizes of those plugs.

Another aspect of this work is investigation of the extreme condition where a large plug with the same diameter as the vortex tube is used to block the hot end of the tube. Temperature and pressure are measured and the efficiency of this extreme situation is calculated. This is the first research of the vortex tube efficiency with the hot end of the tube blocked.

The purpose of this experiment is to find the relationship between the hot-end plug diameter and the efficiency of the vortex tube system. It is clear that the size of plug determine the cold mass fraction, which results in different efficiencies, and the high performance occurs when the area ratio is between 0.9 and 0.98. Highest efficiency occurs at the area ratio of 0.96 where the cold mass fraction is 0.76. Because of the extremely condition that big plug is used to block the hot nozzle, the secondary circulation model can not be used for this test and the heat generation in the tube caused by the vortex flow still can be found.

REFERENCES

1. Promvong P., Eiamsa-ard S. Investigation on the vortex thermal separation in a vortex tube refrigerator. *Science Asia*, 2005;**31**:215-223
2. Gao CM, Bosschaart KJ, Zeegers JCH, de Waele A.T.A.M. Experimental study on a simple Ranque-Hilsch vortex tube. *Cryogenics*, 2005;**45**(3):173