Energy Separation Mechanism in Unconfined Laminar Compressible Vortex

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ABSTRACT

A theoretical investigation from the view point of gas-dynamics and thermodynamics was carried out, in order to clarify the energy separation mechanism in an unconfined laminar compressible vortex, as a primary flow element of a vortex tube. The mathematical solutions of density and temperature in a viscous compressible vortical flow, with tangential velocity, were examined using an evaluation equation of total temperature. It is found from the results that a hotter gas in the peripheral region of the vortex is mainly generated by heat caused by viscous dissipation. A colder gas in the vortex center is mainly generated by viscous shear work done by the fluid element onto the surface of the surrounding gas. In addition, it is also found that the larger the representative Mach number of a vortex is, the lower the total temperature at the center of the vortex is, and at the same time, the higher the maximum total temperature in the peripheral region is. The increase in specific heat ratio of the working gas has the same effect, as increasing the representative Mach number of the vortex, on the total temperature in the vortex.

KEYWORDS: Energy separation mechanism; Theoretical analysis; Vortex tube; Vortical flow

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