化工学报 2007 58 (03): 596-601 ISSN: 0438-1157 CN: 11-1946/TQ

传递现象

# 基于涡流管能量分离效应的数值模拟

周少伟[1];姜任秋;王朋涛;宋福元;张鹏; 陈跃进; 高超

哈尔滨工程大学动力与能源工程学院

收稿日期 2006-4-10 修回日期 2006-8-17 网络版发布日期 2007-4-2 接受日期

摘要 获得涡流管内的温度场分布是揭示涡流管内气体能量分离机制的首要问题和关键问题。考虑到管内气体运动的强旋流特性，采用计算流体力学(CFD)中的Realizable湍流模型对涡流管内三维可压缩强旋流气体所产生的能量分离效应进行了数值模拟，获得了相应的总温、静温与动温沿轴向、径向的分布。由于涡流管中的零轴速包络面是内外旋气流的分界面，依据数值模拟结果，分别得到了涡流管中内外旋气流的混合平均动能和混合平均滞止焓沿其出口方向的变化曲线。为了验证数值模拟结果的准确性，将冷端气流温降随冷气流率的变化关系与实验值相比较，二者吻合较好。同时采用无量纲的分析方法将数值结果与前人的实测结果加以比较，进一步验证了模拟结果的准确性。

关键词 涡流管；能量分离；数值模拟；温度场；动能；滞止焓；量纲1分析

分类号

# Numerical simulation of energy separation effect inside vortex tube

**Abstract**

Acquisition of the temperature distributions inside the vortex tube is a principal and key problem for disclosing the fundamental mechanism underlying the energy separation effect inside the tube.The “Realizable κ-ε”turbulence model of computational fluid dynamics (CFD) was used to simulate the energy separation effect produced by three-dimensional compressible flow with strong swirl inside the vortex tube.Then the axial and radial distributions of total and static temperature were obtained.The mean kinetic energies and the stagnation enthalpies of the peripheral and inner flows per unit mass along the airflow direction were also examined respectively because the enveloping surface of zero axial velocity is the interface between peripheral and inner airflows.In order to validate the numerical results, comparisons between the numerical predictions and the experimental results were conducted for the cold air temperature drops as a function of cold fraction, and satisfactory agreements were observed.A non-dimensional strategy was adopted to compare total, static temperature distributions along the radial direction at a given axial location with the experimental data from previous studies, so the accuracy of the numerical results was further validated.

**Key words** vortex tube；energy separation；numerical simulation；temperature distribution；kinetic energy；stagnation enthalpy；non-dimensional analysis

DOI:



通讯作者 周少伟 hrbgczsw@163.com