INTRODUCTION TO HEAT TRANSFER RESEARCH GROUP (Niigata University, Japan)

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DNS OF TURBULENT HEAT TRANSFER Topics on turbulent flows and heat transfer are studied through large-scale computation for fundamental systems in order to carve essence from complex physics.

So far, challenge was made for solving directly the basic equations for heated jet, turbulent heat transfer over a ribbed wall and spatially developing turbulent heat transfer in a curved channel. The situations, formerly studied, can be categorized into classic problems, but our direct numerical simulation enlightened unexplored structures:

(1) Inverse energy cascade near convex wall due to continuous growth of micro-scale structures to organized wave (see Fig. 1);
(2) Washing action of spanwise vortex causing dissimilarity between momentum and heat transport;
(3) Three-dimensional hairpin-shape vortex in established stage of developing jet (see Fig. 2).

Papers were published in international journals including "International Journal of Heat and Mass Transfer" and "International Journal of Heat and Fluid Flow" and domestic journals for mechanical engineers. Presentation has been made in symposia such as "Turbulence and Shear Flow Phenomena" and "international symposium on Heat and Mass Transfer".

SIMULAITON OF COMBUSTION AND PARTICLE-LADEN TURBULENCE Our major concern is to reveal fundamental physics of turbulent transport. However, recently, we make the effort to advance into development of practical scheme for simulating spray combustion. The basic scheme of our computation is based on traditional RANS (Reynolds averaged NS eq.) simulation but combined with PDF (probability density function) approach for temperature and chemical compositions. In this type of simulation, the local non-uniformity of chemical species can be resolved through Lagrangian simulation of fluid particles. Therefore, closure problem does not occur in computing chemical reaction term under influence of fluctuating concentration, which results in great benefit for simulation of combustion flows. Outline of numerical simulation has been already composed, and some trial numerical codes were successfully made to reproduce the spray combustion in an expanded furnace as displayed in Fig. 4. We continue efforts to complete the numerical code through 2008 and 2009.

This kind of study aims to build basic skeleton of pragmatic scheme. But, we noticed some inconsistency in use of PDF approach for two phase flow including gas and oil droplets. Therefore, we are going to start construct the PDF method consistently applicable to particle-laden turbulent flow as a fundamental research topic by means of direct numerical simulation of turbulence contaminated by solid particles.

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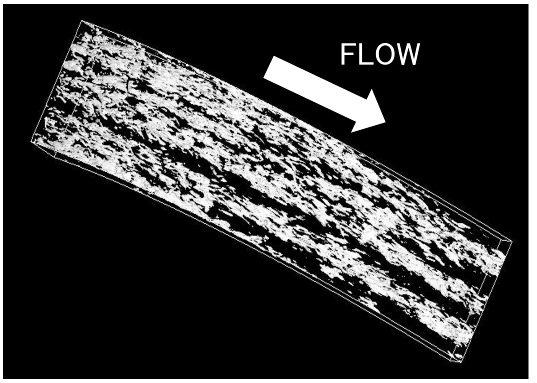

Fig. 1 Visualization of vortex (white blob) in curved channel by spatially advancing DNS

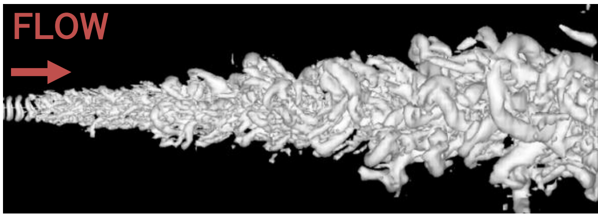

Fig. 2 Visualization of ring-shape vortex and hairpin-shape vortex in the developing jet by DNS

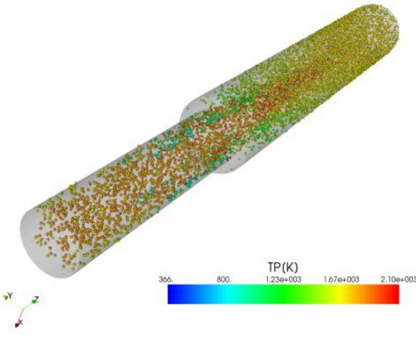

Fig. 3 Temperature distribution of spray combustion in expanded furnace by RANS simulation combined with PDF approach

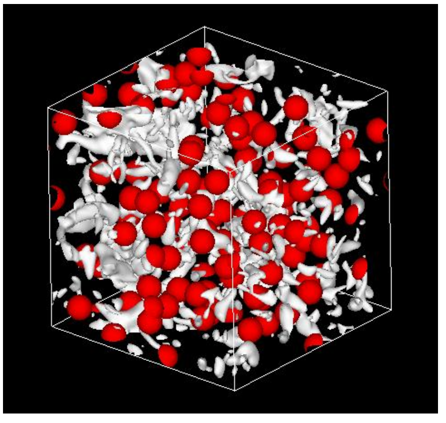

Fig. 4 DNS of particle-laden homogeneous turbulent flow