Visualization of natural convective flows with a lagrangian technique

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The mixing properties of the flow of a fluid moving by natural convection inside a cubic container can be visualized with a Lagrangian technique. The natural convective motion is produced by maintaining the temperatures of two opposite vertical walls of the container at constant but different values; all other sides are considered thermally insulated. The wall temperatures oscillate as functions of time with a non zero relative phase. Due to the combined effect of time-dependent temperature difference and gravity acceleration, vortices are generated at different times and in different zones of the container. Under appropriate circumstances, the vortices may lead to mixing. In order to investigate quantitatively the effeciency of mixing in this flow, the mass, momentum and energy conservation equations were solved numerically together with the appropiate boundary conditions. Flow visualization is acomplished using Lagrangian surface tracking (LST) which is a direct generalization of a particle tracking. In LST, a set of points is distributed on a surface at the onset of the convective motion. In the particular example presented here, the we defined a set of 180×180 points distributed uniformly on the surface of a sphere of a diameter equal to 3/4 of the side of the cubical container. The position of the set of points at subsequent times is defined by the respective path lines resulting in the deformation of the surface. The geometrical properties of the surface contains information about dynamics of the flow; in particular, it is possible to identify zones where flow stretching and foldings occur. In Fig. 1, we present the deformed surface after four cycles of the wall temperature oscillations. The rigth hand side vertical wall is heated and the left hand side is cooled. The vertical boundary layers generate stretching while the the horizontal walls force the flow to bend. Calculations and visualizations were made in an Origin 2000 and in an Onix computer respectively.

Acknowledgments

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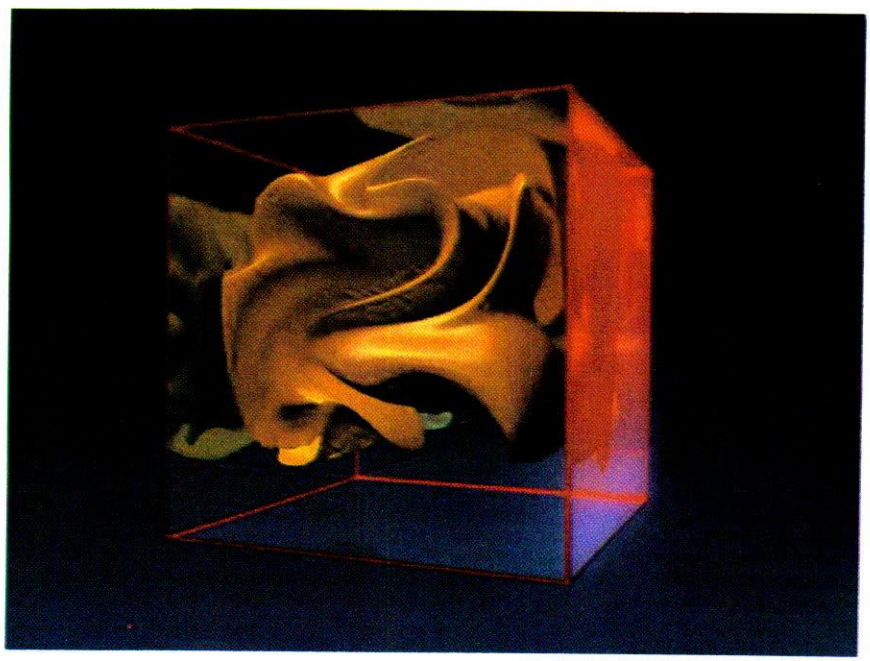

FIGURE 1. Visualizations of natural convective flows with a lagrangian technique. In yellow is the deformed surface after four cycles of the wall temperature oscillations.