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A topology optimization method for a flow field using the lattice Boltzmann method considering wall boundary conditions

Kazuo Yonekura [1], and Yoshihiro Kanno [2]

[1] IHI Corporation, Japan
[2] The University of Tokyo, Japan

Abstract

We formulate a topology optimization method for a flow field considering wall boundary conditions. The Reynolds number of the flow is about 1000 which is relatively high compared with those of existing researches. The optimization method is based on the sensitivity analysis. We define the sensitivity using transient information of a flow field. By using the transient information instead of fully converged flow information, we can reduce computation time. In addition, the sensitivity is formulated considering the wall boundary conditions. In order to define the location of the boundary, we use a level-set function that distinguishes the fluid region from the solid region. Then, the boundary between fluid and solid region is defined using the level-set function.

We solve the flow field using the lattice Boltzmann method (LBM). As a LBM model, we use a three-dimensional model with multiple-relaxation time scheme, which is stable for flow fields at moderate Reynolds number. As a wall boundary condition, we use the bounce-back conditions. If we use the bounce-back conditions, the boundary locates at the midpoint of adjacent fluid and solid grids. We appropriately consider the location, and formulate a differential operator which is suitable for the optimization method.

In the presentation, we show numerical examples. The computation time is sufficiently short in the application point of view. We also compare the optimization result using naive differential operator and our differential operator.