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Two-Phase Adiabatic Flow Analysis using Semi-Lagrange Galerkin Method

Kohei FUKUYAMA[1]

[1]Department of Civil Engineering, Chuo University
1-13-27, Kasuga, Bunkyo-ku, Tokyo, JAPAN

*Corresponding author: kouhei@civil.chuo-u.ac.jp

The adiabatic flows mean the compressible flows assuming adiabatic state in the present study. In actual natural phenomena, almost flows are compressible flows. However, actually, the incompressibility assumption is often used to analyze compressible flows. Numerical results by the analysis assuming incompressible flows are almost the same as those of compressible flows, especially at low velocity flows. However, analysis of the compressible flows must be conducted depending on whether velocity is high or not. The numerical results of adiabatic flows are almost the same as those of compressible flows in case of moderate velocity flows.

In the governing equation of the flow problems, the advection term and the diffusion term are included. In case of either term is superior, the characteristic of flows are different. If the advection term is superior, the computation has an inclination to be unstable. Therefore, depending on the characteristic of flows, the suitable appropriate technique is required. For preventing this instability, the characteristic method is used in this study. The terms of temporal differentiation and advection are expressed in the form of material differentiation and transformed by the characteristic method. In addition, the advection calculation is forwarded by the non-advection calculation. After calculation of the advection term by the semi-Lagrange method, the non-advection term is calculated by the implicit method. This technique is called the semi-Lagragian Galerkin method. In the advection and non-advection calculation, the Hermite interpolation function is used for velocity and density. The Hermite interpolation function is composed of 10 degrees of freedom, i.e., function values at the three nodes, values of the first derivative, and a function value at the center of gravity. Therefore, the Hermite interpolation function is the complete third order polynomial interpolation function on the triangular element.

In this study, the purpose is an analysis of the two-phase flow. The two-phase flow means the fluids which have two different field different densities at each field. A surface tension which acts on a boundary of two fluid fields is an important factor. The surface which divides the two-phase flow is expressed by the B-spline interpolation. In addition, for calculating the high precision values at the surface point, the re-meshing is employed.

As a numerical study, a fluid having high density is set at the center of a fluid field is analyzed. The surface which divides into two fluids has the surface tension. As the first example of numerical analysis, the two-phase flow is analyzed using the semi-Lagrange Galerkin method with low density difference. As the second example, the two-phase flow is analyzed with high density difference.

Keywords: finite element method, adiabatic flows, semi-Lagrange Galerkin method, two-phase flow, Hermite interpolation function, characteristic method