Numerical Simulation of Interaction of Largely Deformed Membrane and Fluid

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Numerical simulations of deformable structures in viscous flows often encounter numerical instability, which arises from incompatibility of boundary conditions on a fluid-structure interface. In this work, we develop the efficient numerical procedure for interaction problems of largely deformed membrane and fluid based on the conserving time integrator. In the present procedure, a finite difference method with overlapped grids is employed to solve a fluid problem accurately. To approximate large deformation of membrane, the B-splines Galerkin method is employed together with the energy-momentum method for the temporal discretization. The B-splines Galerkin method gives us smooth finite difference grids around the membrane, which improve accuracy and numerical stability.

1. Introduction

In this paper, a numerical procedure for interaction problem of largely deformed membrane and fluid is proposed. Numerical simulations of deformable structures in viscous flows often encounter numerical instability, which arises from incompatibility of boundary conditions on a fluid-structure interface. In this work, two aspects of compatibility condition including the balance of energy on the fluid-structure interface and the coupling algorithm are discussed and measures to improve attainment of them in numerical procedures are proposed.

2. Numerical procedure

To solve a fluid problem accurately, a finite difference method with overlapped meshes is employed in this work. For a membrane, the energy-momentum method that ensures the conservation of energy and unconditional numerical stability is applied to the temporal discretization. To approximate large deformation of membrane, a quadratic B-spline Galerkin approximation is employed instead of a linear finite element method used in our previous work.(1) By using the B-spline approximation, smooth grids for the fluid problem , which improves accuracy and numerical stability, can be generated around the membrane. Numerical solutions of these two subsystems are coupled by the block Gauss-Seidel method which is a simple iterative partitioned algorithm to attain the strong coupling solution.

3. Numerical results

The problem of three dimensional flow past an elastic membrane corresponding to the experiments in the literature(2) is computed with the proposed numerical procedure. The problem set up is shown in Fig. 1.

Figure 2 indicates deformed shapes of the membrane obtained by two dimensional flow calculation with the inflow velocity of 13m/s.

Numerical results indicate validity and capability of the proposed procedure.

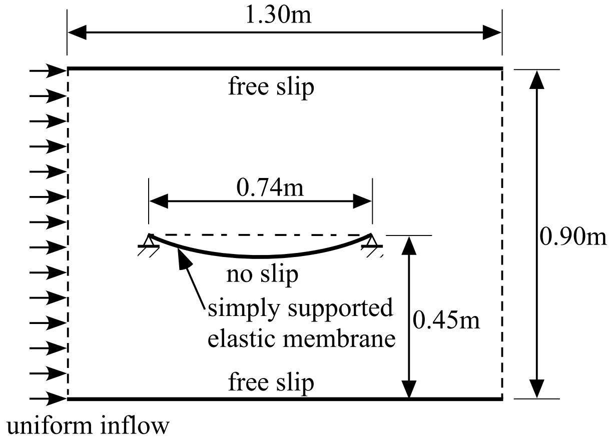

Fig. 1 Definition of problem.

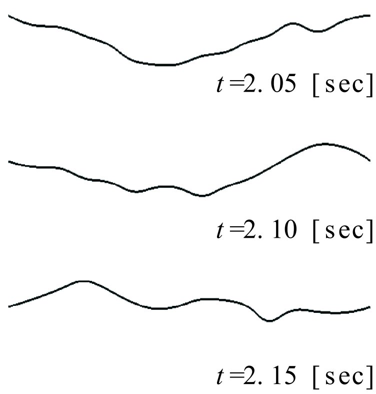

Fig.2 Deformed shapes of membrane(2D flow, inflow velocity: 13 m/s).

Bibliography

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