

11-4 Technology to Speed up Fluid Structure Interaction Simulation

— Simulation Technologies for Flow-Induced Vibration in a Nuclear Power Plant —

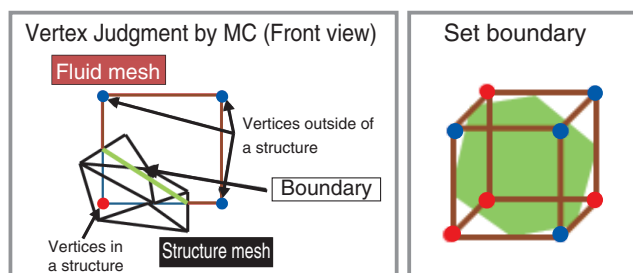


Fig.11-8 Setting of boundaries using MC

Using the results of a judgment regarding whether vertices are included in the structure mesh, the boundaries in a calculation domain are set. The processing cost is significantly reduced because the shape is calculated approximately.

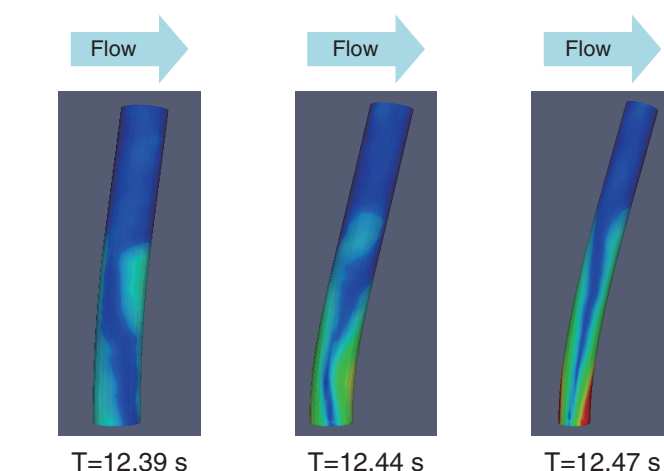
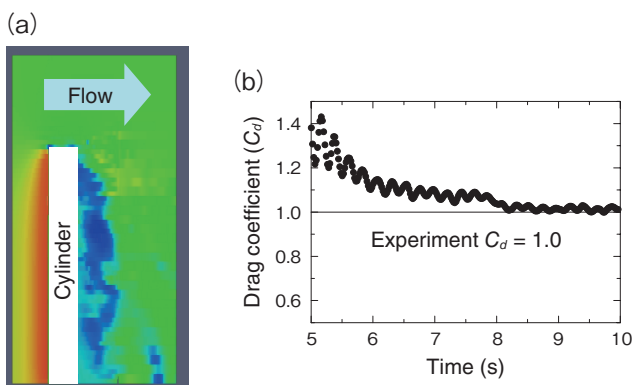


Fig.11-10 Time variations in cylinder deformation

Red shows high-stress region; blue shows low-stress region. The figure indicates that the cylinder deforms because of the pressure difference around it. The deformation amount is enlarged 100 times.

Fig.11-9 Pressure and time variations in drag coefficient

(a) Pressure distributions. High pressure (red) occurs at the upstream side, and low pressure (blue) occurs at the downstream side. (b) Drag coefficient versus time. The simulation result exhibits good agreement with the experimental data.

Flow-induced vibration is a very important phenomenon in a nuclear power plant because it causes breaks in the instruments or pipes. To analyze this phenomenon, fluid structure interaction simulation technologies have received considerable attention in recent years. In a fluid structure interaction simulation, a mesh consisting of small polyhedra is generally used to describe the fluid and structure regions. To date, a method that describes accurately the shape of the boundary between the fluid mesh and the structure mesh has been used. In this method, when the structure shape is highly deformed, the mesh shape also becomes awkward. Consequently, the simulation accuracy and speed are reduced. One of the methods of overcoming this problem is the immersed boundary method. However, setting the boundary conditions in the calculation domain requires considerable time.

In this study, a new algorithm that uses Marching Cube (MC) to set the boundaries approximately was invented (Fig.11-8). The processing speed is more than 20 times faster than that of

traditional methods. This makes it possible to finish a simulation that requires half a year by traditional methods within 10 days. Consequently, the method enables us to perform more practical simulations.

For verification, the method was applied to a simulation of the flow-induced vibration around a circular cylinder. Figs.11-9(a) and 11-10 show that the simulation can compute the deformation of a cylinder due to a pressure difference around it. The drag coefficient (Fig.11-9(b)) and amount of deformation of the cylinder are in good agreement with the experimental data. This study confirmed that the proposed method maintains adequate accuracy for application to practical problems.

This method enables us to perform large-scale complex simulations of flow-induced vibration with adequate accuracy within a practical timeframe. It is hoped that the method will contribute to the development of technologies to increase the safety of nuclear power plants.

Reference

Kino, C. et al., Flow Analysis around an In-Line Forced Oscillating Circular Cylinder using IB-Method, Nippon Kikai Gakkai Ronbunshu, B Hen, vol.78, no.796, 2012, p.2113-2126 (in Japanese).