Direct Numerical Simulation of Time Evolution of Vortex Ring

M. Hashiguchi[1]

[1]Keisoku Engineering System Co., Ltd., Chiyoda-ku, Tokyo, Japan

Abstract

Vortex ring can be useful to generate thrust force on e.g., jellyfish, but its mechanism has not been clarified. In this field, it seems that numerical simulation has an important role of understanding the propulsion mechanism of creature.
This paper, as a preliminary study, investigates the time evolution of a laminar vortex ring within a circular pipe numerically. Danaila et al. (2008) has treated this flow configuration with the aid of direct numerical simulation (DNS) based on finite-difference scheme. In this paper, finite-element analysis was executed by using the laminar flow interface of the COMSOL Multiphysics® software. By switching off any numerical stabilization in this interface, we can also apply direct numerical simulation of this flow configuration. The shape element type utilized in the flow computation was changed from P1-P1 type to P2-P1 type in order to satisfy the fundamental theorem.
The computational region is shown as in Fig.1. Here the axisymmetric flow field is assumed. Incompressible fluid is injected from the inlet of the cylindrical channel with a given time-dependent velocity profile in both axial and radial directions. Mesh arranged here is also shown in Fig.1. In order to boundary layers developed on the surfaces of the wall, the mesh was concentrated to the surfaces as depicted in Fig.1.
The present computational results are displayed in Fig.2, which are compared to the results of Danaila et al. (2008). It was found in Fig.2 that the present DNS results coincide very well with those of Danailia et al.

Reference

Ionut Danaila and Jerome Helie, PHYSICS OF FLUIDS 20, 073602 (2008).

Figures used in the abstract

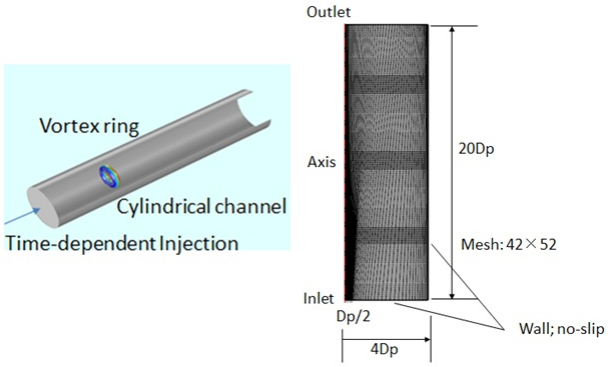

Figure 1: Computational conditions and mesh system

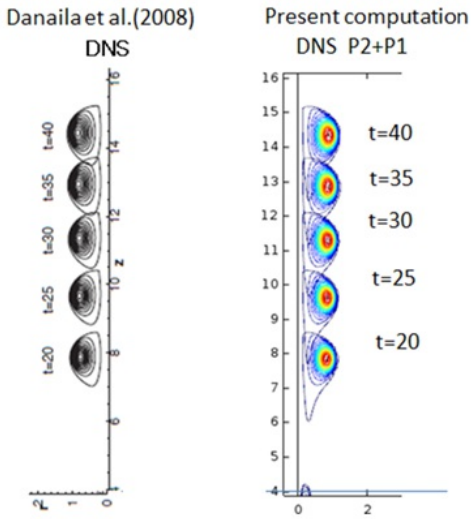

Figure 2: Time evolution of vortex ring (Lp/Dp=4)