Unsteady Characteristics of Tip-Leakage Flow in an Axial Flow Fan

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An axial flow fan with a shroud generates complicated tip-leakage flow by the interaction of the axial flow with the fan blades and shroud near the blade tips. In this study, large eddy simulation (LES) is performed for tip-leakage flow in a forward-swept axial flow fan inside an outdoor unit of an air-conditioner (Fig. 1), operating at the design condition of the Reynolds number of 547,000 based on the radius of blade tip and the tip velocity. A dynamic global model (Lee et al., 2010) is used for a subgrid-scale model, and an immersed boundary method in a non-inertial reference frame (Kim and Choi, 2006) is adopted. Schematic diagram of the coordinates, computational domain and boundary conditions are shown in Fig. 1(c). The present simulation reveals the evolution of tip-leakage vortex (TLV) near the blade tip. After inception of TLV near the leading edge of the suction-side of the blade tip, it develops downstream, and migrates toward the pressure surface of the following blade (Fig. 2(a)). Along the trajectory of the TLV, the turbulent kinetic energy and pressure fluctuations are high due to the oscillatory feature of the TLV. Energy spectra of the velocity fluctuations near the following blade and the trajectory of the TLV indicate that the TLV shows low-frequency wandering movement (Figs. 2(b)-(d)).

REFERENCES