Journal of Visualization, Vol. 11, No. 1 (2008) 5

Portfolio Paper

Visualization of Unsteady Viscous Flow around Turbine Blade

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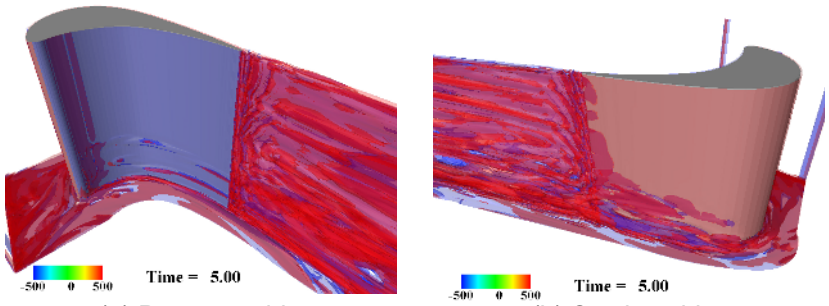
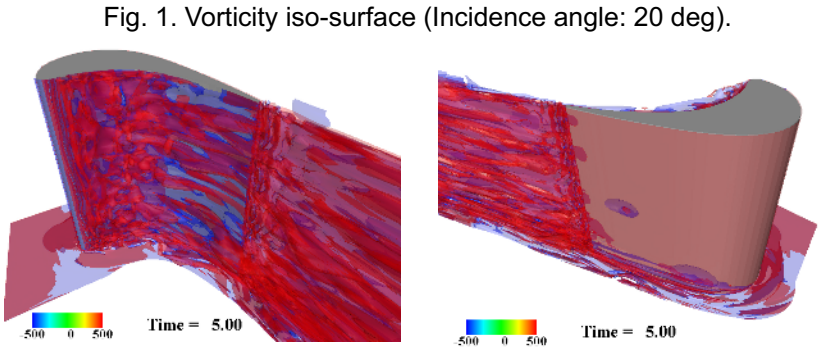
Received 2 November 2007 and Revised 5 November 2007



(a) Pressure side (b) Suction side

Fig. 1. Vorticity iso-surface (Incidence angle: 20 deg).



(a) Pressure side (b) Suction side

Fig. 2. Vorticity iso-surface (Incidence angle: 70 deg).

3-D unsteady viscous flow analysis around turbine blade cascade using Higher-order LES turbulent model(1) is carried out to investigate basic physical process involved in the pressure loss mechanism. Analysis simulated wind tunnel cascade test. The basic equations are unsteady 3-D continuity and momentum equations for incompressible flow and boundary conditions are as follows, wall boundaries are blade surface and hub surface. Single computation domain is used assuming that large number of blades with equal pitch is arranged in the pitch-wise direction and periodic boundary considerations are used in the span-wise direction.

In Fig. 1(a) and (b) are presented the results of 3-D computation on vorticity iso-surface(2) at the pressure side and suction side of turbine blade, respectively for flow incidence angle of 20 degree. Fig. 2(a) and (b) are those for flow incidence angle of 70 degree. Results presented in Fig. 1 and Fig. 2 indicate that in the wake region there occurs mixing between the clockwise vortex represented by blue color on the pressure side and anticlockwise vortex represented by red color on the suction side. In Fig. 1, secondary vortex formation at the hub wall can be observed. Flow is affected by secondary vortex and vortices at the wake region due to entrainment of fluid from the hub region, and pressure loss is increased. In Fig. 2, separation vortices are observed at the blade pressure side.

References : (1) Biswas, D., AIAA Paper, (2006), 2006-3684. (2) Yokono, Y. and Biswas, D., J. of Visualization, 10-3 (2007), 271-280.