Unsteady Flow at Midspan in a Turbine Rotor Due to Rotor-Stator Interaction

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1. Introduction

With the new generation of small-sized gas turbine engines, low Reynolds number flows have become increasingly important. In this study, the unsteady flow field at midspan in an axial-flow turbine rotor at low Reynolds number ($Re_{out,RT} = 3.6\times10^4$) was investigated experimentally using a laser Doppler velocimetry (LDV) system. The time-averaged and time-dependent distributions of velocity, flow angle, vorticity, turbulence intensity, and Reynolds stress were analyzed in terms of both absolute (stationary) frame of reference and relative (rotating) frame of reference.

2. Experimental method

The LDV system was a standard two-color, four beam, two-dimensional measuring system with a fiber-optic probe. An incremental rotary encoder (1,800 pulses/revolution) was attached to the rotor shaft to detect the rotor angler position. An automatic measurement system controlled by a personal computer was adopted in this study. Figure 1 shows the LDV measurement locations at the midspan.

3. Results and conclusions

Figure 2 shows the time-dependent unsteady relative velocity and turbulence intensity in the relative coordinate system. In Fig. 2 (a), the relative velocity fluctuated periodically because of the rotor-stator interaction. The separation region on the rotor suction surface was also affected by the effect of the nozzle wake. In Fig. 2 (b), the high turbulence intensity region of the nozzle wake is seen to accumulate on the rotor suction surface. The unsteady flow in a turbine at low Reynolds number was successfully measured and the effects of the turbine nozzle wake on the rotor were evaluated qualitatively and quantitatively.

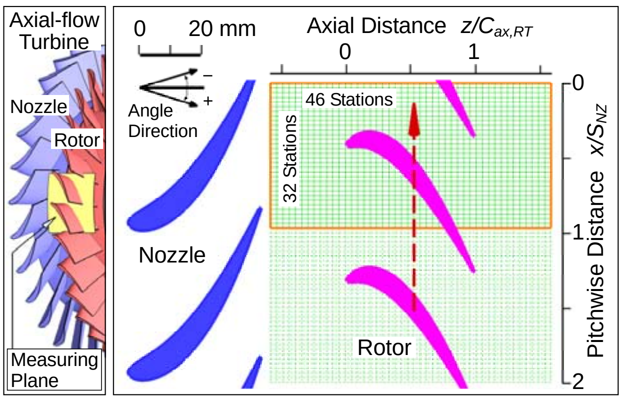

Fig. 1 LDV measurement locations

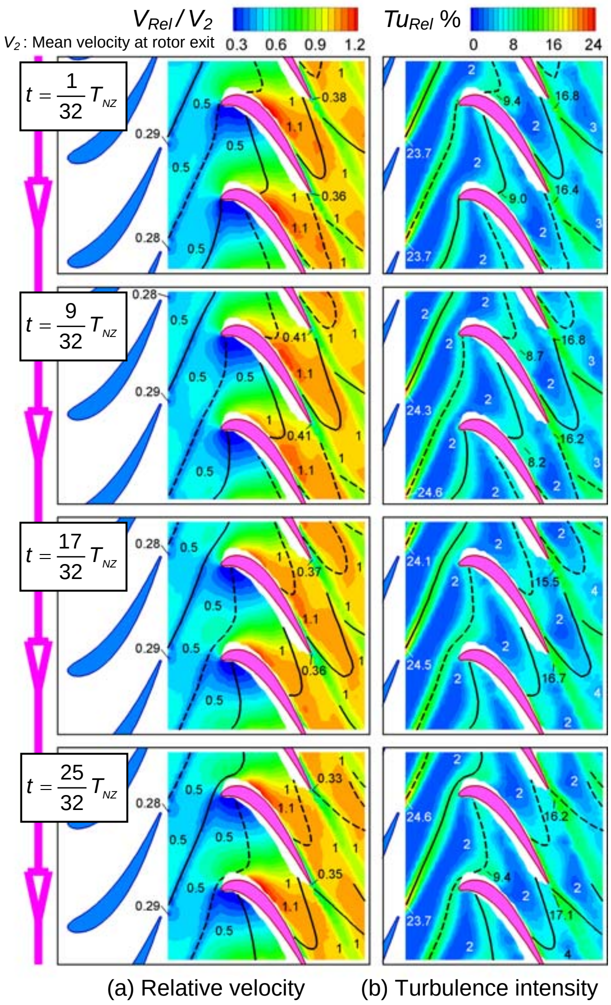

Fig. 2 Time-dependent unsteady flow in relative frame of reference

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