HEAT TRANSFER AND FLOW CHARACTERISTICS ON A GAS TURBINE SHROUD

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ABSTRACT

The heat transfer coefficient and flow on three kinds of turbine shrouds with a flat surface, a tapered surface and a spiral grooved surface are investigated in an axial flow turbine of actual turbo-charger. Heat transfer measurements are performed under experimental conditions of a uniform wall temperature and a uniform heat flux. The nature of tip clearance flow and flow pattern in the downstream region of rotor blades are measured by a hot-wire anemometer in combination with a periodic multi-sampling and an ensemble-averaging technique. The effects of inlet flow angle, rotational speed and tip clearance on the heat transfer coefficient are elucidated under on-and off-design flow conditions. The heat transfer coefficient is correlated with the blade Reynolds number and tip clearance, and compared with the experimental correlation of Karimova et.al.(1973) and the measurements of Kumada et.al.(1994) for a flat surface. A comparison is also made for the measurement of static pressure distributions and it is shown that a leakage flow exists in the downstream beyond the middle of the surface opposite to the blades, and a leakage vortex is recognized near the trailing edge on the suction side of the blade.

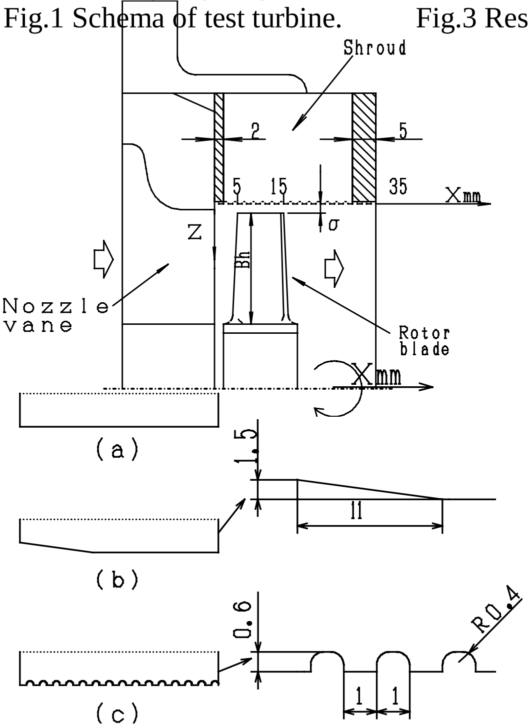
TYPICAL RESULTS

Figure 1 shows the measuring section of the test turbine, which has 169 mm in rotor diameter with 53 blades and the range of rotational speed was from 2,000 to 14,000 rpm. The shape of the shroud surface opposite to the blade tip is also shown in Fig.2.

A typical result of heat transfer measurements for a blade tip clearance is shown with different shroud surfaces in Fig.3, in which the average Nusselt number on the shroud is correlated with the blade Reynolds number at the design flow condition. The measurements make clear to give a lower value in comparison with the experimental correlation of Karimova et.al.

Figure 4 shows a result of the statics pressure measurements along the shroud surface for the different blade Reynolds number at the design flow condition, and the distribution is compared with different shrouds and with different blade tip clearances. A relatively large difference in the distribution between grooved and tapered surfaces is recognized in the locations correspond to the blade leading-edge region and the downstream region of blade rows.

Fig.1 Schema of test turbine. Fig.3 Result of heat transfer measurements.



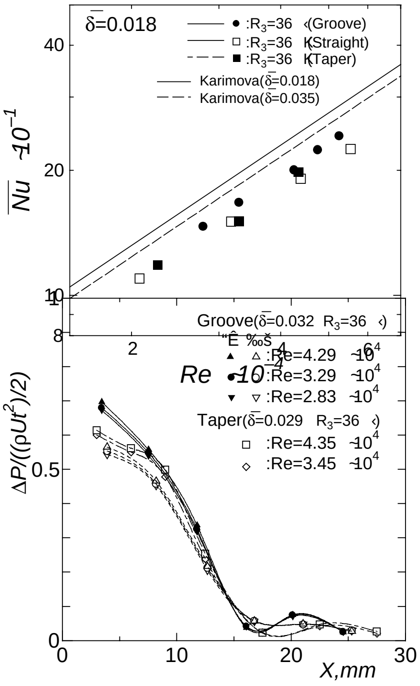


Fig.2 Shape of shroud surface.

Fig.4 Result of static pressure measurements.

CONCLUSIONS

(1) The average heat transfer coefficient can correlate with the 0.8th power of blade Reynolds number Re as similar as the heat transfer correlation of turbulent flow on a flat plate.

(2) The value increases with the increase of Re, decreases with the increase of tip clearance, and is affected a little by the inlet flow angle of blades.

(3) The static pressure distribution on the shroud wall surface shows a rapid decrease from the nozzle outlet to the downstream and Re has little effect on the pressure distribution.

REFERENCES

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