Flow Instabilities Associated with a Shock in Two-Dimensional Supersonic Cascade: Part 1 - Numerical Investigation for Viscous Flow

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1. Introduction

In this paper, numerical studies were carried out to investigate instabilities of viscous and supersonic flow in a two-dimensional cascade(1).

2. Numerical method

The calculation code based on Harten-Yee's upwind-type TVD scheme (second order accuracies both in time and space) were applied for a two-dimensional flow field in the frame moving with the cascade.

The computational grid was generated around ARL-SL 19 cascade(2), assuming the periodicity over 10 blades. The total number of grid nodes was 121260. Inlet and outlet boundaries were located at two blade chords upstream/downstream from the leading/trailing edges, respectively.

The inlet total temperature T_{01abs} of 300 K and the total pressure p_{01abs} of 0.1 MPa were fixed in the absolute frame.

3. Results and conclusions

Figure 1 shows the performance curves. Unsteady phenomena were observed at operation points with labels A – S. Among them, circumferentially traveling fluctuations were found in the points with circled labels. They are grouped into four types: (1) conventional rotating stall found in operation points N – S, (2) backward traveling fluctuation related with fluctuating leading edge shock, observed at operation points A and K, (3) intermittently appearing, forward and backward traveling fluctuation observed at operation point B, and (4) forward traveling fluctuation with oscillating passage shock observed at operation points F and I. It was found that rotating stall and forward traveling fluctuation correspond to flow instabilities predicted by our previous actuator disk analysis(3).

Here, we focus on the forward traveling fluctuation found in operation points F and I since it is considered as the newly found type of the shock oscillation. At these operation points, the higher pressure region in the downstream moves faster than the rotor speed in the absolute frame. Blade passage shocks also fluctuate interacting with this region. The animation of the static pressure contour in operation point F is open in the web site(4).

References

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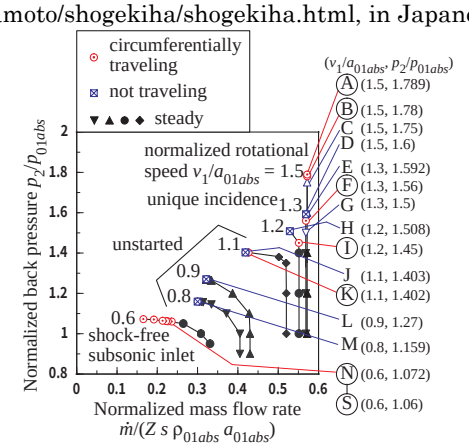

Fig. 1 Performance curves by 10 blades viscous calculations

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