Interface Construction for Thermal Stress Analysis in Virtual Turbine and Stress Evaluation*

CHEN Jinxiang[1], OGAWA Akinori[1], HASHIMOTO Ryosaku[1] and YOSHIDA Toyoaki[2]
1.Japan Aerospace Exploration Agency, 2. Tokyo University of Agriculture and Technology

1. Introduction

In order to construct a database of structural strength for a TIT 1700℃ class virtual turbine made of single-crystal (SC) Ni-base superalloy, an interface and a stress evaluation system were required. This paper mainly describes the construction of the interface and its applications to turbine vanes of TIT 1400℃ class as an example.

2. Model and Analytical Condition

The TIT 1400℃ class virtual turbine vane model and the material of SC Ni-base superalloys TMS-75 have been used in this paper.

3. Interface Construction and Stress Evaluation

In the constructed interface, a data conversion method is proposed. It compares the spatial coordinates of each node in the strength analytical model with that of CFD nodes. As shown in Fig. 1, for a node E of the strength analysis model, we project the small curved surface E1 around node E to the XZ and YZ plane and chose the XZ plane with larger projected area to be the interpolation plane (Fig. 1 (A)). This selection is based on the idea that interpolation can be carried out more precisely in larger area. Next, we keep node E in coordinates origin O, and for each of the four quadrants we detect one CFD node whose spatial distance to origin O is the closest (Fig. 1 (B)). Then, the temperature of node E can be calculated by the two-dimensional interpolation using temperature at four CFD nodes.

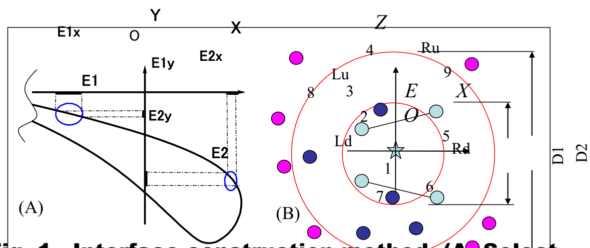

Fig. 1 Interface construction method. (A) Selection of interpolation plane, (B) detection of CFD nodes, ☆ : FEM node E,○: CFD node.

Stress evaluation is carried out by using the Von Mises stress normalized by 0.2% proof stress of its metal temperature (proof ratio) as the evaluation index. Proof ratio of each node of the turbine vanes is calculated and the result is shown in Fig. 2 (A), (B). This figure of proof ratio is visualized by utilizing the analysis software. It is clear from Fig. 2 that the visualization method introduced in the present work is effective for the evaluation of characteristics of thermal stress.

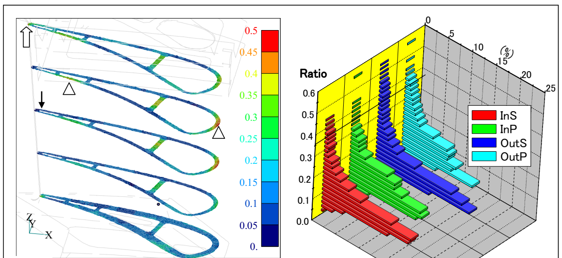

Fig. 2 Proof ratio (A) in section, and (B) at various surfaces (for example, InS indicates inside surface of suction side).

4. Conclusions

(1) The computation to construct the interface by applying selection of plane coordinates and the two-dimensional interpolation is simple and accurate, and has wide application.

(2) In the stress evaluation, the evaluation parameters were effectively visualized and the characteristics of thermal stress were made clear.

References

Chen J., Ogawa A., Hashimoto R., and T. Yoshida, *GTSJ*, Vol.**32**, No.1(2004), pp.34-39, in Japanese.

*:The research is a part of High-temperature material 21 project.

1. Aeronautical Environment Technology Center
7-44-1 Jindaiji, Chofu, Tokyo 182-8522, JAPAN
Phone: +81-422-40-3475, FAX: +81-422-40-3440
2. Department of Mechanical Systems Engineering
2-24-16 Nakacho, Koganei Tokyo 184-8588, JAPAN
Tel/Fax: +81-42-388-7087