Increase in Calculation Speed of Radiative Heat Transfer in Precision Casting Furnaces of Gas Turbine Blade

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1. Introduction

A fast radiative heat transfer program is developed for the simulation of unidirectional precision casting of gas turbine blade. Calculation speed is increased by incorporating three new methods. View factors are calculated by introducing an approximation formula and simplified surface integral. The visibility at surface elements is judged by extended plane-sweep method. For radiosity calculation in the radiative heat transfer analysis, multiple reflection is neglected. As the result, the present algorithm reduces the computation time for a model with 700 elements from 300sec to 4sec within accuracy of 3%.

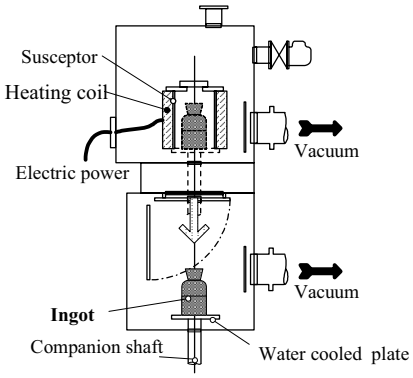

Fig. 1 The model of a precision-casting unidirectional solidification furnace

2. Numerical analysis

The model of a precision-casting unidirectional solidification furnace is shown in Fig. 1. The geometrical configuration of a wall-surface element, the element which moves in a furnace, and wall-surface emissivity are given to the radiative heat transfer program as an initial value. Figure 2 is a schematic showing a extended plane-sweep method. As are shown in Fig. 2 (a), all the wall-surface elements are first projected on a certain level field, then, as is shown in Fig. 2 (b), plane-sweep in respect of vertical projection is performed. Figure 3 summarizes the error of the heat which flows into the mold when making wall-surface

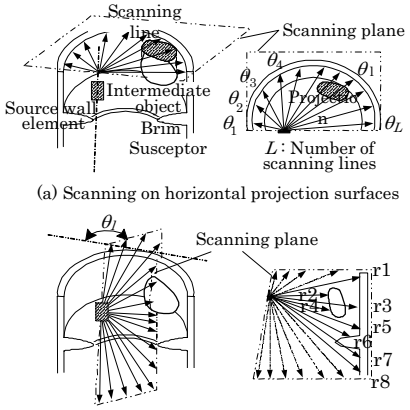

Fig. 2 Plane-sweep method

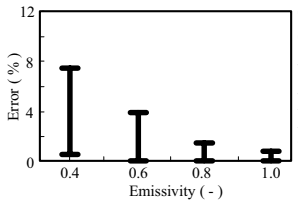

Fig. 3 The error of the heat quantity analysis

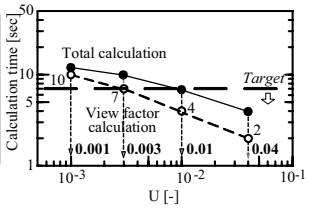

Fig. 4 Result of analysis time

emissivity into a parameter. If wall-surface emissivity is small, the effect of multipath reflection will become large and analytic accuracy will fall. Figure 4 shows the result of the analysis time of the developed program. The black dots in the figure are the computation time of view factors and a heat transfer calculation, and a white dots show the computation time of only view factors.

3. Conclusions

The high-speed and highly precise program used for the simulation of the fluidity and the coagulation process at the time of gas turbine aerofoil precision casting was developed.