An Efficient Numerical Strategy for Debonding Detection in TBC of Heavy-duty Gas Turbine Blades Based on Eddy Current Thermography

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Debonding is easily generated in Thermal barrier coating (TBC) of Heavy-duty Gas Turbine Blades due to extremely high temperature and high pressure. Debonding will potentially lead to degradation of thermal properties, oxidation resistance, and corrosion resistance. Hence, various nondestructive testing (NDT) techniques have been utilized to detect debonding in TBC. Among these NDT techniques, eddy current thermography presents significant potential in efficient detection of debonding due to its internal heating source, high sensitivity and rapid full-field imaging. However, the numerical simulation is computationally intensive as a result of small thickness of the debonding in TBC which requires a large amount of elements. Therefore, this study aims to develop an efficient numerical algorithm for debonding detection in TBC based on eddy current thermography. The numerical simulation of eddy current thermography comprises of simulation of electromagnetic field and calculation of thermal field. First, the discontinuous nodes (DN) method is employed to simulate the response of electromagnetic response of debonding. The DN method assumes that the debonding is insulative, which reduces the elemental density considerately in debonding region. Moreover, the reduced magnetic vector potential (Ar) method utilizing edge elements is employed to calculate the electromagnetic field rapidly. Thereafter, the interface element is exploited to simulate the thermal response of debonding. On the one hand, the zero-thickness of interface element make the geometry match between the electromagnetic field and the thermal field which is beneficial to the load transfer between these two fields. On the other hand, the interface element is capable of simulating thermal response of debonding in a geometrically flexible and physically reasonable manner. Finally, the numerical simulator is developed based on Fortran90, which is then validated numerically and experimentally. This efficient numerical simulator not only can achieve quantitative evaluation of debonding in TBC, but also provide powerful tools for sensors optimization and inversion problem.