FOD Simulation on Ceramic Gas Turbine Blade

YOSHIDA Hiro
National Institute of Advanced Industrial Science and Technology
LI Yin-Sheng
Fuji Research Institute Corporation

1. Introduction

Foreign object impact damage (FOD) is the inevitable subject of ceramic gas turbine (CGT). In the test runs of CGT, it was often reported that some remarkable damages appeared in the trailing edge area of the rotor blade, where foreign particles hardly impacted, i.e. structural damage. In order to understand this type of damage behavior, a finite-element analysis was carried out under the elastic assumption. As the target ceramic material, the type of SN252 ceramic (Kyocera Corp.) was assumed.

2. Finite Element Analysis

2.1 2D Wedge Case

For simplicity, we tried to analyze 2-dimensional (2D) wedge case first. The base and the height of the wedge were set to be as 3 mm and 20 mm, respectively. Those were decided according to the actual ceramic rotor blade of CGT-302 (Kawasaki Heavy Industries Co.,Ltd.). 1mm diameter samarium-cobalt particle was assumed as the impactor. Two impact cases were calculated, where the particle impacts from the side of the wedge at 3.3 mm and 6.7 mm (corresponds to the center of gravity of the wedge) distant from the wedge base. The time history of the impact load was as assumed as follows: The stress linearly increased from 0 to 17.7 GPa in the first 2.2 μsec and remained constant at 17.7 GPa level for 0.5 msec, then dropped to 0. We observed that in both cases of impact, stress peaks appeared not only at the impact point but also in the trailing edge area due to interactions of the stress waves produced by the dynamic loading. Note that the rear peaks never occur under the static loading condition.

1-2-1 Namiki, Tsukuba, Ibaraki 305-8564, Japan
Phone : +81-29-861-7079 Fax : +81-29-861-7275

2.2 3D Blade Case

The blade shape and the location of the maximum principal stress are shown in Fig.1. In Fig.1a and b, A denotes the impact point on the suction and the pressure sides of the blade, respectively. The particle impacts on the suction side.

3.Conclusions

It is found that impact at the upper leading edge generates several stress peaks in the trailing edge area and root of the blade. Those peak locations qualitatively well correspond to the fracture behavior observed in the particle impact experiments. The numerical results supported the possibility that impact at upper leading edge of the blade caused falling off of a part of the trailing edge and failure at the blade root.

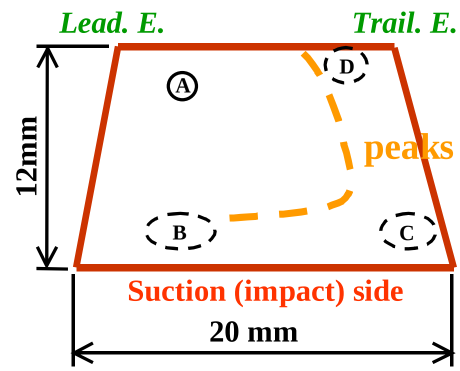

Fig.1a Peak stresses on the suction side.

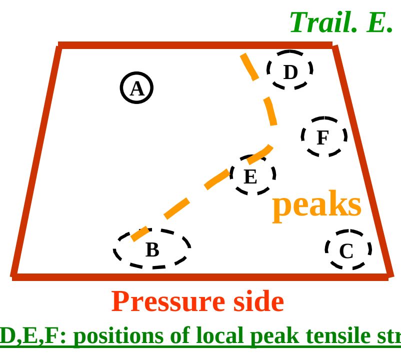

Fig.1b Peak stresses on the pressure side.