Material Integrity Solutions, Inc.

PROJECT BULLETIN

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Failure Risk Due to Creep Cracking of a High-Pressure Turbine Rotor

BACKGROUND

High-pressure (HP) turbine rotors are exposed to a high-temperature environment, whose damaging mechanisms include thermal fatigue, solid particle erosion, and creep. These conditions can cause cracking of the blade-fit area (*Fig. 1*). A fossil power plant experiencing problems with its HP rotor called upon MIS to evaluate the rotor's condition. This rotor had a number of problems, including heat groove cracking and material softening of the bore and the 1st stage.

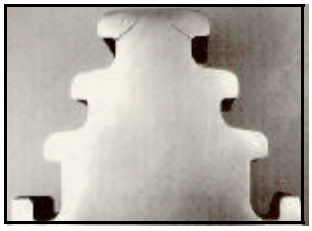

Figure 1. Cracking in the blade-fit area of an HP rotor

The rotor manufacturer recommended either replacement of the rotor or a large reduction in operating temperature. MIS evaluated the condition and the remaining life of the rotor's heat groove, bore, and blade-fit area to establish an alternative to the rotor manufacturer recommend.

DISCUSSION

Applying a state-of-the-art analytical approach, MIS provided the following services:

- Estimation of the remaining life and reinspection interval for heat groove cracking.
- Development of modeling techniques for evaluation of creep deformation, load shedding, crack initiation, crack interactions, and crack growth in the blade-fit area of the rotor's 1st stage.
- Estimation of the remaining life of the blade-fit area during the crack growth phase.
- Development of failure probability in the blade-fit area under creep.
- Development of an inspection action plan and repair alternatives for the 1st stage.

By using finite element and fracture mechanics analyses (*Fig. 2*) and the plant's operating records, MIS estimated the condition of the rotor. We developed "a sequential and time increment crack" (STIC) growth model (*Fig. 3*) for evaluation of creep crack initiation, interaction, and growth in the blade-fit area. Effects of creep deformation and cracking on load transfer between the blade and the rotor were included. This model uses both deterministic and probabilistic approaches. We applied this model for evaluation of a specific problem, and developed the 1st stage's failure probability as a function of time (*Fig. 4*).

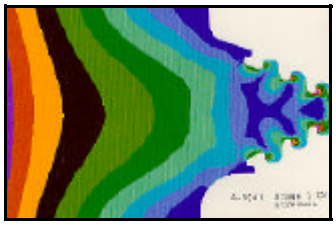

Figure 2: Stress contour plots of the fit/rotor under creep

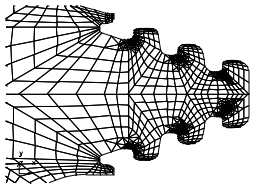

Figure 3. FE mesh of the fit area with crack in each hook

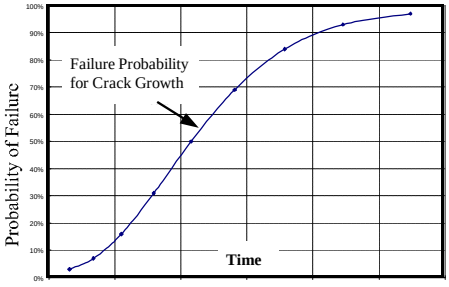

Figure 4. Probability of failure for 1st stage blade-fit area of a HP turbine

CONCLUSION

A new method was developed by MIS that can be used to estimate the risk of failure of the blade-fit area under creep conditions. We call this method the "STIC" growth model.

This method was applied to evaluate creep cracking problems of a HP rotors' 1st stage blade-fit. The results of our analyses enabled our client to develop a reliable estimate of the equipment's remaining life and find alternatives to the manufacturer's recommendations, resulting in major savings.