Material Integrity Solutions, Inc.

PROJECT BULLETIN

NL-21

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Mitigating Nozzle Cracking in Gas Turbines

BACKGROUND

Cracking of 1st stage nozzles occurs routinely in gas turbines (*Fig. 1*). Such cracking, which sometimes is observed only after a few operating cycles, leads to short intervals between overhauls and expensive repairs or replacements of the nozzle sections. However, despite the enormous economic costs associated with nozzle cracking, their root cause and mitigation have not been convincingly determined. In fact, many OEM's consider nozzle cracking as a "fact of life" and have issued recommendations for their monitoring and replacements. Realizing potential benefits from finding the cause, the impact, and mitigation of such cracking, our client commissioned this study to evaluate their Frame-3 gas turbines.

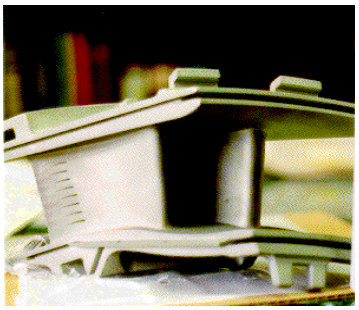

Figure 1. Typical gas turbine nozzle

DISCUSSION

This study covered many tasks including survey of gas turbine operators, an extensive literature search, measurement and reverse engineering of a typical nozzle (*Fig.2*), finite element modeling of the nozzle for gas dynamics, heat transfer and stress analyses, on-line measurement of the operating parameters, and simulations for temperatures (*Fig.3*) and stresses (*Fig.4*) in the nozzle during typical operating cycles using non-linear time history analyses. This study revealed that the cracking mechanism is that of low cycle fatigue caused by high cyclic stresses. We determined sources for the nozzle's high stresses to include thermal and pressure shocks caused by transonic events occurring during startups. Also, the effect of cyclic operation and unit trips were determined. Finally, recommendations on how to mitigate such cracking were developed.

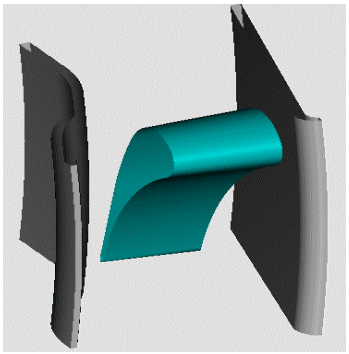

Figure 2. 3D CAD representa-

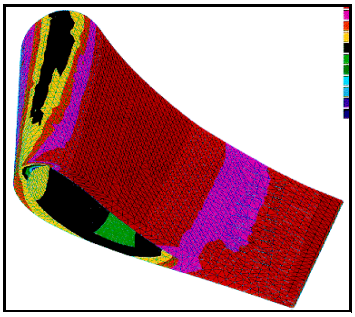

Figure 3. Nozzles temperature contour plot at a time step

Figure 4. Stress time history at a critical location on the nozzle

CONCLUSION

Mechanisms, causes, and sources for 1st stage nozzle cracking of gas turbines were identified and recommendations to mitigate such cracking were developed. In addition to finding the causes for damage and cracking in these nozzles, this work also developed models and procedures for simulating the effect of operating conditions on temperature and stresses in similar nozzles.