Life Assessment of Combustion Liners by Fracture Mechanics Approach

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Introduction

The structural integrity, durability and reliability of the critical components of gas turbine engines for power generation govern the safety of power plants. The thermo-acoustic instabilities in combustion systems cause high sound pressure levels resulting in vibration of the structure. It is important to predict the residual lifetime and evaluate the damage of the liner material in the way of achieving a lean combustion and reduced emissions in gas turbines [1].

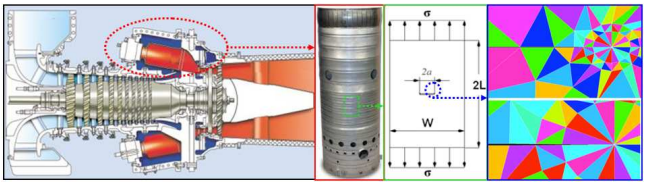

Figure 1 : Fracture-mechanics on gas turbine liner.

Aim of the project

Life assessment due to the limit cycles of thermo-acoustic oscillations in gas turbine combustors that is motivated by the need for lean combustion technologies and reduced emissions. This research:

- Calculates strain and stress distribution around the crack tip by fracture mechanics analysis.
- Enables to predict plastic work field on a stable mode I crack growth on SS310 steel liner material.
- Evaluates damage of the propagating crack tip for the residual lifetime prediction.

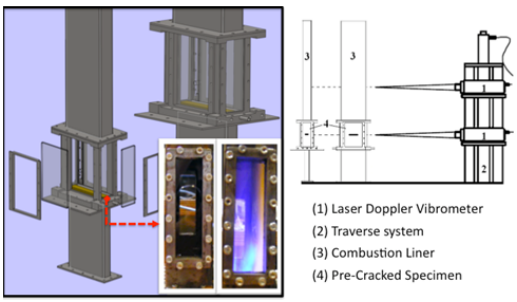

Figure 2 : Vibration-based monitoring on combustor.

Modeling procedure and solution

- Nonlinear elastic-plastic stress analysis and fracture mechanics parameter calculation run collaboratively.
- In the linear regime, the stress intensity factor is calculated, in the non-linear regime J-Integral method is applied at the crack tip region and crack opening displacement procedure has been employed.

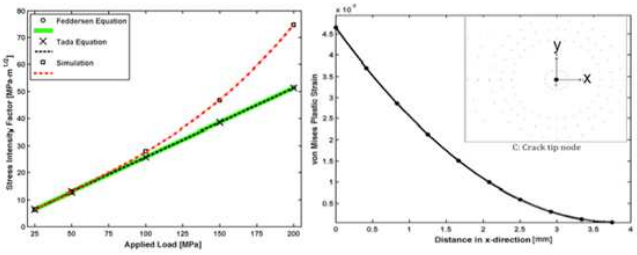

Figure 3 : Stress intensity calculation (left), von Mises plastic strain profile in x- direction (right)

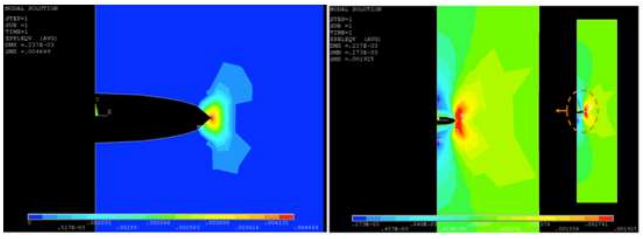

Figure 4 : Von Mises plastic strain field (left), von Mises elastic strain field (right) at the crack tip.

Conclusions

- The residual lifetime of a cracked structure has been evaluated considering both the effects of plasticity and stable crack propagation.
- The metallic material exhibits localized plasticity at the crack tip creating a plastic zone and the strain magnitude decreases as a function of the crack tip distance.

References

1. Altunlu, AC, van der Hoogt, P., de Boer, A., ”Damage evolution by using the near-tip fields of a crack in gas turbine liners”, In *Proceedings of ICSV17*, Cairo, Egypt, 2010.

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