Reliability Improvement in FCC Hot Gas Expander using CFD Modelling

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Long Abstract

Introduction

The fluid catalytic cracking (FCC) hot gas expander are used to generate power by recovering pressure energy from flue gases. Hot gas expanders faces several reliability challenges because of high speed and presence of fine particles in the gases. The expander in Reliance Refinery at Jamnagar is designed for 27 MW. It used to face several reliability issues in form of high vibrations. Thermal cycling and abrasive cleaning is used as short term measures to bring down the vibrations. However, frequent thermal cycling puts significant cost and efforts to organization. The present article focuses on finding the long term resolution to problem by understanding the detailed fluid mechanics and particle dynamics.

1. Methods

A detailed 3D CFD analysis was carried out to understand the flow and particle behavior inside the expander. Though some of the previous literature [1] have used only a section, complete 360 degree model was used in this analysis to capture certain non-symmetric fluid mechanics including gravity forces. Stator rotor interactions were captured using the moving mesh technique. While generating flow aligned gridlines, emphasis has been given on accurate resolution of tip clearance between rotor and shroud. Physics model selected included ideal gas law, k-w SST turbulence model and langrangian frame of reference for the catalyst particles.

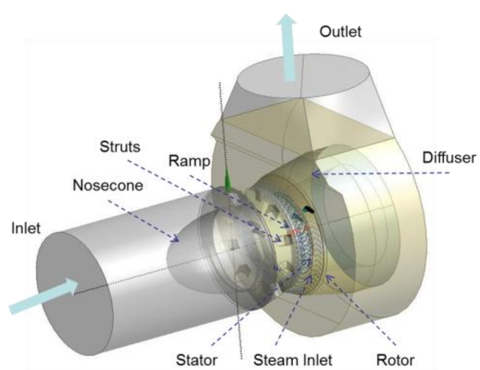

Figure 1. FCC Hot gas expander fluid domain

2. Results

The simulations helped to understand flow features to a great extent. The velocity in both stator and rotor region were found to be approaching sonic value. The erosion predicted by model seem to match quite well with the observed erosion marks on used blades. More importantly, model was able to identify the areas highly susceptible to deposition of the fine particles.

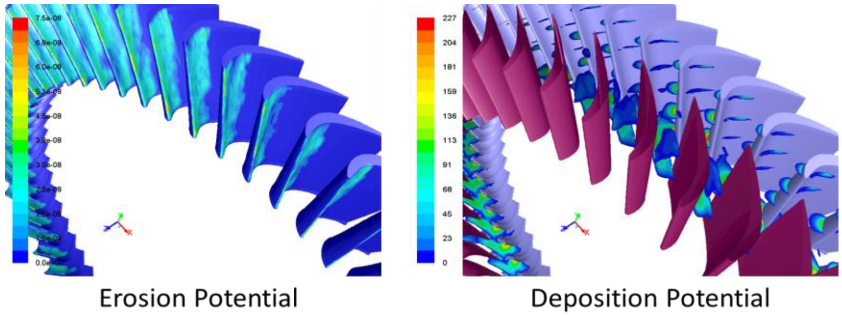

Figure 2. Erosion and Deposition Potential

Root cause of the vibration phenomena was traced to presence of an extra pressure force originating from the non-uniform tip clearances. It found to have direct effect on base vibration of expander and hence, explain the different vibration level observed in past with different tip clearances. It should be noted that though absolute value of clearances will have little effect on the base vibrations, effect of non-uniformity of clearance had different effect at different average tip clearances.

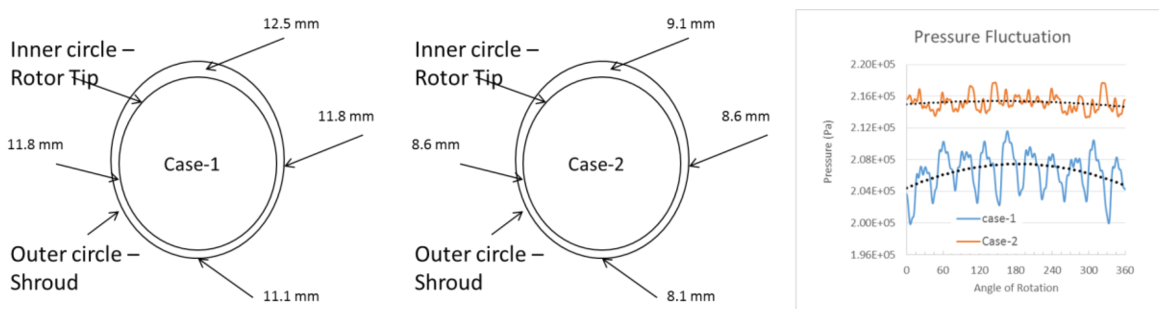

Figure 3. Effect of non-uniform tip clearances

The finding was later verified in the field with expander tip clearances were made uniform similar to case-2 during the shutdown. Base vibrations as well as thermal cycling frequencies were reduced significantly leading to significant savings for the refinery.

3. References

[1] B. Carbonetto, and G. Hoch. Advances in Erosion Prediction of Axial Flow Expanders. *Proceedings of the Twenty-Eight Turbomachinery Symposium*, 1-8, 1999