CASE STUDY

UNDERSTANDING THE AEROMECHANICAL BEHAVIOR OF EMBEDDED COMPRESSOR ROTORS COMPUTATIONALLY

An important topic in the gas turbine industry is blade aeromechanics, which can lead to engine failure. GUIde Consortium launched a project to better understand the underlying physics of multi-row interactions in gas turbine compressors. The Aeroelasticity Research Group at Duke University investigated this phenomenon computationally, in conjunction with physical testing at the Zucrow labs at Purdue University. The research involved high-fidelity 3D time domain computational simulations using Ansys CFX and a few in-house codes.

"Understanding the impact of multi-row interaction on the embedded rotor forcing function is essential to prevent catastrophic aeromechanical failures on compressors. Ansys CFX was used extensively to understand this phenomenon and predict the forcing function."

Shreyas Hegde
Ph.D. Candidate, Duke University

Challenges

The computational cost involved in turbomachinery simulations is primarily due to nonuniform pitch ratios across multiple rows. This warrants the use of full-wheel 3D computational domains, which are very expensive computationally. By using the model reduction techniques available in CFX (particularly the time transformation method) we were able to reduce the computational times significantly and obtain high-quality results.

Technology Used

- Ansys CFX

Engineering Solution

- CFX was primarily used to obtain the unsteady pressure and thus the modal force under different operating conditions and Campbell diagram crossings.
- Several post-processing techniques were developed to understand the physics of the problem better. These parameters, which were obtained by reconstructing the results from Fourier coefficients, provided insight into the flow field, which was dependent on both the crossing and operating conditions.
- These results were fed to an in-house code to obtain individual blade response.

Benefits

- We integrated our understanding in aeromechanics with CFX and developed a new workflow for conducting forced response analysis fully within CFX.
- We developed several post-processing modules for aeromechanical analysis which could be added to the existing post-processing framework in the future. Our unique academic partnership with Ansys has led to mutual benefits which have resulted in exploring several new ways of solving the same problem.
- The model reduction technique developed for 2-3 rows has been used for 5-row simulations and the results have matched exceedingly well with experimental data.

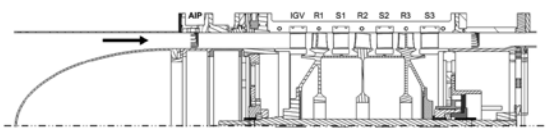

Figure 1: A schematic of the test rig. The computational model is created in the same manner.

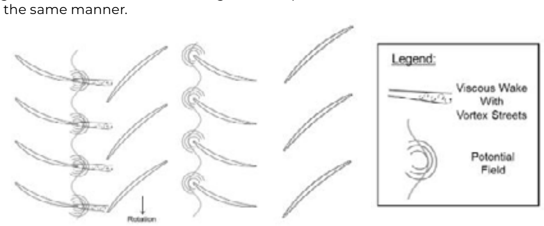

Figure 2: A depiction of the physics involved in multi-row interaction in turbomachines, showing physical wave reflection from downstream rows.

Company Description

The Aeroelasticity research group at Duke University is one of the most reputed groups across the world and are known for their expertise in the field of aeromechanics and aeroelasticity. This research was funded by the GUIde Consortium, which involves most of the gas turbine companies in the world. The methods developed and utilized as a part of this research provide valuable guidance to the entire gas turbine industry.

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