

## Impeller Frequency analysis:

The air separation industry relies on efficient and reliable turbomachinery to create the highest performance air separation plants possible. Key to this is ACD's expansion turbine that expands high pressure air to reduce the temperature to cryogenic conditions and produce work.

ACD uses the design analysis 'Simulation' software integrated within SolidWorks to perform steady-state stress and modal (frequency) analysis. The use of Campbell and interference diagrams, as well as animated mode shapes from Simulation helps to visualize the potential dangerous interactions of impeller mode shapes and shaft excitation.

The first step in the analysis process is to transfer 3-D impeller geometry created in SolidWorks into Simulation. A very accurate representation of stiffness and mass of the impeller is required; hence the use of a sound mesh topology and a high-density parabolic tetrahedral mesh is crucial to accurate frequency prediction. The Finite Element Analysis (FEA) simulation then calculates the natural frequencies and mode shapes at either zero rpm or at design speed to include stress stiffening effects using actual boundary condition and material properties. From the plotted mode shapes, it is important to identify blade and disk modes that are critical in assessing the likelihood of dangerous resonance conditions.

The frequency analysis helps ACD avoid vibration-based failures by modifying geometry of the impeller hub and back disk including designing shrouded impeller if needed. All the geometry modification can be managed during the initial design phase thus avoiding costly rework and rejection after manufacturing and testing.

Impeller failures can be very costly both in terms of dollars and in lost production, making the avoidance of these failures of great interest to both ACD and our customers. The ability to predict impeller natural frequencies using Simulation coupled with experimental modal analysis (EMA) allows us to easily

and accurately determine the quality of our impeller designs by providing an appropriate margin against fatigue damage.

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