Dresser-Rand Impeller Scallop Design Study

Overview
Dresser-Rand, A Siemens Business is a world leader in energy conversion technology, including the manufacture of centrifugal compressors. One of the most critical components in a compressor is the impeller. In order to ensure impellers perform effectively it is essential to prevent fatigue cracking on the outer diameter (OD), which is caused by the coincidence of the impeller's natural frequency and the excitation frequency of the downstream diffuser vanes.

Objectives
In order to prevent fatigue cracking along the OD of the impeller, the team has been tasked with creating an optimal scallop shape that increases the natural frequency of the impeller above a safe margin, while also maintaining similar stress levels and outer diameter deformations.

Approach
- Determined customer needs from an initial site visit with the sponsor
- Performed finite element analysis (FEA) to determine benchmark values for natural frequency, stress, and deformation from the original un-scalloped impeller
- Created 11 unique scallop design concepts
- Performed ANSYS pre-stressed modal analysis on each of the original 11 designs
- Screened and scored the designs using weighting factors based on the original customer needs
- Developed five final designs based on the FEA results
- Performed a second round of FEA on the five final designs
- Determined a final scallop design that best met the original needs expressed by Dresser-Rand

Outcomes
- The natural frequency of the impeller was increased 15% above the project target value
  - Project Target: 4,153 Hz
  - Final Design: 4,806 Hz
- The maximum stress levels in the impeller blades remained within the allowable range
- Analysis results showed that maximum OD deformation was not increased
- Final scallop shape was machinable and did not introduce any significant stress concentrations
- Scallop implementation had negligible effects on the fluid flow path