

CAD model of redesigned compressor blade

Designing for Quality

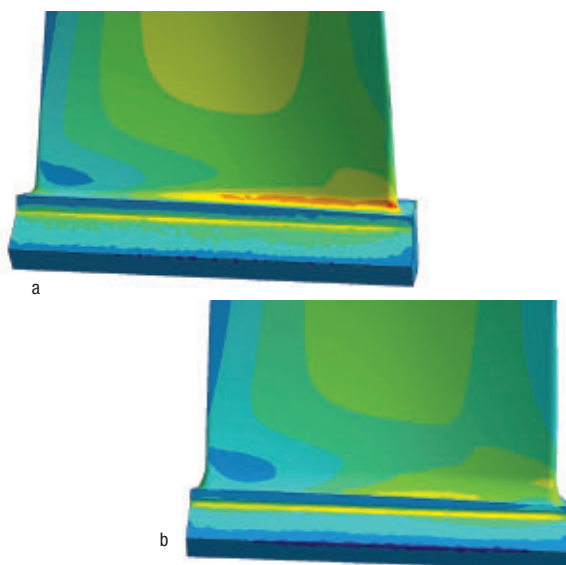
Simulation paired with optimization helps eliminate compressor blade failure.

Power Systems Manufacturing (PSM) is a global provider of aftermarket gas turbine components in the industrial power generation industry. The company's product line includes stationary and rotating airfoil components, low-emission combustion systems, and advanced components for GE Frames 6, 7 and 9 and Siemens 501F-class machines. In one specific redesign case, an original equipment manufacturer (OEM) first-stage compressor blade design for a popular large gas turbine used for generating electricity was not reaching its expected life.

Field failure scenarios included blade breakage resulting in considerable downstream damage. Companies running these engines then had to shut them down for lengthy periods while making repairs, losing the revenue from the electricity that the engines would normally generate. "Several of our customers were running into the same problem with this compressor blade and asked us if we could improve and fix the issue," said Page Strohl, former lead structures engineer for PSM. "Any new design that we developed had to fit into exactly the same envelope and to have the same aerodynamics as the original blades."

PSM designers and engineers worked together to model and simulate the original blade design, taking into account the aerodynamic and centrifugal loads. Using simulation, PSM located the highest static stresses in the

blade. In addition, PSM engineers determined that the blade design had several vibratory modes that were excited during engine operation that when coupled with the static stresses could result in failure. PSM's analyses predicted



Close-up of the maximum principal stress on the pressure side of (a) the original equipment manufacturer's and (b) the redesigned blades

that the blade would fail in the exact locations at which failures occurred in the field.

Using the ANSYS DesignXplorer tool to study a range of design variations, Strohl defined the blade parameters he wanted to vary, assigned acceptable parameter ranges, and identified the variables he wanted to optimize, which in this case were blade natural frequencies and peak steady stresses at several locations on the blade. Based on the peak stress locations, design space definitions were created. ANSYS DesignXplorer software redefined the CAD model and generated the series of design variations needed to carry out experiments for the entire range of parameters. Strohl then used the ANSYS Workbench environment to mesh each of these designs, solve the models, capture the results and perform the statistical analyses needed to identify the optimal design. Once Strohl identified an

optimal design, the aerodynamics team made minor design modifications in order to ensure that the design performed aerodynamically as required.

The resulting design reduced all peak steady stresses. The vibrational issues were eliminated as well with these design modifications. The blades are performing as expected and have been in operation since May 2008. Additional sets are now on order.

Strohl concluded, “Key to these improvements was the ability of the ANSYS Workbench platform to interface with our CAD system, allowing us to quickly prepare new geometries for analysis and to control the CAD system to explore a design space. We were able to quickly iterate to a design that was optimal, all while maintaining the same aerodynamic properties as the original design.” ■

Transitioning into the ANSYS Workbench Environment

ANSYS Advantage editors talked to J. Page Strohl, former Lead Structures Engineer for Power Systems Manufacturing in Florida, U.S.A., about his challenges in redesigning blades for turbomachinery.

You'd been a long-time user of the traditional ANSYS Mechanical interface. Did you have any hesitation transitioning to the ANSYS Workbench platform?

I found it hard to put down something that I was already comfortable and proficient with in order to start using something completely new. It wasn't until I attended an “Intro to ANSYS Workbench” training that I attempted to really utilize it.

When this compressor blade analysis came up and we were faced with a time crunch, I knew I could save time by taking advantage of the connectivity to Pro/ENGINEER® and the fact that the actual component settings stay with the model as it is passed from the CAD environment to ANSYS Workbench. By using this approach, the long lead tasks became the CAD modeling and the aerodynamic analysis efforts, not the structural analysis-specific ones.

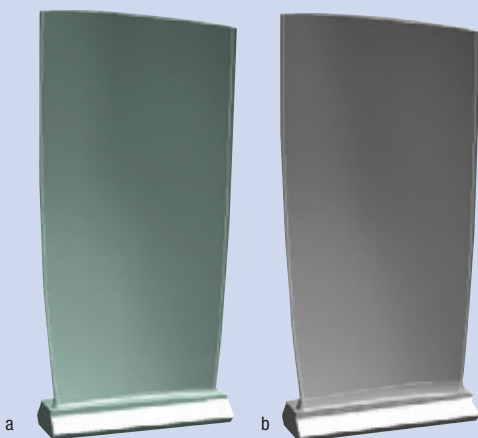
Has using ANSYS Workbench changed how you approach some of your projects?

I find that I look for projects that can take advantage of the ease-of-use benefits that ANSYS Workbench offers. PSM recently started a major redesign of another compressor airfoil and we jumped right into ANSYS Workbench and ANSYS DesignXplorer for it. I created the baseline model and showed the aerodynamicist how to duplicate it, regenerate a modified Pro/ENGINEER model, then solve and check the results. I actually gave my work away.

How did this new process work?

It was very easy to perform the simulation — a great benefit of ANSYS Workbench. If the geometry had problems reading in or didn't pass all of the built-in checks, I would slide my chair over to the aerodynamicist's workstation and take a minute or so and fix things. It was really a benefit in that I was able to do other work while we were in the iterative phase of the design. I, like many, am workload-challenged these days, and ANSYS Workbench helped to relieve me of that particular task.

From a larger project perspective, it gave the aero guy a good look at all the items that needed to be reviewed outside of his aero world. Several of my coworkers joke with me that my job consists purely of clicking the mouse button one or two times for an analysis job; they say that the hard ones are when I have to click the mouse three times. The real trick in this case was setting up the original baseline model. Once I did that correctly, it was a piece of cake to have someone else turn the analysis around with ANSYS Workbench.



Geometry of original equipment design (a) and modified geometry (b), as created using ANSYS DesignXplorer software