

Nabtesco Corporation

Industrial Equipment Case Study



Challenge

Design the most advantageous crowning for pinion gear teeth to minimize stress by increasing contact area and decreasing average contact stress.

Solution

The engineers at Nabtesco used Abaqus finite element analysis (FEA) software to calculate the contact area and stress of various pinion gear designs. With the help of their own subroutine, the engineers were able to model both contact area and stress history for easier design evaluation. Isight was also utilized for post-processing automation and design optimization.

Benefits

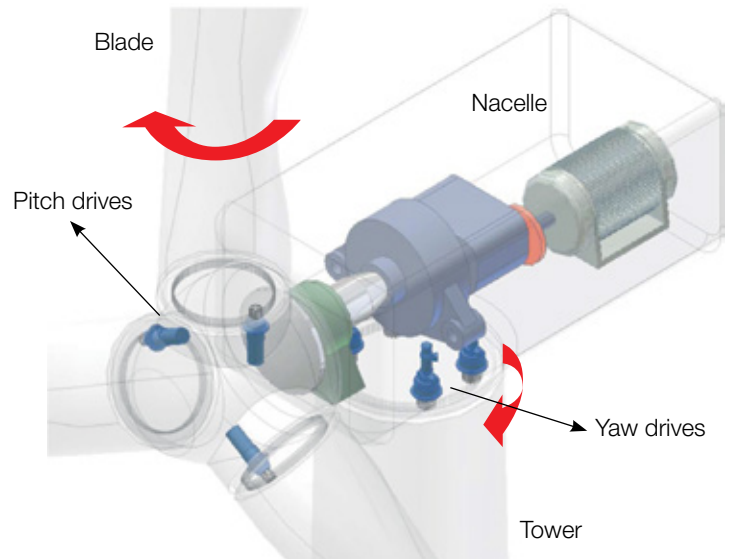
Abaqus allowed the Nabtesco engineers to maximize gear contact area, while minimizing average stress contact. This resulted in a significantly more durable gear design that led to decreased maintenance and cost without requiring numerous physical experiments. With Isight, the design time was reduced drastically.

Wind turbines have become an iconic symbol of alternative energy with their tall, upright towers and graceful, spinning blades. Choosing a proper site for the towers is certainly the starting point for maximizing the output of a large wind farm. But for the most efficient conversion of the kinetic energy of wind into mechanical energy, or 'wind power,' additional control over the position of each turbine's nacelle and blades is essential. This is the task of the yaw and pitch drives, which adjust the physical orientation of those components in response to fluctuations in the velocity and direction of prevailing breezes.

Located at the base of the nacelle, a yaw drive changes the direction which the nacelle faces. Where each blade meets the nacelle, a pitch drive changes the angle of the blades. Working in tandem, these computer-driven gear mechanisms automatically optimize the orientation of the turbine relative to the wind so power can be generated in the most efficient manner possible.

Gearing up for large wind turbines

Precision yaw and pitch drives for robotic reduction gears are a specialty of Nabtesco Corporation of Japan, known worldwide for unique technology that allows those components to be smaller and lighter than many conventional robotic drives. But when the company expanded into energy harvesting equipment, such as wind turbines and solar energy collector trackers, they realized that



Location of yaw and pitch drives on wind turbine.

'smaller and lighter' have their limits in large industrial structures. "Particularly in the wind industry, our biggest challenges are ensuring sufficient gear strength and long-term endurance in gusty conditions," says Kazuhiko Yokoji, CAE manager, CAE & material department, whose team provides computer-aided engineering (CAE) services for the entire Nabtesco group. "Our reduction gears are made up of a lot of very complicated assemblies, with many parts that come in contact with one another. For each wind turbine configuration, we have to provide our customers with the best possible design that minimizes overall stress while maintaining durability."

Every yaw and pitch drive in a wind turbine engages with a pinion gear, made from specialized treated steel, that transmits power from the drive to the nacelle or blade. In a huge wind turbine, the rotation angle between drive and pinion gear teeth is particularly small, so repeated contact over time—particularly under the 'routine' stresses of high winds and tower vibration—has the potential to damage tooth surfaces and cause assembly breakdowns.

Balancing contact for best performance

To minimize such hazards, the engineers strive to balance the contact between ring and pinion teeth so that the 'normal' stress of rotation and the shear stress of the teeth against each other are reduced. Decreasing the stress on teeth improves their durability—and that of the entire assembly as well.

computation time for this portion of the model, they created a submodel that contained only those areas of acute interest. When compared against the painted gear rig tests, the FEA results showed good agreement.

“We still wanted to get a complete picture of how the total contact area and stresses fluctuated over the course of the entire engagement processes,” says Yokoji. “This would provide us with the ‘big picture’ of contact history that we needed for evaluating tooth designs for durability.” So his team developed a proprietary post-processing

technique that employed an Abaqus user subroutine to show the history of how stress developed from the start of engagement, through changes in the rotation angle, to the end of engagement. Now they had a complete toolset to start fine-tuning individual pinion tooth shape.

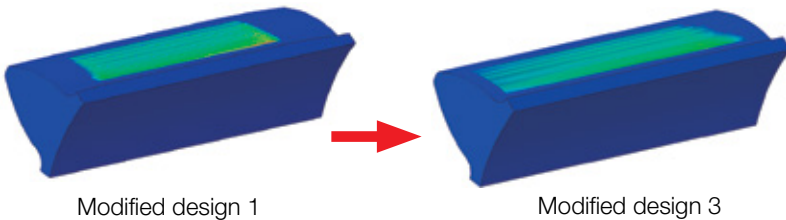
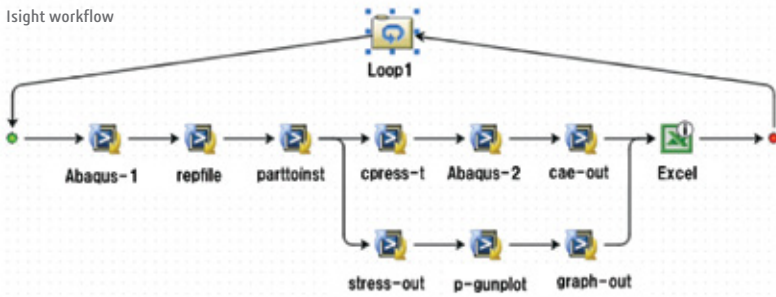
Optimizing the analysis with Isight

At this point the group turned to Isight process automation and optimization software, coupling their own in-house program for creating contact stress distribution history into the workflow. This allowed them to quickly generate clear results from huge result files and evaluate both the immediate (stress) and the long-term (strength/durability) consequences of every design change. They then plotted the results into three-dimensional stress distribution graphs that tracked all phases of gear engagement and let them see how modifying gear crowning contours affected overall performance.

“Our CAE workflow now enables us to optimize crowning of pinion gear teeth designs accurately and with far less manpower than before,” says Yokoji. “This method reduces design times dramatically.”

Nabtesco’s newly designed gears are just being introduced into the field and the company is gathering data to generate accurate comparisons with previous models. “We believe that there will be a significant improvement in durability,” says Yokoji. “Abaqus and Isight give us confidence that we can design durable gears that can stand up to the rigors of wind power generation.”

Isight workflow



Optimizing gears with Isight resulted in a design that lowered contact stress across the entire surface.



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