ANSYS®
CASE STUDY

ANSYS Helps Electric Motor Manufacturer Optimize Endshields

WEG INDUSTRIAS S/A

EXECUTIVE SUMMARY

Challenge:

To evaluate the endshields in an electric motor by analyzing design, load stresses during operation, and assembly, to achieve greater overall optimization

Solution:

Implement ANSYS® to perform design optimization testing and analysis

Benefits:

Reduce endshield aluminum mass

Improve die-casting conditions

Improve part removal from the endshield die

Reduce die manufacturing time, die wear, and maintenance

Increase machining speed

Automate shearing process

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Introduction

Facing increased worldwide competition, WEG Industrias S/A - Div Motores (www.weg.com.br) seeks to maintain its competitive advantage/market position by reducing costs and improving product quality throughout the company. Established in 1961, WEG today is the largest electric motors manufacturer in Latin America, with operations currently in over 60 countries on five continents.

To support WEG's global strategy, which is to become the world's largest electric motor manufacturer, every division within the company is committed to identifying ways to enhance product quality without increasing design or manufacturing costs. In the Motors division, engineer Alex S. Barbosa Passos met with his manager to discuss possible tactics for improving performance within their department.

Using the design optimization capabilities of ANSYS, Passos conducted a finite element analysis of the optimized geometry of DE and NDE aluminum endshields used in washing machines. Specifically, Passos wanted to examine the mechanical stresses placed on the motor during operation, and at the same time identify ways to streamline the production process and improve product quality - factors that would ultimately enhance overall engine performance.

In WEG's AC induction electric motors, windings are placed around the stator to produce a roughly sinusoidal distribution. When AC current is applied to the windings, it creates a rotating magnetic field.

"The best optimization results, in my opinion, consider material mass reduction, the manufacturing process, and assembly," said Passos. "ANSYS allowed us to study the different aspects of product design and the manufacturing process together, which gave us the data we needed to implement significant improvements."

Challenge

In WEG's AC induction electric motors, windings are placed around the stator to produce a roughly sinusoidal distribution. When AC current is applied to the windings, it creates a rotating magnetic field. The rotor (lamination and aluminum bars) is assembled on a shaft and supported by ball bearings inserted into the endshields, which allow it to operate. But during rotation, the rotor is unable to keep up with the stator's rotating magnetic field. The ball bearing allows the rotor and the bearing assembly to rotate on the endshields, which keeps the rotor working on the center of the stator. For this reason, the reliability of the endshield is critical to maintaining motor performance.

Because WEG had used ANSYS solutions successfully in the past, Passos and co-worker Marcelo Verardi selected ANSYS once again to conduct the endshield design analyses. To achieve their objectives, Passos needed critical information about several key areas of the proposed design, such as:

- Die casting
- Manufacturing and maintenance of die
- Shearing
- Machining
- Motor assembly

"We knew the most difficult part of this project was validating the finite element model," Passos

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"Results like this provide the momentum we need to achieve our corporate objectives and stay ahead of the competition."

said. "The reliability of the numerical results depends on the accuracy of the model, which requires precise software input data as well as information about application and machining forces." Because of its complexity, the project involved several steps to ensure that product and process requirements were addressed.

Solution

A geometry model generated by SolidWorks CAD was transported to the ANSYS software to perform the design simulation/calculations. Passos conducted the analyses using an Intel Pentium III 850 Mhz dual processor, 1GB of memory, 40GB MD SCSI, and a Microsoft Windows NT 4.0 workstation. Comparisons of the actual and proposed designs yielded significant findings.

Calculations using fluid flow equations showed that while both designs had the same hydraulic diameters, the proposed design had a smaller area from its thinner walls, meaning the amount of aluminum needed to manufacture each endshield could be reduced. "Results from our analysis of the die casting indicated that the new design allowed us to reduce overall aluminum mass in the DE and NDE-endshield by 18% and 27%, respectively," said Passos.

Since the proposed design matches the milling cutter diameter to the distance between the chuck fastening and cutting edge of a spherical finish-milling cutter, the die manufacturing can start and finish on the same machine tool.

By incorporating adequate closed planes, the optimized geometry of the proposed design supports automated manufacturing. "Since endshield burrs and risers are now located on predetermined planes," Passos explained. "The deburring process can be automated for faster production."

Because the proposed design changes the fastening positions and machining forces on the endshield, the cylindricity error (ovalization) occurring in the machining process is reduced. "We felt that if the amount of deformation occurring during machining could be kept the same along the whole cutting perimeter, there would be no ovalization problem," Passos said, "only a dimensional tolerance problem that could be easily eliminated. The smaller the

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bearing hub cylindricity error, the smaller the compression force that ovalizes the external bearing cap, which reduces the noise level and bearing wear, and ultimately increases the bearing's useful life."

To ensure the proposed design does not impact the assembly process, Passos used ANSYS to determine where the highest stress occurs during assembly. By isolating the area where force is applied, Passos found that the distortion in the contact area between the endshield and the bolt head does not affect motor performance since acting stresses are lower than the flow stresses of the actual material.

As a final step to validate the proposed design, Passos created a prototype to not only evaluate the machining and assembly processes, and motor performance, but also confirm the reliability of the ANSYS calculations.

Benefits

Using ANSYS, Passos was able to validate a new endshield design model that provides WEG with significant benefits in process optimization, manufacturing and maintenance, machining, and shearing. Specifically, the aluminum mass in the DE and NDE-endshield has been reduced by 18% and 27%, respectively. The die-casting system has been improved because the new design eliminates sharp edges and small concordance radii. Additionally, the extraction angle has been increased to 6.5 degrees, which has made removing the part from the die easier.

Die manufacturing time and maintenance have been reduced because the concordance radii have been custom-fit to the internal die radius, allowing the same machine tool to perform deburring and finishing. Die wear has also been reduced and maintenance checks are needed less often. Since the new design allows the endshield die to close in suitable planes, automated shearing in a robotic cell is now possible.

Because the new design does not require an intermittent cut, one unique polycristaline diamond-cutting tool can be used which expedites the machining process and increases overall productivity. In addition, this tool lasts longer than the previous hard metal tool and produces a better surface finishing of the endshield.

"With ANSYS, we were able to identify valuable process improvements that cut design time, reduced the number of prototypes needed and increased overall product quality," said Passos. "Results like this provide the momentum we need to achieve our corporate objectives and stay ahead of the competition."

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