SIEMENS

Consumer and industrial electronics

Miele

Using LMS Virtual.Lab Acoustics enables appliance manufacturer to reduce time-to-market

Product

LMS

Business challenges

Speed time-to-market

Penetrate global markets

Reduce product development time

Maintain reputation for producing high-quality products

Keys to success

Use virtual prototyping to predict radiated sound levels

Use acoustic simulation to design quietness early in the development process

Work with Novicos to implement LMS Virtual.Lab Acoustics

Uncover new sources of noise radiation

Results

Verified that new designs meet the company's high-quality standards

Compressed the time needed to develop quiet, innovative products

Siemens PLM Software solution helps Miele continue to produce high-quality washing machines

Reducing the noise

Instead of damping some of the noise with hit-or-miss changes and numerous prototype tests late in development, engineers now have a proven process for designing quietness into their products early in the cycle. This predictive capability radically compresses development time and is a key part of the company's strategy to deeply penetrate new markets with a broad range of machines soon to hit showroom floors around the world.

The outside of a washing machine is a deceptively simple looking metal box. But dynamic assemblies and subsystems are tightly packed inside, creating more potential sound sources than any other home appliance. So designing these machines to run quietly is an engineering challenge, especially trying to limit noise during the spin-dry cycle when high-speed drum rotation can set up intense vibrations that resonate throughout the structure.

Miele and Company KG (Miele), one of the largest family owned and operated appliance businesses in the world, is an expert in noise reduction. The German-based manufacturer is known across Europe for top quality appliances, and takes pride in the intensive work devoted to developing its high-end products. With plans to deeply penetrate global markets in the United States and Asia, Miele needs to quickly

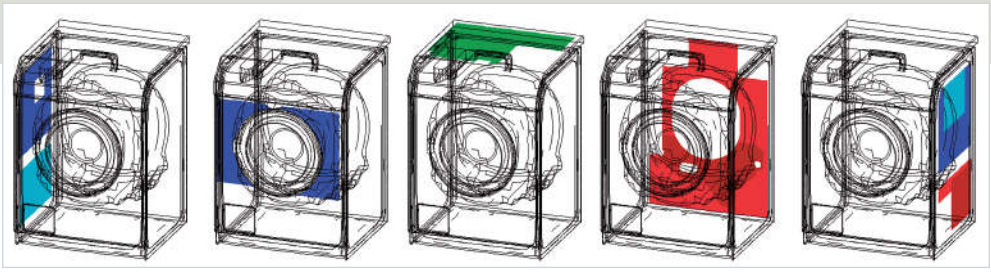
Results *(continued)*

Minimized sound levels by exploring the impact of a variety of factors

Arrived at optimally quiet design early in the development process

"From a purely engineering standpoint, having this broad range of analytical functionality in a single suite of integrated software enables us do the best possible job of predicting noise levels early in development and helping Miele quickly arrive at an optimally quiet design."

Olgierd Zaleski
Chief Executive Officer
Novicos GmbH



develop new models while maintaining its strong reputation for quality standards. To accomplish this aggressive business goal, Miele is moving beyond the time-consuming development methods traditionally used throughout the appliance industry, in which companies go through numerous physical prototype test cycles and make hurried hit-or-miss engineering changes late in design to damp out some of the noise. Instead, Miele is working with consulting firm Novicos GmbH to use virtual prototyping to predict radiated sound levels with LMS Virtual.Lab™ software, acoustics technology from Siemens PLM Software. This enables engineers to readily determine noise levels so they can use their expertise to modify washing machine dynamics to more effectively reduce sound levels early in development.

Speeding up development

Acoustic simulation technology is a critical element of this competitive strategy. Dr. Eduard Sailer, managing director at Miele, cites the important role of virtual prototyping in the company's plans for future business development.

"To build a strong presence in the global market, we absolutely must develop new models of appliances as quickly as possible while maintaining the same top-quality standard that has set us apart from competitors for over 100 years," explains Sailer. "The use of advanced technology is critical to this strategy. For example, using acoustic simulation enables our engineers to effectively design quietness into our new washing machine models early in the

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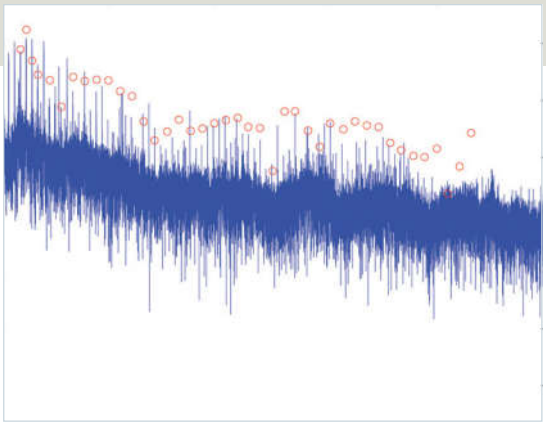
Hans-Walter Beckman
Senior Mechanical Engineer
Miele



development process through the use of virtual prototypes and computer analysis."

According to Sailer, these tools enable Miele to leverage the tremendous expertise of the company's technical professionals, who have exceptional experience in taking washing machines to the highest level of quietness, reliability and convenience.

"Use of advanced technology demonstrates our technological leadership position in the appliance industry and our continuing commitment to our traditional high standards of quality and customer satisfaction," says Sailer.

Accurately predicting sound levels

To assist in its acoustic simulation work, Miele has partnered with Novicos, a consulting firm specializing in noise and vibration for a wide range of clients, including Airbus, BMW, DaimlerChrysler and Volkswagen. The goal was to develop and benchmark a process that could be used systematically in Miele's development cycle to accurately predict sound levels early in the design of new washing machines.

As a first step, the project team devised static displacements and structural vibration modes of individual components, such as the motor and pump that are computed with finite element analysis (FEA). Next, the FEA results were transferred to nodes on a flexible multi-body dynamics (MBD) model, which accounts for imbalanced masses in the machine, centers of gravity, rigid body momentum, motor characteristics, the run-up profile and characteristic curves of springs, dampers, supports and door seals. This MBD analysis provides data on resonant vibration modes and transient structural response in the form of modal coordinates, thus representing the overall dynamic behavior of the entire machine. Output from this coupled FEA/MBD analysis is transferred to a script written using the MATLAB® environment and programs written by Novicos using Fortran. This custom interface translates the data into a form for direct transfer of Eigenvectors and surface velocity amplitudes onto the acoustic mesh using LMS Virtual.Lab™ Acoustics software. The software provides an indirect boundary element method (IBEM), which in contrast to conventional direct BEM techniques, can be used to perform a sound field analysis on unlimited areas of structures with free edges as well as branched surfaces.

In this manner, Novicos engineers use LMS Virtual. Lab Acoustics to accurately predict sound pressure levels surrounding the washing machine, with output displayed in a variety of graphic formats, including sound pressure distribution surrounding the machine at a given frequency, plots of sound amplitude at specified locations for a range of frequencies, or color maps showing major noise contributors by amplitude and frequency.

Verifying results

To verify the accuracy of the process, Miele and Novicos worked on an initial project in which they simulated sound levels for an existing washing machine and checked results against noise measurements. Miele measured sound levels from the machine at spin-dry speeds by recording sound levels from six time-series microphones and analyzing the signals to determine characteristic features of the acoustic emission.

"Optimization features are some of the most valuable capabilities of LMS Virtual. Lab Acoustics in working on the Miele designs. This technology allows us to minimize sound levels by exploring the impact of various factors, such as mount stiffness, wall thickness, motor placement, the gap between the frame and sidewalls, or location of sound-damping fleece mats."

Olgierd Zaleski
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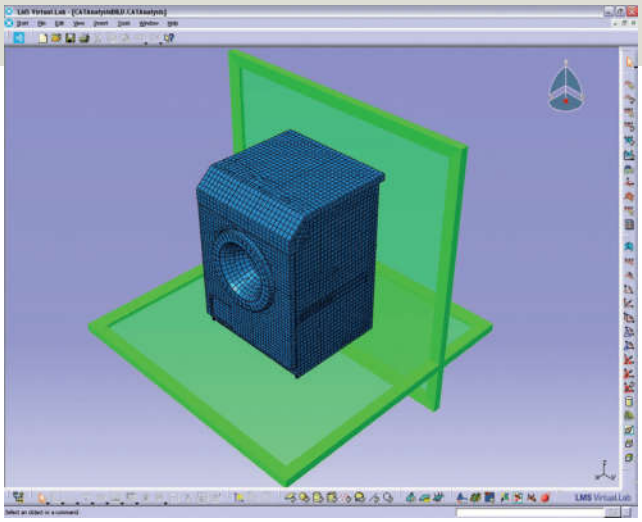

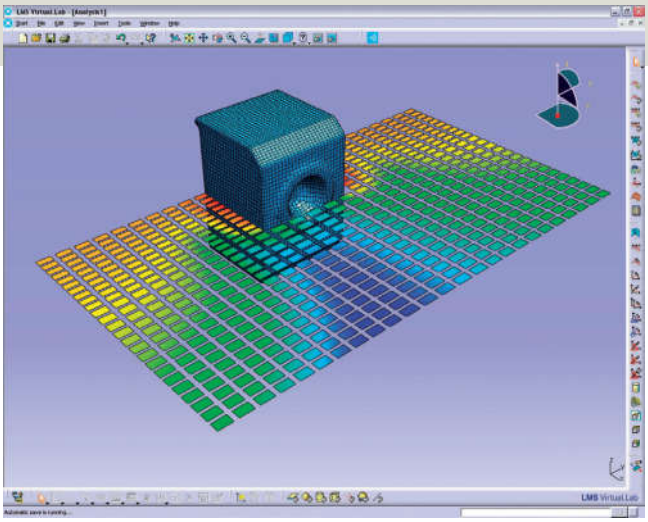

Hans-Walter Beckmann, a senior mechanical engineer at Miele who was in charge of the project with Novicos, says that Novicos computations from LMS Virtual. Lab Acoustics compared very favorably with measurements taken on the washing machine, thus verifying the accuracy of the approach.

"We have demonstrated the feasibility for simulating sound levels early in design and validated that such a process can support us in reliably predicting noise emissions of new washing machines," says Beckmann.

Beckmann explains that even though Miele strongly believes in the potential of virtual prototyping, empirical testing of hardware prototypes remains an important part of development.

"The LMS test software has given us years of excellent service and will continue in its vital role of verifying that new designs meet Miele's high-quality standards," says Beckmann. "We definitely consider acoustic simulation as a technology that can enable us to better direct our efforts in investigating noise issues with fewer tests that are more focused."

Saving valuable time

According to Beckmann, acoustic simulation has provided considerable insight into noise sources and how the sound is transmitted throughout the structure. One significant revelation for both Novicos and Miele engineers was discovering that the side panels transmitted more sound to the outside air than was previously believed, leading to further studies on placement of sound-absorbing materials.

"We've been working with these machines for decades, yet the acoustic analysis showed us aspects of noise radiation that we were not aware of," says Beckmann.

"Acoustic simulation can be extremely valuable in our product development cycle in predicting radiated noise and allowing us to easily make changes to reduce sound levels. Modifying the design and running a new simulation is orders of magnitude faster than building and testing physical prototypes. This can undoubtedly compress the product development cycle and thereby enable our engineering staff to develop many more new high-quality appliance models in far less time."

For competitive reasons, Miele justifiably guards exact details on time savings. However, in an industry in which top-of-the line washing machines may undergo five or six prototype testing cycles – with each cycle taking weeks – it is not unreasonable to assume that an appliance maker that is able to cut the number of cycles in at least half could shave several months of precious time off its development process.

Solutions/Services

LMS Virtual.Lab Acoustics
www.siemens.com/plm/lms-virtual-lab/acoustics

Customer's primary business

Miele is a world leader in premium domestic products such as cooking, baking and steam-cooking appliances, refrigeration products, coffee makers, dishwashers, laundry and floor care products. Miele also produces specialized dishwashers, washer-extractors and tumble dryers for commercial use as well as washer-disinfectors and sterilizers used in medical and laboratory settings.
www.miele.com

Customer location

Gütersloh
Germany

Leveraging leading technology

"Optimization features are some of the most valuable capabilities of LMS Virtual.Lab Acoustics in working on the Miele designs," says Olgierd Zaleski, the chief executive officer (CEO) of Novicos, who joined with Dr. Marian Markiewicz to spearhead the acoustic simulation work for Miele. "This technology allows us to minimize sound levels by exploring the impact of various factors, such as mount stiffness, wall thickness, motor placement, the gap between the frame and sidewalls, or location of sound-damping fleece mats."

Zaleski cites the ease and power of automated features in LMS Virtual.Lab Acoustics for setting boundary conditions with a single mouse click instead of having to perform multiple separate operations to define the envelope of the model, free edges, junctions and other conditions. Zaleski notes, "Automating these tasks speeds up the process, ensures that boundary conditions are properly set and guarantees that none are forgotten.

"We see similar benefits in using tools such as skinning the mesh and wrapping the mesh for more easily preparing the acoustic mesh based on geometry obtained from the FE model. This type of functionality enables us to create a high-quality mesh in a few hours instead of several days. In some cases, without these automated capabilities, building an accurate mesh representation wouldn't be possible because of the extremely large number of elements required for some detailed parts of the model.

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"From a business perspective, LMS Virtual.Lab Acoustics is unquestionably of immense value for us as a service provider for our customers, who reap the benefits of radically compressing the time to develop quiet, innovative, high-quality products that reinforce brand value and drive top-line revenue growth."

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