NOW HEAR THIS!

SIMULIA tools help improve product design and reduce development time for hearing-aid producer GN ReSound

Danish manufacturer GN Store Nord A/S is a global leader in sound processing. Producer of the popular Jabra line of wireless headsets, the company enjoys a rich history of technological advancements, beginning with its work in the telegraph industry in 1869. What was once the Great Northern Telegraph Company has since diversified, and today markets a deep portfolio of audio products across several subsidiary companies.

One of these is the GN ReSound Group, which designs and manufactures a broad line of hearing aids and accessories. Its mission is straightforward: to continuously develop solutions to help people rediscover hearing, so they can live rich, active and fulfilling lives.

That mission is on target: According to the World Health Organization, more than five percent of the world's population suffers debilitating hearing loss, measured as a reduction in sensitivity to sound of 40 decibels (dB) or greater. That's 360 million people unable to participate in a quiet conversation, or enjoy the gentle sounds of a rainy night. Nearly one-tenth of them are children.

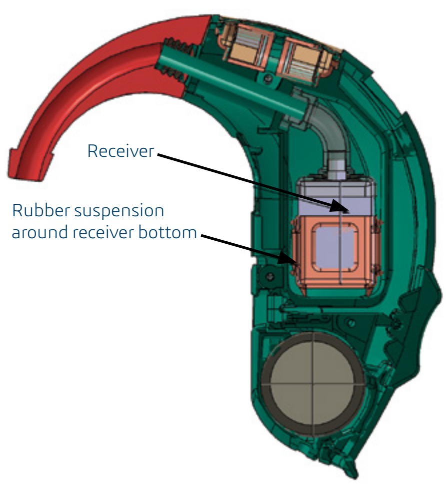

Figure 1. Anatomy of a hearing aid.

Of course there are far more people than that with some level of "normal" hearing loss, the most common cause being age—roughly half of all adults 75 years and older experience difficulty hearing—although head trauma, chronic ear infections, certain medications, tinnitus (ringing in the ears), and workplace wear and tear may all lead to loss of hearing. The good news is that most of these problems are easily solved through the use of a hearing aid.

GN ReSound brings high-tech to hearing aids. The days of bulky boxes and not-so-discreet cords have been replaced by sleek digital devices that fit in the ear or directly behind it, eliminating the stigma associated with Grandpa's clumsy analog trumpet. So too has sound quality improved, with noise-processing software that tunes out background clutter while providing a more natural and focused listening experience. GN ReSound even has an app for that, allowing the connection of Bluetooth-enabled smart phones and accessories to its line of 2.4 GHz wireless hearing aids. Simply put, GN ReSound helps people hear better.

SIMULATING A RIGHT FIT

Designing smaller, smarter hearing-aid devices is no easy task. It requires advanced product engineering and manufacturing techniques to fit sophisticated electronics into a package no larger than a fingernail. And even the best of designs can go awry once worn outside controlled laboratory conditions, where hearing aids are susceptible to environmental conditions such as heat and moisture, vibration, and impact damage. Testing against these failure modes is just one of the reasons why GN ReSound turned to Abaqus Unified FEA from SIMULIA, the Dassault Systèmes brand for realistic simulation.

As Morten Birkmose Søndergaard, Senior Acoustic Engineer at GN ReSound's Research and Development facility in Ballerup, Denmark, explains, "These days the development of hearing aids demands shorter time to market and higher rate of success in achieving all the requirements of each device. So it's very important to be able to reliably predict performance and improve designs early on in the process."

The GN ReSound team began using Abaqus in the R&D lab over 14 years ago. Simulation has since become a permanent task in the project plan for any new product rollout. "Without simulation," Søndergaard says, "it would be impossible for me and the team to do our jobs."

"Before Abaqus, we would have to use a trial and error approach to product testing. Now simulation helps us understand potential problems much more quickly, and improve the quality and robustness of our designs. We also have the opportunity to front-load a project with simulations to gain as much knowledge we can early on, giving us the best possible starting point."

JUST DROP IT—VIRTUALLY

One of these projects involved simulating a free fall of a BTE (Behind The Ear) instrument against a hard surface.

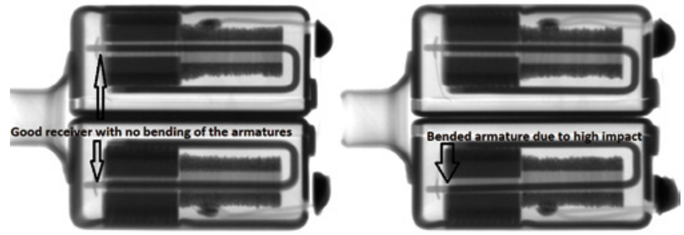

Image 2. X-ray of hearing aid receivers showing intact (left) and bent (right armatures).

The delicate mechanism responsible for high-quality sound reproduction—the receiver—is prone to damage when the hearing- aid device is dropped, a fairly common occurrence when swapping out batteries (see Figure 2). Søndergaard says understanding the results of accidents such as this is increasingly important as products become smaller, leaving less room for error when designing internal components.

The team split the test into two simulations. The first involved modeling of the rubber suspension that houses the receiver, isolating it from vibration and preventing feedback. This is also the primary protection against a fall. STEP files of the hearing-aid assembly were imported into Abaqus/CAE. Material attributes and mesh values were then assigned to the various components—in the case of the rubber suspension, mechanical stress-strain parameters were used together with the material's dynamic shear modulus. A "shrink fit" function was then applied to the suspension using Abaqus/Standard, virtually stretching the rubber over the receiver's rigid body to assess the rubber's viscoelastic behavior when placed in its intended position (see Figure 3).

The second simulation modeled the final two milliseconds of the BTE's free fall to planet Earth. By applying a velocity condition to the hearing aid model in Abaqus/Explicit, the engineers were able to calculate the g-force experienced by the receiver on impact, which beyond a certain level bends the tiny armature within, destroying its transmission capabilities. Engineers had previously determined the maximum allowable g-force at 14,000 g's, yet Abaqus quickly predicted that up to 15,000 g's of peak force was possible when striking at that velocity, well above the receiver's limit.

Image 3. Pre-deforming of rubber suspension. The deformed suspension is shown to the left and the undeformed to the right

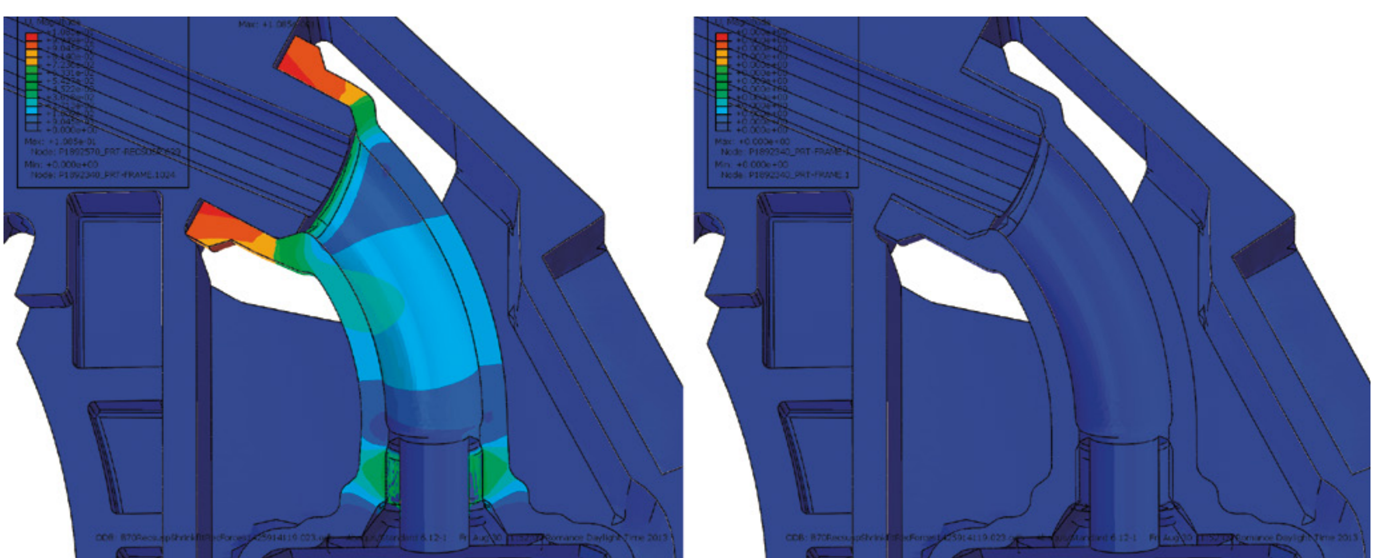

Image 4. High-speed video is used to record impact. Left photo is 0.9 after impact, middle is 0.1 after impact, right is at impact. Note motion of receiver at center of device.

Since there's no way to measure actual g-force inside such a small device, simulation results were correlated using high-speed video of the impact (see Figure 4). A number of impact tests were also conducted, repeatedly striking each side of the device using a pendulum to mimic drop force. In each instance, physical damage correlated to the simulated g-forces within Abaqus, thus validating the models.

LISTENING TO THE DATA

Product engineers were then able to use this data to redesign the area surrounding the receiver. "Even during the first simulation, we could see how the internal parts were moving around during the impact," Søndergaard says. "Abaqus increased our understanding of the problems, and gave me and the team new ideas of how to solve them." To further constrain the movement of the suspension and its precious cargo at the time of impact, several iterations of small rubber tabs were added, eventually giving the engineers a product that consistently reduced force to 11,000 g's.

There's more to receiver testing than watching for bent armatures. Vibro-acoustic tests are also required, since even a slight amount of deviation here may cause harmonic distortion, or even a feedback loop between the receiver and nearby microphones. Here, GN ReSound used SIMULIA's Tosca suite for structural optimization of rubber components, identifying the ideal topology that delivered the best vibro-acoustic stability.

Based on their recent successes, the team looks forward to expanding its simulation efforts with SIMULIA tools. "We have also tried Isight for process automation and design exploration, and I believe we will use both it and Tosca more and more in the future along with Abaqus," says Søndergaard. Future plans for simulation also include changing more of the rigid components in the BTE model into elastic-plastic ones, to better simulate behavior on impact, as well as further refine the material properties of models.

"Ultimately, it's about developing the very best products possible for our customers. SIMULIA's tools help us do just that."

—Morten Birkmose Søndergaard,
Senior Acoustic Engineer, GN ReSound

Future investigation is also planned to query several assumptions made in the initial tests, including the use of a fixed "tie" between the suspension and receiver that bypasses unknowns in the friction coefficient between the two materials. Also, the "hit" on the test device was made at the exact same point and direction in each simulation, eliminating variance that may be a factor in real-world conditions and should be included in later analyses.

"Simulation has proven to us that it's quite capable of handling the complexity of our hearing aids, and I'm confident we can work with even bigger models without any issues," Søndergaard says. "Tools such as Abaqus and Tosca have definitely helped us to be more innovative. They increase the speed at which we can build new models more precisely and increase our understanding and knowledge of the challenges."

"The faster you can make a good model, the more it benefits the project overall. This is important, because the acoustic technology we're developing today will be used in hearing aids a year or two from now. Ultimately, it's about developing the very best products possible for our customers. SIMULIA's tools help us do just that."

For More Information

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