

MAXIMIZING PRODUCTIVITY FOR GORENJE WITH RAPID NOISE MAPPING

The sound quality of home appliances is a critical competitive factor. In addition, white goods manufacturers must measure the sound levels of their appliances to the relevant standard. When investigating sound sources was taking too much time in their busy anechoic chamber, Gorenje looked to increase efficiency with a quicker characterization system.

gorenje



CHALLENGE

To maximize the productivity of research time in Gorenje's anechoic chamber, by minimizing the time required to investigate the sound sources on white goods of varying sizes and types.

SOLUTION

A bespoke, portable microphone array coupled to a data acquisition system optimized for rapid, easy setup and fast identification of noise sources

RESULTS

- Significantly reduced test time
- Increased research throughput
- Better appliance sound quality

BACKGROUND

Gorenje Group is one of the leading European home appliance manufacturers with a history spanning more than 60 years. The headquarters and main production facility are located in Velenje, Slovenia. Their home appliances elevate the quality of living in ninety countries around the globe, and are sold under the brands: Gorenje, Gorenje+, Atag, Asko, Pelgrim, Mora, Etna, Körting and Upo.

The group has an enormous range of white goods products, with over 1700 varieties of refrigerators alone. Speed and efficiency are of the utmost importance, and Gorenje is continually searching for ways to reduce costs. In one example, a new vibration isolator was introduced because it saved one Euro per washing machine, on an annual production run of three to four million units.



Sound quality is an essential parameter for modern white goods, and a critical differentiator. In addition, in order to sell goods in the EU, Gorenje must make sound power measurements on all of their product types. They use a hemi-anechoic test chamber that is consequently in use 24 hours a day. For approximately 80 percent of the time, Gorenje's engineers use the anechoic chamber for standardized sound power measurements on finished products, to ensure their compliance with the relevant ISO standard. During the remaining 20 percent of their time, Gorenje's acousticians are troubleshooting unexpected events, or performing R&D.

Gorenje's acousticians sought to increase their testing productivity, and since building an additional anechoic chamber was out of the question due to space and cost restrictions, they sought a technical solution.

Sound standards for white goods

Gorenje is a member of European Committee of Domestic Equipment Manufacturers (CECED) which represents the household appliance industry in Europe. In 2012, the members of CECED agreed on a common basis for noise declaration (sound power levels) for Europe based on standards EN60704-1, EN60704-2-X and EN60704-3.

CHALLENGE

When not performing standardized sound power measurements – during the remaining 20 percent of their time – Gorenje's acousticians perform R&D. This is when the team needs more understanding of the sound, such as after a component has been changed. Dr Nikola Holeček, the Head of the Acoustics Department at the Gorenje site in Velenje, Slovenia says: "It is here that we saw we could greatly improve the efficiency of our processes. For example, we wanted to assess the influence of different mitigation measures taken on the electric motor of a washing machine. These are the type of measurements that are more time-consuming and we often need a few days or a week to conduct them."

However, R&D tests are also the ones where Gorenje needed to quickly find an appropriate solution, in order to maintain manufacturing productivity. To broaden their resources, Gorenje had used external consultants to help with more extended research. However, they found that these more academic pursuits took more time than they could afford, with consultants that had limited time available. Gorenje wished to achieve a faster overall response from when they initiated research in the field of sound emission, and needed to speed up the execution of measurements.

Diverse, complex, moving noise sources

The white goods that Gorenje must test can vary in size from two-metre-high refrigerators, to microwave ovens, to dishwashers. In some

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cases, the location of the sound sources moves as the machine operates. In addition, these are all complex noise sources that comprise a larger number of elementary sources. These diverse factors must be confidently dealt with. As Nikola says: "In order to reduce the noise we have to be able to identify and locate the dominating noise source and define and describe it in both the time and frequency domains."

Previously, Gorenje used a sound intensity probe together with a robotic positioning system, but this discrete point method was time-consuming and only suitable for stationary noise sources.

SOLUTION

Brüel & Kjær assessed Gorenje's needs and designed a system to meet them that features a new microphone array. With many different home appliances and diverse tests, Gorenje is interested in a wide frequency range, so the array is optimized for frequencies from 200 Hz to 3 kHz. The array is rectangular to effectively cover objects that are normally rectangular, and can quickly be adjusted up and down on its tripod to allow testing of objects at different heights. Its built-in camera – located in the middle – allows Gorenje's acousticians to accurately relate the resulting sound maps to the correct parts of the physical test object.

The array allows a mixture of measurement approaches that reflects the needs of Goren-

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je's experts. According to Nikola, "When we do measurements, we always start from the far field, so we use beamforming. Then, for even more information we continue with the use of wideband holography and near-field acoustic holography." The microphones in the array are irregularly spaced, to allow the same array to be used for these different disciplines. As Nikola says, "This new equipment brings us a gigantic advantage in relation to the execution of our measurements, and the data acquisition system is simple and reliable."

RESULTS

Easy understanding

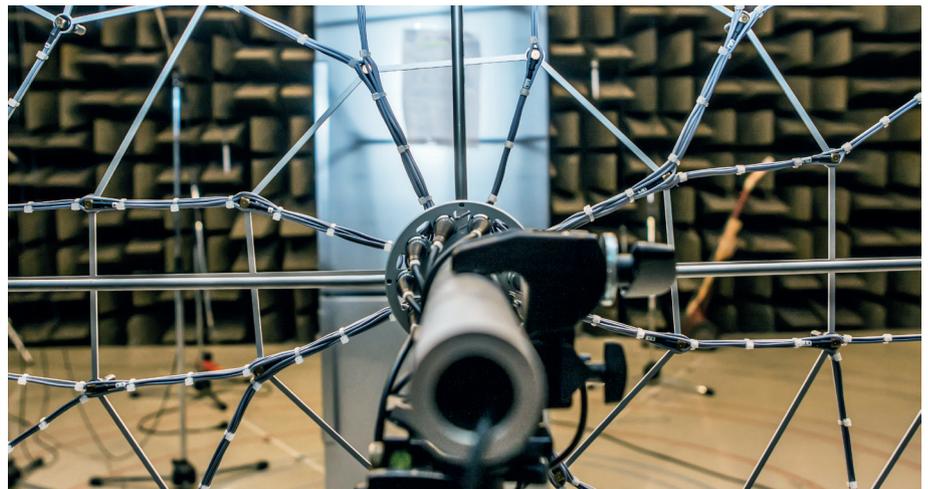
Gorenje can now measure and map domestic appliances much quicker than they previ-

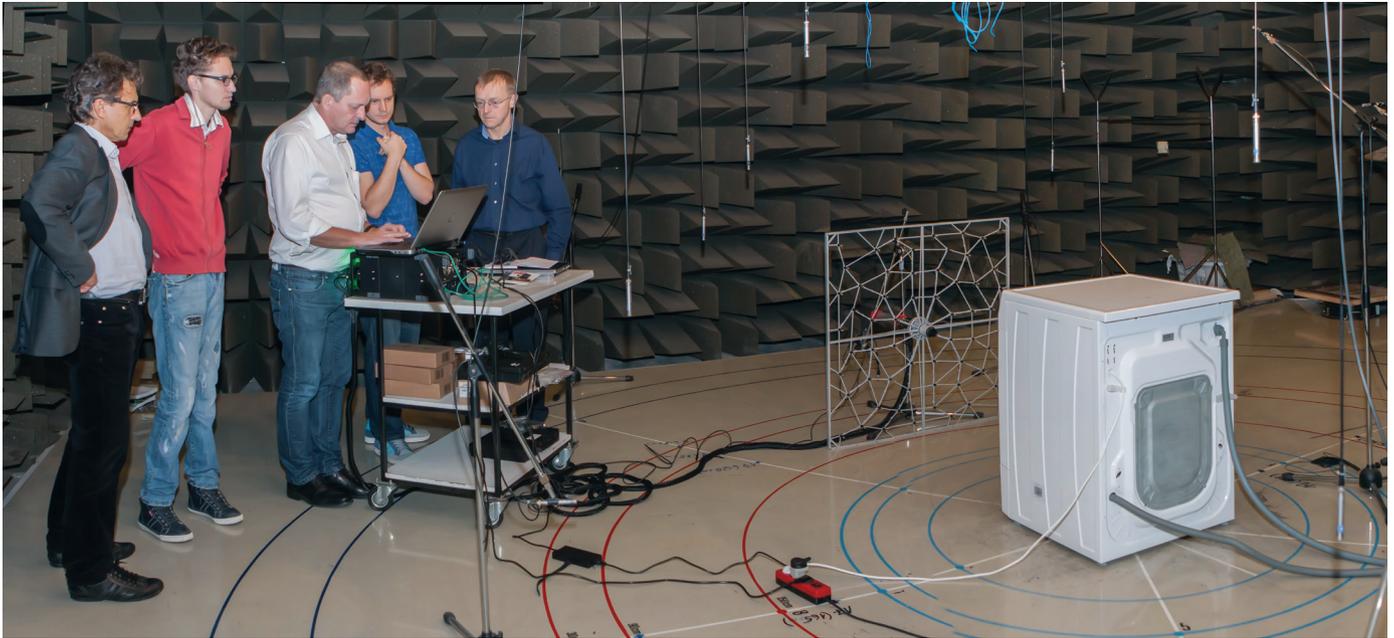
ously could with the sound intensity probe technique. "The speed, repeatability and accuracy of the measurements has increased drastically," says Nikola. "Now, measurements that used to take multiple hours can be done in seconds or minutes."

Easy sound visualization is a vital aspect of this, as Nikola says: "On appliances that have complex sound sources, we have to identify elementary sound sources. The visualization of the sound field leads us intuitively to the localization of each sound source. Visualization has enabled us to clarify some complex technical dependencies, and confirm our assumptions about dominant noise sources on the machine. This has also reduced the strain on the staff."

During site acceptance testing, an overview of the noise radiation from a refrigerator was obtained using beamforming, which revealed the compressor system as the main noise source. By moving the array closer and employing wideband holography, the spatial resolution was improved, showing the noise generation from the capillary tubing and the radiation patterns from the compressor itself

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During testing of quasi-stationary noise produced by a microwave oven, a few seconds was sufficient to obtain an overall sound power spectrum. For the washing machine, a measurement time of several minutes was used, to cover several phases in the washing cycle

These clear results have led to improved sound control and mitigation approaches as well. Here is Nikola again. "On some machines we have improved partial sources and also added additional sound insulation. We wanted to optimize existing insulation. We have done this by ensuring it is in the right place, and rearranging it if it is not. And sometimes by actually reducing it!"

Greater test efficiency

As before, Gorenje's acousticians work 16 hours per day, and use the acoustic chamber 24 hours per day. However, the productivity of the acoustic chamber during the 20 percent of the time reserved for noise source research has increased. Consequently, Gorenje now uses their noise source location equipment substantially more than before.

More time allows more research, which results in better sound quality for Gorenje's products. This is a vital advantage. As Nikola says: "To

lead the field in an ever more competitive market, every 1/10th of a dB counts."

CONCLUSION

Gorenje has significantly increased the efficiency of their finite resource: the 20 percent of the time when their anechoic chamber works on research. This has been achieved with a complete sound data acquisition and analysis system from Brüel & Kjær that was configured to meet their needs, based on the assessment of Brüel & Kjær's acoustics experts.

Gorenje's Head of Acoustics, Nikola Holeček, is pleased with the investment, which is set to keep paying back for years to come. "Brüel & Kjær has compact and robustly manufactured measurement equipment that can be used for decades," he says. "In these times of fast changes in information technology this is a very important element, because equipment that is not intended for a longer lifetime, is often sold. Brüel & Kjær measure-

ment equipment is intended for professional use without compromise."

Beyond measurement hardware and software, the training and support received by Gorenje to help establish their solution has also been essential. "Without the training, the entire project would be less successful," concludes Nikola.

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*Nikola Holeček,
Head of the Acoustics Department, Gorenje*

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