

LMS helps BSH Bosch und Siemens Hausgeräte GmbH dish up superior dishwashers

BSH Bosch und Siemens Hausgeräte GmbH chooses LMS as its preferred partner for acoustic dishwasher testing



Huge robotic arms move in precise synchronicity as they place the shiny metal sheets into the molds from which they will emerge as stainless steel dishwasher tubs, ready to move to the next station in the impressive BSH assembly line. Located in Dillingen, Germany, it is the biggest dishwasher plant in the world – approx. 2 million dishwashers are produced here annually. From the smallest component to the motor, BSH manufactures the entire dishwasher completely from scratch. And even the highly automated assembly line is BSH-made. The company has a dedicated department that designs and develops the assembly line and its machines. While many competitors moved production to low-cost countries, BSH is one of the few companies that still has a production of dishwashers in Germany. Committed to superior quality and with over 200 engineers working on dishwasher development in the competence centre in Dillingen alone, BSH produces dishwashers of the highest standards and with the latest and most innovative design.

Careful balancing act

While delivering clean dishes is still the ultimate goal, dishwashers nowadays have to live up to ever-demanding customer expectations and different design requirements. Engineering and manufacturing a dishwasher has thus become a careful and often tricky balancing act between performance, cost, energy efficiency, acoustics and esthetics. For instance, dishes will be cleaner when the water is applied with higher pressure, but more pressure generates more noise and poses acoustic challenges. Using less water

is more energy efficient yet it might not leave dishes completely spotless. In other words, a lot needs to be taken into consideration when designing a dishwasher.

In recent years, dishwasher sound quality has gained considerable importance. New trends in kitchen design have forced kitchen equipment manufacturers to address the noise produced by their appliances. In open kitchens, kitchen appliances have turned into functional furniture that not only needs to work impeccably, it is also supposed to correspond esthetically with the chosen decorating style and operate as silently as possible. In fact, the absence of annoying operating noises has become a critical brand attribute that is heavily promoted in marketing campaigns and that household appliance producers can no longer afford to ignore. Dedicated acoustics departments therefore concentrate on finding ways to reduce appliance noise levels and optimize acoustic performance.

Advanced dishwasher acoustics

Improving the sound quality of their dishwashers receives careful attention at BSH. The acoustics department is responsible for a wide variety of tasks. They are involved in all pre-development projects, perform acoustic measurements, and carry out absorption material testing among many other things.

“We are continuously developing new features and enhancements for our dishwashers. Since we have over 1800 variants on three different platforms, we are constantly innovating. It goes

without saying that we need the latest and most efficient acoustic testing systems to keep up with the ever-shortening development cycles while continuing to deliver high-quality test results. The growing importance of acoustics and shorter time span in which we have to carry out measurements, made us look into acquiring a new testing system to accelerate our testing processes and create a more uniform platform,” commented Bernd Schwenk, Dipl.-Ing. (FH), Pre-development engineer for Acoustics in Product Area Dishwasher at BSH.

In their search for advanced sound engineering solutions to reduce the sound power level of their dishwashers and decrease manufacturing costs, BSH turned to LMS. With a unique portfolio of integrated solutions for test-based engineering and simulation software as well as engineering services, LMS proved to be the perfect innovation partner that could help BSH troubleshoot its acoustic issues, accelerate its product development and reduce production costs thanks to optimized designs.

How to silence a dishwasher

Lowering the noise produced by a dishwasher can be done in many different ways: building solid foundations to minimize vibrations, using independently isolated components, applying rubbers straps to suspend motors and pumps, or adding damping materials. Before the noise can be controlled and the sound engineered however, it is crucial to determine where the noise is emanating from and what is causing it. Once the noise sources have been identified, a targeted approach can be adopted.



Tackling unwanted sound

BSH asked LMS to help them decrease the dishwasher sound power level, optimize overall acoustic performance and lower production costs by reducing damping material. LMS Engineering Services worked together with the BSH acoustic engineers and performed an acoustic survey, a panel contribution analysis and a damping modification evaluation. An acoustic survey of a dishwasher consists of various crucial steps that help locate the sound sources. These steps include a subjective evaluation, a spectrum analysis with motor run-up, source analysis, a water drop impact analysis and a water reservoir noise generation analysis.

With the data from the acoustic survey, solutions can be found to address the various noise sources that have been discovered. One way of tackling the unwanted noise is applying damping material to the dishwasher parts that vibrate and generate too much sound. In this respect, the tub side panels are especially problematic. Vibration of these thin plates during operation moves the surrounding air and thus creates noise. To augment the acoustic performance, it is critical to know which of these metal sheets contribute most to the sound pressure level produced by the dishwasher.

To perform a contribution analysis, LMS uses a method called ASQ (airborne source quantification). While ASQ is a method that LMS uses mostly on cars, it can just as effectively be applied to other products such as dishwashers.

With this particular approach, the accelerations of the tub side panels are measured in operating conditions. The plates are divided into patches and equipped with accelerometers. The produced sound power level is then measured with microphones in various target positions. Next, the acoustic frequency response functions (FRFs) that characterize the path between the target position and patch are measured and averaged to calculate the partial sound pressure level for each specific plate.

After processing the data, it became clear which panels contributed most to the noise generated by the dishwasher. It thus also became clear which panels needed to be treated with bitumen (damping material) and which panels did not need extra damping material since their contribution to the overall noise level was limited.

“Thanks to the plate contribution analysis, LMS helped us optimize the overall acoustic performance of our dishwasher as well as reduce production costs by identifying the panels for which a bitumen treatment could be decreased. With more than four million dishwashers produced per year, using less damping material meant that we could significantly cut costs,” noted Mr. Schwenk.

Adopting a one-platform approach for acoustic testing

After the successful LMS Engineering Services projects, BSH decided to invest in the LMS Test.Lab Acoustics portfolio to create a homogenous environment in which to carry out their acoustic testing

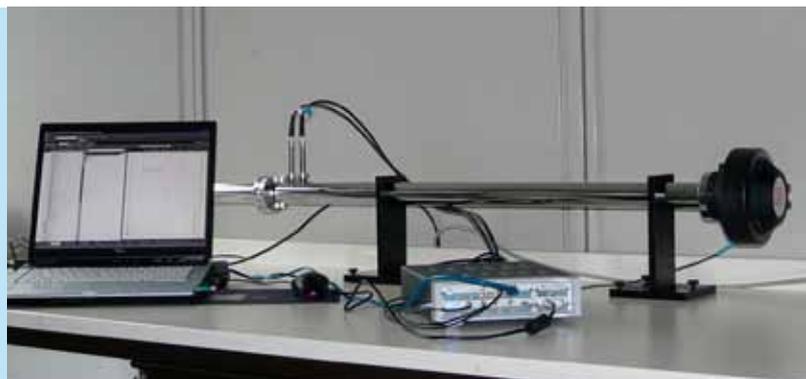
projects. LMS Test.Lab Acoustics offers a complete and unique suite of software and hardware solutions for acoustic testing and analysis and covers many applications such as straightforward acoustic testing, material and component testing, sound power testing, sound source localization and sound quality testing. Performing measurements in an integrated software environment and in one workflow greatly improved the efficiency of the BSH acoustic department and saved a lot of time and effort.

“We now use LMS Test.Lab for all our noise measurement tasks: we have one testing system that everyone can work with and that makes exchanging data easy and effective. This is a big step forward for us. Previously we worked with four different systems, which was time-consuming and complex. With the LMS Test.Lab suite, we only need to know how to operate one single software platform. We have a homogenous development environment and this has greatly increased our measurement output and simplified post-processing and reporting,” stated Mr. Schwenk.

“LMS Test.Lab is very intuitive and easy to learn. The platform is flexible and particularly fast when you want to focus on a measurement detail or when you need to obtain information from the test results. We now only have one software platform and database, which definitely makes testing much more straightforward,” added Mr. Stefan Lukschnat, who works for Appliance Design in Product Area Dishwasher at BSH.

“LMS has helped us take the leap into simulation so we can design and produce even more energy-efficient, high-quality and quieter dishwashers.”

Mr. Bernd Schwenk, Dipl.-Ing. (FH), Pre-development engineer for acoustics, Product Area Dishwasher, BSH.



Material testing in a flash

Especially the LMS impedance tube proved to be highly effective in verifying the acoustic characteristics of absorption and damping materials. In the pre-development phase of a dishwasher, engineers test many materials to determine how suitable they are for sound damping and insulation. The impedance tube may be used to determine the normal incidence complex acoustical impedance and absorption coefficient of a material, each as a function of frequency according to ISO 10534-2 and ASTM E1050.

Measurements are conducted by inserting a small sample of the material under test into a sample holder that is mounted at the end of a plane wave tube. The LMS Test.Lab Absorption testing impedance tube application is used to acquire complex transfer functions (FRFs) between a pair of closely-spaced microphones flush-mounted in the tube wall while the sample is exposed to random noise from an acoustic driver mounted on the opposite end of the tube. The plane wave tube is a carefully machined instrument for the accurate measurement of sound pressure amplitude and phase. The tube is made of dense, highly damped materials making it superior to thin-walled aluminum tubes used in other systems. The tube is so well sealed that it may be used in a noisy factory environment.

“Material testing is very important to us because we need to determine which the best passive material is to reduce the dishwasher noise. On a yearly basis, we test on average about 70 to 80 material samples. Before it took us almost one hour to test the acoustic properties of one material; now we can do it in five minutes. The great advantage of the LMS impedance tube is that it is easy to use – the set-up time is very short – and it gives exceedingly fast results,” asserted Mr. Schwenk.

One unique solution for a wide variety of acoustic tests

Besides applying damping and insulation material, BSH also increases the dishwasher sound performance by decoupling components to avoid that one vibrating component would excite

another. With two measurement cabins, the BSH acoustic lab is well-equipped to perform all kinds of acoustic testing: sound source localization, sound intensity and sound quality, and sound power testing. LMS Test.Lab Acoustics provides BSH one unique solution to perform all these different acoustic tests. Since BSH tests the entire washing cycle, measurements take on average about two hours.

The declared sound power level from dishwashers is an important specification and the testing procedures are defined in IEC 60704-2-3. At BSH, two LMS Test.lab systems are used to execute sound power tests in a reverberant room (ISO 3743-1) and a semi-anechoic room (ISO 3744).

“While we cannot speed up the actual measurement time, we gain time in the data processing and analysis with LMS Test.Lab Acoustics. Since we worked with multiple testing systems before, it was very complicated to make advanced analyses and we were limited in what we could conclude from the different data sets. With LMS Test.Lab, we can perform advanced analyses on the measured data such as determine frequencies of the dishwasher and of separate cycles, split cycle noise in different frequencies and recognize noise sources,” noted Mr. Lukschnat.

Leaping into simulation

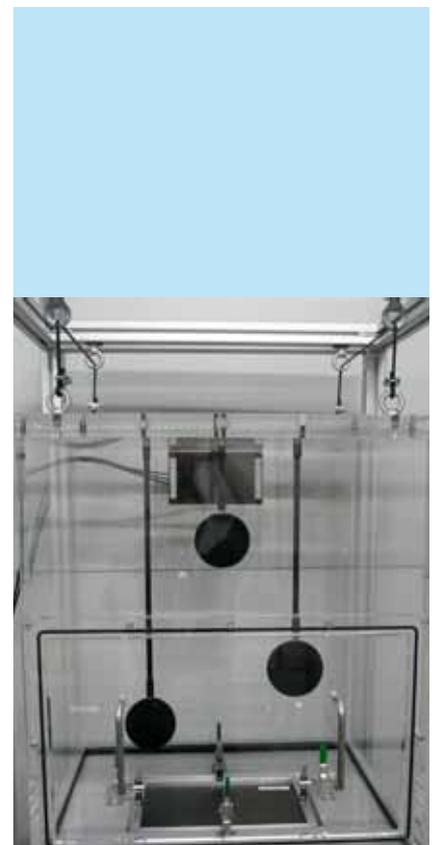
Since the successful implementation of LMS Test.Lab Acoustics, BSH is now also looking into expanding its acoustic research with simulation. Recently, it acquired LMS Virtual.Lab Acoustics to model the major sound source in a dishwasher: the stainless steel tub. LMS Virtual.Lab Acoustics is a unique solution for acoustic performance engineering from concept development and design refinement using virtual models to test-based validation.

“Simulation helps us make well-informed choices during the dishwasher concept stage, and systematically refine and optimize our dishwashers’ acoustic performance. It reduces our reliance on expensive physical prototypes and lets us try out different configurations,” maintained Mr. Schwenk.

Staying ahead thanks to an innovative partnership

Energy efficiency and design will be the key words for future dishwasher innovation. Reducing the water consumption and developing more eco-friendly and silent dishwashers that fit esthetically in the kitchens of tomorrow, will be the critical challenges for BSH dishwasher engineers.

“As the market leader for dishwashers, we need to always stay one step ahead of the competition and continuously innovate. Thanks to LMS, we were able to decrease the amount of acoustic absorption material in our dishwashers, increase their sound quality and, as a result, strengthen our market position and reduce costs. LMS has helped us take the leap into simulation so we can design and produce even more energy-efficient, high-quality and quieter dishwashers,” concluded Mr. Schwenk. ■





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