Silencing the Dishwasher in the Drawer

The old adage that children should be seen and not heard applies equally well to today's generation of home appliances, where quietness is a "must-have" quality. With competitive pressures bearing down and a time crunch in developing a whole series of low-noise dishwashers, New Zealand's Fisher & Paykel teamed up with LMS Engineering Services in some fast-turnaround detective work that quickly lowered radiated noise in time to meet tight product launches.

Think outside of the box. That's what engineers at Fisher & Paykel Appliances did when they came up with the world's first dishwasher in a drawer. The DishDrawer® consists of two completely independent dishwashers. Put delicate crystal in one drawer and heavily soiled pots and pans in the other, then customize the wash in each drawer – or only use a single drawer to economically wash a small load. Drawers can even be located separately, such as on either side of the sink. A flagship product of the company, the DishDrawer has won numerous design awards, sold over 1 million units since its introduction and earned an energy star rating for meeting the strict energy efficiency guidelines set by the U.S. Department of Energy and Environmental Protection Agency.

Behind the appliance's market success and compact styling is impressive technology and considerable engineering effort. Smart electronics automatically adjust water pressure, temperature and wash duration according to load requirements. The high-efficiency pump has an integral, variable-speed, brushless, direct-current motor: an innovation pioneered by the company to reduce part counts, fit in a small space, lower energy consumption, and provide quiet operation for home appliances. A lid automatically lowers to seal the top of the tub when the drawer is closed.

Brand Image on the Line. Within the DishDrawer, vibration damping materials are used along with thermal insulation for noise control. Drawer seals provide an added sound barrier to limit acoustic radiation. Indeed, the DishDrawer boasts incredibly quiet operation that lets you easily carry on a conversation in the kitchen while it's running.

With this first-class brand image on the line with each new model, noise and vibration engineers at Fisher & Paykel are sticklers who constantly strive for lower sound levels. To test noise levels, Fisher & Paykel has an anechoic chamber and extensive systems of microphones and accelerometers. During several prototype testing cycles, engineers count on their decades of experience in modifying the design and strategically positioning vibration damping materials until sound levels are acceptable.

Under a Time Crunch. Due to time constraints, the normal prototype testing cycles were considered a somewhat inconvenient necessity. But in late 2008 – with intense competition and the global economy spiraling downward – engineering schedules were particularly tight for hitting the release-to-manufacturing, design-freeze dates for upcoming new models. At the top of the list was the new Tall DishDrawer featuring a significantly higher tub for larger plates, a completely redesigned racking system, styling upgrades – and incredibly quiet operation.

Figure 1. Fisher & Paykel's DishDrawer®.

With timelines cut short, Fisher & Paykel contacted LMS Engineering Services to help lower the sound level of the new dishwasher model as much as possible before starting production. With the clock ticking, LMS had only a short time to identify noise sources and determine the best control modifications. The project was a collaborative partnership between Fisher & Paykel and LMS, leveraging the expertise of both to arrive at optimal noise reduction.

Pinpointing Noise Sources. In the first phase, LMS engineers used LMS Test.Lab acoustics to perform a survey where six microphones were positioned 50 cm from the dishwasher to measure sound pressure levels during the complete operating cycle. At the same time, arrays of accelerometers spaced at 10- to 15-cm intervals measured vibration throughout the machine's interior. Using spectral analysis, LMS Test.Lab then generated a color map of vibration amplitudes vs. frequencies for these areas.

Next, speakers were placed around the dishwasher to generate broadband white noise, and reciprocal frequency-response-function (FRF) measurements were made inside the dishwasher. Transfer-path analysis (TPA) and acoustic source quantification (ASQ) capabilities of LMS Test.Lab then determined the vibration paths through the dishwasher and pinpointed the greatest sources of noise.

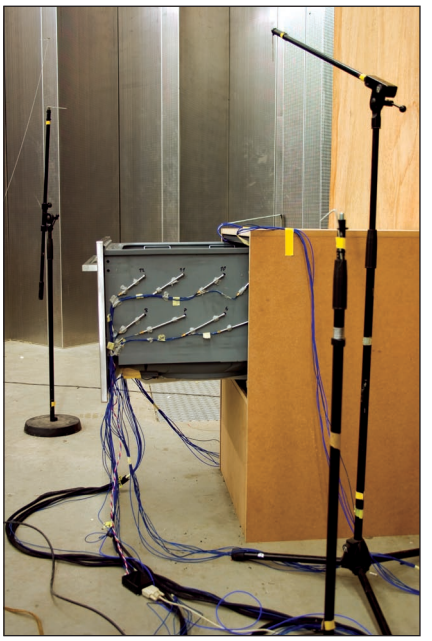

Figure 2. LMS engineers used LMS Test.Lab to perform an acoustic survey using an array of 6 microphones. At the same time, additional microphones localized the background noise levels during operation.

"With these reciprocal measurements, TPA and ASQ work backward to determine where radiated noise came from at various frequencies during normal dishwasher operation," explains LMS Engineering Services project leader Olivier Kirten.

"Two major noise sources were pinpointed. At higher frequencies from 300 Hz, the biggest contributor was the tub lid, excited by water jet spray during the wash and rinse portions of the cycle. At lower frequencies of 200 Hz and below, pump noise radiated through the front door."

Noise Control Treatments. In the second phase of the project, LMS engineers studied the effect of various noise abatement modifications. These methods were based on their experience and background with a wide range of acoustics projects in various industries, including automotive, construction equipment, aerospace, industrial machinery, and recreational equipment, to name a few.

An extra layer of asphalt mastic vibration damping material added to the tub lid decreased noise levels by more than 35%. Rubber strips placed between the pump and a filter on the underside of the tub elimi-

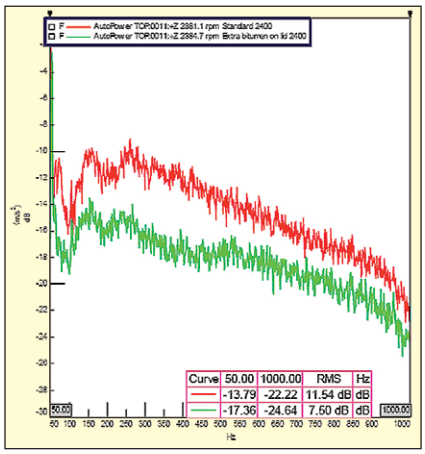

Figure 3. An extra layer of vibration damping material decreased noise levels more than 3 dB from the tub lid.

nated virtually all noise spikes produced by the five pump impellers. Modifications to the ventilation hole at the rear of the unit showed that adding a one-way flapper valve could potentially reduce noise levels by 0.5 dB. Silicon sealant added between the frame and door seal eliminated acoustic

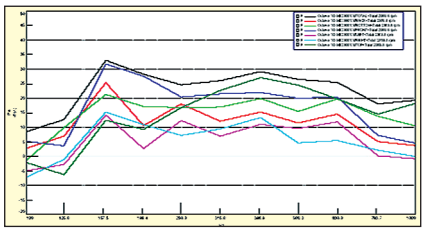

Figure 4. Acoustic source quantification (ASQ) analysis from LMS Test.Lab shows noise emissions from different parts of the dish washer.

leaks from the front of the unit. Averaged sound pressure measurements taken around the machine after all modifications were made showed a decrease of two to three dB overall.

Impressive Business Value. "We are extremely pleased with LMS Engineering Services and with their fast turnaround on the noise and vibration project," explained Fisher & Paykel senior noise and vibration engineer Ricky Kim. "They obviously know their stuff and have the advanced tools to zero in on problems and quickly find solutions. They met with us extensively and familiarized themselves with our product, inside and out. LMS Engineering Services completed the noise reduction project in just two months – a task that would have taken us almost a year and several rounds of prototype tests."

Fisher & Paykel manager of wash systems, Steven Black, notes the business value of working with LMS. "Our partnership with LMS Engineering Services let us implement noise- reducing modifications much sooner in new models than would be possible with our resources alone. The result is that our ability to develop quiet machines has been stepped up considerably, putting us in the same league as the largest global players in the industry. With quietness now a major factor in today's appliance market, the lower sound levels of the new models now in production and those still in development for future release will undoubtedly boost sales and strengthen our position as a force to be reckoned with in the growing worldwide appliance industry."

For more information on LMS Test.Lab acoustics and other LMS products, please visit www.lmsintl.com.