CASE STUDY

The Renault Group

France
Automotive
Array-based Noise Source Location – PULSE

In order to achieve higher test efficiency, Renault needed to enhance its existing installed Brüel & Kjær system and reduce the time spent in the test cell. Renault wanted to ease the setup, data processing and measurement validation processes before activation of batch calculations. Another important requirement was a new reporting functionality. The overall objective was to simplify the workflow and calculations in the measurement process and thus decrease idle time when measuring according to a predefined procedure.

Photos courtesy of The Renault Group

Brüel & Kjær

The Company

The Renault Group, with headquarters in Boulogne-Billancourt, France, was founded in 1899 as Société Renault Frères by Louis Renault and his brothers Marcel and Fernand. They quickly made a name for themselves in motor racing, notching up a string of wins with their voiturettes. Indeed, the Renault reputation for innovation was fostered very early on – in 1902 Renault launched the first production sedan car as well as patenting the first turbocharger. In 1996, the company was privatised to create Renault S.A. Today, Renault is present in 118 countries and has a work force of over 127000 employees. Brands include Renault, Dacia and Renault Samsung Motors. Renault-Nissan sold 7,276,398 vehicles worldwide in 2010.

As well as its distinctive styling, Renault is also known for its car safety and is currently the car manufacturer with the largest number of models achieving the maximum 5 star rating in EuroNCAP crash tests.

Located in Lardy, 40 km south of Paris, the main testing centre dedicated to Renault's powertrain engineering, covers an area of over 130 ha. With 13 km of tracks and over 250 test benches of all types, it employs nearly 2000 people. Integrated in the NVH department, more than 70 of them devote their activity to controlling various powertrain noises in specialised testing facilities that are among the most modern in Europe.

The NVH Development Process

NVH is critical in the development process. Customer perception is an important factor in vehicle quality. The sound of an engine is designed to avoid or limit disagreeable noise and tune others to be more pleasant.

Jean-Marc Kieffer, NVH engineer and expert in powertrain radiated noise (see picture, left) has been with Renault for 21 years. He says, "The NVH development process is a parallel between the engine and powertrain on one side and the whole vehicle on the other. These eventually converge to obtain relevant solutions for both sides. In this process, the role of the powertrain department is to characterise the noise and vibration of the powertrain, compare the results with the requirements/specifications and to design, redesign and tune the technical solutions according to the requirements. This ensures that the powertrain that is mounted in the vehicle won't cause a noise problem for the customer".

The Challenge

To evaluate noise source location for powertrain and engines, Renault GMP looked at Brüel & Kjær's array applications for Beamforming and Holography measurement techniques to enable standard benchmark testing.

For Renault, it is important to get standardised Sound Power values and report them, not only because of vehicle regulations and legislation but also as a key competitive, qualitative element in the field of Engineering, Research & Development. Jean-Marc Kieffer, explains, "We have two principle areas of emphasis. The first is the law – the sound level that is required for the vehicle in, for example, pass-by – and the second is customer comfort. As well as these two, we also have the pollution issues and the rules/legislation that apply. These often contradict with vehicle noise. For instance, when you want to reduce the carbon dioxide levels of emissions you must act on injection parameters and this will affect the noise level. Other different rules and regulations also often conflict so we have to find compromises".

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It is, therefore, important to be able to locate and quantify noise sources with reliable, fast and accurate techniques. Mr. Kieffer says, “Much of our work is dedicated to optimising our processes and to reducing the cost or duration of development especially in NVH measurement, which involves a lot of expensive systems. Being able to validate fast solutions on the same prototype is also a major advantage for quick troubleshooting tests”. Brüel & Kjær’s challenge was to try and simplify the workflow and calculations in the measurement process in order to reduce standardised testing time.

Proposed Solution

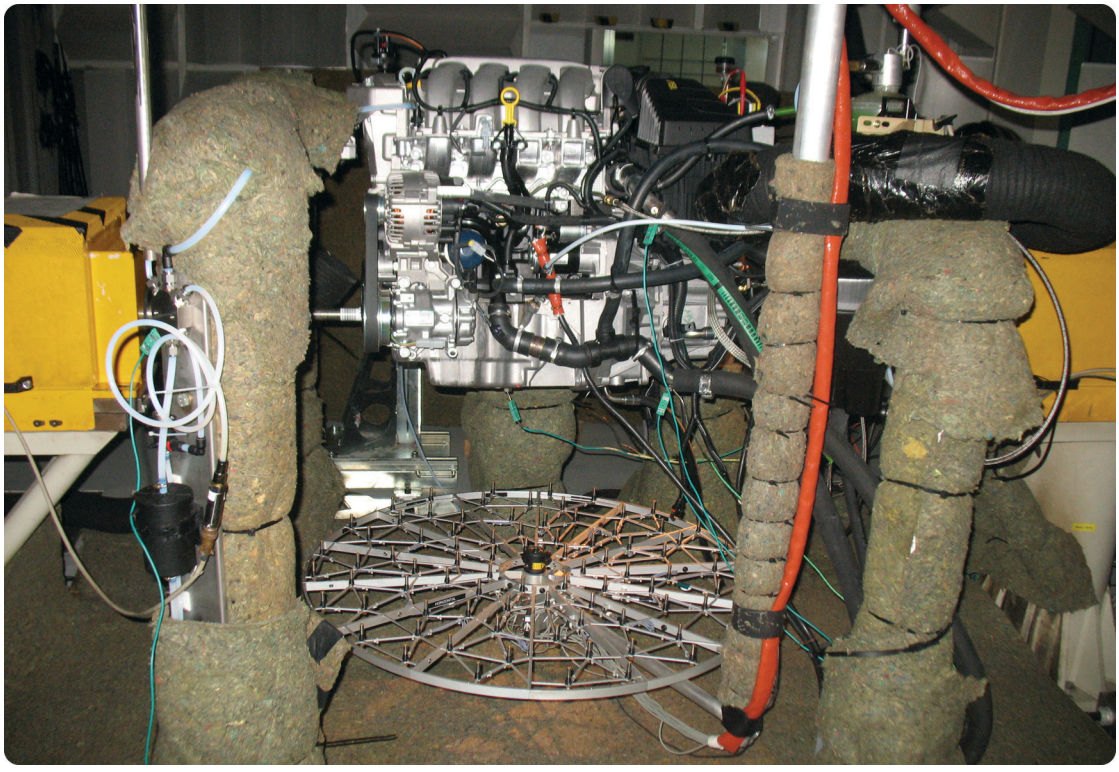

Fig. 1
Combo array fixed to a robot at “under engine” position

In order to address the requirements from Renault, Brüel & Kjær proposed a range of enhancements to the current version of the Beamforming and SONAH application together with associated Noise Source Identification software in PULSE. Noise Source Identification was targeted as a method to characterise Sound Power for predefined areas on an engine/powertrain. The solution would enable Renault to make the measurements suited for standard benchmark testing while using a simple and effective user interface from setup of data acquisition to reporting the results in Excel. Brüel & Kjær’s proposals included:

- Simplified data acquisition setup and GUI
- Predefined calculation setups for the different sides of an engine
- Automated calculation setup simplifying the procedure and post-processing workflow
- Combined stationary beamforming and SONAH calculation on the same dataset
- Overnight management and performance of batch calculations
- Sound Power areas defined as part of calculation setup

Unique Array Design

When working with arrays on a running car engine, it is a challenge to practically position the array close to the surfaces that have protruding parts that cannot be removed. To solve this, Brüel & Kjær’s array has removable outer sectors. With one sector removed the array can, for example, span a driveshaft and still cover the entire engine side. When a sector is removed, this is automatically detected by the cable break detection feature in the front-end and the missing measurement points are automatically ignored in subsequent calculations.

Renault were pleased with the proposition. “The most important area within which we work with Brüel & Kjær is to identify and quantify the noise sources,” says Mr. Kieffer. “A few years ago we were working with intensity measurements and a complete measurement for powertrain took around one week to complete,” he explains. “Renault and Brüel & Kjær worked together to improve the way we make sound power

measurements and we decided to work with the new array. Today, we have reduced the time of characterisation from five days to one or two days. On top of that, we can now get information that intensity measurements are unable to provide. At higher frequencies you have a higher resolution than with intensity measurements, even if you measure with points that are close to each other, and you improve the resolution in the NSI localisation. You can also characterise your sources in non-stationary ways of running, especially in run-up. It is, for us, the chance to simulate the behaviour of the engine during, for example, a pass-by test measurement."

A Ten-year Relationship

Brüel & Kjær and Renault's relationship goes back more than 10 years and there are several reasons why this relationship came about. As Mr. Kieffer explains, "First of all, Brüel & Kjær is known worldwide as a microphone manufacturer and has a reputation for being one of the best. For us it was important to have a good transducer as the basis of our measurement chain. That's one reason for our choice. Another is that Brüel & Kjær was the most advanced in the domain of sound power measurement whether with intensity probe or array. That's why, ten years ago, we chose a holography system with Non-stationary STSF from Brüel & Kjær. Following that, Brüel & Kjær continued to improve its systems and what cemented our choice was when Brüel & Kjær proposed the combined system with holography and beamforming. Using the same transducer and the same acquisition system for both beamforming and holography measurements was extremely important to us and made us more productive as we didn't have to make any changes during measurements. Moreover, choosing the PULSE™ platform was a guarantee to getting a versatile, upgradeable and sustainable solution in terms of both hardware or software. Finally, the ability for target setting and data correlation, for example, acoustic vs. vibration, through the database management of the PULSE™ PDM tool was also a determining factor".

The Future

There is increasing pressure an the automotive industry to be more cost effective while producing ever more sophisticated and refined vehicles, for example, the development of electrical/hybrid powertrains which represents one of the automotive industry's fastest growing segments. Mr. Kieffer explains, "The problem we encounter with energy and the environment is the extreme pressure on reducing development time. Whether it be traditional, hybrid or electrical engines, we are obliged to develop quickly and efficiently. That's a constant pressure in our industry". He continues, "We have less time because circumstances are moving faster. There are some critical factors that force us to produce answers as soon as possible, for example, energy availability and the problem of environmental pollution. These demand a quick reaction so we have to be more efficient than we actually are today".

However, testing time is not the only issue at Renault. Renault has largely succeeded in reducing this by using array measurements. According to Mr. Kieffer, "The next big challenge is to make a lot of improvements to how we post-process data. One reason for this is that we deal with huge amounts of data today. For example, it's possible nowadays to measure the behaviour of the powertrain in non-stationary conditions but post-processing the measurements is very time-consuming. Our challenge and priority is to improve our post-processing and data storage capabilities".

The technologies that drive the development of hybrid and battery-driven vehicles are changing the perception of NVH in the automotive industry. "Just run a little test with an electrical vehicle," says Mr. Kieffer, "and you will soon realise that the sound is quite different to that of traditional vehicles." He continues, "It is clear that we have to develop new methods of processing, new algorithms, etc., to improve the performance of our systems in measuring high frequencies. For us, another aspect of the problems with electrical engines is the very low sound level of the engine compared to other components. Keeping the ability to analyse the noises and to evaluate and localise their sources is vital to us. Recently Brüel & Kjær has, on our request, added the order filtering option to their beamforming solution. That is essential for engine investigations."

In addition to all the new technologies experienced by the automotive industry, Mr. Kieffer believes that fast exchange of data and images is also an absolute must. "This is important," he explains, "because when you have to deal and communicate with people it is often quicker and easier to show them an animation or a mapping where the different sources at different frequencies or different engine speeds can clearly be seen. Audio files are another possible option".

Animation and simulation are, therefore, becoming increasingly important and are a way of reducing the length of the development process because they affect more accurate calculations. And there are different ways of using these. "You can modify your development process and make more calculations at the first stages of the process and less at a later stage," says Mr. Kieffer, "This means you can reduce the number of prototypes which are expensive. You can also reduce the number of test bench hours. A great way of

developing is to be able to provide accurate measurement results in order to improve and validate new calculation methods especially in complex matters like engine radiated noises. Undoubtedly, the coming years will present exciting challenges for Renault and Brüel & Kjær; challenges that will strengthen our cooperation to improve the comfort and performance of the next generation of vehicles”.

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