



NVH Simulation and Testing: Correlation Studies to Establish Integrated Validation Strategies

Client

Europe's biggest carmaker, Volkswagen Group delivers over 10 million cars to customers each year and has annual group sales revenue (2015) of €202.5 billion. Almost one in four new cars (24.8%) in Western Europe are made by Volkswagen, a group which comprises 12 leading brands from seven European countries: Volkswagen Passenger Cars, Audi, SEAT, ŠKODA, Bentley, Bugatti, Lamborghini, Porsche, Ducati, Volkswagen Commercial Vehicles, Scania and MAN.

Challenge

Developing a reliable validation strategy for gearbox noise, vibration and harshness (NVH) to allow design changes to be made with confidence, and satisfying the demanding needs of the market-leading brands.

Solution

Romax software for gearbox simulation, fast and accurate NVH analysis, at each stage of design and validation.

Benefits

Time-saving and confident developments through the creation of a reliable and accurate validation strategy, which can be reused for future projects.

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Carsten Schmitt, Volkswagen

Employing over 15,000 people, Volkswagen's primary transmission site at Kassel, Germany, supplies about four million manual and automatic transmissions every year. Volkswagen engineers at Kassel have used Romax software for more than five years, to support the effective production of gearboxes and to ensure the required NVH quality is achieved. Kassel's Acoustics and System Simulation department focuses on NVH correlation and simulation: "Our main challenge is gear whine, and the need to support our high acoustic standards," says Carsten Schmitt, PhD student of Volkswagen's postgraduate program. "NVH is such an important issue in the industry today because of the rise in electric motor developments, and the simultaneous increase in the production of complex gearboxes. We use Romax software so that we can perform accurate simulation of these new gearbox designs, and assess the NVH performance."

From trial and error to simulation for development

Previously, sporadic correlation studies on the main parts of a gearbox would be conducted based on eigenfrequencies, which allowed for little correlation guarantee. "We have a requirement to develop simulation models that are representative of the real world, so that our design changes can be made with confidence," says Schmitt. "This gave rise to the need for an integral validation strategy, which we investigated in Romax software. We have already used the software for over five years on multiple projects. The speed and unique system-level simulation which Romax software offers stand it apart from other products currently available on the market."



Gear contact pattern testing

"Only with Romax software can we quickly and accurately investigate gear whine phenomena on a system level – looking deeper into models to work out where the problems are. This is what allows us to meet high expectations for NVH within even the most cutting-edge system designs... The speed and unique system-level simulation which Romax software offers stand it apart from other products currently available on the market."

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An integral validation strategy

The strategy developed by Volkswagen focuses on a step-by-step process, allowing correlation between measurement and simulation along the acoustic transfer path at each of the following stages: gear excitation, shaft systems, bearings, gearbox housing, and whole vehicle testing. "If test and simulation are compared only at the end of the system development, then it is not possible to work out where discrepancies may arise, hence the need to perform correlation at each level. This gives us an understanding of exactly where problems are occurring, so that we can resolve validation errors quickly and easily, and avoid time-consuming investigatory work," Schmitt explains. "And Romax software plays a big part in this investigation. Only with Romax software we can quickly and accurately investigate gear whine phenomena on a system level – looking deeper into models to work out where the problems are. This is what allows us to meet high expectations for NVH within even the most cutting-edge system designs. Romax's unique system level view is a huge benefit to us, as well as its easy-to-use bearing catalogues, which make it easy to model gearboxes even if you are not a bearing expert, and its reliable and accurate transmission error calculations."

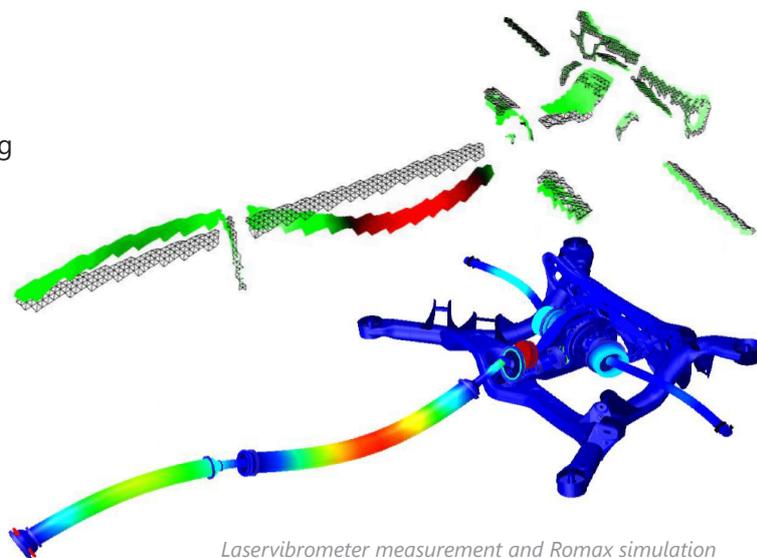
A step-by-step process

The gears are validated first, with testing and simulation performed across a range of loads. The gear contact pattern is checked; poor correlation indicates either incorrect micro-geometry in the simulation, or deviations in the manufacturing process. The next stage is shaft system validation, which consists of modelling single parts and assemblies, then performing finite element analysis (including pretest analysis and experimental modal analysis, if necessary). This is again validated against test data, and if this is unsuccessful the model must be updated in Romax software. Whenever correlation is not successful, changes can be made which will improve the process for the future, as Schmitt explains: "In the first run we did, we found that the model did need updating. The updates that we performed, including accounting for Young's modulus and part-to-part stiffness connections, improved the correlation significantly."

The third stage is correlating the bearing stiffness, and the final step is the correlation for the gearbox housing, for which there are two options, as Schmitt explains: "The validation can be performed by building up the components separately using different tools and testing each individually, and then adding together to make the final model. Alternatively a single model can be created in Romax software which means just one experimental modal analysis, one correlation analysis, and only one model to update. We found that there was little difference between the methods, so the full housing assembly was done in order to save time and effort – this is a very useful way of doing the correlation."

"Now we have developed the framework, we are confident that the work that we have put into this implementation will enable time and cost savings for future projects, as well as maintaining our customer's trust in our ability to deliver their requirements," Schmitt concludes. "We have developed a clear strategy to perform straightforward model updating procedures, and extended the validity and trust of our Romax gear whine models. Our design changes are not reliant on trial and error, but are based on proven, trustworthy simulation."

- **Meet increasing demands for NVH which satisfy cutting-edge gearbox designs, e.g. for electric motors or complex gearboxes**
- **Resolve validation errors quickly and easily through an understanding of exactly where they occurred, removing the need for time-consuming investigatory work**
- **Obtain and maintain customer trust – deliver exactly what they require, with confidence**
- **Know that design changes are made not relying on trial and error, but based on proven, trustworthy simulation**



Laservibrometer measurement and Romax simulation of rear wheel drive and drive shaft

Since the time of writing this case study, the Romax product offering has evolved. The features and benefits described here most clearly map onto our new product Spectrum.



To find out more

Contact us via marketing@romaxtech.com or visit www.romaxtech.com or www.volkswagen.co.uk