LMS engineers minimize interior and pass-by noise on new chinese vehicle

Full Service Approach Delivers Prototypes that Meet JMC's NVH, Cost and Manufacturability Requirements

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ENGINEERING INNOVATION

LMS engineering consultants substantially improved the interior and pass-by noise on several new Jiangling Motor Corporation (JMC) vehicles for the Chinese market. JMC needed to reduce noise to meet government regulations and to comply with market expectations. LMS engineers optimized the interior trim of the vehicle, improving the articulation index by 30% with only a 3-kilogram increase in weight. They developed design modifications to greatly reduce low-frequency engine booming noise. They also made changes to the intake manifold nozzle and exhaust system that reduced pass-by noise levels from 77 dB to 73 dB. As part of its full service approach on this project, LMS took responsibility for modifying and testing vehicle prototypes to validate the design changes and worked with suppliers to ensure their manufacturability.

An integrated NVH approach

Jiangling Motor Corporation, a Chinese manufacturer of light trucks, buses, pickup trucks, and commercial vehicles, recently introduced several new vehicles based on an Isuzu pickup and the Ford Transit commercial van. The first prototype series were not satisfactory in terms of NVH refinement and pass-by noise standards. JMC therefore sought an engineering partner that could optimize the NVH characteristics of these vehicles on a full service basis while cooperating with the company's suppliers to assist them in producing components and subsystems with the right NVH characteristics. They also wanted a supplier that would work closely with their own engineering staff to transfer technologies that would increase JMC's capabilities in the NVH area.

Xiao Liling, Vice President of Jiangling's Product Development Center, explained why the company selected LMS for the project. "Over the last twenty-five years, LMS has built up extensive expertise by participating in co-development projects with the majority of the world's leading automotive OEMs. The credibility gained through its worldwide engineering operations convinced Jiangling to partner with LMS to optimize the NVH performance of the vehicles we bring to the Chinese market."

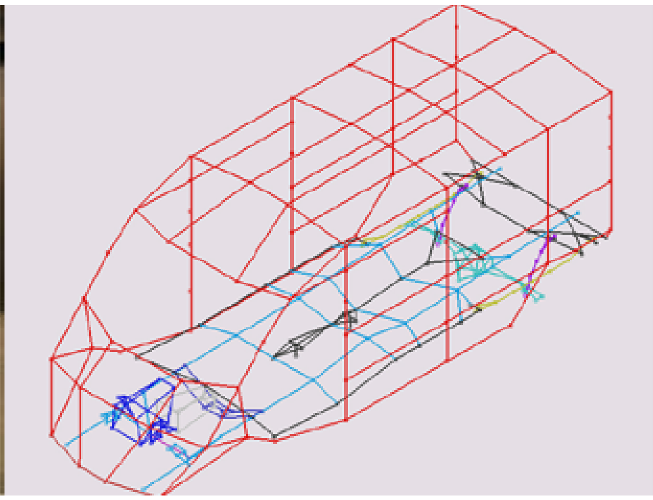
As part of the contract, LMS guaranteed that the pass-by noise characteristics of these vehicles will comply with Chinese regulatory requirements. LMS's responsibilities included defining modifications on the complete vehicle, including trim, body structure, intake and exhaust design and engine integration.

LMS was also responsible for delivering a prototype vehicle that met JMC's NVH targets and also satisfied constraints relating to packaging, manufacturability, engine cooling, durability, etc.

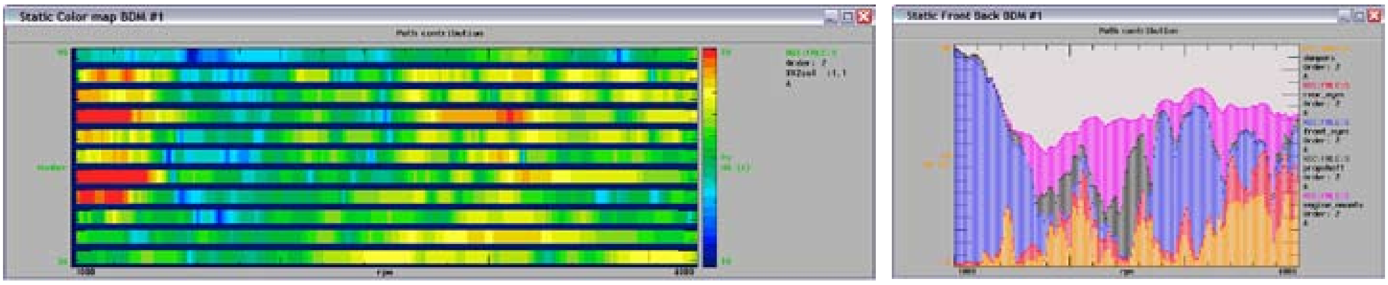
Optimizing interior trim

The first phase of the project involved optimizing the interior trim. Firstly a windowing method was implemented by LMS engineers. This consists of identifying the panel contributions to the noise by covering the panels with a dramatic absorption layer on all the panels, and removing it successively on each panel. Acoustic leakage was also identified. This process demonstrated that a high proportion of the interior noise was contributed by the front floor, front door step, and other floor panels. The study also showed that a significant amount of noise

LMS engineers performed extensive indoor pass-by-noise tests on the LMS chassis dyno in the large semi-anechoic room. The advantage of this approach over exterior pass-by-noise measurements is the high repeatability of the measurements and quick setup.



Operational measurements were performed on 253 points on the drivetrain, rear suspension, floor and body to understand the dynamic deformations and critical resonances.



LMS engineers began the low-frequency noise optimization process by using transfer path analysis (TPA) to determine which structure borne and airborne paths contribute the most to interior noise.

was contributed by gearshift lever vibration. The engineers then evaluated a wide range of alternative damping, insulation, and absorption solutions through virtual simulation, in order to identify a total solution that would meet the interior noise target while minimizing weight and manufacturing cost. The proposed solution included adding damping layers to high contribution areas, adding sealing at the junction between panels, adding foam to body pillars, and adding soft trim layers under the existing trim panels. LMS engineers developed reliable models of the new components and worked with suppliers to validate cost and manufacturability. The new design improved the articulation index by 30%. It also resulted in a more clear-cut low-frequency noise performance, which helped optimize low frequency noise in the next phase of the project.

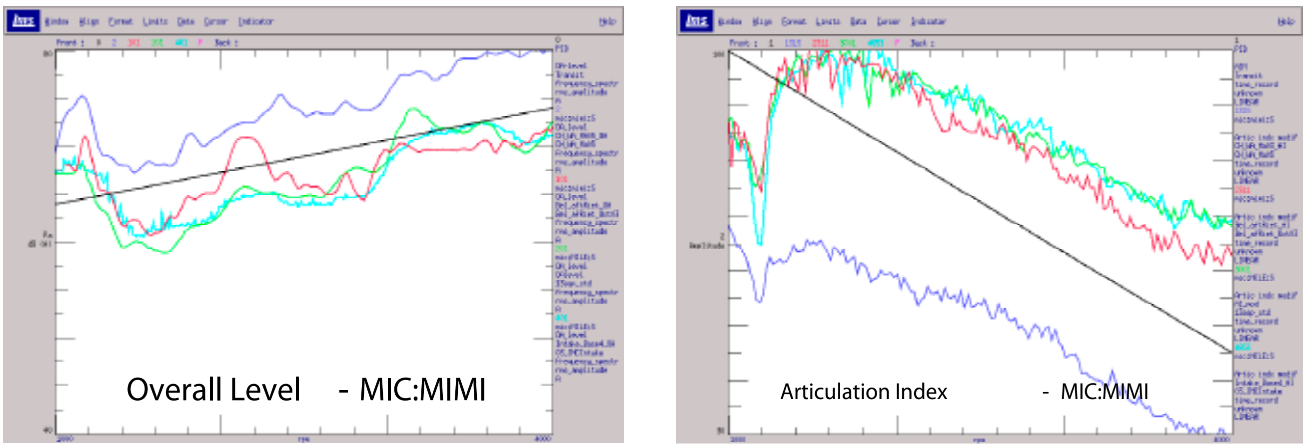
Reducing low-frequency noise

LMS engineers began the low-frequency noise optimization process by using transfer path analysis (TPA) to determine which structure borne and airborne paths contribute the most to interior noise. They used a combination of fast methods that separate between the main sources, and detailed transfer path analysis, which identify the contributions of critical paths in detail. Using this focused approach, it proved possible to quickly identify the main contributions.

Once the main transfer paths were identified, the project team investigated the high contributors in detail. The strength of each source and related transfer paths were analyzed based on LMS experience with best in class vehicles. LMS engineers also evaluated the local body stiffness at engine and suspension mounting locations to determine the potential for improvement of the integration of the engine and suspension. Operational deflection shape (ODS) analysis was used to understand the behavior of the driveline and the suspension at the critical conditions and frequencies by identifying dynamic deformations and critical resonances. Small lightweight accelerometers were used to capture deflections and the results were visualized to understand the noise generation mechanisms.

To start the problem-solving phase, simple, non production-like modifications, such as adding a large mass on a highly vibrating panel or covering a critical source, were tried to evaluate the potential that could be gained by strengthening each identified weakness. The most promising preliminary modifications were converted into realistic prototype modifications in close collaboration with the customer to take into account constraints related to packaging, cost, manufacturability, engine cooling, durability, etc. Suppliers were also followed-up to ensure the quality of their modifications.

In one of the vehicle development projects, this approach was used to reduce low frequency noise. The TPA revealed a large 4th order contribution of the intake at 2350 rpm and the ODS indicated corresponding large vibrations of the body panel close to the intake nozzle. Therefore it was assumed that the body panel did radiate noise in the interior and that by modifying the panel an improvement could be expected. A mass was added to the body panel to



Overview of the interior noise test results of the original vehicle (blue) versus the different prototype vehicles transformed by LMS (red and green), and the target performance (black line)

LMS Engineers improved the existing engine undershield and developed a new gearbox undershield to reduce the direct gearbox contributions.

The LMS project team worked a complete sound package for the interior of the van including specific damping and insulation on the front floor, main floor, front roof and front instep.

verify this assumption. This proved to have a large positive effect and enabled to find a solution to the problem. For another vehicle version with a gasoline engine, LMS redesigned the air intake to minimize its contribution. This was done by using a boundary element acoustic model to analyze and optimize the acoustic attenuation of the intake at the critical frequencies. The addition of two resonators significantly reduced noise levels. This and other changes substantially reduced the low frequency noise of the vehicle.

Meeting pass-by noise requirements

LMS used its indoor pass-by noise technology and facilities to reproduce pass-by noise level measurements on a semi-anechoic chassis dynamometer, making it possible to carry out detailed diagnosis and modification tests in a well-controlled environment. LMS used the airborne source quantification method, to generate a detailed ranking of noise sources. The main pass-by contributions were revealed to come from the intake and exhaust nozzles, the exhaust manifold shell, and direct noise radiation from the engine and gearbox. Additionally, an annoying whistling sound could be heard during vehicle pass-by. This was traced back by the LMS engineers to the rear muffler shell noise radiation.

LMS engineers addressed the major pass-by noise contributors and proposed concrete modifications. Intake nozzle position, intake nozzle tube length and diameter, engine tube diameter, gearbox undershielding, and exhaust system were modified to meet regulatory requirements.

At the end of the process, LMS delivered a prototype vehicle to JMC that met the company's regulatory and quality requirements while also addressing cost, manufacturability, weight, and other issues. The project demonstrated LMS Engineering Services' vehicle knowledge, experience, technology, processes, people, facilities, and project management skills to take full responsibility for vehicle NVH performance. The approach carried out by LMS reached the target in a limited time frame by identifying the root cause of the problem. The project also highlighted LMS's ability to transfer technologies and processes used throughout the project so that the customer will be able to use the same methods in future generation vehicles.