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Automotive and transportation

Nissan Motor Company

Simcenter Engineering helps Nissan Motor Company uncover the complex interaction between body flexibility and vehicle handling performance

Product

Simcenter

Business challenges

Gain insight into the relationship between body stiffness characteristics and vehicle handling performance

Relate the subjective driver experience to changes in the body load distribution

Develop a method for body design and body stiffness target setting for handling performance

Keys to success

Identify the operational loads between body and suspension in time domain

Create a modal model of the trimmed body containing both global body flexibility and local flexibility in the interface points with the suspension

Visualize body deformation as well as the contribution of the individual body modes in time domain

Investigate how body loads build up during a maneuver, and their combined effect on driving dynamics

Siemens Digital Industries Software develops advanced testing methodologies to determine force distribution and visualize body deformation during vehicle handling.

Understanding the relationship between body flexibility and vehicle handling

Adding extra stiffness to a car body can improve vehicle handling performance and the subjective driving experience, but established measurement techniques or computer-aided engineering (CAE) fail to explain this relationship. When designing a next-generation lightweight platform, any additional mass from stiffening elements should be carefully considered, and the right balance between handling and noise, vibration and harshness (NVH) should be maintained. Simply adding body reinforcements based on experience or by trial and error is very inefficient, and can lead to undesired and expensive body design changes late in the vehicle development process. Therefore, automotive original equipment manufacturers (OEMs) look for technologies which enable thoughtful decision-making. Simcenter Engineering services experts from Siemens Digital Industries Software conceived an innovative testing methodology that helped Nissan

Results

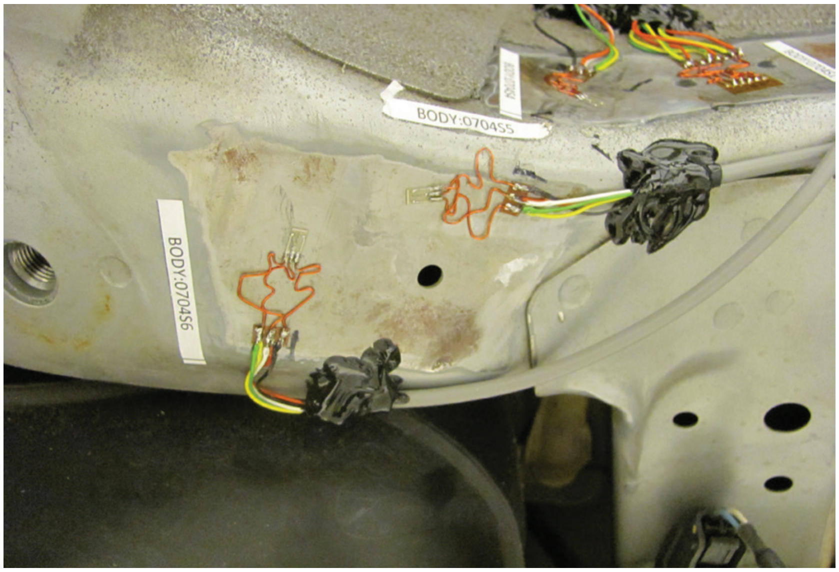
Gained insight into the relationship between the subjective perception of an expert driver and the influence of body rigidity changes on the vehicle's dynamic performance

Defined a process for improved vehicle handling through targeted structural body design modifications

Developed a method that enables insightful decisions on body flexibility earlier in the vehicle development process

Motor Company get the required understanding to do so.

"Body development for handling performance usually takes a lot of time and can be a substantial additional part costs," notes Hitoshi Kyogoku, manager of the Vehicle Dynamics CAE Group at Nissan. Kyogoku belongs to an integrated CAE department that optimizes vehicle performance using computer simulation. The department evaluates vehicle characteristics such as crashworthiness, strength, NVH and handling before testing them on actual cars, and is constantly looking for new technologies to improve accuracy and increase its application range. When investigating the effect of body reinforcements on the driver, the engineers joined forces with their colleagues from the design and testing departments, and decided to involve Simcenter Engineering experts, to learn about new high-end testing methodologies. Together, they conducted a detailed study involving different body variants, hoping to fully understand the relationship between body stiffness changes and their effect on handling performance.



A unique test approach on the track

"Simcenter Engineering employs unique and high-level measurement technologies, especially in operational conditions," explains Kyogoku. "That is very important for us." Approaches like static stiffness tests on the bench can quantify the effect of body reinforcements into a single static stiffness value, but when evaluating on the track, objective global vehicle performance quantities like yaw-rate, lateral acceleration or roll angle are typically difficult to directly relate to body stiffness changes. "The solution Simcenter Engineering experts presented could reveal the underlying mechanism," says Kyogoku. Simcenter Engineering helped us identify forces and visualize body deformation in time domain, and that was very valuable information for us."

Accurately identifying operational force distribution

Global vehicle handling performance quantities result from the combined effect of all forces between the suspension and body. Understanding the underlying mechanisms starts by studying those individual contributors on the track, but accurate load identification is complex. Vehicle handling studies cover transient phenomena, usually dominated by lower frequencies. Classic, acceleration-based matrix inversion often fails because of the bad numerical condition of the inversion matrix. At low frequencies, only a few independent body modes are involved, leading to a significant coupling between the transfer functions in the inversion matrix. Simcenter Engineering proposes an alternative matrix inversion method using strain responses. These are much more sensitive to local structural phenomena, enabling a better matrix decoupling, which allows accurate load identification in time domain.

Simcenter Engineering experts have vast experience with strain measurements. Being experts in both testing and simulation, they employ CAE to explore the proximity of the suspension to body interface points for strain hotspots, and define the optimal sensor locations for matrix inversion. These significantly outnumber the forces to be identified, and represent sufficient diversity of body dynamics for a well-conditioned equation system. By combining operationally measured strains with laboratory force-to-strain transfer functions, the forces could reliably be estimated for the different body variants. "We were very impressed with the results," confirms Kyogoku. "The differences in the contributing forces due to the body reinforcements we tested could be well observed, with good repeatability. Accurate time domain body load identification was crucial to investigating what happened."

Objectively observed assumptions match expert drivers' subjective feelings

Simcenter Engineering experts and Nissan engineers collaborated on estimating the effect of the modified measured force distribution in the connection points on vehicle handling characteristics. "Simcenter Engineering masters very high-level technical methods," says Kyogoku, "but the permanent and open communication between our engineers and the people from Siemens Digital Industries Software was one of the most important factors that made this study a success." This collaboration resulted in a clear indication of what an expert driver could experience on the track.

Both the force amplitudes and their time-delays with respect to the steering angle input (also called the "phase," or the "body force build-up") were important in these discussions. Studying the force interactions in detail, it was found that for evaluated modifications to a base model, a set of fast-acting lateral forces increased in

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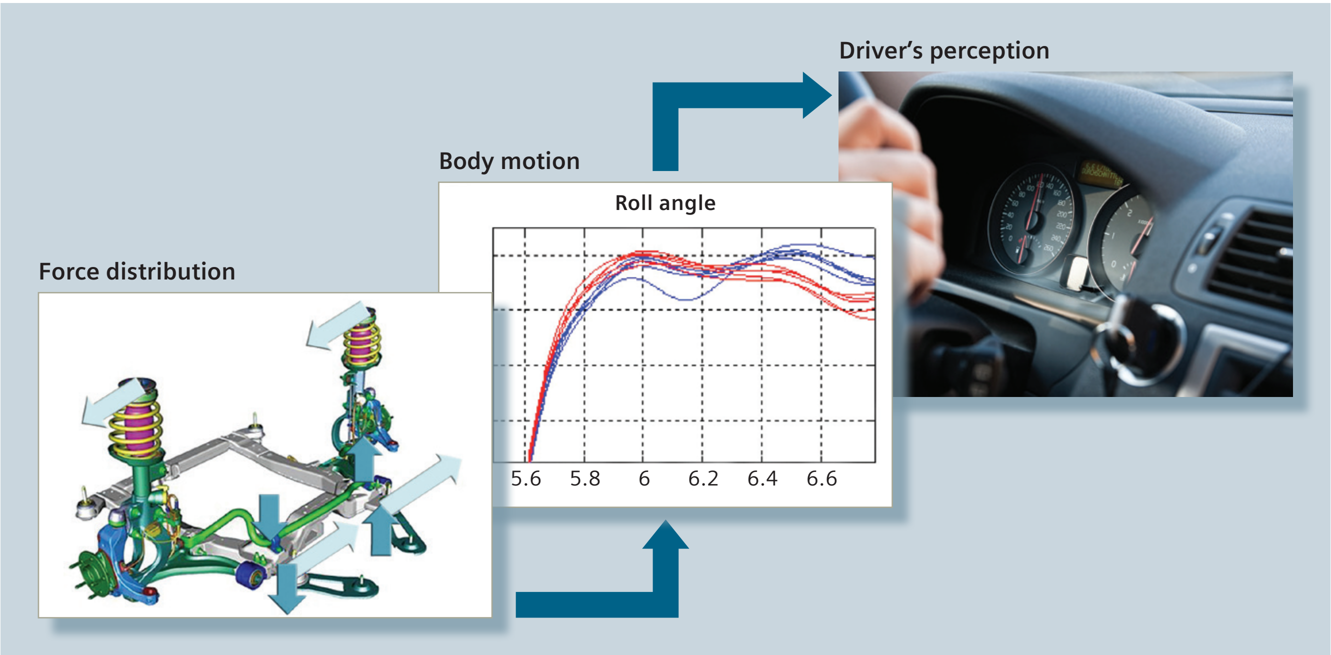

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level, while the vertical forces were redistributed over a fast and a slow load path.

As the lateral forces excite the body roll motion and the vertical loads counteract, a moderate change of transient body roll motion was assumed. At the same time, the engineers expected limited effect on lateral acceleration because of mutual cancellation between the lateral forces. These objectively observed assumptions exactly matched the subjective feeling of the expert driver on the track.

Making targeted body design decisions for optimal vehicle handling in the future

For further in-depth investigation, the identified time domain forces were combined with a modal model of the trimmed body, made from transfer functions, measured in free-free boundary conditions. The resulting total body deformation could be animated, and decomposed into individual modal contributions. This allowed the study of the relative importance of global torsional and bending modes, as well as local flexibilities to the force mechanism, at each stage of the handling maneuver. This was very informative when comparing the dynamic behavior of different body variants.

Compared to traditional static stiffness tests on the bench, which typically only provides one single stiffness value for the entire body, this method allowed attributing stiffness modifications to body modes. In the future, this knowledge can be used to investigate where structural reinforcements can be more effective, and will enable a more targeted approach to optimizing body flexibility for vehicle handling.

Nissan engineers are looking forward to the

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next step. "We will try to reproduce the observed phenomena in CAE," confirms Kyogoku. Leveraging this knowledge for simulation purposes will lift this application to earlier stages of the design cycle.

It will help to make more rational decisions on body flexibility for vehicle handling, while safeguarding the requirements for NVH during the development of next-generation lightweight vehicles. And it will avoid late stage repair costs. Simcenter Engineering is in the pole position to play an important role in the deployment of this new engineering process. "I think Simcenter Engineering has three main differentiators," concludes Kyogoku. "Firstly, they combine high-end testing with CAE. Secondly, they have a very vast experience with automotive OEMs. And finally, Simcenter Engineering has a very talented global team of experts."

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