Luxury carmaker Bentley accelerates into the fast lane with LMS TecWare

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Bentley places heavy emphasis on the design of its suspensions, with buyers of super-luxury cars such the automaker's £230,000 Brooklands model demanding high quality and the most comfortable ride possible.

Maintaining renowned Bentley brand characteristics such as unquestionable quality and the distinctively unique Bentley driving experience are important factors when expanding the vehicle model range. This is why Bentley Motors Ltd. uses LMS load data processing technology to double testing speeds for their impeccably tuned suspensions.

Since the late 1990s, production at the UK-based automaker has increased from 1,000 to more than 10,000 vehicles. That's double the overall five-fold growth rate in the highly exclusive €6 billion market for super-luxury vehicles costing over €150,000 according to a recent article in the October 2007 issue of CNBC European Business.

Big, fast and in hot demand

Bentley's new Brooklands coupe weighs nearly 6,000 pounds. Its 530hp twin-turbo 6.75 liter engine produces the highest torque of any automotive V8 in the world. Like all Bentleys, it is hand-assembled to buyer specifications,

including an all-leather cabin trimmed in the buyer's preferred choice of wood. With a base price of £230,000, the Brooklands sold out its first-year limited production run just a few months after being unveiled in early 2007.

Impeccable vehicle quality and high-class driving character

Maintaining their legendary quality standards and uniquely distinctive driving experience across this expanding range of vehicles is essential for Bentley. Particularly close attention is paid to suspensions, which must be specially designed to withstand the high loads produced in such large cars and finely tuned to provide the ride and handling performance associated with the Bentley name.

Testing these types of advanced suspensions on the company's multi-axial hydraulic rig is critical to the development process – and one of the most time-consuming factors. Ordinarily, suspension prototypes were exercised

around the clock for months on the four-post rig. This was the only way to accurately replicate the real-time loads that vehicles must withstand over hundreds of thousands of miles. And not only rig riding took up time.

To squeeze out as much time as possible and hit critical launch dates for new vehicle models, Bentley is implementing LMS TecWare load data processing software to compress and refine fatigue testing on the rig. By eliminating "noise" spikes and other extraneous data from road test data and smoothly blending together the most damaging signals, the software lets engineers exercise the suspension using an accelerated test scenario that significantly shortens rig time and lowers the risk of "false failures" reducing test reruns.

Shrinking the test schedule

"The process starts by taking component-level suspension measurements on a test vehicle driven through Bentley's proving ground durability circuit," says Bob

Upcott-Gill, Design Analysis Manager, Chassis Department. "The circuit includes a series of three-g bumps, rough gravel, tight curves, corners, hills and other road profiles that the driver navigates through while making a number of starts and stops. The road test yields 12 signals of loads, accelerations and displacements at various points on the suspension as well as driving forces measured on the vehicle wheels."

Next, Bentley engineers use LMS TecWare to filter out noise spikes, sudden load peaks and other extraneous parts of signals. Based on their expert knowledge of the amplitudes and slopes of valid data, engineers establish "gate" levels in LMS TecWare to automatically remove signal portions. They can also visually inspect and analyze any borderline signals with the system's validation and editing tools.

A set of rainflow counting, time domain and frequency domain tools is then used to determine the fatigue content on each signal part. In other words, the cumulative impact of small but highly repetitive loads such as a standard road surface vibration together with very large but infrequent loads such as the wheel hitting a pothole. LMS TecWare automatically determines the "damage equivalent" of these signals, identifies which portion of the test drive produced these loads, and categorizes signals based on amplitude, repetitiveness and duration. Removing the non-damaging and extraneous signal portions, the system blends together the remaining valid fatigue load data into a condensed test schedule that replicates the damage equivalent to years of vehicle usage.

Making the right decision

Comparison and correlation tools such as frequency response function (FRF) plots are then used to validate condensed load cycle effectiveness against original test data. "This validation process is highly iterative in arriving at a condensed test schedule that has the right equivalent damage content without excessive velocities, forces and accelerations," explains Upcott-Gill. Automated "gap spotting" features detect discontinuities between blocks of truncated data and add "ramps" that smooth these transitions to avoid any sharp jumps in the test routine that could falsely overstress shock absorbers and other suspension components.

"Load data processing gives our engineers the possibility to make the right decision when creating optimal condensed test rig scenarios," says Upcott-Gill. "LMS TecWare provides features for automating routine data-processing tasks while at the same time giving our engineers flexibility to make necessary judgment calls regarding which signals to keep, where data needs to be tweaked, and how the tests should proceed. Without LMS TecWare, trying to create a valid condensed test scenario would be an overwhelming process."

"With LMS TecWare, we're shortening the time on the rig for each suspension fatigue test by half."

Bob Upcott-Gill, Design Analysis Manager, Chassis Department, Bentley
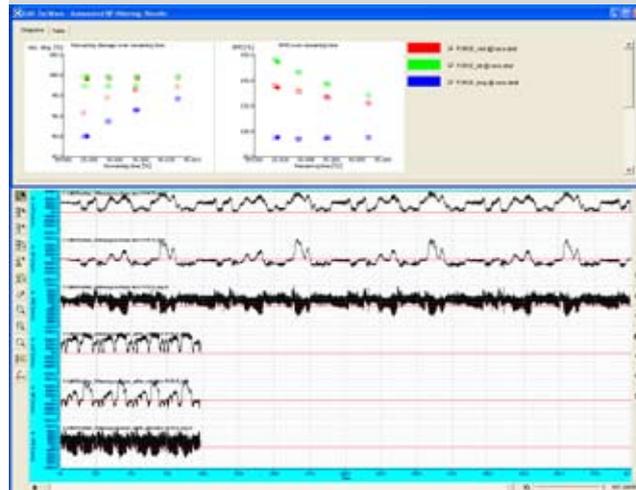
Multi-axial hysteresis filtering with parameter optimization reduces time signals to the shortest possible length while preserving the damage content for each channel.

LMS TecWare allows companies to standardize processing tasks across their organizations to guarantee user-independent, repetitive results.
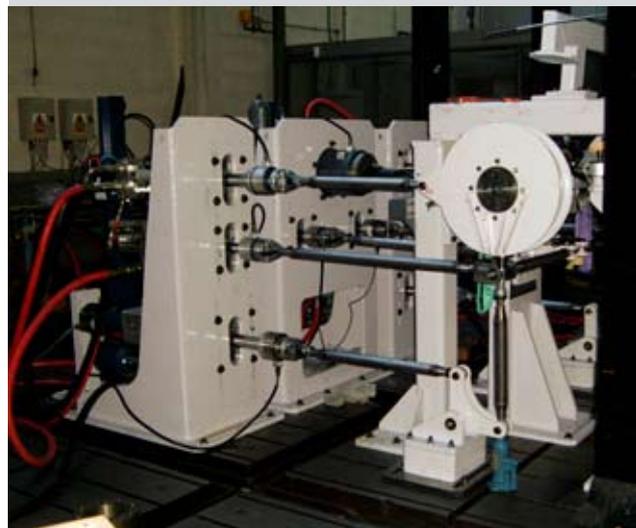
Driven by load signals from LMS TecWare, hydraulic rams on Bentley's multi-axial test rig exercise vehicle suspensions with wheel forces and displacements, braking moments, and driveshaft torque.

Cutting the rig-ride time in half

"We're currently using LMS TecWare on suspension testing pilot projects to validate the approach, work out any kinks in the process and evaluate major benefits," says Upcott-Gill, who notes that gains so far are impressive. "With LMS TecWare, we're shortening the time on the rig for each suspension fatigue test by half. We are in the early stages of making best use of the software," He also noted that with less test rig failures, fewer reruns are needed.

"Overall increased efficiency means that fatigue testing is no longer a bottleneck in suspension development. Furthermore, by not having to rent so much time on the expensive rig, our department is saving money," he says. "LMS TecWare pays back quickly. It's a good piece of technology." Using LMS TecWare to determine the damage equivalent of signals and where these loads originate gives engineers greater understanding of fatigue throughout the suspension system. Better insight into areas that receive the most wear and tear simply gives the engineers at Bentley more information to match the suspension design to the performance targets.

So what is next?

After the process is validated, the plan is to put the method to use for all of Bentley's full-axle suspension durability tests. Transferring this same approach in other departments, such as Body and Powertrain, may be on the horizon as well. In the longer term, Bentley is also investigating using the load data processed by LMS TecWare as an input for LMS Virtual.Lab Durability to predict suspension component fatigue.

"Fatigue life prediction based on measured load data is a powerful capability enabling engineers to design better parts, explore what-if scenarios and evaluate alternative suspension configurations quickly and easily with virtual models before committing the final design to hardware," says Upcott-Gill. ■

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