Application Case

DaimlerChrysler Reduces Time To Generate Testing Signals By One-third

DaimlerChrysler - Mercedes Benz has reduced the amount of time needed to match road-testing signals to equivalent loads for laboratory fatigue testing by one-third, while also reducing the potential for variations between the two. The improvements were achieved by switching to the LMS Durability software that reduces the time required to reproduce measured or synthesized drive signals.

One of the 8 IST chassis test rigs as used by DaimlerChrysler for durability testing

LMS software tools TecWare and TWR interface with IST's fully digital servo-hydraulic controllers used to drive actuators applying loads to the individual components. “Our goal is to exactly duplicate the loads experienced in specific proving ground testing routines,” said Bruno Seufert, Manager of Chassis Durability for Mercedes Benz, Stuttgart, Germany. “Reducing the time required to generate testing signals from the five days typically required in the past to three and a half days now helps maintain our engineering workload at manageable levels. At the same time, the new approach gives us more confidence that the test signals converge because they eliminate the ‘magic box’ required with the previous methods.”

Matching road testing to lab testing

The company measures forces at the wheel spindle while driving prototype vehicles on the test track. The driving schedule used on the track follows an intensely rigorous course that compresses the time needed to evaluate component durability into a fraction of a normal vehicle life. This course generates very high forces on suspension components and under these conditions system dynamics are nonlinear. This step is challenging because set-up conditions are different between test track and laboratory. In addition, errors are inevitably created during the process of building up the test program from several sources. First of all, the behavior of the controllers used to drive the test rigs varies along their length, and since there are three axes of motion the total combination of these variations are infinite. In addition, the process of building a transfer function assumes a linear system so it does not take into account nonlinear factors such as the shock absorber and rubber mounts. These factors help to explain the importance and difficulty of matching the damage caused by the road testing to the laboratory testing program.

Less of an art, more of a science

In the past, reproducing time histories on multi-axial test rigs required highly experienced staff at Mercedes Benz. It also took so much time that it created a significant burden for the engineering organization. Years of experience and a considerable amount of intuition were needed to generate files that matched the damage produced by the test track. Engineers had to manually generate the transfer functions needed to create the test program and then run a rainflow analysis to compare the damage that it produced to the original measured loads. Inevitably, the damage didn't match so the process needed to be repeated. On average 15 iterations were required to achieve the required level of damage correlation. The complexity and length of the process was increased by the many simulation channels that must be measured at the spindle, such as vertical displacement left, vertical displacement right, vertical load left, vertical load right, longitudinal load left, longitudinal load right, lateral load left, lateral load right, brake torque left, brake torque right and drive torque.

In recent years, Mercedes has made major strides to improve suspension durability testing. One important step has been in switching from analog to digital test rig controllers from Instron Structural Testing Systems (IST). One of several advantages of digital control is the ability to use gain scheduling that allows the vertical actuator to be operated in load control, resulting in exceptionally high levels of correlation of field-measured loads with those reproduced in the laboratory. The IST Labtronic 8800 controller is tightly integrated with the LMS TecWare and IST/LMS Time Wave Replication (TWR) durability testing software used by Mercedes as the primary tool for analyzing, reducing and reproducing test data.

Generating durability test scenarios

The first step in the process is to correlate real customer usage with the test track. Mercedes Benz engineers use LMS TecWare to generate durability test scenarios based on data from measurement campaigns. Different road profiles can be superimposed on one matrix representing a single loading environment. The software then calculates the optimum mix of basic test-track sections that match the target. It, for example, automatically determines that three passes of Belgian block, six potholes and two off-road circuits are required. The software then automatically identifies and deletes those time sections that are below specified limits or outside a particular rainflow cycle range, helping to reduce the time required for testing. "By eliminating the parts that are not relevant to durability, we are able to significantly shorten our driving schedule," Seufert said.

Creating frequency response function models

RS TWR, a joint development between LMS and IST, is designed specifically for the task of reducing the amount of time required to reproduce measured or synthesized drive signals. It includes features that evaluate the quality of the system model and provide rainflow counting and range pair diagrams,

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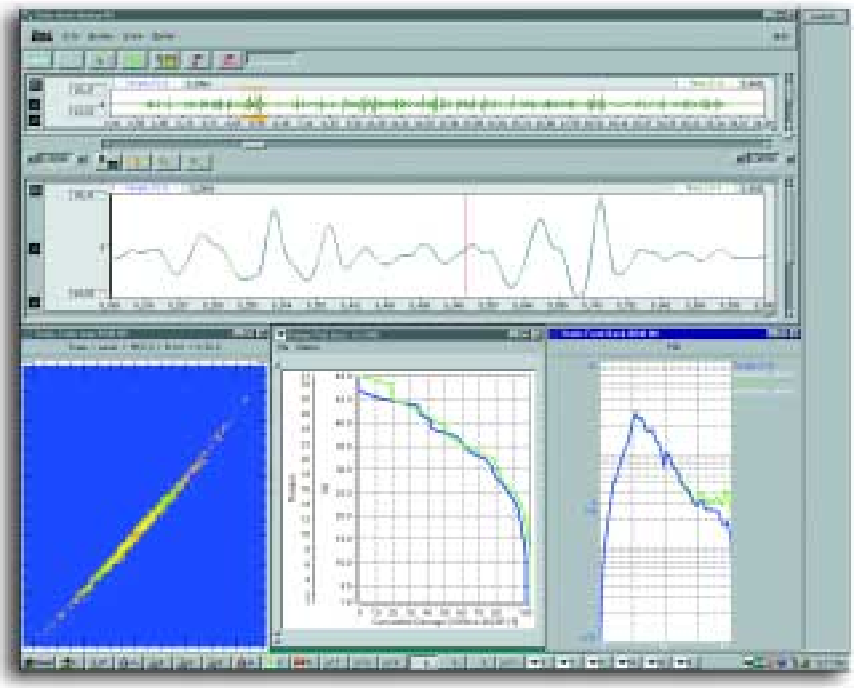

RS TWR – Automated damage correlation by comparison of test track and test rig measurements in time, PSD and range-pair diagrams.

structural frequency response functions, time histories and error displays. All this allows a faster and more accurate simulation process. The advanced multiple input, multiple output technologies quickly model the system using high-quality, high-bandwidth frequency response function models. TWR automatically calculates the synthetic drive signals that are shaped to the road profile to be reproduced. Reproducing these forces on the test rig requires the creation of different forces in different directions that provide the same amount of damage. The software provides immediate feedback on the quality of the proving ground measurements by identifying loose accelerometers, badly connected wheel force transducers and broken strain gauges, saving valuable rig time. A key advantage of TWR is that it excites the whole test structure in all directions simultaneously, which is much faster and more realistic than the traditional approach of using one active exciter at a time.

Damage correlation

Mercedes engineers first use TWR to create a multiple input, multiple output frequency response function model that is much more realistic than those producible in the past. The software automatically generates the rainflow matrices used to compare the damage produced by the road tests to the files used to drive the test rigs. It provides a wide variety of online graphical indicators and displays for direct and interactive comparison of measured and target signals. The user can view the time history, an XY histomap, and range pairs and power spectrum distribution graphs overlaid upon each other. To add even more realism to the test, damage ratios of measured and target signals can be calculated to allow a fatigue relevant evaluation of the simulation quality. "The new tools reduce by one-third the number of iterations required to match the test program to the measured loads and also eliminate the tricks that were required in the past to obtain a good fit," Seufert said.

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Gain time and quality

"We have accomplished two main things by using the new software to convert road measurements into fatigue life durability programs," Seufert said. "The first is that we have reduced the time needed to ensure that the signals used to drive the laboratory tests match the proving ground data by about one-third. These timesavings are not large enough to have a significant impact on the product development cycle but they are very beneficial in helping our engineering staff deal with tight project deadlines. Another important advantage is that the process of generating our fatigue test programs is now much less of an art and more of a science. The new software generates system transfer functions based on predefined parameters, eliminating the need for adjustments in excitation levels and frequency content which could cause variations between programs produced by different engineers."

Seufert added that he still sees room for considerable improvements in the matching process. "We are working to better utilize the software to further reduce the time needed to match the measured loads to the test program," he said. "We are also interested in using software to make analytical component durability predictions."

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