Vibration control technology

Mahle uses M+P International's advanced, true multitasking vibration controllers for testing its complete product portfolio

Mahle Filtersysteme, which produces air filtration and engine components for vehicles, operates a test facility at its research and development site in Stuttgart, Germany. The facility is part of a Centre of Competence (CoC) and available to all automotive business units across the group. It has five vibration test rigs that use vibration controllers from M+P International. The CoC works very closely with other Mahle development and production sites, enabling test data and procedures to be shared.

In addition to the Stuttgart facility, M+P International vibration controllers are used in the neighboring Thermo-management business unit, at the Filtration and Engine Peripherals Development Center in Brazil, and at the Filtering System headquarters in St Michael, Austria. This enables testing setups to be exchanged quickly and easily and for raw measurement data to be transferred and analyzed by colleagues at other sites.

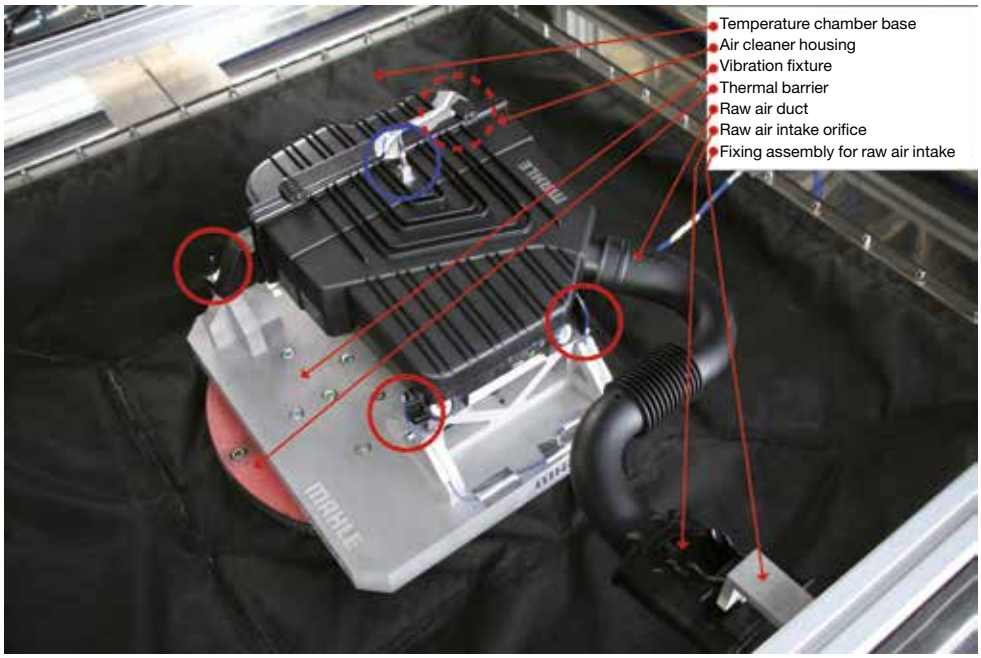
Four of the CoC test rigs use electrodynamic shakers, three of which are equipped with a slip table and temperature chamber. They are used for environmental simulation tasks combining vibration excitation with temperature control. If required, test conditions can also be extended to include air pressure (high and low), electrical control of the item being tested, and the circulation of conditioned coolant or hot gas.

ABOVE: Vibration test rig with M+P International measurement front end

To meet the different test specifications and specimen types, test engineers at Mahle use shakers of various sizes, capable of generating force vectors up to 80kN. By selecting the appropriate size of shaker, Mahle can also satisfy the necessary compromise between the mass of the complete test assembly and its stiffness.

The range of items tested includes the entire Mahle product portfolio, with an emphasis on filter systems. It covers individual components, modules and complete systems for: air intake systems consisting of raw air intake ducts, air cleaner housing (including filter element), clean air ducts, and ducts for pre- and post-pressure charged air; intake modules; cylinder head covers; oil mist separators; actuators; oil and fuel filter modules; oil and water pumps; activated carbon canisters; exhaust gas turbochargers; charge air coolers; cooling modules; and special applications for advanced development and other business units.

The wide variety of specimens and vibration test equipment places very high demands on the control of the test rigs. The vibration controller needs to combine very precise control, easy programmability and flexible parameter settings for the



ABOVE: The experimental setup for an air intake system excited in the vertical direction, showing the position of all the controls and electronics

various specimen-dependent shakers. Other crucial factors include the clear presentation of the control parameters online and offline for post-analysis, the definition and monitoring of diverse abort criteria, and straightforward data handling.

All these requirements are met by two M+P VibRunner vibration controllers, which are used as stationary systems on the two most powerful vibration test rigs. These 16-channel systems control the large and complex test rigs using various control strategies (average, minimum and maximum) and measure and monitor the response behavior of the specimens at several analysis points. The notching function is an essential software tool in order to avoid over-testing attached parts and components, such as electric actuators.

Mahle mainly uses classical test modes to simulate the excitations of engine and body: sine (swept sine, fixed-frequency sine, resonance dwell, multi-sine); broadband random; shock; and sine-on-random.

The M+P VibRunner front ends support different sensors and measuring instruments for control, monitoring, visualization and data acquisition. These include accelerometers, force transducers, displacement transducers, laser Doppler vibrometers and stroboscopes.

The image above illustrates a classic test rig for an air intake system in a temperature chamber, where the excitation is applied vertically. The specimen is a complete air intake system, which is mounted to the engine at four attachment points. Testing also includes the raw air duct and the corresponding raw air intake orifice (bellmouth) installed in the front end of the vehicle. This is normally mounted to the body, and so is attached to a fixed point in the temperature chamber in order to simulate the relative movement between engine and body during the vibration tests. This is the most realistic way to load the system under test, especially the air intake bellows section of the raw duct, to evaluate the interfaces between the components.

To meet the excitation profile (reference) demanded by the test specification, four accelerometers (marked in red, left) are used as inputs for vibration control. They are placed close to the four attachment points of the air cleaner housing and ensure that the specimen is excited at the correct level, based on the multipoint control strategy set by the user in the vibration control software.

Another accelerometer (marked in blue in the same image) is mounted on the air cleaner housing to measure its vibration response during a resonance search. This search is performed before and after the main test sequence. Its task is to compare the pre- and post-test vibration responses of the system to detect any possible structural damage such as cracks, breaks and wear. The acquired data is also used as proof of the system's structural integrity (see chart left), thus complementing the visual assessment.

M+P International's vibration control system with its multitasking capabilities greatly simplifies daily testing. The user is able to set up or edit a test, run a test, and analyze the acquired data all at the same time. This makes it very convenient to prepare a complete test series and to start analyzing while the tests are performed in parallel. ❮

BELOW: Comparison of frequency spectra (acceleration magnitude and phase) before and after testing