Observation of high-frequency vibration characteristics: **Who Verifies the Test Station?**

Laser scanning vibrometry has proven itself as a fast, accurate method process for non-contact vibration measurement in many applications. Examples can be found in automotive engineering, aviation engineering, mechanical engineering, microsystems, quality control, production control and even, for example, in manufacturing consumer electronics or home appliances. Laser scanning vibrometers have also proven to be important tools for the testing and optimization of high-frequency test stations for engine component mounting materials used in electric vehicles.

When it comes to the mounting of engines in electric cars, microcell polyurethane (PU) can be regarded as an attractive alternative to the rubber mixes regularly used for combustion engines. It is light and can be used to reduce the high-frequency whining noises perceived to be especially loud in electric cars.

As a result, BASF took it as a matter of course that mounting prototypes should be developed using this elastomer and that its behavior should be tested at high frequencies up to several kilohertz to draw conclusions about its suitability for use in engine mounts. To accomplish this task, a comparatively simple test station was designed (Figure 1). To ensure that its natural vibrations would not distort the measurement results, the test station had to be “tested”. The goal was to determine its vibration characteristics in order to further optimize it. As part of this vibration analysis, it was important to measure and illustrate the resonance vibrations of some initial elastomer samples to determine their suitability as a material for engine mounts.

3D SCANNING VIBROMETER IN THE AUTOMATIC TEST CENTER

These measurements on the BASF test station were carried out in Waldbronn at the RoboVib® Test Center of Polytec GmbH (Figure 2). The automated system has been in operation since 2012 and is comprised of two robot-assisted PSV-500-3D Scanning Vibrometers. It facilitates comprehensive 3D vibration measurement of all ▶

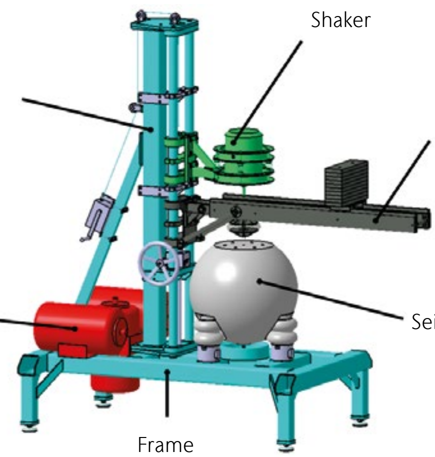

Figure 1: Test station for the investigation of high-frequency transmission behavior of components

surfaces on any given test subject. The process is based on laser Doppler vibrometry. The machine calculates the vibration frequency and amplitude of the laser light reflected off a vibrating surface. In scanning vibrometers, the laser Doppler
vibrometer is combined with a scanner mirror unit and a video camera in a sensor head. As it measures, the laser beam scans the surface of the object and provides a series of spacial, high-resolution individual point measurements (Figure 3).

The sequentially measured vibration data is then combined to create one extensive data model and can be evaluated according to the intended application. The position and thickness as well as the deflection shapes for resonances in the spectrum can be determined. The very high spacial resolution and non-reactiveness of the data facilitate detailed comparisons with simulations.

VIBRATION CHARACTERISTICS OF THE TEST STATION AND SAMPLE

Ideally, the mechanical test equipment for the elastomers should not have any noticeable natural resonance in the frequency range from 100 Hz to 2 kHz, or even better 4 kHz, since this could disrupt the evaluation of the elastomer sample's resonances. To investigate this, the test setup is first excited with an external vibration source (shaker) and the resonance frequencies and deflection shapes of the test structure are recorded. Approximately 60 robot positions and between 1,400 to 1,800 measuring points were defined for the characterization. The laser scanning vibrometers take the place of 1,400 to 1,800 individual 3D vibration sensors that must be affixed and connected. Not only would this take an unrealistic amount of work, but it would also influence the mechanical vibrations (Figure 3).

Furthermore, the test station was measured while in operation, meaning that the specimen was excited with the internal vibration unit of the testing station to determine and record its deflection shapes (Figure 4). These test results reveal that the testing equipment is well-prepared to fulfill its purpose, since amplitudes ►

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Figure 1: RoboVib® Structural Test Center at Polytec in Waldbronn, Germany

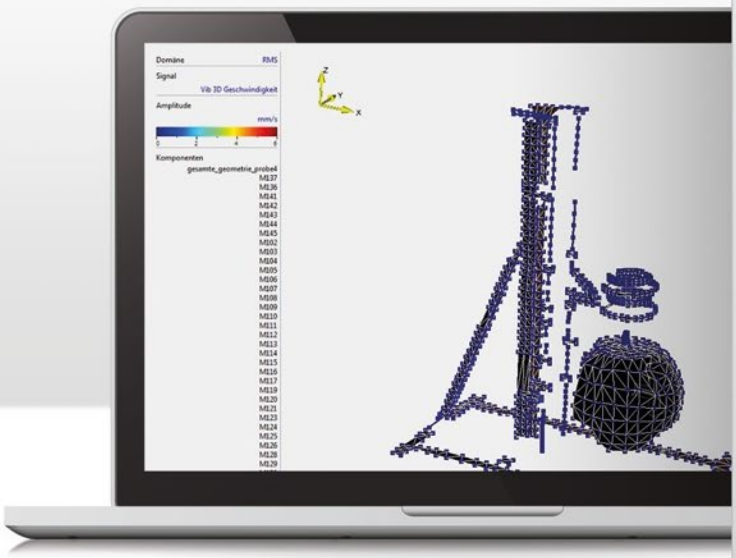

Figure 3: Object and measurement grid used. All blue dots correspond to a measurement point of the RoboVib® system.

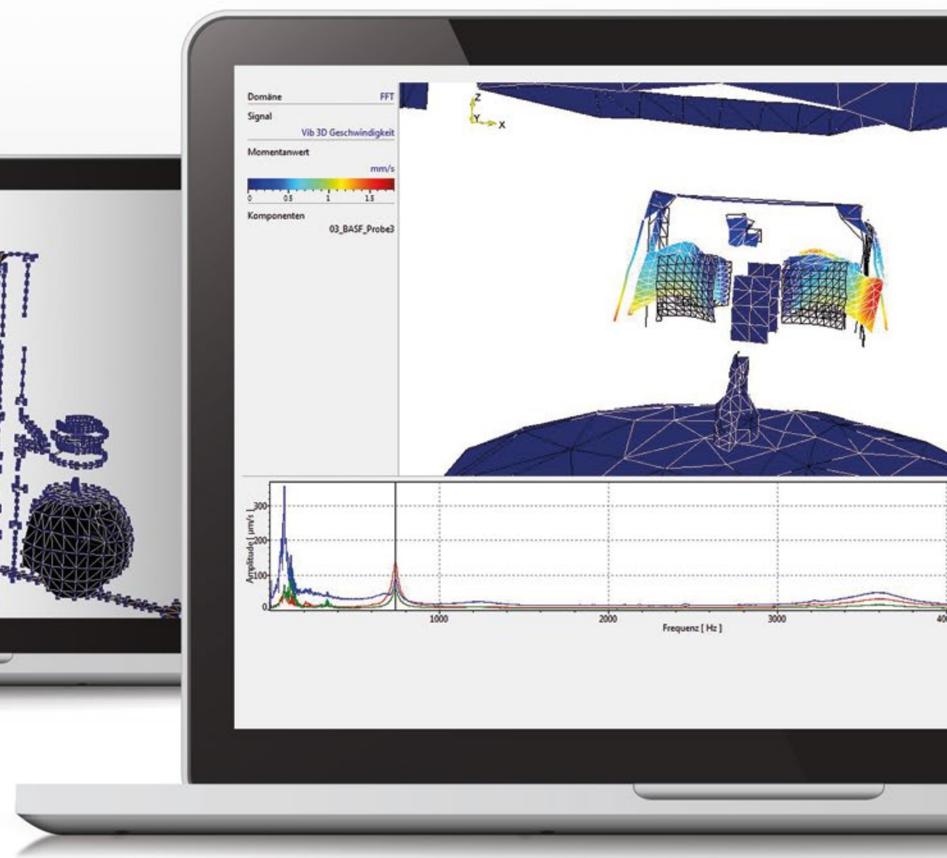

Figure 4: Resonance deflection shape of the sample at 742 Hz

of the eigenmode of its structure during operation of the internal shaker are negligible in comparison to amplitudes of the sample.

In Figure 5, an example is shown of the amplitude distribution for a sample resonance at 1,306 Hz. It is apparent that noticeable amplitudes only occur in the area immediately surrounding the sample, and that the test station construction itself is essentially inactive.

The locations of the resonant frequencies, the widths of the resonances, and the resonance deflection shapes of different PU elastomer samples were then measured. Despite the microcellulare nature of the material, the natural vibrations of the sample itself were easy to observe with the laser vibrometer. The influence of the test setup on the measurement quality was small. The measured results matched very well with the values calculated for the preliminary design of the test station.

Since the first successful vibration analysis at Polytec, additional experiments have been carried

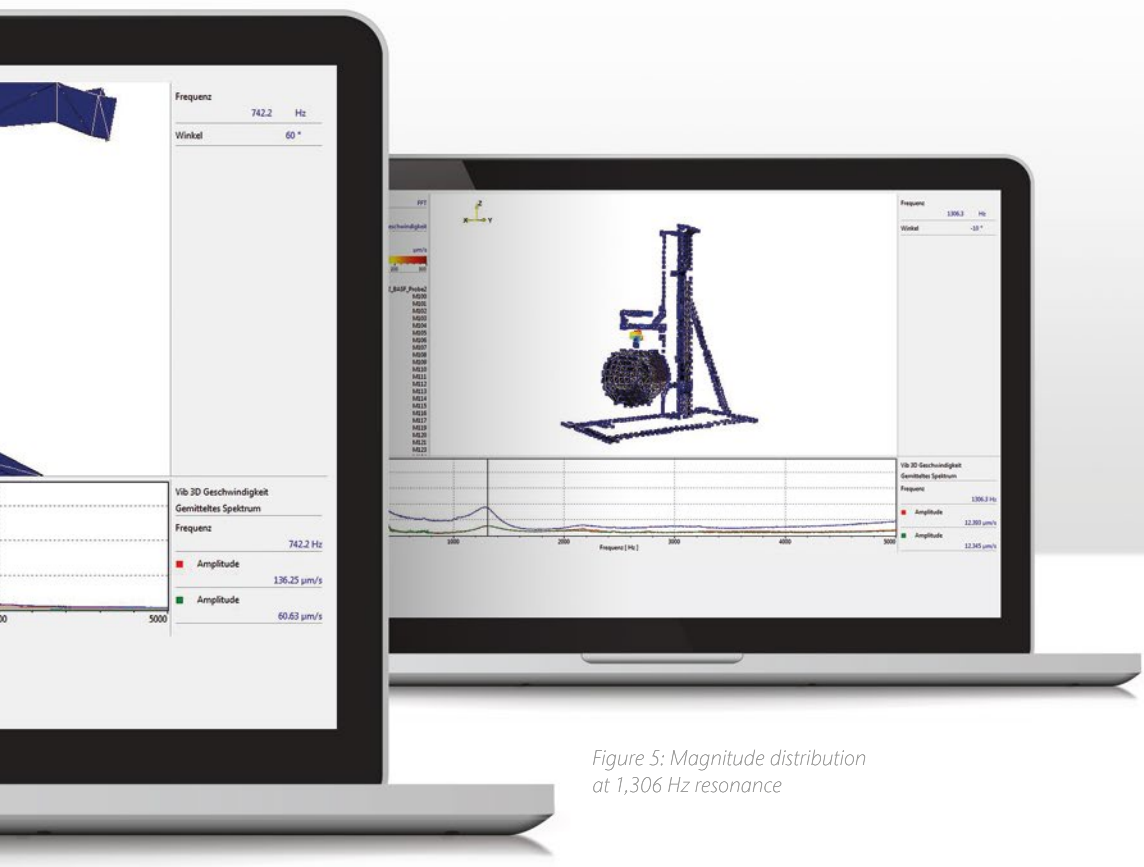

Figure 5: Magnitude distribution at 1,306 Hz resonance

out on samples with different designs. Currently the system is being optimized so that cardanic, soft samples can be tested at high initial loads in the highest frequency range without buckling. Once this work is complete, it would be interesting to run the test again with the laser scanning vibrometer to determine combinations of frequency ranges and initial loads suitable for average samples.

The high-frequency test station will probably be tested again for this reason. ■

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