Flexible seat foam test with NI DIAdem and EtherCAT

Abstract

Ever-increasing customer demands regarding the quality of motor vehicles are resulting in a growing testing workload and the need for new test methods in development and production. This applies in particular to seating comfort and, consequently, to the foams used in the seats. As commercially available test systems often only support individual test methods and – if at all – can only be adapted to changing test procedures with considerable effort, müller+krahmer GmbH has, at the customer's request, developed a seat foam test rig based on standard hardware and software that can be flexibly adapted to new test tasks. Key components here are application software NI DIAdem and the high-speed industrial Ethernet standard EtherCAT.

Adaptable thanks to standard software

Car drivers expect high quality and a long service life of all their vehicle's components. It is therefore only logical that worn-out seats are no longer acceptable, even with high mileage. The challenge, therefore, is to develop seats that are, on the one hand, very comfortable and, on the other, guarantee a long service life. In order to predict the fatigue strength of new seat foams, the industry has developed test standards that make it possible to simulate the stresses of an entire seat's lifetime in a comparatively short period of time. Under defined climatic conditions, foam components are subjected to cyclic loading and unloading over defined periods – days or weeks. At specified intervals, characteristic values are determined, which then provide an indication of the test specimen's service life behaviour.

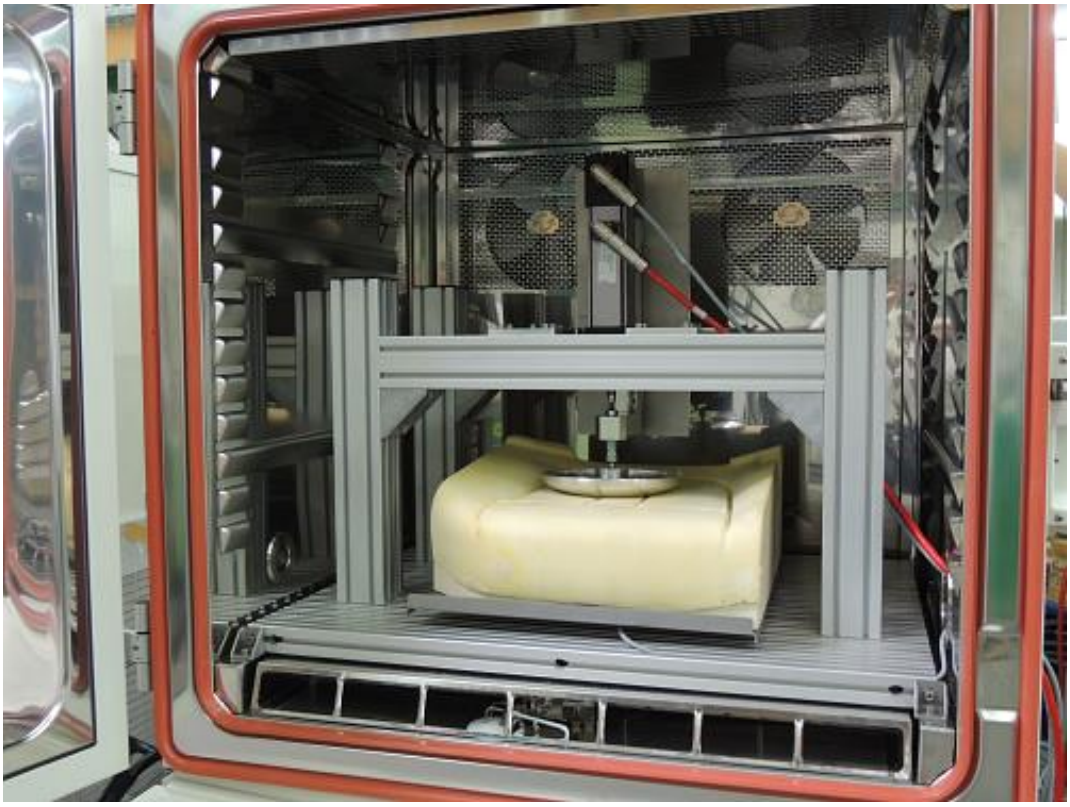

Figure 1: The seat foam test is carried out under defined conditions in the climate chamber. All components are designed for operation in a warm and humid environment.

Whilst the standard systems available on the market for foam endurance test largely meet the requirements of existing standards, they often lack flexibility when it comes to adapting to new test procedures and methods. For this reason, a seat foam test rig based on standard components was

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developed on behalf of car manufacturers and suppliers; this enables automated testing in accordance with various current standards, whilst at the same time allowing for easy adaptation to new test requirements.

Key components are the standard software NI DIAdem and a DIAdem real-time extension developed by müller+krahmer based on TwinCAT, which connects various hardware devices with EtherCAT interfaces to DIAdem. DIAdem handles the user-oriented software functions of the application, ranging from user guidance and the input of test parameters to sequence control, visualisation and report generation. The real-time extension performs the time-critical processes of measurement data acquisition and output, signal generation, control of the indentation force and data storage.

The DIAdem application allows the test to be defined as a sequence of up to 10 test steps. These include conditioning, the indentation hardness test, the dynamic fatigue test and a constant-load pounding test in accordance with ISO 3385. Conditioning enables the setting of configurable climatic conditions during the test. First, a target temperature is set in the climatic chamber and, once this has been reached, the specified humidity. Once this has also been reached, a waiting period begins during which the set climatic parameters are maintained in order to achieve a stable state of the test specimen. The indentation hardness test is used to determine the hardness of the test specimen. In this process, the test indenter is pressed into the test specimen three times with a maximum indentation depth and then once with the specified measurement indentation depth. During the final indentation, the force-displacement curve is recorded. The indentation processes each begin at the zero point, which has been determined whilst a defined preload is applied. In the dynamic fatigue test, the test specimen is subjected to cyclic force-controlled loading, whereby the test indenter presses into the test specimen with a defined setpoint force in accordance with a specified number of load cycles. The setpoint force curve is sinusoidal, with the offset, amplitude and frequency of the setpoint function resulting from specifications for indentation force and loading frequency. Over a specified number of cycles, the force, displacement, climate chamber temperature and humidity, as well as the test specimen temperature, are recorded. The constant-load pounding test involves a cyclic, displacement-controlled loading of the test specimen with force-dependent offset correction. In this process, the test punch is pressed into the test specimen by a defined displacement. The displacement curve is sinusoidal, with the amplitude and frequency of the set function determined by the specified indentation displacement and loading frequency. The offset of the sinusoidal force curve is readjusted during the test so that the reversal point always lies at the parameterised maximum indentation force. The current deviation of the offset from the offset at the start of the measurement can be read from the ‘displacement difference’ display. Data acquisition corresponds to that described for the dynamic fatigue test.

Up to this point, the DIAdem-based seat foam test rig does not differ fundamentally from standard test machines available on the market, even though many of these systems are only capable of performing one of the aforementioned test steps. However, a key advantage of this solution, which is based on standard software, becomes apparent when it comes to implementing new test specifications – whether due to changes in statutory requirements or the need to carry out manufacturer-specific tests. The open-architecture DIAdem application can then be modified in every respect. By adapting the measurement task definitions and the DIAdem DAC diagrams via a relatively simple graphical configuration, new test algorithms can be implemented. New evaluation and analysis functions can be implemented using script programming in the easy-to-learn programming language Visual Basic Script. Finally, new requirements regarding the layout of test reports can be met interactively and graphically within DIAdem REPORT.

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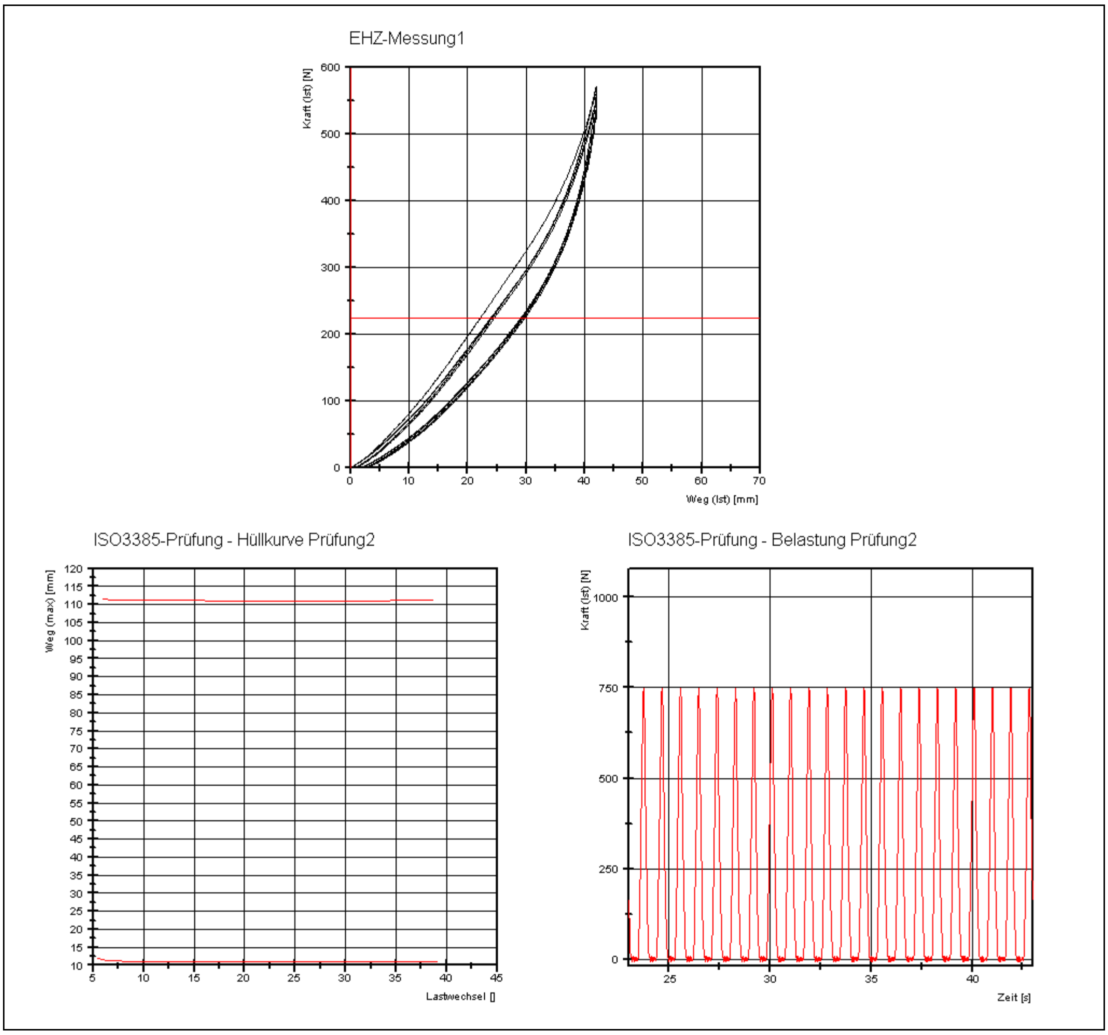

Figure 2: The data recorded during the various test stages enables predictions to be made about the service life behaviour of the test specimen.

EtherCAT core component

In addition to the performance of the application software itself, the hardware architecture of the system and the connections between the components are crucial to the functionality of the overall system. The system was therefore designed based on the high-speed Industrial Ethernet standard EtherCAT, and all time-critical hardware components were selected to ensure their optimal connection to this bus. Analogue and digital signals are acquired and output via an EtherCAT slave chassis (NI 9144) and the associated C-Series I/O modules. A Metronix ARS2105 servo controller, in conjunction with an Exlar GSM linear actuator, applies defined forces to the test specimens. The mechanical test rig, actuators and sensors are integrated into a Vötsch VC³ 4100 climate chamber, which – as there are no real-time requirements here – is connected to the test bench control system via an Ethernet interface.

The interface between the application software and the bus system must transmit data at high sampling rates and in real time in order to ensure the required response times for control. This is made possible by the DIAdem real-time extension, which also provides an easy-to-use connection between DIAdem and EtherCAT. Communication between DIAdem and the extension takes place via the generic TwinCAT ADS interface, which enables direct access to all parameters. The real-time extension can generate signals based on the NI TDM data format and stores its data in a DIAdem-compatible format, which simplifies data exchange between the components. The problem of synchronising different hardware is eliminated, as the data from all bus participants is transmitted in a single telegram.

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Distributed measurement points also pose no problem, as the Fast Ethernet physical layer allows distances of up to 100 metres between two participants. Consequently, the application does not have to be operated within the often cramped and noisy test bench environment. Instead, it can be relocated to a quiet office environment without this having any negative impact on signal quality or real-time performance.

Summary

With the seat foam test bench, müller+krahmer GmbH has provided customers with a system that enables flexible solutions for a variety of test tasks using standard hardware and software components. Signal acquisition and output via hardware with an EtherCAT interface ensure the operation of a distributed, Windows-based system in real time. The open software architecture based on DIAdem enables customers to adapt the system to future requirements. Thanks to the test rig, the evaluation of newly developed seat foam materials is more flexible and – as all tests can be carried out on a single system – more cost-effective than is possible with the test machines typically used.

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