SIEMENS
Ingenuity for life

Academic

University of Ferrara

College uses multi-axis vibration testing from Siemens Digital Industries Software to increase efficiency and realism of vibration tests

Product

Simcenter

Business challenges

Increase efficiency and realism of vibration tests

Innovate testing methods and prove applicability to industry processes

Keys to success

Rely on innovative hardware and software to develop advanced methods

Adopt an approach that meets industry needs

Collaborate with industry players on research activities

Results

Validated testing method

Successfully completed first industry projects

Pioneered future and advanced testing methods

The University of Ferrara develops methods using a 3D vibration shaker controlled by Simcenter testing solutions

A pump's structural integrity is at risk when subjected to harsh or prolonged vibration. An Italian pump manufacturer was confronted with this issue during the transportation process from the manufacturing plant to the customer's location. On more than one occasion, the pump arrived damaged and unusable.

The gear pumps, designed specifically for use in automotive applications, bear a small o-shaped ring. The pump manufacturer discovered that the vibration the pumps experienced during road transportation caused the ring position to shift, ultimately damaging the pump's performance.

To solve this issue, the manufacturer turned to the University of Ferrara in Italy, recognized in Italian public rankings as a top 10 university for scientific research. MechLav is a laboratory located at the University of Ferrara, dedicated to industrial research, technological services and technological transfer of methodologies and solutions in industrial and production applications. MechLav offers industrial research, solutions and services in the fields of mechanical engineering, computer science and vibro-acoustics. Professor Emiliano Mucchi, an associate professor in the university's engineering department, accepted the challenge of solving the vibration issue. He and his team relied on the capability of state-of-the-art multi-axis exciters and control systems to test the pump and find the issue's root cause.

Why multi-axial vibration testing?

Vibration control tests are a standard feature in development and production processes in many engineering applications. The tests allow an engineer to verify if an item, product or subsystem can withstand the vibration levels it will be subjected to throughout its lifetime. The vibration levels can be caused by the operation of the manufactured device, the machine itself, the operation of adjoining machines in a factory environment or, as in the aforementioned example, during transport.

Vibration control tests are performed to replicate the real-life dynamic environmental conditions of an item and to understand its structural responses with the highest possible level of fidelity. In real life, a structure is generally excited in multiple directions. Realistic vibration control tests will reproduce this multidirectional excitation.

The current standard procedure for laboratory testing prescribes sequential single-axis tests (called sequential single-input single-output or SISO tests) to replicate multidirectional excitation. This practice has technical limitations. Using sequential SISO

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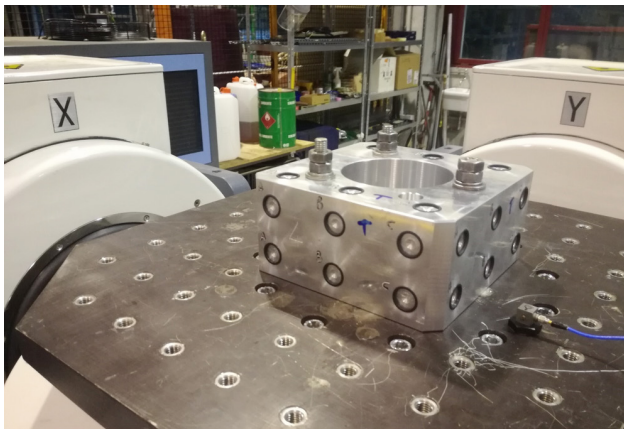
tests, the time-to-failure ratio is grossly overestimated. Sometimes, test teams also witness failure modes resulting from SISO tests other than the ones observed in real-life conditions, meaning that the item under test breaks differently. In other words, from a practical standpoint, sequential tests are imprecise.

As opposed to sequential single-axis testing, multi-axial excitation takes into account the interaction between the main excitation sources and paths. Moreover, the combined loading effects caused by three-axis excitation gives additional insight into the various stress/strain states and dynamic behavior of the structure. This is why pioneering techniques such as simultaneous multi-axial excitation methods with multi-input multi-output (MIMO) vibration control are drawing the attention of the engineering community as they accelerate the test procedures and increase confidence in the results.

Implementing innovative methods to solve common issues

Being at the forefront of research and education, MechLav has equipped its laboratory with a tri-axis electrodynamic shaker. The shaker, manufactured by



Dongling Technologies in China and controlled by Simcenter Testlab™ software and Simcenter SCADAS™ hardware from Siemens Digital Industries Software, is the first in Europe. Tests conducted using the method developed by MechLav are expected to significantly improve test realism and efficiency.

The tri-axis, electrodynamic shaker has three shaker elements of 10 kilonewtons (kN) that excite structures in the three perpendicular directions with a maximum payload of 100 kilograms (kg). It has a frequency range of 2 kilohertz (kHz) and

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can reach up to 10 g-force (g) of acceleration. The three shakers are controlled by Simcenter Testlab. Mucchi comments: "The quality of the controller is a very important factor for the success of a vibration qualification test. The controller should be capable of tuning the signal excitation in real time, usually in a nonlinear scenario. This is why we rely on Simcenter Testlab software. We performed various tests imposing specific reference profiles either in the frequency domain, using the MIMO random or MIMO sine software functionalities, or in the time domain by using MIMO tome waveform replication."

The academic team also used MIMO vibration control testing to resolve the problem encountered by the Italian pump manufacturer. In the beginning, the team fitted tri-axial accelerometers connected to a Simcenter SCADAS Mobile software inside the truck to monitor vibration levels during a full-day (measured for exactly 4,100 seconds) transit. The engineers then designed a specimen that offered three design variations, characterized by the varying position of the rings. The purpose of the evaluation was to investigate the optimal design: the one in which the ring's position will not shift despite transport conditions.

The specimen was tested on the three-dimensional shaker, using Simcenter Testlab software to replicate the truck vibration levels in the time domain. Multiple ring locations were tested simultaneously in order to obtain acceptable

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Solutions/Services

Simcenter Testlab
siemens.com/simcentertestlab

Simcenter SCADAS
siemens.com/simcenterscadas

Customer's primary business

The University of Ferrara fosters an international scientific and academic community focusing on the pursuit of the highest teaching and research standards, targeting specific areas of excellence and thriving on the presence of a strong historical and cultural identity.
unife.it/international

Customer location

Ferrara
Italy

statistical results. The signals replicated by the tri-axis shaker were almost identical to the signals acquired in the truck. Additional tests were performed that reduced the overall duration of the signals from 4,100 seconds to a few minutes while maintaining the same level of vibration.

"With multi-axis vibration testing, we were able to minimize the time spent on testing the items while increasing the realism of the test," says Mucchi. "The project was completed to the satisfaction of the manufacturer commissioning the research. As an end result, we were able to define the best location of the o-shaped ring on the pump."

Confirming methods

Researchers are constantly working to improve and validate the test method. Mucchi says: "We have already successfully worked with several automotive and aerospace companies. We performed vibration qualification tests on various components such as pumps, brackets and electronics equipment. We observed that we were able to reproduce the vibratory environment in a more realistic way, which leads to better results."

Those results encouraged the team to continue its research assignments. The research mainly addresses the definition of new norms for the fatigue lifetime of products and components, based on simultaneous multi-axial vibration tests.

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