Issue 02 | 2011

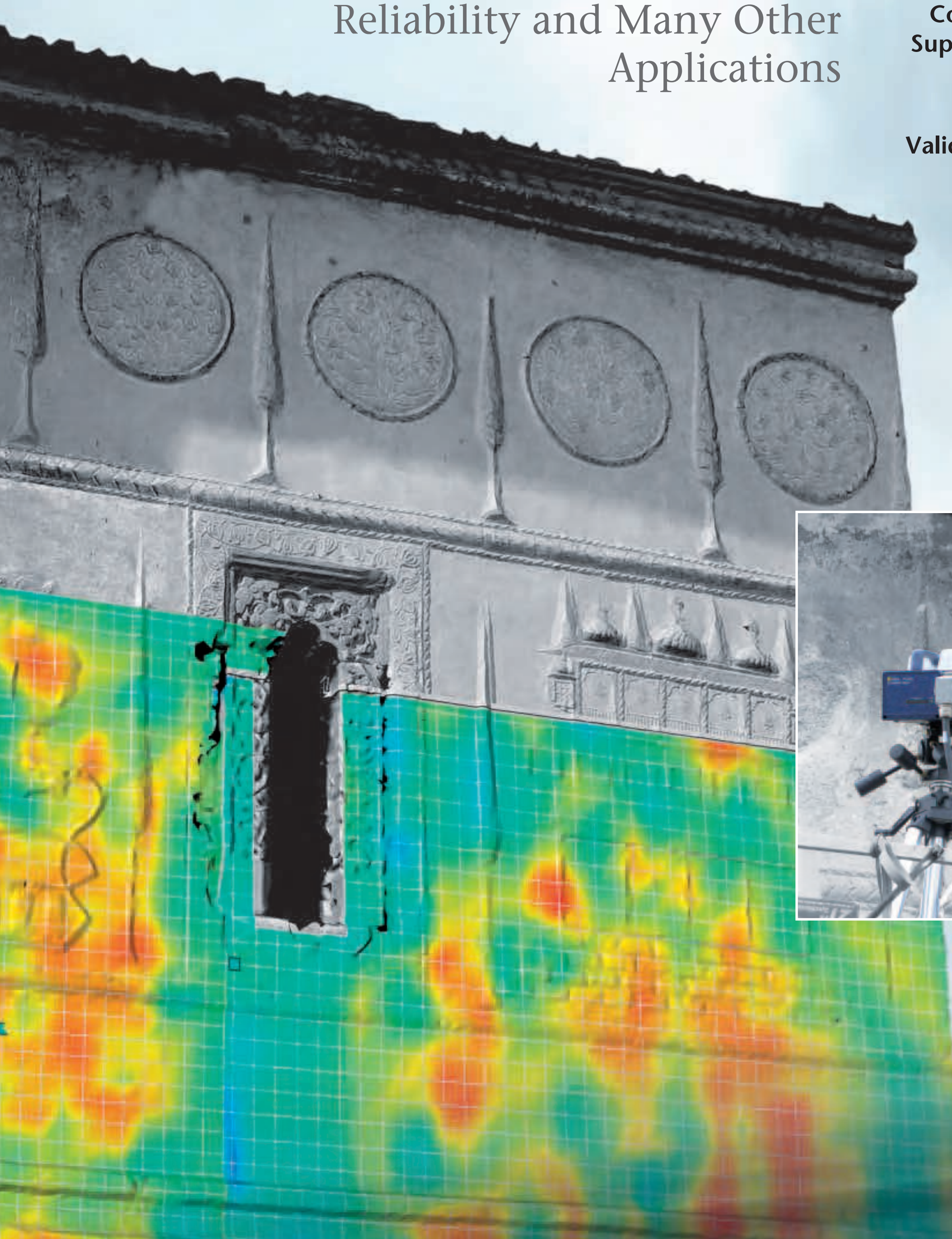
Polytec

InFocus

Optical Measurement Solutions

Non-destructive Testing

for Structural Health Monitoring, Reliability and Many Other Applications



Eric Winkler

Dr. Hans-Lothar Pasch

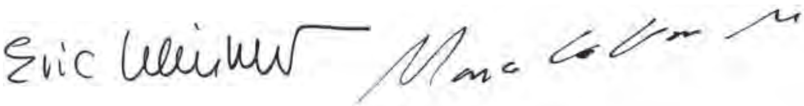
Dear Readers,

As all of us know, the physical properties of engineered structures will deteriorate over time under dynamic load, an effect generally known as material fatigue. Mechanical engineers would refer to the term "high cycle fatigue load". This fatigue is caused by alterations in the material structure or micro-damage, which can develop inside the material and might not be visible from the outside. For structures where safety is a concern, the only way out is continuous or regular inspection (structural health monitoring).

Laser vibrometers from Polytec can, in effect, see inside these structures. The reason is that material alterations lead to changes in dynamic system characteristics – thus internal damage can be identified and located by a targeted analysis of the measured vibration data.

Our customers are increasingly using laser vibrometers for non-destructive testing, beyond the more familiar applications in acoustics and structural dynamics. We are happy to share this fascinating field of application with you and to illustrate it with practical reports and examples.

We hope you will enjoy reading the articles and wish you many new insights and fresh ideas!



Eric Winkler
Optical Measurement Systems

Dr. Hans-Lothar Pasch
Managing Director Polytec GmbH

Groundbreaking News from Polytec

At the end of October the first turf was cut to prepare the ground for expansion of Polytec's Headquarters in Waldbronn, Germany by a further 8,000 square meters. The new building will be finished in 2012 to provide sufficient space for development, manufacturing and sales as well as new application and demo labs for the next 5 – 10 years. This expansion reflects positive business development, a continuously increasing number of employees, and will provide sufficient resources for further growth.

Polytec's UHF-120 Vibrometer Wins 2011 Industry Prize

During the 2011 Hannover Messe trade fair, the UHF-120 Ultra-High Frequency Vibrometer was awarded the 2011 Industry Prize under the microsystems engineering category. The award was judged by a panel of professors and trade press experts according to the level of innovation and future potential of the products. Polytec, as a developer of innovative measurement technology, is frequently awarded renowned research and industry prizes, for instance the 2009 Innovation Award of the German Economy for the robot-assisted automatic RoboVib Test Station and the MessTec & Sensor Masters Award for the Optical Derotator. The industry prize was received by Dr. Karl Spanner, Managing Director of Polytec (see photo, second from right) together with Vice President Eric Winkler and Product Managers Dr. Wilfried Bauer and Dr. Heinrich Steger (left).

Polytec Top Rated Business Partner

Polytec was awarded a top rating in the index of creditworthiness as part of the annual certification of "Top Business Partners" granted by Hoppenstedt, one of the leading suppliers of business information in Germany. In early 2011, Hoppenstedt evaluated 4.5 million companies on a scale of 1 to 6 with regard to creditworthiness and concluded that Polytec ranks within the top 3.3% of the best rated German companies.

2011 Polytec Technical Days and UK Users' Meeting

September 21st/22nd saw over 60 delegates travel to Warwickshire's Heritage Motor Centre to attend the latest Polytec UK Technical & Users Group Meeting. The delegates comprised a mix of existing users and non-users, all with an interest in finding out more about the technology, seeing systems first hand and being able to talk to other users and Polytec engineers about those systems and applications.

As with previous meetings, the technical day covered the instruments and basics of laser Doppler vibrometry, with practical demonstrations of a range of single point and scanning laser vibrometers including the PSV-3D system and the new UHF-120 ultra-high frequency and RSV-150 long distance measuring vibrometers. The 2nd day featured speakers talking about their own Polytec vibrometer applications. The subjects were wide-ranging, covering such diverse subjects as dynamic measurements on rotating structures, human and insect hearing, ultrasonic drilling, microstructures, long range bridge and building response, vehicle brake testing and stress/strain determination. Most delegates were very complimentary about the meeting, going away with fresh ideas to further their work. In Germany, another 60 participants visited a series of Technical Days during October located at Ulm University, Erlangen-Nuremberg University, at the Institute for Microelectronics and Mechatronics Systems (IMMS) in Ilmenau and at Polytec Headquarters in Waldbronn. Attendees were given a unique opportunity to see live demonstrations of many of Polytec's optical measurement systems' product range.

Polytec New Affiliate in Big Partner Networks

By actively maintaining a professional but intimate relationship with our customers as well as with scientific and technical institutes, associations and networks, we learn and understand the requirements that make each new product a better solution. These innovative solutions allow thousands of customers to maintain their own technical leadership and meet future challenges. Among others, new partnerships have been established between Polytec and the MEMS Industry Group®, as well as national and regional associations like the Fraunhofer Vision Alliance and MST BW Mikrosystemtechnik Baden-Württemberg e.V.

More info:
www.polytec.com/partners

www.memsindustrygroup.org

MSTBW
www.mstbw.de

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Application Overview

Defect Detection Using Lamb Wave Testing

Defect Detection in Composite Structures

Defect detection is currently of great interest, especially in the aerospace sector but also in the automotive sector and generally in lightweight construction. One of the main reasons is the ever wider availability of composite materials, such as carbon fiber reinforced composite (CFC) structures which, in spite of their extreme lightness and strength, are particularly prone to certain types of structural defect. For safety reasons, the detection of such defects above a certain damage size is critical.

Classically, such components are frequently inspected ultrasonically, provided they can be immersed in a water bath or wetted with water. An ultrasonic transmitter and receiver are generally placed on either side of the test piece because the through-transmission of sound provides better sensitivity than can be obtained using reflection. This enables extremely fast, often automated inspection with very good resolution.

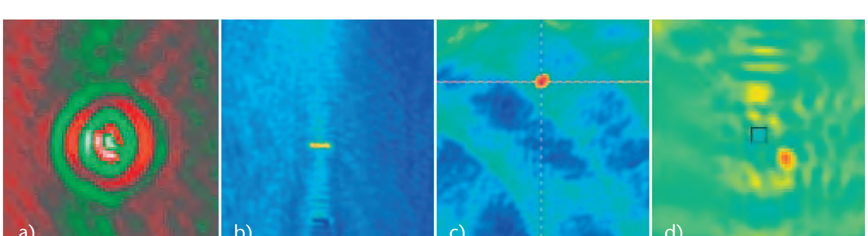
The Alternative: Lamb Wave Tests

A highly promising alternative for test pieces and applications where this approach is not possible, is to investigate the propagation of Lamb waves in the material using laser vibrometry. Lamb waves are vibration waves in plate-like structures that propagate as both bending and compression waves. The propagation is influenced by irregularities of the structure. Lamb wave methods may be used to determine impacts, cracks, delaminations and also adhesion defects in composite structures (Fig.1), possibly even micro-cracks and porosity.

Please read on to learn about Investigations performed at the Helmut Schmidt University at Hamburg (pages 6/7) and about a laser ultrasonic scanning system developed at the Korea Advanced Institute of Science and Technology (pages 8/9). A further potential area of use is in the design of piezo-sensor networks, which are integrated into the component so that material defects can be monitored during operation (see article by T. Windisch et al., InFocus 1/2011). Fundamental research is a further application area for Lamb wave measurements in that, for example, material parameters in anisotropic composite materials can be investigated.

Summary and Prospects

As discussed above, classical ultrasonic inspection carried out in a water bath, where applicable, is generally more accurate, faster and easier to implement. Nevertheless, the Lamb wave method has impressed many customers and users of laser vibrometry due to the nature of this contact-free, elegant measuring technique and its possible use on components which cannot be inspected with classical water-coupled ultrasonic testing, or for on-site inspection of components. Aids have not been developed yet for the automatic identification of defects. A 1-D scanning vibrometer is often sufficient for inspections aimed to simply display defects at the manufacturer's site. For fundamental, detailed research into wave propagation, the PSV-400-3D comes into its own.



Please download the full article as Polytec Application Note VIB-G-23 on **www.polytec.com/applications.**

Fig.1: Wavefield images of various structural defects:
a) impact b) cracks
c) delaminations d) adhesion defect

Hidden Defects Revealed

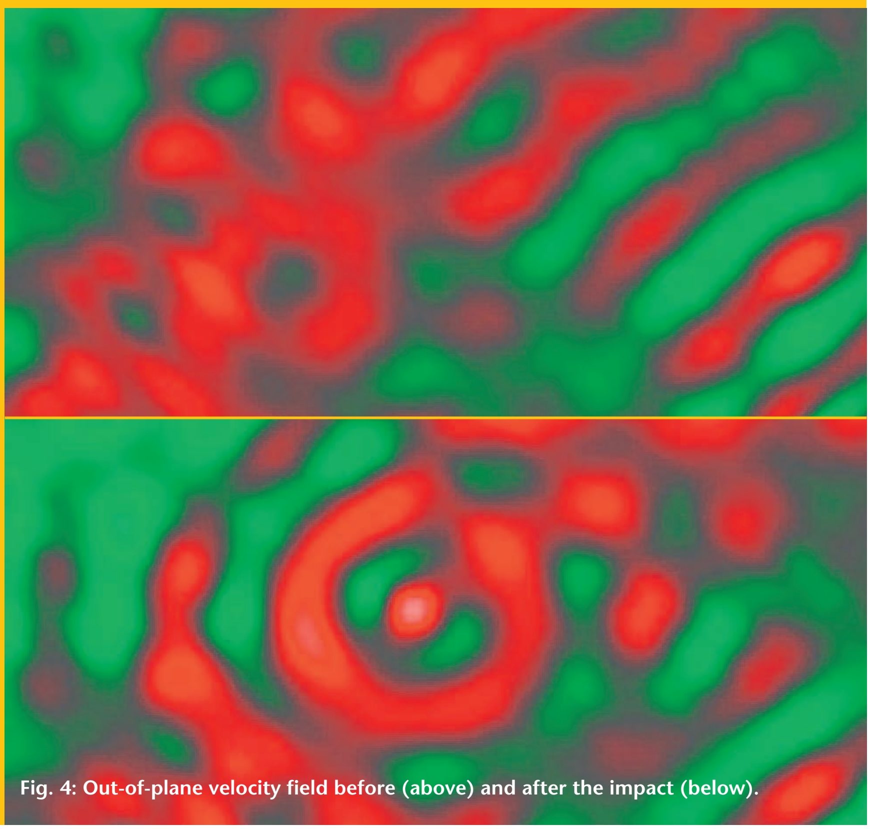


Fig. 4: Out-of-plane velocity field before (above) and after the impact (below).

Scanning Laser Vibrometry for Structural Health Monitoring using Ultrasonic Surface Waves

Structural damage in components is often invisible from the outside. However, ultrasonic waves can be used for Structural Health Monitoring. The propagation of waves and their interaction with defects can be measured and displayed in a contactless, full-surface, high-precision manner using scanning laser vibrometry.

Lamb Waves for Identification of Defects in Fiber-reinforced Composites

In the past, thin-walled, load-bearing components were made almost exclusively of metal sheets, but are today increasingly being made of carbon fiber reinforced plastic panels (CFRP). In those structures, waves propagate as flexural waves and compression waves within the plate. Fig. 1 shows a cross-section through groups of flexural and compression waves in aluminum (actual measured data).

Regardless of whether a material defect or structural damage is located on an inaccessible face or in the middle of the material, a wave, which can be monitored from the accessible face, interacts with it and thus its behavior is changed.

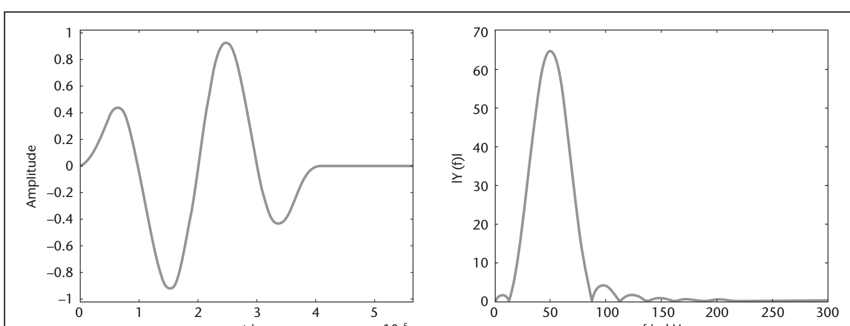
This monitoring can can be easily and effectively achieved using scanning laser vibrometry. Furthermore, current vibration amplitudes in the high tens of nanometer range, and excitation frequencies up to several hundred kilohertz can be achieved without difficulty.

Lamb wave theory assumes ideal elasticity, homogeneity, and isotropy. A good approximation to ideal elasticity can be assumed (in the technically relevant frequency range) for fiber-plastic composites based on thermoset matrix materials. This simplification cannot be made for materials with greater internal damping. By definition, homogeneity is as inapplicable to fiber composites as isotropy. The anisotropy of the elasticity parameters leads to deviations from the otherwise circular shape of the wave fronts.

Besides analytical approaches, numerical calculation methods such as the finite element method quickly reach their limits in the prediction of the propagation and interaction behavior of waves. The realistic modeling of individual carbon fibers would be associated with unacceptably

Fig. 1: Flexural and compression waves in aluminum sheet over 250 mm, true sheet thickness 1 mm, true vibration amplitudes less than 100 nm.

Fig. 2: Excitation signal in the time domain (left) and corresponding amplitude spectrum (right).



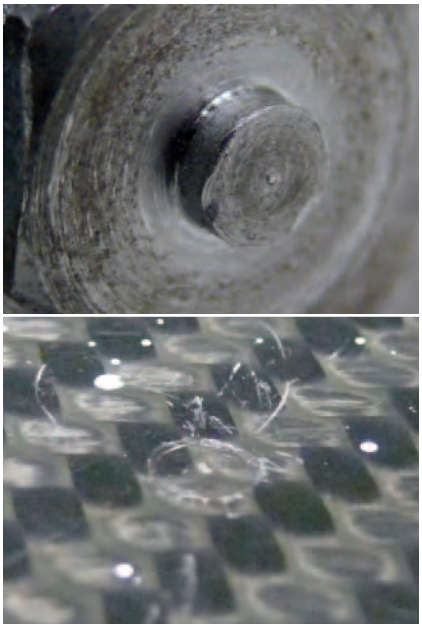


Fig. 3: Above: Front face of the drop hammer. Below: Impression after the 2.5 J impact.

high costs, however each simplification requires experimental validation of its acceptability. Therefore, measurements are essential for modelling the propagation of Lamb waves.

Experimental Detection of Structural Damage Caused by Wave Interaction

Structural damage and material errors are frequently indistinguishable. An important example is impact damage to CFRP structures, which often manifests as delamination, i.e. detachment of individual laminate layers from each other.

3-D measurements are carried out on an undamaged, quasi-isotropically laminated CFRP panel to obtain reference data. The excitation is provided by a sine-windowed burst signal

$$V = \sin(\omega t) * \sin(\tfrac{1}{4}\omega t)$$

of two cycles in length applied to a piezoceramic wafer, with the measurements taking place in the time domain. Fig. 2 shows the signal and its amplitude spectrum. Application of the window reduces the unwanted secondary maxima in the spectrum. The experiment is then repeated for different excitation frequencies.

Initially, a group of compression waves passes through the observation area, subsequently, because of the lower phase velocity, a group of flexural waves.

To cause an area of impact damage, a drop hammer with a kinetic energy of 2.5 J and a circular impact area of 12.5 mm^2 (fig. 3, above) strikes the rear side of the panel. This results in an impression on the surface of 0.05 mm in depth (fig. 3, below).

The measurements were repeated under the same conditions after the damage. Fig. 4 (page 6) shows a snapshot of the out-of-plane velocity field in the observation area before (above) and after (below) the impact event. By way of example, a 50 kHz excitation was used here.

In the snapshot, the defect is faintly identifiable due to the circular secondary waves. The difference between the two data records is imaged using the signal processor (software option PSV 8.7 or higher) or via MATLAB. Fig. 5 shows, at the top, only the out-of-plane components; at center, only the in-plane components; and, at the bottom, all the vibration directions simultaneously.

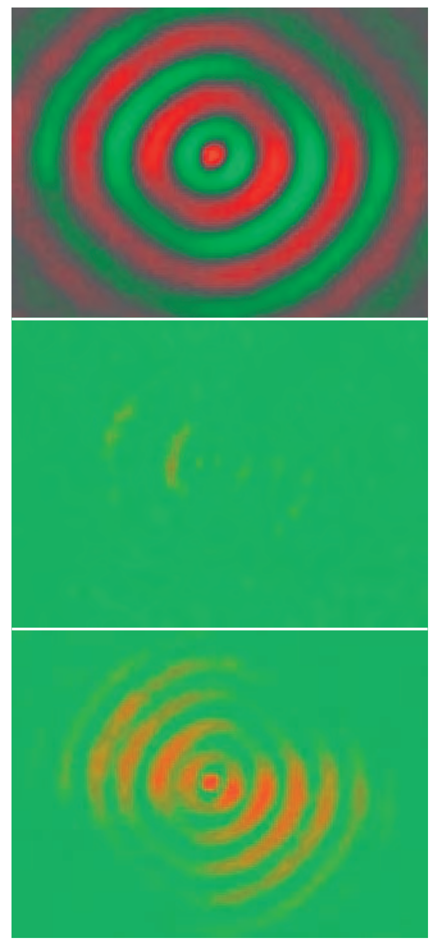
The difference data give a clear indication of the position of the structural damage. Here also it is clearly apparent that out-of-plane vibrations give much clearer results than in-plane vibrations.

Concluding Observations

The observation of Lamb wave propagation using scanning laser vibrometry is a promising tool for damage detection in panel structures. The measurements allow the observation of both compression and flexural waves. The propagation of the entire wave field is made visible, thus permitting conclusions to be made about the structural properties. Systematic errors, which always arise using 1-D measuring technology, can be avoided using 3-D measuring technology and allow for more precise results to be obtained.

Defects are visualized as distortions in the wave field, primarily in the form of secondary waves created from mode conversion. Therefore, using this method, defects can be detected in samples where it would not be possible to detect them using conventional ultrasonic testing or where it would only be possible with considerable extra expense and complexity.

Fig. 5: Difference data (Above: out-of-plane, Center: in-plane, Below: all components).



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Laser Ultrasonic Scanning for Structural Damage Diagnosis

Creation of Ultrasonic Wavefield Images with High Spatial and Temporal Resolutions

This article presents a laser ultrasonic scanning system developed by a research team from the Korea Advanced Institute of Science and Technology (KAIST) and its applications to damage detection and impact localization using Polytec's PSV-400 Scanning Vibrometer.

Fig. 1: The ultrasonic scanning system developed by the KAIST research team.

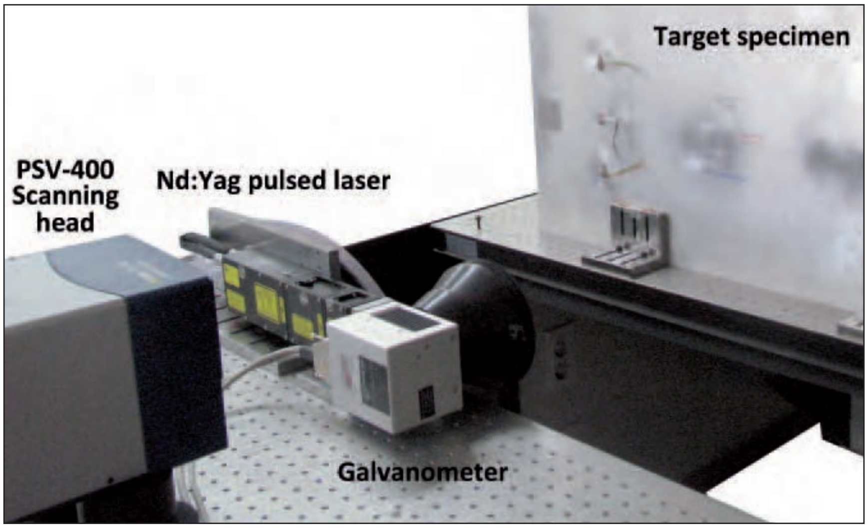


Fig. 3: Multi-layer composite panel provide by The Boeing Company.

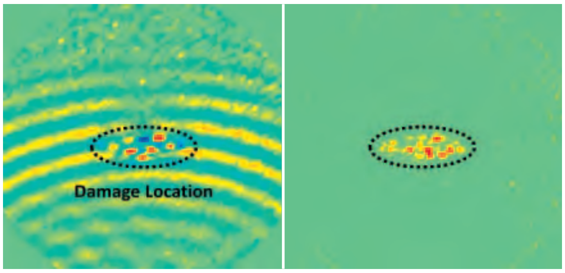


Fig. 4: Delamination detection using the measured wavefield image (left) and additional image processing (right).

The system is composed of a Nd:YAG laser for ultrasonic excitation, a laser Doppler vibrometer for ultrasonic sensing, and galvanometers for scanning. By scanning the excitation laser beam or the sensing laser beam (or both simultaneously), ultrasonic wavefield images can be generated and processed on a target surface to identify and locate defects such as delaminations in composite specimens or cracks in metallic structures. This scanning system can also be used for obtaining training data sets needed for locating impact events within a target structure. This system has a broad range of potential applications because it is able to create ultrasonic wavefield images with high spatial and temporal resolutions without the need for placing transducers on a target structure.

Development of the Laser Ultrasonic Scanning System

Fig. 1 shows the new system developed by the KAIST research group. An ultrasonic wavefield image can be produced by aiming the excitation laser at a fixed point on a target structure and scanning the sensing laser over the target area (Fig. 2a). A reciprocal wavefield image can also be obtained by fixing the sensing laser beam on a single point and moving the excitation laser over the target scanning area (Fig. 2b). Furthermore, the scanning system can be used together with built-in ultrasonic transducers (Fig. 2c) [1].

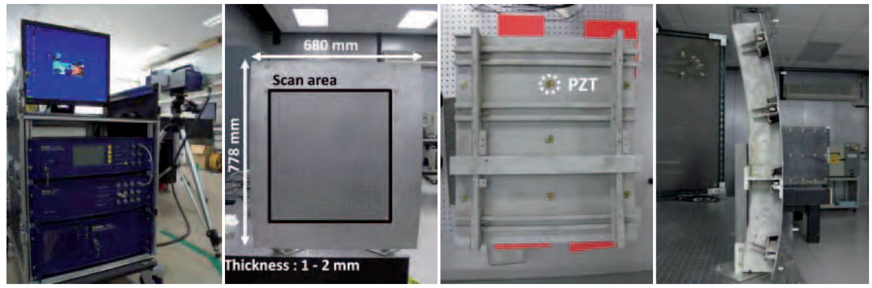
Non-Contact Delamination Detection

This laser ultrasonic scanning system is employed to detect hidden delamination in a multi-layer composite panel provided by The Boeing Company as shown in fig. 3. When propagating ultrasonic waves encounter an internal delamination, they are reflected and scattered in the vicinity of the delamination as shown in fig. 4, left. A standing wave filter was developed by the KAIST research group to further accentuate the effect of the delamination as shown in fig. 4, right [2].

Laser Ultrasonic Training for Impact Localization

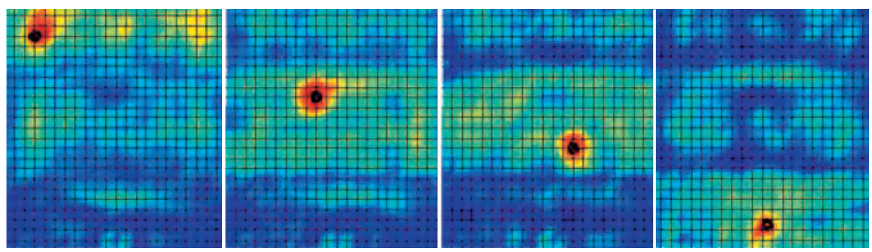
Next, the scanning system is used to pinpoint the location of an impact event within an actual aluminum aircraft fuselage segment provided by the Air Force Research Laboratory in Dayton, Ohio (fig. 5) [3]. The curved test segment has two vertical ribs and three horizontal stiffeners, adding further complexities to the specimen. Seven PZT transducers are mounted on the inside surface of the fuselage. First, an impulse response function (IRF) between an impact location and a PZT transducer is approximated by exciting the sensor and measuring the response at the impact location using the PSV-400. Then, training IRFs are assembled by repeating this process for various potential impact locations and PZT transducers.

Once an actual impact event occurs, the impact response is recorded and compared with the training IRFs. Finally, the training IRF that gives the maximum correlation is chosen from the training data set, and the impact location is identified. The correlation maps in fig. 6 demonstrate that the impact events are successfully identified in spite of the complexity of the specimen.



(a) PSV-400 (b) Front view (c) Rear view (d) Side view

Fig. 5: An aluminum fuselage for impact localization tests.



(a) Test 1 (b) Test 2 (c) Test 3 (d) Test 4

Fig. 6: Impact localization results obtained from actual impact events. Red: likely impact locations; black: actual impact locations.

Conclusion

The newly developed laser ultrasonic scanning system is advantageous for damage diagnosis because no transducers need to be placed on a target structure and damage can be automatically detected without using any baseline data. By relaxing the dependency on previous baseline data, the proposed technique can minimize false alarms due to changing temperature and loading conditions. In addition, the scanning system is used to simplify the training process often required for impact localization.

Acknowledgements

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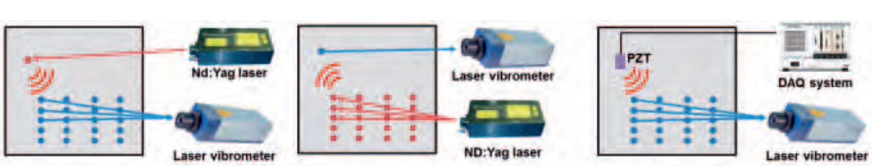

Fig. 2: Three different scanning schemes: (a) fixed-point excitation and sensing scanning, (b) fixed-point sensing and excitation scanning, and (c) surface-mounted PZT excitation and sensing scanning.

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RSV-150 Remote Sensing Vibrometer – The Acid Test

The 110 year-old Müngsten bridge near Solingen, the highest railroad bridge in Germany, was the site of intensive measurements undertaken by German railways operator Deutsche Bahn (DB) alongside Polytec in September 2010.

DB's Bridge Measuring Group in Magdeburg is responsible for the condition assessment of their railroad bridges. Laser vibrometers have proven for many years to be the method of choice for measuring structural displacements required for this purpose. However in September 2010, the Bridge Measuring Group encountered an especially difficult challenge. The Müngsten Bridge near Solingen, at 107 meters high, became the site of the latest measurement-based condition assessment.

During the measurements in September (fig. 1), a prototype of the new RSV-150 Remote Sensing Vibrometer, which was specially developed for measurements over long distances, was used alongside the OFV-505 vibrometer measurement heads. The vibrometers were used to measure the lowering of the crown as well as the horizontal buttress head displacement. The RSV-150 was used to measure this displacement and the bridge abutment was used as a fixed reference point.

To be able to measure the horizontal movement of the buttress head under load at over 135 m, the Bridge Measuring Group attached a projecting structure with a reflector to it in order to ensure optical visibility. Already installed was an OFV 505/-5000 vibrometer measuring system (fig. 2), which the Bridge Measuring Group of Deutsche Bahn has successfully used for

Fig. 2: OFV-505 used for bridge measurements.

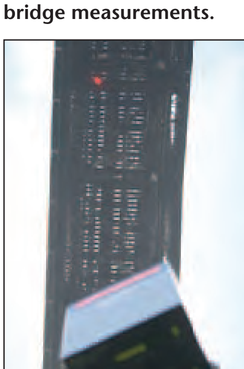

Fig. 1: The Bridge Measuring Group's measurement set-up.

several years. To provide mechanical excitation, three diesel locomotives coupled together as a unit (approximately 240 tonnes of moving weight) were driven over the bridge with and without braking.

The displacement measurements had to be carried out under these conditions with the maximum possible accuracy. In a direct comparison between the two systems, the RSV-150 Remote Sensing Vibrometer was able to play to its strengths. Even at large distances and with unfavorable weather conditions such as rain and mist (fig. 3), the measurement results were still reliable. In contrast, operation of the OFV-505 required an experienced technician to take a critical look at the measurement results to determine if the system was still within its range of use.

In view of the adverse conditions, the conclusion of the Bridge Measuring Group was: "If we hadn't had your (RSV) system, we would not have been able to measure the buttress head so accurately."

Based on this positive experience the Measuring Group has purchased two RSV-150 systems. Thus, the Deutsche Bahn "Track Measurement Centre" now has the latest most advanced laser optical kit for its measurements and will use it to maintain the safety of rail traffic.

More Info: **www.polytec.com/rsv**

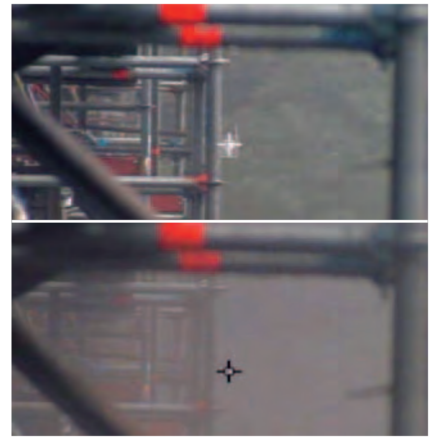

fig. 3: The measurement point for the OFV-505 and RSV-150 in good (above) and poor visibility (below).

Apology: In the InFocus issue of 1/2011 we provisionally reported about the September 2010 measurements and at that time wrote "The results led to the bridge being closed to rail traffic, however in the coming five years it should be completely restored." This statement does not accurately reflect the facts and is consequently revoked.

RSV-150 Remote Sensing Vibrometer

Remote Detection of Vibrations on Large and Distant Structures

Vibration and displacements on structures, machine parts and buildings can now be detected quickly and effortlessly even over long distances. The RSV-150 is designed for condition monitoring and testing of dynamics of structures from a remote distance with a simple point-and-shoot operation. Its advanced laser Doppler interferometer technology saves time by avoiding contact sensor installations and it's ready-to-use for trouble shooting for any vibrational issue.

The Complete Solution

The RSV-150 from Polytec provides a full solution for vibrational analysis: An interferometric optical sensor equipped with long range lens and an in-line video camera for targeting. A green targeting laser allows precise targeting on short and medium distances. The image of the video camera shows precisely the measurement spot at any distance. The RSV-150 is shipped with a rigid tripod system featuring coarse adjustment with a 3-way geared head and additional fine adjustment for precise targeting on remote objects. The controller converts the sensor signals into a voltage output for velocity and displacement that can be used with any data acquisition system or data logger.

Benefits

- High range >100 m depending on the surface reflectivity and the amplitude – allows for remote access to hazardous areas, e.g. explosion hazard or electric hazard for high-voltage electrical power supply components
- µm resolution – reveals also slightest displacements
- True 0 Hz capabilities with mHz resolution – low frequency response and displacement measurements on civil structures
- Wide bandwidth up to 25 kHz – enables condition monitoring e.g. of gearboxes
- Class 2 laser – safe operation without laser safety restrictions
- Easy setup in minutes and point-and-shoot operation – no cabling or measurement point preparation
- Works for nearly all surface properties – even on encrusted and dirty locations and also on hot surfaces like furnaces, pipes etc.

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Condition-based Maintenance in Open Cast Mining

Fig. 2: Support roller.

Fig. 3: RSV-150 Remote Sensing Vibrometer.

Non-contact and Cost-effective Monitoring and Differentiation Between Good/bad Support Rollers on Conveyor Belts in Open Brown Coal Cast Mining

Worth its Weight in Coal!

Brown coal is a source of energy that is important for the security of energy supplies, is available worldwide and is a relatively cheap source of energy because it is extracted in open cast mining. However, open cast mining is very capital-intensive so it is of primary importance for the conveyor belts to be constantly available if production is to be organized cost-effectively. Preventive maintenance is therefore a key task in open cast mining operations.

The dimensions of an open cast mine are enormous. The mine stretches over an area of 5 x 5 km². The seam of coal is about 60 m thick and is up to approx. 400 m below the surface, meaning the overlying rock has to be dug away first. This means that conveyor belts are required as well as bucket-wheel excavators to transport brown coal and excavated material in open cast mining.

The conveyor belts (fig. 1) have up to 12 MW driving power, are 2.8 m wide, typically 1.5 to 3 kilometers long, and move at speeds of e.g. 7.5 m/s. The belt is carried by support roller arrays that consist of 3 support rollers each. Monitoring this technology regularly is already challenging because of the dimensions and distances involved.

The Challenge of Monitoring the Condition of Equipment

Instead of a 100% measurement of all support rollers, the challenge of condition monitoring was to identify rollers with a single defect in areas where an increased noise level had been noticed or measured, but simple acoustic measurements would not be suitable to detect the array containing any support rollers with defective bearings. Therefore, the R&D department at RWE searched for a technology to be able to recognize defective bearings

Fig. 1: Conveyor belts for excavated material.

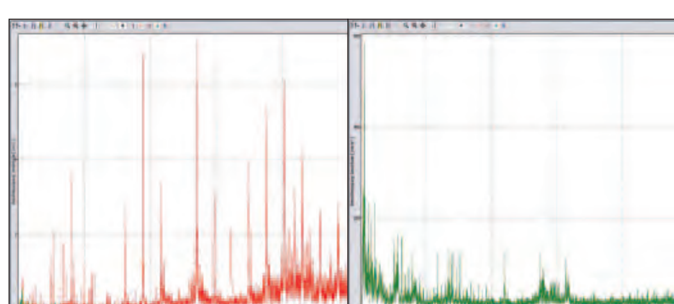

Fig. 5: Comparison of spectra of a defective bearing (red) and a good bearing (green).

Polytec

on support rollers during operation (fig. 2) and to investigate their vibrational behavior over a broad frequency range.

The spectral signatures of good and defective bearings have already been ascertained in tests. Now all that is needed is reliable and fast measurement technology to acquire the spectra. The option of gluing on accelerometers, or attaching them with magnets would take too much time for every roller and the dirt on the rollers would mean that the measurement point would have to be cleaned every time. In addition to that, user safety needs to be taken into consideration. The support rollers are tight up against the conveyor belt moving at great speed and are thus in an area with a high risk of injury.

Non-contact Laser Vibration Measurement

A viable alternative is a non-contact process that can be used from a safe distance. The RSV-150 Remote Sensing Vibrometer (fig. 3) is perfectly suited for this task. This optical solution saves the installation time while simultaneously ensuring safety, as it is possible to make a measurement over several meters. In the application shown here, the stand-off distance was 5 to 7 m. The RSV-150 is a universal instrument for non-contact acquisition of surface and structural vibrations over large distances. Depending on the amplitude and the backscattering properties of the surface, the distance from the object can be between 5 m and 150 m. fig. 4 shows the target alignment in the video image.

Good/Bad Differentiation now Possible with no Trouble

The examinations with the RSV-150 Remote Sensing Vibrometer show the following:

- A support roller array containing at least one defective roller can clearly be distinguished from those consisting of only good rollers (fig. 5). The spectra are very different. Additional resonance peaks and their harmonics, caused by defective bearings, appear in the spectrum of the defective roller. As only the spectral frequencies are decisive and not the amplitudes, the alignment of the vibrometer is only of secondary importance. Furthermore, the study proved that during operation, even good support rollers show high-frequency resonances, probably caused by slipping sealings. These resonances were hard to hear due to the high frequencies, but caused a lot of trouble during the automatic evaluation of measurement results produced during a trial on a support roller test rig of RWE Power AG.
- Measurements can be made from both sides of the conveyor belt. The spectral signature of the defect is transmitted to the measurement point. The vibrometer is sensitive enough to measure both spectral characteristics.
- The vibrometer is not sensitive to ambient noise, in particular there is no cross-talk when making a measurement on a defective support roller array merging the characteristics into those of a good array across the framework.

The Efficient Solution Provided by RWE: the Mobile Sensor

The mission of the maintenance department of RWE Power AG was to perform test measurements at two conveyor belt systems with about 100 support roller arrays each. To save time, the sensor was attached to the 4 wheel drive vehicle (fig. 6) using a self-built sensor support based on a big suction cup. This means that a mobile measurement and evaluation center is available. The condition can already be evaluated on location (fig. 7). The mains power is supplied to the RSV-150 via the on-board supply system of the vehicle.

Optimization Options

The measurement rate between two support roller arrays is about a half minute if one roller is measured from each vehicle position respectively. However, it is also possible to measure three rollers in sequence from one vehicle position, as the amplitudes are not decisive for evaluating the damage. The decisive information on a defective roller is only provided by significant occurrence of resonances of defective bearings and their harmonics. The RSV-150 is sensitive enough to make measurements on rollers from different angles and distances without any impact on the signal quality being observed. This means that the measurement rate and thus also the efficiency can be increased.

More Info: **www.polytec.com/rsv**

Fig. 4: Measurement point with position of the laser beam in the video image of the RSV-150.

Fig. 6: Measurement technology in use on location.

Fig. 7: Graphic representation of the results in the back of the vehicle.

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Reliable Green Electricity

Vibration Test Validates Design Enhancements on Electrotechnical Components of Converter Modules for High Voltage Direct Current Transmission

Introduction

Offshore wind farms, much like drilling platforms, are often more than 50 km off the coast. They are connected to the mainland grid over longer distances using high voltage direct current (DC) transmission systems. These systems and their components, supplied by Siemens Energy, must fulfill extreme demands with regard to reliability and provide a service life of more than 30 years. To achieve this, the electrical energy of numerous wind turbines is “collected” at sea in a local alternating current (AC) grid, then converted to DC using a rectifier, before being transported to land via sea cable. There it is again converted, via an inverter, into AC and fed into the high voltage grid. During operation, the technical systems are subjected to a wide range of stresses and strains. For example, mechanical vibrations in the converter structure arise from its rectification function. The electrical current produces mechanical forces which generate vibrations that could excite eigenmodes in the structure. An awareness of this condition is necessary in order to implement a design that will prevent component overload. The determination of the eigenmodes permits targeted design improvements, the success of which can then be practically verified, using vibration tests.

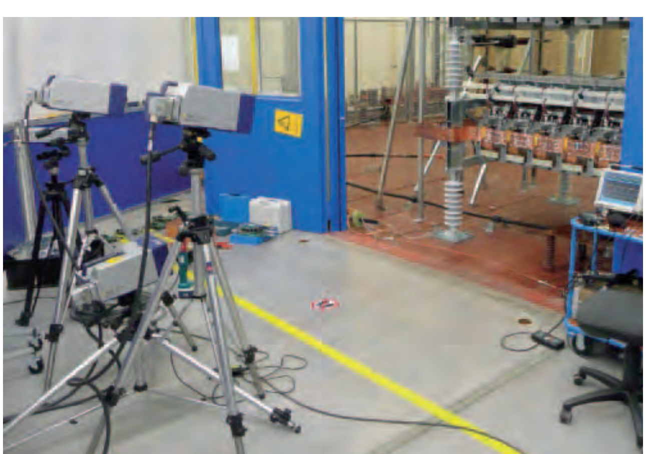

Fig.1: HVDC test facility, scan heads positioned in front.

Fig. 2: HVDC test facility, scan heads set-up for testing the rear side.