LM INFO Special

Polytec

LASER MEASUREMENT SYSTEMS ISSUE 1/2004

HOMING IN ON AUTOMOTIVE NOISE

New products, strong partners, innovative solutions

Everything in your car moves – wheels and drive shafts rotate, springs vibrate, pistons rise and fall. Each of these vibrating and rotating parts also makes a noise – often irritating, audible noises which noticeably detract from your driving experience. Automotive engineers want to find the sources for these noises and reduce their occurrence and transmission through the body of the car. Two studies related to automotive noise suppression are examined in this issue – minimizing brake squeal and characterizing the propagation of sound into the passenger compartment.

To understand why brakes squeal, researchers at Robert Bosch GmbH needed to examine the vibration characteristics of brake disks in great detail. They chose Polytec's PSV-3D Scanning Vibrometer to provide the necessary three-dimensional measurement technology. The results of their work allow highly specific optimization of the brakes and are discussed on page 8.

How does sound move from its source through the automotive labyrinth to the driver's ear? Thanks to an ingenious experimental setup at HEAD acoustics and Polytec's PSV Scanning Vibrometer, acoustic specialists have found the sonic transfer paths and have identified the precise points at which countermeasures are most effective. More on page 10.

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EDITORIAL

Michael Frech

Dr. Helmut Selbach

Dear Reader,

"Stay as you are and change every day" – We would like this challenging aspiration to accompany both you and us through the new year.

In 2004 you will continue to benefit from Polytec's state-of-the-art technology, reliable quality, competent service and our many years of experience, enhanced by a new strategic partnership to secure our market leadership.

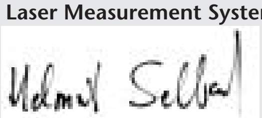
We are continually updating and enhancing our products to make laser measurement technology more powerful and user-friendly. Exciting new instruments such as the IVS-300 Digital Industrial Sensor, the PSV-400 Scanning Vibrometer and the unique PSV-400-3D Three-Dimensional Scanning Vibrometer offer engineers and scientists powerful new features for development and production applications.

Our appearance is also changing. New instruments are being given an innovative and functional design. Even our internet appearance has changed. Take a moment to visit www.polytec.com and and see details of our new products and related information.

In this edition of LM INFO Special, we cover all these topics as well as provide many new and interesting examples of applications of our laser vibrometers and velocimeters.

Have fun reading!

Michael Frech
Head of Business Unit
Laser Measurement Systems



Dr. Helmut Selbach
Managing Director Polytec GmbH

Polytec, Inc. *separates from PI in USA*

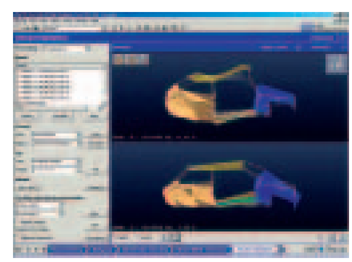
Polytec is the undisputed leader in vibrometer applications for commercial and R&D markets.

Advancing Measurements by Light, Polytec is developing the best test and measurement instruments, producing market growth through a focus on innovative, new R&D applications of vibrometer technology and an emphasis on integrating Polytec's world class laser vibrometers and velocimeters into industrial automation and control.

Polytec serves its customers globally with direct sales and service facilities in the United States, Germany, England, Japan and France and a specialized network of distributors in Europe and Asia.

Prior to January 1, 2004, Polytec-PI, Inc. was responsible for North American sales and service for both Polytec and PI. Effective the beginning of 2004, Polytec and PI have separated their North American operations so that each can focus on their distinct markets while building on the brand awareness each company has developed worldwide.

Polytec's North American headquarters is now located in Tustin, California with an eastern regional office in Auburn, Massachusetts. Mike Townsend leads the newly separate Polytec, Inc. as president, bringing with him his many years in the precision instrumentation market.



New Interface

between Polytec and LMS Test.Lab™

LMS International is one of the leading suppliers of NVH test and multidisciplinary CAE solutions in R&D. In the LMS analysis software packages, users often process measurement data which has been obtained from vibration measurements made with a Polytec Scanning Vibrometer (PSV).

Engineers from Polytec and LMS are now working together on a new interface which, with the aid of Polytec File Access, will allow direct access to geometry parameters, transmission functions and other data from PSV files in the LMS Test.Lab™ environment.

FURTHER INFORMATION?

www.lmsintl.com or e-mail info@lms.be

LMS INTERNATIONAL
Empowering Engineering Innovation

New Products

The New Polytec Vibrometers and Velocimeters

A new generation at Polytec: innovative technology with modern design

LSV-6200 Velocimeter Controller

Laser Surface Velocimeters (LSV) are non contact sensors that determine the velocity and length of extruded products or strips such as sheet steel, cast iron, paper or textiles. The new LSV-6200 Velocimeter Controller distinguishes itself with state-of-the-art DSP processor technology. Combined with the LSV sensor head, it makes fast and reliable measurements. The laser surface velocimeter eliminates the problems of slippage, scale deposits and bearing damage that plague traditional measurement methods such as contact rollers. For a detailed description of the way an LSV works, take a look at the pullout "Basic principles of Laser Surface Velocimetry" in this magazine.

PSV-400 Scanning Vibrometer

The completely redesigned PSV-400 is the best scanning vibrometer ever made. It combines the advantages of non-contact, precision vibration measurement with scanning technology to produce a fast, high-precision measurement grid from which data can be collected, processed, exchanged and displayed in intuitive ways. More on page **4/5**.

PSV-400-3D Scanning Vibrometer

For complex measurement tasks requiring complete three-dimensional vibration analysis, Polytec has developed the PSV-400-3D Three-Dimensional Scanning Vibrometer. More on page **6**.

IVS-300 Digital Industrial Sensor

This integrated single box vibrometer has already been presented in LM INFO Special issue 1/2003 and will be featured in a future issue for industrial applications.

OFV-505/OFV-5000 Modular Vibrometer Product Line

For detailed information on the new OFV-5000 Vibrometer Controller and the OFV-505 Vibrometer Head, read page **7** in this magazine.

New Software Releases

The PSV Software Version 8.1 is now more flexible, powerful and user-friendly. The VibSoft Release 4.1 for single point measurements supports all of the new OFV-5000 Vibrometer Controller functions. More information is on page **13**.

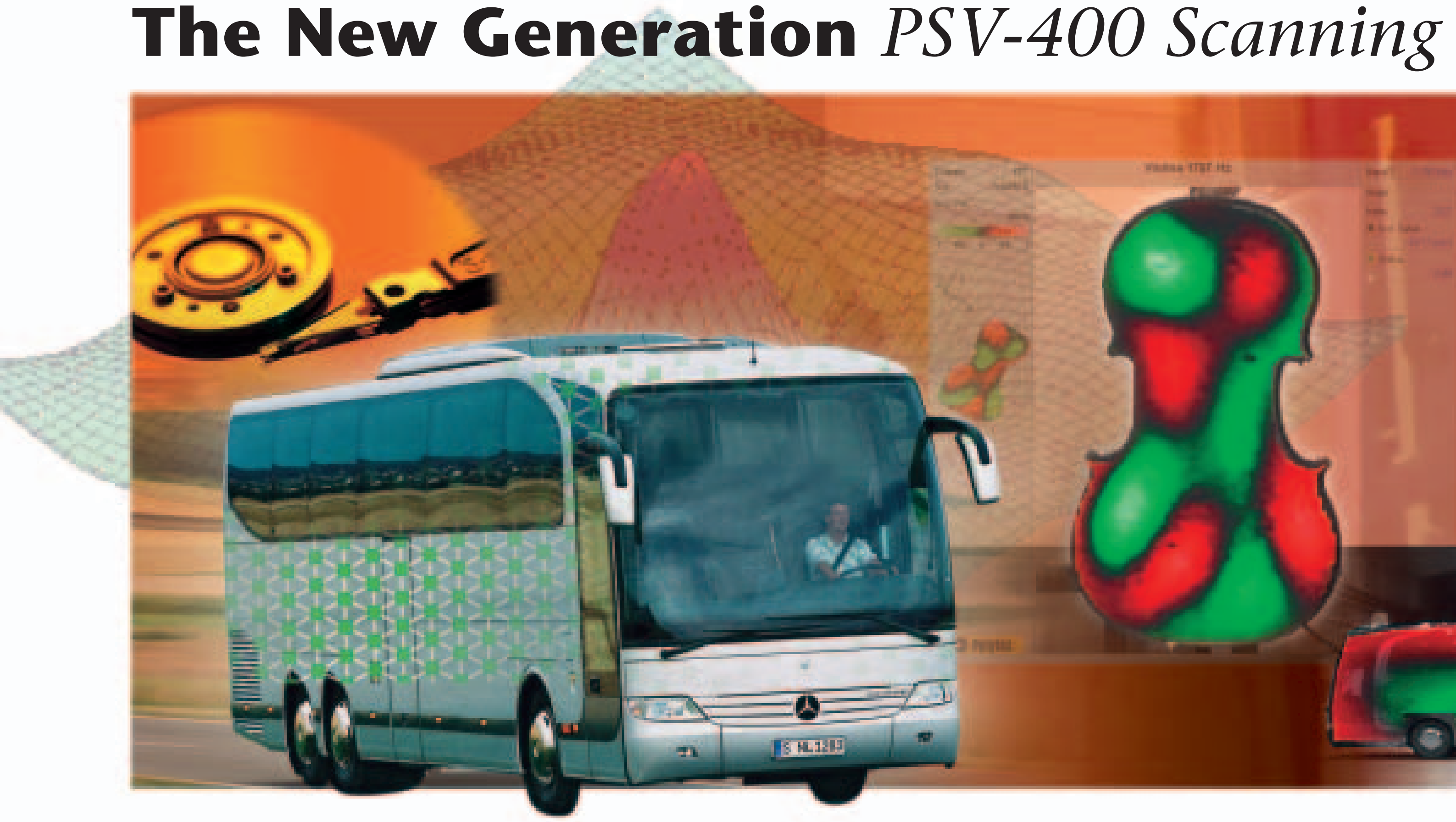
FURTHER INFORMATION?

To see the complete product range, please download our brochure "Laser Vibrometers" at www.polytec.com

Our New Look on the Web

Polytec has completely restructured and enhanced its appearance on the internet. Now customers can find up-to-date information on all Polytec products and services at www.polytec.com. Complete product descriptions, specification sheets and application notes are available on-line or as PDF downloads. Come and visit often. We are "hot off the press."

The New Generation *PSV-400 Scanning*



Non-contact Vibration Measurements cover Millimeter to Meter-sized Surfaces

The completely redesigned PSV-400 Scanning Vibrometer is the best scanning vibrometer ever made. It provides non-contact, state-of-the-art measurement technology for modal and structural analysis.

Advantages

The PSV-400 combines the advantages of non-contact, precision vibration measurement with scanning technology to produce a fast, high-precision measurement grid from which data can be collected, processed, exchanged and displayed in intuitive ways. In comparison to the time-consuming application of numerous individual accelerometers, the user very quickly acquires a transparent, easy to understand and precise graphic representation of the global vibration characteristics of a zero mass-loaded structure.

The System

The PSV-400 Scanning Vibrometer is a combination of state-of-the-art hardware and software components. This includes a compact sensor head with an integrated scan unit, the new modular OFV-5000 vibrometer controller and a data acquisition and management system. These components function under a powerful software package to control the scanning and data acquisition process and to condition and visualize measurement data (read more on page 13).

The combination of precision optics, autofocus and the optional distance sensor allows highly qualified and exact measurements and yet the package is very easy to use.

Vibrometer

Applications

Polytec Scanning Vibrometers are used for modal analysis on structures in the automobile industry, in the aerospace and aviation industries, in the construction of electrical systems and instruments and across a wide range of research and development areas. The PSV-400 is ideal for vibration measurements on millimeter to meter-sized structural surfaces. In so doing, it is possible to detect frequencies up to 20 MHz and vibrational velocities up to 20 m/s. For corresponding measurements on micro structures, Polytec offers the MSV-300 Microscope Scanning Vibrometer and the MMA-300 Micro Motion Analyzer.

Polytec's modular design approach offers optimal adaptability, the greatest possible flexibility and future security. The PSV-400 is based on an existing OFV-5000 controller and can be extended to become a fully equipped PSV-400-3D Three-Dimensional Scanning Vibrometer (see page 6 of this issue).

Performance Characteristics

- Fast, remote, non-contact measurement process
- Simple, intuitive operation
- Measurement with a given or interactively defined measurement grid
- Focus position can be individually defined and saved for each sample point
- Optional distance sensor can acquire geometric data
- MIMO (Principal Component Analysis)
- User Defined Data Sets for extended evaluation options
- Design based on the OFV-5000 Vibrometer Controller and the OFV-505 Vibrometer Sensor Head
- Can be extended to a PSV-400-3D Three-Dimensional Scanning Vibrometer

FURTHER INFORMATION?

Please download our data sheet "PSV-400 Scanning Vibrometer" at www.polytec.com.

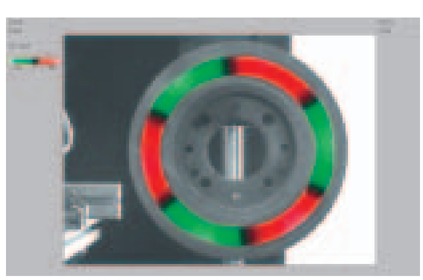
PSV-400-3D: *The New Dimension*

Measure and Visualize 3-D Vibrations Simply and Intuitively

The new Polytec PSV-400-3D Scanning Vibrometer is the perfect measurement instrument for gathering three-dimensional vibration data from both simple and complex structures. Designed to reduce product development times, the PSV system improves performance by eliminating triaxial accelerometers and by providing rapid measurement grid definition. In short, the system makes measurements that are flexible, controllable, accurate and fast.

Building on the reliability of the award-winning PSV family of scanning vibrometers, the PSV-400-3D uses three independent scanning vibrometer heads to simultaneously measure the vibration velocity from three different directions for each respective sample point. From these three measurements, the components of the 3-D vibration vector are calculated. All three scanning heads are controlled centrally by the PSV measurement and control software.

This ability to determine the three-dimensional vibration vector on the surface of a measurement object during a single scan significantly reduces the effort required to perform experimental modal analysis. The newly developed geometry import feature simplifies measurement preparation and allows the measurement grid to be defined by an FEM model.
The vibrations can be visualized with the new PSV software (page 13) as animated graphics, scan point or isoline graphs and two-dimensional or three-dimensional color plots. Of particular interest is the simultaneous presentation of the measurement results in x, y and z with the 3-D vibration shape superimposed on the 3-D geometry (See page 8/9). Additional graphical representation and analysis options are available through exporting the measurement data in a Universal File Format file to external software packages such as ME'Scope, LMS, or IDEAS. After selecting the structures and vibrations or spectra of interest, these files can be exported to any modal analysis software which supports the specifications of Universal File Format.
To find out how the 3-D Scanning Vibrometer was used to track down the source of squealing brakes, read the report on page 8.



Color-coded representation of the vibrations of a brake disk

FURTHER INFORMATION?

Please download our data sheet "PSV-400 Scanning Vibrometer" at www.polytec.com.

Unbeatable *Teamwork*

New Modular Vibrometer Product Line for Non-contact Vibration Analysis

The modular OFV vibrometer system is growing as its applications expand, offering a wider range of excellent innovations, which make vibration analysis more precise, more flexible and easier.

Everything under Control

The OFV-5000 Vibrometer Controller is used to manage Polytec vibrometer sensor heads to decode velocity and displacement from the raw signal.

Various analog and digital decoder options seamlessly cover the entire amplitude range up to a top speed of 10 m/s and a maximum frequency of 20 MHz. Polytec has designed optimal decoders to cover most any application from automobile acoustics to micro-mechanical resonances to high frequency ultrasonics.

By combining the OFV-5000 with a laser sensor head appropriate for the required application, a complete vibrometer measurement system is assembled.

The Sensor – the Eye of the System

The engineering pièce de resistance is the new OFV-505 vibrometer sensor head. This product distinguishes itself with excellent optical sensitivity and motorized focusing of the laser beam. Each focus position can be saved in memory for automatic recall with successive scans. An autofocus function and the option to lock the focus position to ensure stable handling under different operating requirements are also designed into the new OFV-505.

The OFV-5000 controller fully supports the new OFV-505 sensor head, the OFV-503 base model, the OFV-511 single fiber head and the OFV-512 with two fibers for differential meaurements.

You want more?

The modular design of the OFV-5000 controller is so flexible that, as requirements increase, it can be extended to become a Scanning Vibrometer System by adding and exchanging components. Expansion stages from the PSV-400 Scanning Vibrometer to the PSV-400-3D measuring in three dimensions are possible (Read the articles on pages 4 and 6 in this issue). The Microscope Scanning Vibrometers are also based on the OFV product family.

FURTHER INFORMATION?

Please download our data sheets “OFV-5000 Vibrometer Controller”, “OFV-505/503 Vibrometer Sensor Head” and “VD/DD Decoder Guideline” at www.polytec.com.

Hot on the Trail of *Squealing Brakes*

Extensive 3-D Vibrometry on Brake Disks
3-D Vibrometry makes the Cause of the Noise Visible

Optimizing automotive noise behavior is an important aspect in new vehicle designs. Using Polytec's innovative measurement technology, researchers at Robert Bosch GmbH have managed to track down the causes of undesired noises when braking.

Modern brake systems in cars are more powerful than ever and distinguish themselves through functional diversity which not very long ago would have appeared impossible. So that all components in a braking system still work together as well as possible despite the increase in complexity, it is necessary to have a deep understanding of the system. Bosch manufactures all the most important components itself and can thus offer car manufacturers complete solutions from a single source.

When developing braking systems, Bosch does not only optimize the function of the individual components, they also focus on the way it all works together as a system and on the interfaces with the whole vehicle. Sound knowledge of the vibration characteristics of their products makes it possible for the Bosch engineers to minimize the risk of squealing and rumbling brakes which then contributes towards increasing comfort levels for the driver and passengers. As the world's largest manufacturer of brake and brake control systems, Bosch offers car manufacturers complete brake assemblies and systems. This includes products for vehicle safety, such as an Antilock Braking System (ABS), Traction Control System (TCS) and the Electronic Stability Program (ESP).

Task

The purpose of a brake is to attenuate effectively and evenly the kinetic energy of a vehicle. This is done by conversion into heat energy which is generated due to the friction between the brake pads and the brake disk. Under certain operating parameters, during the braking process, high frequency vibrations of the brake disk can be excited. These significant structural vibrations of the brake, which do not have any influence on the actual braking effect, are heard as an undesired, acoustically-perceptible squealing of brakes.

The so-called out-of-plane vibrations are physically responsible for the noise emission from the brake disk when squealing. In this case, the surface of the friction ring of the brake disk vibrates at right angles to the disk plane.

The decelerating braking power between pads and brake disk however has its effect in the disk plane. Thus from this introduction of force, primary vibrations in this plane are excited (in-plane).

The Bosch researchers now asked themselves the interesting question: What connection is there between the in-plane excitation as a result of the effect of the braking power and the out-of-plane vibrations responsible for the emission of noise?

It quickly became clear that, for this challenging study, special techniques would be necessary which can simultaneously measure both in-plane and out-of-plane components of the vibration movement with high frequency resolution at a large number of sample points on the brake.

In-plane and out-of-plane

You can easily satisfy yourself of the interaction between in-plane and out-of-plane vibrations with a small test. To do this, you excite something capable of vibration, e.g. use a spoon to excite a plate balanced on a fingertip to vibrate, once from the side and once from the top. In both cases the same modes are excited, however with the in-plane excitation, they have weaker amplitude.

Metrological Task

The existing measurement systems for analyzing structura vibrations were not sufficient to answer the question. Polytec as long-term partner in the area of non-contact metrology therefore developed a scanning laser vibrometer measuring in three dimensions as prompted by Bosch and in close cooperation with the initiators.

In contrast to a conventional scanning vibrometer working in 1 dimension, which can only measure the component of the vibration movement oriented in the direction of the laser

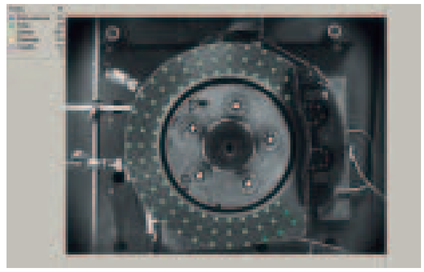


Figure: Brake disk on the test stand

beam, the Polytec Scanning Vibrometer PSV-400-3D uses three separate scanning vibrometer sensor heads which simultaneously acquire the vibration signal at any given point on the surface of the object under investigation from different directions.

Due to the synchronous scanning process, the entire system acquires the whole three-dimensional vibration behavior quickly, without contact and without mass loading, hitting all optically accessible points on the test object. The software takes the raw signals from the three sensor heads and through coordinate transformation, calculates the vector components of the vibration movement in a Cartesian coordinate system.

The following figure shows three different views of a single actual vibration as the result of a PSV-400-3D measurement on a brake disk.

In the left section of the figure, the whole movement is shown in perspective. In the middle, the strong share of the out-of-plane component is clearly visible. In the right figure, the in-plane share of the movement is apparent.

Using the new measurement process, the Bosch researchers were able to clearly characterize the interactions between brake pads and brake disks which are responsible for the squealing brakes. The investigations showed that, with certain combinations of operating parameters, such as brake pressure, temperature and instantaneous velocity, an interaction between in-plane and out-of-plane natural vibrations causes the dreaded squealing noise.

Result

The knowledge gained using the PSV-400-3D Scanning Vibrometer puts the Bosch researchers and engineers in a position in the future to reduce the risk of undesired squealing of brakes even further when constructing the brakes, through careful choice of the component geometry and material parameters.

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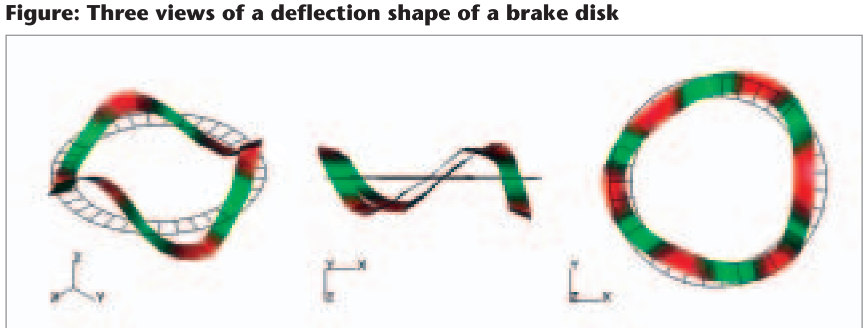
Figure: Three views of a deflection shape of a brake disk



Vibrating Surfaces *Made Audible*

Using Laser Scanning Vibrometry and Binaural Transfer Path Analysis

What kind of a noise is made when the surface of a component vibrates? What path does the noise take to your ear? What component vibration is most undesirable? These are the questions that employees at Polytec and HEAD acoustics are currently trying to solve within the framework of a joint project.

Acoustics are increasingly important in product design. The focus is on how and where are undesired noises generated and at which point or location can countermeasures be taken to eliminate or attenuate the offending noise. Knowing just the vibration characteristics of a component is not enough to describe the acoustical situation sufficiently - the degree of the sound projection, the transmission of the noise to your ear (the so-called transfer function for airborne sound) and the structure of the noise (important for the psycho-acoustic effect on a person) must be considered. Consequently, even though a component's physical vibration might be reduced, the noise that has impact on the listener may not be audibly reduced. Thus, the questions persist: Which vibrations are generating the offending noise? At what location should countermeasures be applied?

A joint project between Polytec and HEAD acoustics aims to answer these questions and make a connection between vibration analysis on the one hand and the noise generated on the other. Polytec has expertise in matters of laser vibrometry and vibration analysis. HEAD acoustics has expertise with regards to auralization of sound sources. The degree of sound radiaition efficiency, of the two companies working together will be a development tool which can be applied to aural acoustic problems in the future.

About HEAD acoustics GmbH

HEAD acoustics GmbH is one of the world's leading companies in the area of acoustic and vibration measurement and analysis technology as well as speech perceivability. Covering all applications, from sound design to decrease of noise pollution, HEAD acoustics offers hardware and software solutions for aurally-equivalent sound recording and playback, measurement and analysis, jury testing and virtual engineering. Binaural transfer path analysis a featured service highly valued by prominent users all over the world.

Due to HEAD acoustic's intensive internal research and development activities and its close connection to national and industrial research facilities, the products of HEAD acoustics are continuously setting standards. Since being founded in 1986, the company issued more than 30 national and international patents and 400 scientific publications.

The new Test Procedure

Starting with a vibrating surface, the projected sound is transmitted through the air and finally reaches the human "victim's" ear in the form of noise. With the aid of transfer path analysis (Genuit, K., & Bray, W. R., Sound & Vibration July 2002), the path of the sound can be determined experimentally. As an extension of the process, HEAD acoustics determines the airborne sound paths binaurally (Sottek, R., Sellerbeck, P., Klemenz M., SAE Conference 2003).
Thus the shape of the head is included in the analysis, making the auralization of component sound sources possible. How do you practically determine the transfer functions for airborne sound binaurally? For this purpose you can resort to the reciprocity principle and measure the airborne sound transfer paths reciprocally with the aid of a binaural sound transmitter (see explanation in the info box on page 12).

Structure-borne Sound and Airborne Sound Measurements

This new process allows you to link laser vibrometer measurements with reciprocal airborne sound measurements. For visual representation of the component vibration, instead of the vibration amplitude measured directly with the laser vibrometer, the amplitude weighted with the reciprocally measured transfer function for airborne sound is given. This representation is a measure of the airborne sound relevance of the component's surface and shows whether, and to what extent, individual areas are responsible for the noise reaching your ear. The acoustics engineer is then directly shown the locations at which acoustic measures need to be introduced.

User Defined Data Sets

User Defined Data Sets are the technical basis for linking the structure-borne data with the transfer path functions. They are available as a new option in PSV Software release 8.1. The User Defined Data Sets allow the operator to apply any mathematical transformation to the measurement data via a standard interface and to visualize the results directly in the PSV software.

Extensions to this software option are being planned. Future releases should make it possible to view non-stationary events. This refers to the possibility of giving a visual representation of the acoustic behavior of a component also subject to any non-stationary operating conditions. This answers the question asked typically in the car industry with regards to engine noise:
At what engine speed and at which component surface is the source for the noise located?

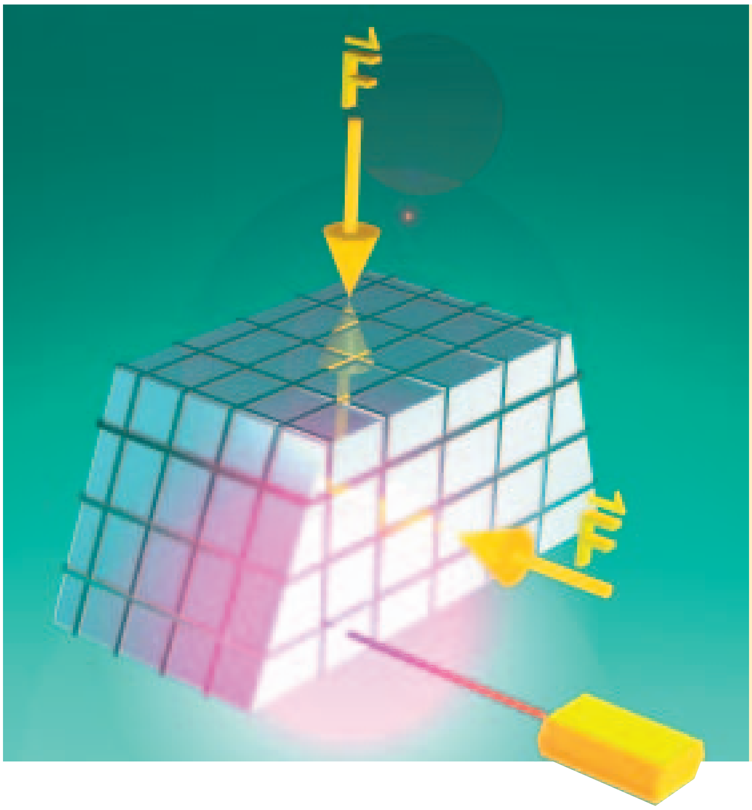
This is to be attained by visualizing filtered time sequences using acoustic transfer functions.
An appropriate software option is currently in development and will be available shortly for Alpha testing.

First Test Applications

Within the framework of these investigations, the process was tested using a model structure which can be seen in the title picture. The model consists of a steel frame on which metal surfaces of different sizes have been mounted. Two shakers introduce the sound. The experimentally determined transfer paths describe the sound propagation from the position of force application to the ears of the test person located inside the model. As is shown in the title image, the test person is represented by an artificial head or by a binaural sound generator respectively.

Continued on page 12

Continuation of page 11



The Reciprocity Principle

The transfer function between sound source and receiving location does not change if the sound source and receiving location are exchanged with each other.
This applies subject to the condition that

a) the emission characteristics of the transmitter are the same as the receiving characteristics of the receiver and

b) only linear systems and quantity pairs are taken into consideration, e.g. acoustic pressure and volume flow.

Therefore, if the receiver is a human head, then consequently the sound transmitter must also be in the shape of a human head. Apart from that, it is absolutely imperative to know the volume flow emitted by the sound transmitter. If these conditions are fulfilled, then reciprocity applies in all environments, independent of the spatial properties.

The transfer paths can be linked with arbitrary time data. For example, time data were taken at the points of force application located at the engine mount of a vehicle under operating conditions and linked with the sound transfer paths of the model. The noise which is generated in the interior of the model is made up of sound contributions from the individual part surfaces, which can also been listened to separately.

Since the procedure works binaurally, a stereo signal is generated which gives a spatial conception of the sound and permits a localization of the respective acoustic source, as if a real person was sitting in the model's interior.

For more information and a PDF copy of this article, please visit Polytec's web page at www.polytec.com or HEAD acoustics at www.head-acoustics.de.

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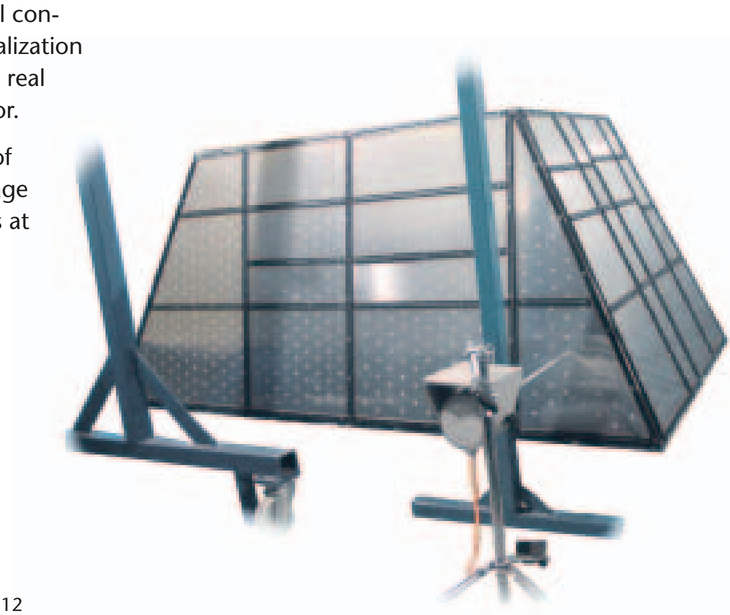

Basic Principles *of Velocimetry*

FOR BEGINNERS AND EXPERIENCED USERS

Laser Doppler Velocimeters are non-contact measurement systems used to make velocity and length measurements on moving surfaces, such as steel sheeting, films, paper, textiles and other strip goods. The non-contact optical measurement process allows very high accuracy. It can be applied in complex measurement tasks, where touch sensors can not make a measurement or only with great difficulty, such as making measurements on red-hot objects.

Thus in continuous casting systems, Laser Doppler Velocimeters replace the measurement rollers traditionally used for measuring casting lengths and velocities. Thanks to the non-contact measurement process, slippage, scaling deposits or damage to bearings no longer affect the results of the measurement as they did when using measuring wheels.

Laser Surface Velocimeters work on the Laser Doppler Principle and evaluate the laser light scattered back from a moving object. Polytec's LSVs are based on the sophisticated heterodyne detection method. Unlike conventional non-contact methods which measure only the absolute value of the velocity, Polytec's velocimeters are able to detect changes in direction and even standstill conditions. The measurement precision is fine enough that minute motions can be accurately measured.

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Both in general and for any velocities, the Doppler problem was solved by Einstein's relativity theory. In summary, the result of his shrewd analysis, that both a stationary and also a moving observer (receiver) measures the same value for the speed of light, but that the respective coordinates which the two observers use to describe processes subtly depend on their relative movement.

The Doppler Effect

How does the laser light scattered back provide any information on the movement status of the scattering object? In the following we demonstrate the effect a relative movement between the source and the receiver has on the wavelength measured, or respectively, on the frequency of the wave.

A stationary light source emits a continuous light wave with the frequency f and the wavelength λ. A wave train with the length λ passes a stationary observer in the time $T = 1/f$. If in contrast the observer moves away from the light source at the speed v, then the wave train needs a slightly longer time T', to pass the observer. What distance c T' does the wave travel in the time T'? The total distance includes the distance λ of the observed wave train and also the distance v T' traveled by the moved observer in the time T'

$$c\,T' = \lambda + v\,T' \quad (c - v)T' = \lambda$$

For the moving observer, the wave vibration has the cycle duration T' and because $f' = 1/T'$ and $\lambda = c/f$ this then results in:

$$(c - v)/f' = c/f$$

and thus the frequency f' to

$$f' = f(c - v)/c = f(1 - v/c)$$

Therefore, if the observer moves away from the light source ($v > 0$), then the light frequency is shifted to smaller values (red shift), if he moves towards the light source ($v < 0$), then an increased frequency is measured (blue shift).

The above analysis is an approximation for small velocities in comparison to the speed of light which is fulfilled very well for practically all technically relevant velocities.

The Differential Doppler Process

To make a measurement on moving objects, which can in principle be of any length, requires a measurement design with an observation axis for the sensor which is at a right angle to the direction of movement of the object under investigation.

Polytec Velocimeters work according to the so-called Difference Doppler Technique. Here, 2 laser beams which are each incident to the optical axis at an angle φ, are superimposed on the surface of the object. For a point P, which moves at velocity **v** through the intersection point of the two laser beams, the frequencies of the two laser beams are Doppler shifted in accordance with the above formula. At the point P of the object which is moving at the velocity **v**, the following frequencies therefore occur:

$$f_{P1,2} = f_{1,2}\,(1 - \mathbf{v}\cdot\mathbf{e}_{1,2}/c)$$

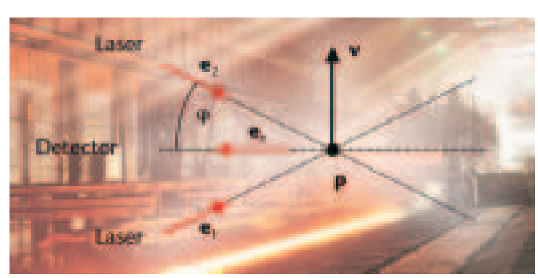
$\mathbf{e}_{1,2,e}$ = Unit vectors of laser beams 1 and 2 and in direction detector

$f_{1,2}$ = Frequencies of the laser beams 1 and 2

$f_{P1,P2}$ = Doppler shifted frequencies of laser beams 1 and 2 in point P

The point P now emits scatter waves in the direction of the detector. As P is moving with the object, the scattered radiation in the direction $\mathbf{e}_e$ of the detector is also Doppler shifted. Thus for the frequency of the scatter waves in the direction of the detector, it can be said:

$$f_{e1,e2} = f_{P1,P2}\,(1 - \mathbf{v}\cdot\mathbf{e}_e/c)$$
$$= f_{1,2}\,(1 - \mathbf{v}\cdot\mathbf{e}_{1,2}/c)\,(1 - \mathbf{v}\cdot\mathbf{e}_e/c)$$



The scatter waves are superimposed on the detector. Due to the interference of the scatter waves from the two laser beams, there are different frequency components in the superimposition. The low-frequency beat frequency of the superimposed scatter radiation which corresponds to the Doppler frequency f_D is analyzed metrologically. When both incidental laser beams are at the same frequency (same wavelength), this is seen as a difference of f_{e2} and f_{e1} to:

$$f_D = f_{e2} - f_{e1}$$
$$= f\,(\mathbf{v} \cdot (\mathbf{e}_1 - \mathbf{e}_2)/c)\,(1 - \mathbf{v} \cdot \mathbf{e}_e/c)$$

If point P moves vertically with reference to the optical axis and at the same angle of incidence φ, it can be said that:

$$\mathbf{v} \cdot (\mathbf{e}_1 - \mathbf{e}_2) = 2\mathrm{v}\ \mathit{sin}\,\varphi \text{ and } \mathbf{v} \cdot \mathbf{e}_e = 0$$

This means the final result is:

$$f_D = \frac{2\mathrm{v}}{\lambda}\,\mathit{sin}\,\varphi$$

The Doppler shift is thus directly proportional to the velocity. A graphic explanation which leads to the same result follows:

Graphic Representation of the Difference Doppler Technique

Both the laser beams are superimposed in the measurement volume and in this spatial area, generate an interference pattern of bright and dark fringes.

The fringe spacing Δs is a system constant which depends on the laser wavelength λ and the angle between the laser beams 2φ:

$$\Delta s = \lambda/(2\ \mathit{sin}\,\varphi)$$

If a particle moves through the fringe pattern, then the intensity of the light it scatters back is modulated.

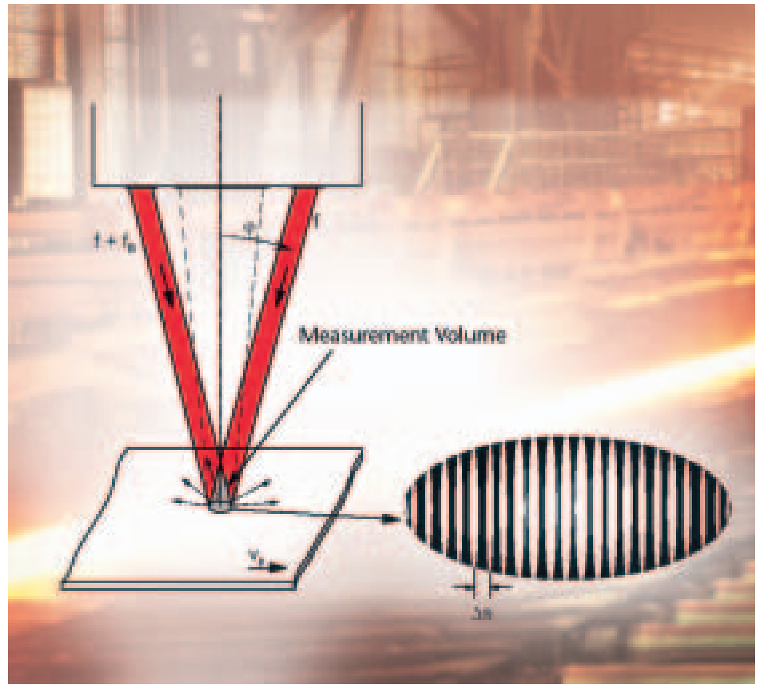
As a result of this, a photo receiver in the sensor head generates an AC signal, the frequency f_D of which is directly proportional to the velocity component of the surface in measurement direction v_p and it can be said that:

$$f_D = v_p/\Delta s = \frac{2\mathrm{v}}{\lambda}\,\mathit{sin}\,\varphi$$

f_D = Doppler frequency

v_p = Velocity component in the direction of measurement

Δs = Fringe spacing in the measurement volume



The value $\lambda/\mathit{sin}\,\varphi$ makes up the material measure for the velocity and length measurement.
It is measured precisely for every sensor head and is printed on the identification label. When configuring the LSV controller, the fringe spacing is written in the flash memory as a calibration factor. There it forms the basis for calculating the measurement values. If the sensor head is exchanged, the new fringe spacing has to be entered using the LSV software.

The Heterodyne Technique

Polytec Laser Surface Velocimeters work in the so-called heterodyne mode, i.e. the frequency of one of the laser beams is shifted by an offset of 40 MHz. This makes the fringes in the measurement volume travel with a velocity corresponding to the offset frequency f_B. This then makes it possible to identify the direction of movement of the object and to measure at the velocity zero. The resulting modulation frequency f_{mod} at the photo receiver in heterodyne mode is:

$$f_{mod} = f_b + v_p/\Delta s = f_b + \frac{2\mathrm{v}}{\lambda}\,\mathit{sin}\,\varphi$$

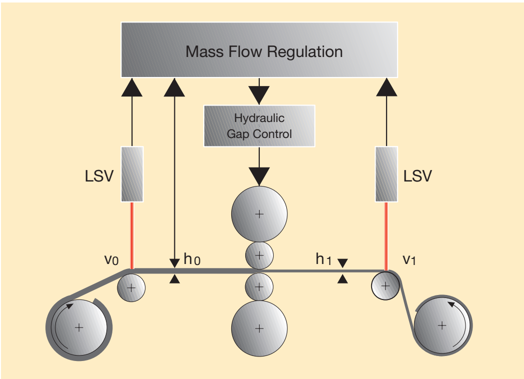
The modulation frequency is determined in the controller using Fourier transformation and converted into the measurement value for the velocity v_p. The length measurement is made by integrating the velocity signal.

Applications for Polytec Velocimeters

A complete LSV series 6000 measurement system consists of an LSV-6200 signal processor and as an option, either the extremely compact optical sensor head LSV-065, or the liquid cooled sensor head LSV-026 for applications in a harsh industrial environment.

Mass Flow Regulation

The processing industry, in particular the automobile industry, sets ever tighter tolerances regarding the quality of the steel and aluminum products used. Making velocity measurements using the LSV, which are not affected by slippage or wear and tear, make it possible to considerably reduce the thickness tolerances of cold pressed steel.
If two Laser Surface Velocimeters make measurements before and after the roll stand respectively, then with the help of the mass flow ratio, the strip thickness can be determined in the roll gap. The shorter response time in comparison to a slave system significantly reduces the strip thickness tolerances using the thickness measurement before and after the roll stand.



Length Measurements on Piece Goods

Polytec's LSV series 6000 is ideally suited for length measurement for controlling cutting materials into lengths, for controlling the length of work pieces already cut into lengths or for positioning the work piece in a saw mill.

The measurement system works reliably on all surfaces, no matter whether it is a pipe, beam, profile or rail. Even making measurements on hot surfaces with temperatures up to 1200 °C are possible. Here some sample applications of how the LSV is used in a pipe rolling mill

- Pipes with a length of between 6 and 20 m move at a virtually constant velocity between 2 and 20 m/s along the roller table. The LSV measures the overall length.
- Once the overall length is known, a second LSV measures the same pipe again at a low speed to cut the pipe into customer-specific section lengths in the saw mill.

There are two ways of triggering the length measurement on piece goods:

1. Self-trigger: The object recognition in the LSV series 6000 reliably starts or stops the length measurement within 100 µs as soon as the object appears or disappears in the AOI.
2. External trigger: The greatest measurement accuracy can be attained for a length measurement if the LSV is combined with external light barriers via existing trigger inputs.

Due to the great depth of field of 200 mm, the LSV can make measurements on different pipe diameters without the distance between the LSV-065 or LSV-026 sensor heads and the roller table having to be readjusted. It is thus not necessary to have a complex traversing system which keeps the distance from the sensor head to the pipe surface constant despite a different pipe diameter.

POLYTEC TUTORIAL SERIES

Principles of Vibrometry (Issue 1/2003) E1 – E4

Principles of Velocimetry (Issue 1/2004) E5 – E8

Software *News*

New PSV Software Version 8.1

Polytec has just released the version 8.1 of the PSV software. This enhanced software now supports all functions on both the new PSV-400 and PSV-400-3D platforms and offers significantly improved 3-D graphical representation of the vibration data. Measurement preparation is much simpler with the addition of Focus Scan and Focus Memory, new features that help determine and secure optimal laser focus settings for every individual sample point. Extensions of the 3-D alignment and the 3-D sample point definition significantly reduce the preparation time for measurements with the PSV-400-3D. The 0 dB reference point can be arbitrarily set and invalidated sample points are automatically remeasured.

Communication with FEM, modal analysis and display software is greatly improved with the addition of Polytec File Access and new import and export functions. In Version 8.1, physical coordinates of the 3-D structure can be imported into the PSV controller to quickly preset the scan parameters and measurement results can be transmitted directly to ME'Scope for analysis. Overall Version 8.1 is more user-friendly and has the "look & feel" expected from software running on Windows XP. Additional Version 8.1 highlights are:

- MIMO option (Principal Component Analysis) software module determines the various excitation contributions from the measured FRFs in the case of multishaker excitation. This option is only available for the PSV-400-H4 system.
- User Defined Data Sets allow the user to apply any mathematical transformation to the measurement data via the Polytec File Access interface and then to visualize the results directly in the PSV software.
- Library to process signals for scripting ("PolyMath") to be used with user defined data sets: Calculations using vectors, RMS, Min, Max, Mean, Standard Deviation, Window Functions, FFT, Inverse FFT, Integration/ Differentiation, etc.

PNA QuickAnalyzer

Software for Acoustic Quality Control

Acoustic quality control is a versatile, non-destructive procedure to assess the quality and reliability of products and manufacturing processes.

Specializing in the design, construction and support of remote, non-contact acoustic test and quality control systems, the Polytec Noise Analysis (PNA) division employs experienced experts in software, defect detection, system engineering and quality monitoring.

QuickAnalyzer software is intended for laboratory use. Engineers can quickly and efficiently capture, present and compare the acoustic signatures of test objects. Acoustic signatures taken from test objects can be grouped prior to being analyzed against reference objects. **QuickAnalyzer** is a development tool that can quickly and effectively establish pass/fail criteria for new products.

Some of the important features of **QuickAnalyzer** software are:

- Online display of the time and frequency domain signals
- Display of single measurements, groups of measurements and statistical results: average value, standard deviation, minimum and maximum values
- Replay of stored signals via the sound board for human evaluation and cross check
- Correlation of objective (by visualization) and subjective (by listening) results
- Several analysis domains: time; frequency; fractional octave analysis; A-, B- and C-filtering; and spectrogram displays

VibSoft Release 4.1

The VibSoft Release 4.1 for single point measurements supports all of the new OFV-5000 Vibrometer Controller functions. It now offers context menus, an improved and extended theory manual, user defined data sets (via Polytec File Access), a library for signal processing and the option of exporting data directly to ME'Scope. The 0 dB reference point can now be freely defined and the vibration direction can be given for every channel: +X, +Y, +Z, -X, -Y, -Z. This information is then used during export in UFF or to ME'Scope.

FURTHER INFORMATION?

E-mail: Lm@polytec.de or www.polytec.com

Velocity and Thickness Measurement

Integrating Non-contact Laser Velocimeters into a Rolling Mill C-frame Platform

The processing industry, in particular the automobile industry, sets tight tolerances regarding the dimensional accuracy and quality of the steel and aluminum products used. To reduce the thickness tolerances of rolled strips even further, modern rolling mills are controlled according to the mass flow principle. Laser Surface Velocimeters (LSV) are easily integrated into a mill and allow reliable measurement of the strip velocity necessary to calculate thickness according to the mass flow principle.

Figure 1: IMS C-frame with integrated Polytec LSV

Non-contact Strip Thickness and Velocity Measurement

The mass flow relationship makes it possible to calculate the strip thickness in the roll gap by measuring the velocity and thickness before the roll stand and the velocity after the roll stand. The strip thickness measurement in rolling mills is usually done using so-called C-frames. The strip thickness is determined by the absorption of x-rays. The x-ray tube and the detector are situated in the upper and lower arm of the C-frame.

Increasing numbers of Laser Surface Velocimeters (LSV) are being used for non-contact velocity measurement in both rolling and steel mills. In contrast to the traditional velocity measurement

A Marriage of Convenience

with measuring wheels or rollers, the LSV works without slippage or wear eliminating common causes of significant measurement errors. The new LSV-6200 controller makes fast and reliable measurements possible (page 3). The special issue in the middle of the magazine has more on the principles of Laser Surface Velocimetry.

Even though the strip thickness measurement for the mass flow regulation is always combined with the velocity measurement, until now, both measurement systems have always been installed on the rolling mill completely separately.

Integration of the LSV Sensor Heads into the C-frame

Since December 2000, IMS, a manufacturer of C-frames, and Polytec, a manufacturer of Laser Doppler length and velocity measurement systems, have been working closely together. The compact construction of the LSV-065 sensor heads and flexible stand-off distances ranging from 300 mm to 2000 mm persuaded IMS to integrate Polytec LSV systems into their own C-frames.

Polytec constructed a custom cooling plate with a turning mirror to integrate the sensor heads into the C-frames. The sensor head sits horizontally in the C-frame, reflects 90° with the turning mirror and views the surface of the strip through a window in the bottom of the upper C-frame (figure 1).

By moving the LSV-065 sensor head relative to the mirror, the system can easily be configured for different production line positions and C-frames gaps. Due to the large depth of field, the sensor heads tolerate production line fluctuations of up to ±30 mm.

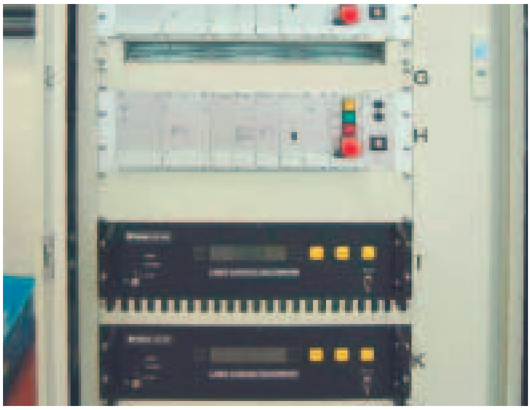


Figure 2:
X-ray control devices (top) and LSV controllers (bottom) combined in a switching cabinet

Figure 3:
Strip velocity of four Polytec LSVs integrated in IMS C-frames (in the 5-stand tandem mill at USS-Posco in Pittsburg, California)

Advantages of C-shaped Stays with an Integrated LSV

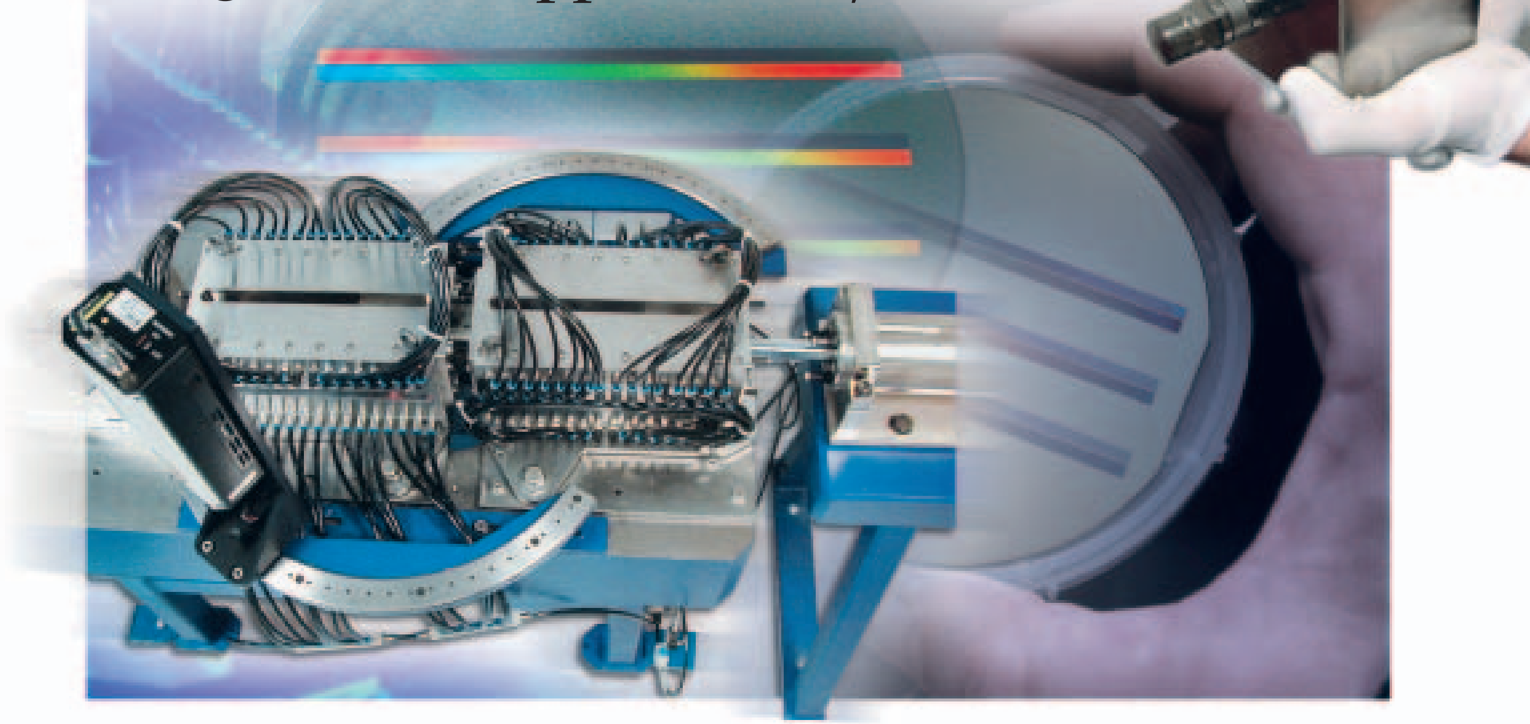
The rolling mill operator benefits from considerable advantages through IMS integrating the Polytec Laser Surface Velocimeter into the C-frame. The additional expense of separate protective and mounting constructions, switching cabinets (figure 2) and utility supply for the laser velocity measurement are no longer necessary. For service work or when feeding in the strip, the C-frame can be moved into the park position. The C-frame has a large maintenance opening which makes the LSV sensor head easily accessible and means it can be exchanged in a matter of minutes. The interior of the IMS C-frame is under slight positive pressure which actively prevents the LSV optics becoming soiled hrough penetrating rolling oil fumes.

The process combination is offered as a complete system by an experienced team. Due to the many advantages it provides, many customers in Europe, China or the USA (figure 3) have already decided on the IMS C-frame with an integrated Polytec Laser Surface Velocimeter.

FURTHER INFORMATION?

E-mail: Lm@polytec.de or www.polytec.com

Measuring Impulse Forces
using Laser-Doppler Interferometers



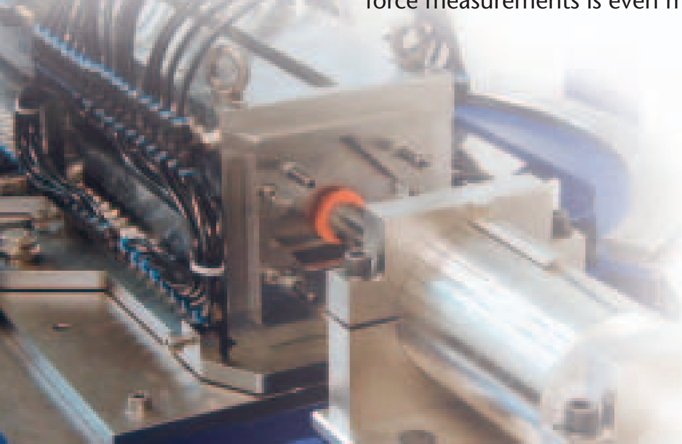
PTB's New Impulse Calibration Device for Forces up to 20 kN

Even though force transducers are used to measure dynamic forces, it is still standard industrial practice to calibrate such transducers under static conditions only. Therefore, the true measurement uncertainties are not well known. A new calibration facility of PTB (Physikalisch-Technische Bundesanstalt, German national metrology institute) performs traceable calibrations of impulse forces for the first time by applying laser vibrometric velocity measurements.

Investigations of force transducers with sinusoidal forces prove a frequency-dependent measurement behavior, which is primarily determined by the inner construction and the type of force introduction. Due to the fact that an impulse excitation has a continuous frequency spectrum and not just a single frequency, the analysis of impulse force measurements is even more complex.

To analyze this topic in detail, PTB established the following goals:

- Investigation of the validity of impulse force measurements: particular attention is paid to the type-specific measurement deviations when using statically calibrated transducers.
- Develop a scientifically based calibration process for impulse forces that is simple and practical to use. This dynamic calibration process is initially seen as a supplement to the established static calibration.



PTB's new Calibration Device

To examine transducers subject to impulse forces, PTB has developed a new calibration facility capable of an accurate generation of impulse forces of up to 20 kN amplitude. The device uses two cube-shaped masses of approximately 10 kg, which are guided by linear air bearings and made to collide with the transducer (A) mounted between them (see figure). The transducer to be calibrated is mounted on mass M_2 that is initially at rest. A spring mechanism accelerates the colliding mass M_1 to its impact velocity v_0 (max. 3 m/s).

By changing the velocity and the compliance of additional pulse shapers the amplitude and duration of the impulse can be varied.

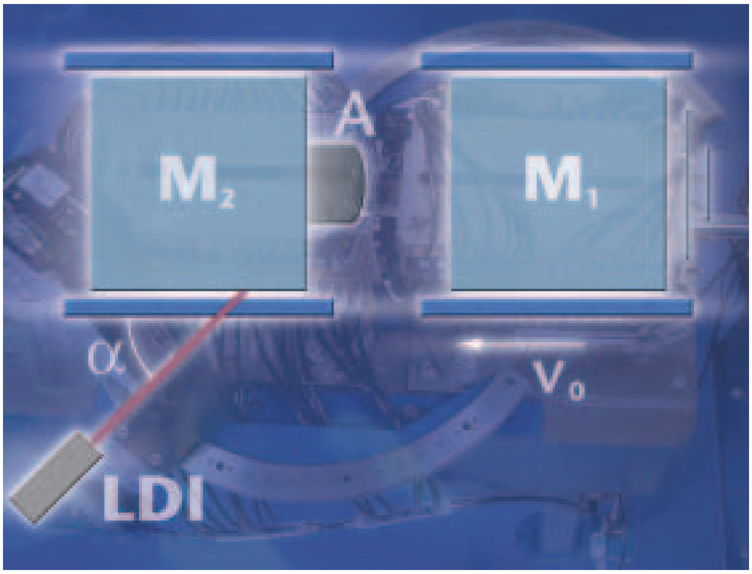
Vibrometric measurement procedure

According to the definition of force given by Newton's law $F(t) = m\,a(t)$, traceability of the generated impulse is achieved by the determination of mass and acceleration. To do so, the velocity of the participating masses (e.g. of M_2) is measured by a Laser Doppler Interferometer (Polytec OFV-353). The acceleration can be calculated through numeric differentiation of the recorded signal sampled at a rate of e.g. 100 kSample/s.

Due to constructional limitations, access to the cubes' end faces in the direction of movement is limited. For this reason, the vibrometers probe the side faces which are easily accessible through slotted holes in the air bearings. The laser beam is directed onto the side face by mirrors that as well set the angle α between the direction of movement and the laser beam. In this case, the measured velocity component is $v(t)\cos(\alpha)$.

Therefore, the accurate knowledge of α is of fundamental importance. By applying a second vibrometer aligned to the moving end face solely for the purpose of angle measurement, α can be determined with high precision from the comparison between the fringe counters of the vibrometer controllers.

To achieve sufficient back reflection of the measuring laser beam under oblique incidence, retro-reflectors are applied to the cubes' side faces. Applications of retro-reflecting adhesive labels result in velocity signals of relatively strong noise due to speckle effects. A drastic improvement in signal quality is attained by a diffraction grating in Littrow configuration.



Outlook

The new calibration device for impulse forces is currently being tested for practical application. Initial tests showed a reproducibility of the force amplitude of approximately 0.1 %. This new facility offers for the first time the possibility for investigations of the dynamic behavior of transducers subjected to known impulse loads.

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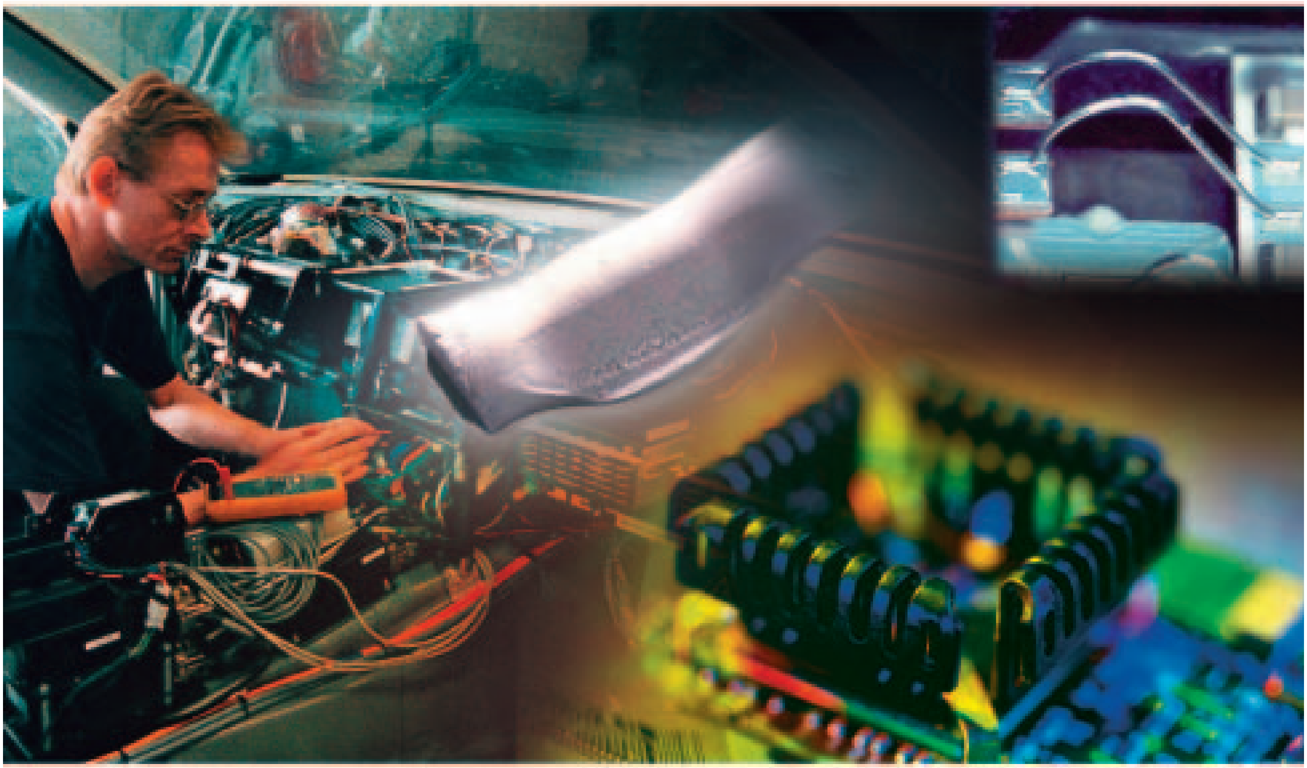
Laser Vibrometry *for a Good Connection*



Using Fiber-Optic Vibrometers for Quality Assurance in heavy Wire Bonds

Thick aluminum wire bonds are widely used to make contact with power semiconductors in the automotive industry. Reliable bond integrity under adverse environmental conditions is critical to maintaining vehicle performance, enhancing quality and lowering costs. Laser vibrometers provide an in situ examination of the bonding process and an important aid in identifying and solving quality defects.

Areas of Application

Automotive power modules are integrated devices that combine low current electronics with high current power electronics to provide control and power to vehicle systems. These devices are becoming more critical as hybrid and electric vehicles enter the market. To make electrical contact with the internal power electronics, thick wire bonding is used. These electrical contacts are produced by ultrasonic friction welding using aluminum wires with diameters ranging from 100 to 600 µm (figure 1). Another thick wire bonding application involves making electrical contact

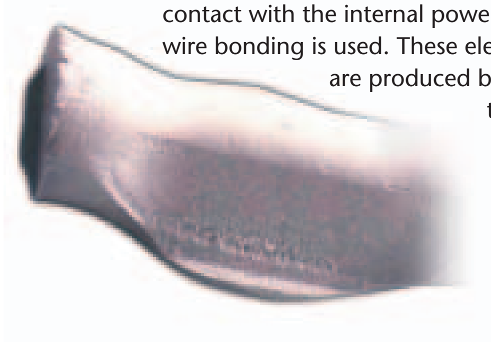
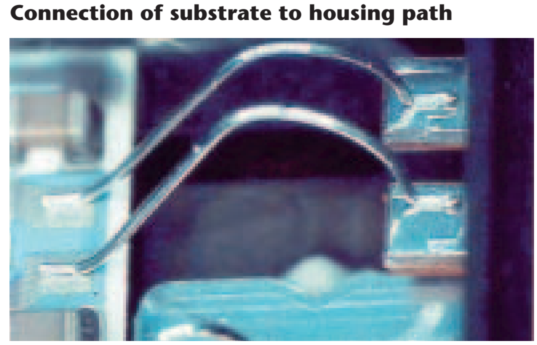


Figure 1: Thick wire bond contact

Figure 2: Connection of substrate to housing path



between substrate holders and plastic injection molded copper parts (figure 2) which in the automotive industry form complex housings with plug-in contacts or copper conductors.

Challenges

There are numerous effects which occur with bonding and can have an impact later when the components are under load. The semiconductors can be damaged mechanically by the bonding tools („Cratering“). Contamination or too much roughness on the bonding surface can produce a poor weld. Reliability problems can occur with unfavorable wire loop geometries. A deleterious effect of plastic injection molded pressed aluminum plated copper parts is that the copper pads can vibrate during the bonding process.

The Bonding Process

Ultrasonic thick wire bonding is realized by pressing the wire onto the pad and introducing ultrasound into the connection zone. The ultrasound is introduced by the bonding tool as it moves the wire at a frequency of 60 kHz with a vibration amplitude of about 5 µm. Initially a strong relative movement between the wire and the substrate surface is essential to break up the oxide layers on the aluminum surface, transport them partially away from the contact zone and allow intimate elemental contact between the aluminum of wire and pad metallisation.

Use of Laser Doppler Vibrometry

With laser Doppler vibrometry the pad vibrations during the bonding process can be monitored. Laser vibrometry provides non-contact displacement measurement with excellent time and spatial resolution. Because there is zero mass loading, there is no effect on the vibration characteristics of the object under investigation.

Vibration measurements using a Polytec OFV-511 fiber-optic vibrometer (figure 3) have been compared with conventional mechanical tests (shearing test) for quality assurance during wire bonding. A significant correlation was found between the vibration amplitude of the bond pad and the quality of the connection.
This correlation substantiates the use of the OFV-511 as a testing device for improved pad design and for production quality bonds.

In addition, with the use of multi-channel or scanning laser vibrometers, it is possible to get important information on bond quality from the vibrations along both the other spatial axes. By providing an additional measurement channel to directly monitor the ultrasonic transducer on the bonding device, it is possible to determine the complete transfer function for the ultrasonic signal.

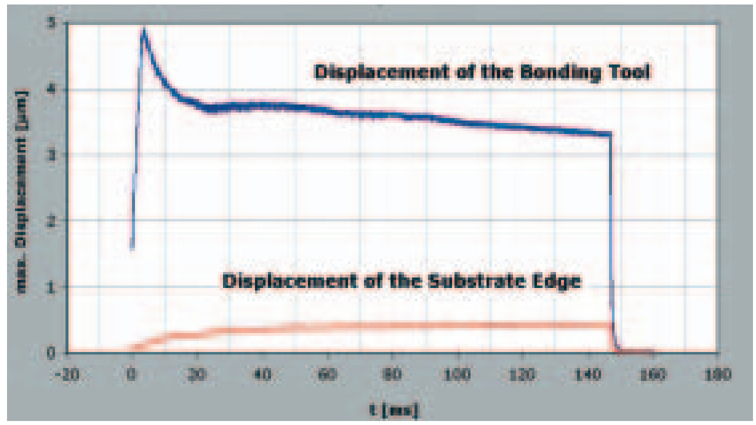


Figure 3: Progression of vibrations during the bonding process

Results and Outlook

Vibrometers can be used to characterize many other types of bonding processes besides the ultrasonic bonding of aluminum to aluminum plated copper in plastic/copper composite housings. One such process is the qualification of clamping systems on lead frames where a large number of bare copper “fingers” must be securely fixed by a hold-down clamp. Another interesting application is the quantitative evaluation of “soft” glues, for stress-free MEMS component mounting where vibrations with micron sized amplitudes are allowed due to the glue’s flexible character.

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Component Inspection *with Non-linear*

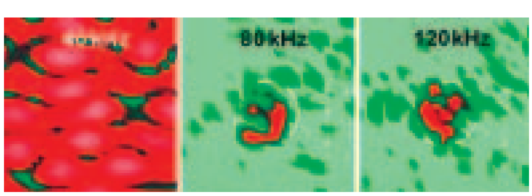
New Method for Non-destructive Testing of Materials and Structures using Non-linear Acoustics

Nonlinear Laser Vibrometry is a new method designed to non-destructively detect defects from higher harmonics produced by a local mechanical rectification of oscillations at the defect. This new method is a reliable quality inspection tool for both production and maintenance applications.

Figure 2: An image of a delamination in a C-C/SiC-Ceramic (Carbon fibre reinforced silicon-carbide) using second harmonic detection (20 kHz excitation).

Introduction

In classical vibrometry a specimen's acoustic response is detected by a transducer like a human ear, a microphone, an accelerometer or a laser interferometer. Defects are found by comparing the specimen's acoustic (resonance) response with a standardized response from a defect-free sample. Resonance frequencies depend on the geometry of the specimen. Variations in specimen size often occur during the production process. These variations in geometry may produce similar spectra to critical localized defects.



Non-linear Scanning Vibrometry

To avoid this ambiguity a defect-sensitive imaging method was developed. Most types of localized defects are correlated with boundaries that can move with respect to each other when acoustically excited. Boundary clapping or rubbing can generate higher harmonics of the exciting frequency (figure 1). This behavior can be seen as a mechanical rectification of an oscillation where, for example, only pressure, not traction, is transferred. This effect is a local non-linearity and is independent of geometry-determined resonances. When a laser interferometer is used as the transducer, the method is known as Non-linear Laser Vibrometry.

Figure 3: Higher harmonics (40 kHz excitation) at a simulated defect: Delamination in carbon fibre reinforced plastics (CFRP).

Laser Vibrometry

Because a localized defect is marked by higher harmonics, while defect-free areas only show the excitation frequency, defects can be distinguished from defect-free areas by frequency selective imaging systems.

Such an imaging system can be constructed from a mechanically-coupled single-frequency resonant transducer that excites an oscillation in the structure to be analysed. Then a Polytec Scanning Laser-Doppler-Vibrometer (PSV 300-S) images the surface of the structure being inspected. The PSV-300-S was chosen for its high spatial (lateral) resolution, accuracy and measurement speed.

Material delamination and cracking are common defects that can significantly degrade the performance of automotive and aerospace products. Nonlinear Laser Vibrometry is used in the following examples (figures 2 to 4) to find localized defects.

In many cases only harmonics of higher order exhibit enough contrast for imaging. By combining 20 kHz excitation with the Polytec Scanning Laser Doppler Vibrometer, defect frequencies up to 1 MHz (fiftieth harmonic) are detectable.

Conclusion

Nonlinear Laser Vibrometry is a new method designed to non-destructively detect defects from higher harmonics produced by a local mechanical rectification of oscillations at the defect. This new method is a reliable quality inspection tool for both production and maintenance applications.

Future Prospects

Given an intense acoustic drive, a localized defect behaves like a highly nonlinear, parametric oscillator. As a result, the resonance effects of the dynamic instability develop in the form of a subharmonic, frequency pair and chaotic oscillations. These effects are localized in the damaged area, making them applicable for locating and imaging of defects.

These effects are currently part of scientific investigations that enhance the understanding and availability of nonlinear effects for defect detection and imaging.

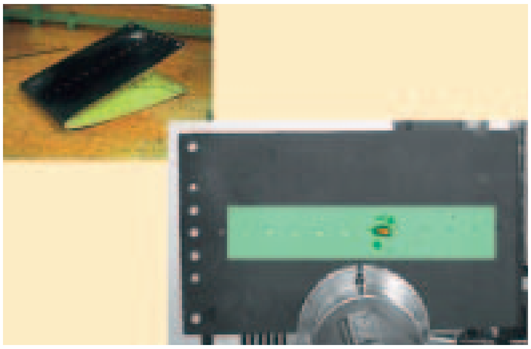


Figure 4: Flaw detection in aluminum: 4th Harmonic (excitation frequency 20 kHz)

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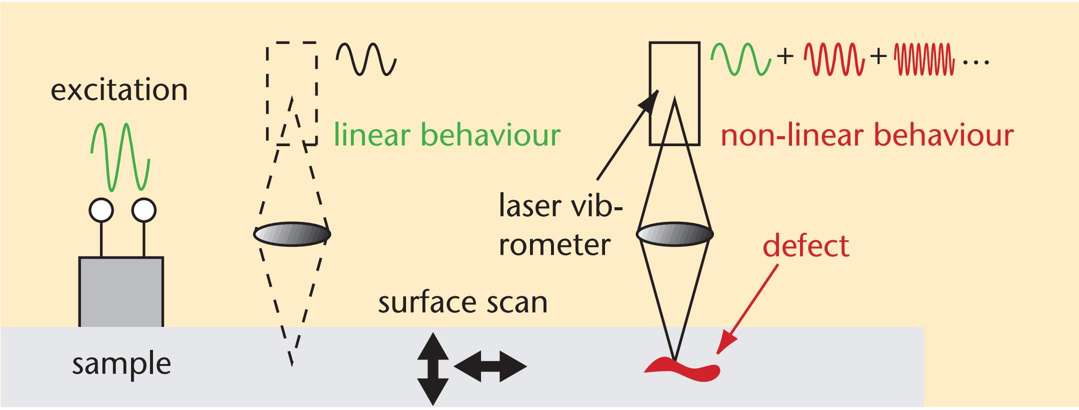
Figure 1: Priciples of non-linear laser vibrometry

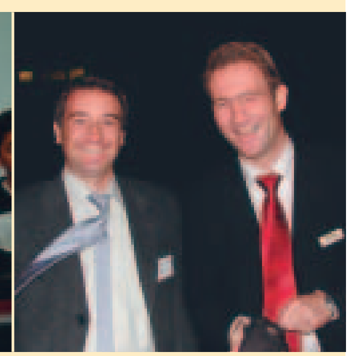


Team *up*

Polytec will be there – Our customers can find us worldwide at well-known exhibitions and tradeshows for optical technologies, MEMS, manufacturing, metrology and quality control. Regional seminars and User Meetings give all users of Polytec vibrometer systems the opportunity to exchange experiences and to expand their vibrometer knowledge. We look forward to these meetings so that we might get to know firsthand the challenging measurement tasks our customers experience each and every day.

First Users Meeting in Brussels:

»A Succesfull Event«



The first Polytec Benelux users meeting/workshop, which took place in the brand new complex at the Vrije Universiteit Brussel, was attended by over 40 academics and industrials from across Europe.

The event was organized by the exclusive distributor for the Benelux "K.Peeraer bvba" together with TechPro Engineering, an engineering company that has expertise in the fields of vibrations and acoustics, signal processing, durability and fatigue testing, instrumentation and optical vibration measurements.

The meeting was hosted by the Faculty of Applied Sciences (Acoustics and Vibration Research Group) of the Vrije Universiteit Brussel.

The two day event provided a unique opportunity for all attendants to gain experience with the newest and most advanced Polytec instrumentation and was a stage for presentations by both Polytec and TechPro Engineering executives and Polytec vibrometer users in general. This resulted in a broad range of topics:

- Emerging technologies in laser vibrometry instrumentation
- Newly developed signal processing methods
- Various industrial applications; use of vibrometers for characterisation, quality control and development of picture tubes and small loudspeakers, mechanical modelling of welding machines and dynamic mechanical characterisation of MEMS.

The participants had also the possibility to exchange a lot of information and own experiences during the social events, where they also enjoyed the fine Belgian Beers and Belgian Cuisine.

2003 Vibrometer Users Meeting USA in Ypsilanti, Michigan

More than 70 of Polytec's vibrometer customers participated in the 2003 Vibrometer Users Meeting held in Ypsilanti, Michigan USA.

Although the meeting was held close to "motor city USA", the meeting reflected the extensive breadth of applications in the USA. Presentations covered topics ranging from using an LDV together with acoustics for revealing cracks in aerospace components, to on-line balancing of automotive drivelines. There was even a fascinating presentation from a Department of Psychiatry professor on LDV sensing of human stress and emotion!

A demonstration of a prototype PSV-400 system and discussions about upcoming PSV software features stirred up a lot of interest and positive comments. So too did the new OFV-5000 modular controller and OFV-505 sensor head. Many appreciated the autofocus feature and the higher resolution offered by digital decoding electronics. Key elements of the meeting were the "round-table" discussion and customer survey. Both were designed to give our users the opportunity to provide feedback about product performance, equipment reliability, applications support and service response. Polytec intends not just to listen but to act upon this very helpful input.

A strong benefit of these meetings is the free advice and training offered not only by Polytec but also by other users. There was a lively discussion about ways to optimize measurements as well as tricks and short-cuts used in some more demanding situations.

Polytec was honored to receive many positive remarks about the format and content of this meeting.

First Press Conference in Waldbronn

»We look forward to coming again!«

On December 1, 2003, Polytec opened its doors to top journalists for a two day press conference covering sensor technology and the automobile industry. Polytec's Laser Measurement Systems presented its new products to an extremely interested audience. The prelude to the conference was a get-together dinner at the special restaurant "Durlacher Turmberg".

On December 2 there were a large number of live demonstrations to go along with Powerpoint presentations and the obligatory round of questions.

A second highlight was the official announcement of the strategic alliance between Polytec and Ometron Ltd made by Dr. Helmut Selbach, Polytec's Managing Director.

The press campaign successfully increased industrial and commercial awareness of Polytec.
A quotation by Herbert Neumann, Editor-in-Chief Konradin-Verlag, summarized our overall impressions: "A campaign of this kind by Polytec was long overdue. We look forward to coming again."

LASER 2003 in Munich

Every 2 years, Munich is the Mecca of the laser world.
The LASER exhibition with its accompanying events is the most important tradeshow in the world for laser technologies.
As a showcase for product innovations, as a communication platform for manufacturers, suppliers and users, as a barometer of the economic climate in the industry and as a compass for the direction of future laser development, LASER is highly rated among the international field of experts.

True to its guiding principle, Advancing Measurements by Light, Polytec exhibited from June 23 to 27, 2003 at two booths covering more than 200 m^2 of floor space. Clearly presented were the wide range of products the company has to offer on all aspects of light: its generation, processing and application to innovative metrology. The obvious highlight was the presentation of the new, modular High-End OFV-5000/505 Vibrometer System for non-contact vibration measurement.

Customer requirements are Polytec's guide to new and improved products. We thank our customers and prospective buyers for the many stimulating discussions at Laser 2003.
You have provided us with encouragement, ideas and direction for future development of Polytec technology.

Trade Fairs *and Events*

Experience the world of laser measurement and meet Polytec at the following events and trade fairs!

Mar 07 – 11, 2004	Nanotech 2004	Boston, Massachusetts, USA	www.nanotech2004.com
Mar 10 – 11, 2004	LMS User Conference	Munich, Germany	lmsconference.lmsintl.com
Mar 14 – 18, 2004	Smart Structures/ NDE 2004	San Diego, California, USA	www.spie.org/Conferences/
Mar 22 – 25, 2004	CFA/DAGA – 30. Deutsche Jahrestagung für Akustik	Strasbourg, France	www.cfadaga04.org
Mar 29 – Apr 02, 2004	Tube	Düsseldorf, Germany	www.messe-duesseldorf.de/ tube2004
Mar 30 – Apr 01, 2004	Aerospace Testing Expo	Hamburg, Germany	www.aerospacetesting-expo.com
Apr 20 – 22, 2004	SEMICON Europe 2004	Munich, Germany	events.semi.org/semiconeuropa
May 11 – 14, 2004	Control	Sinsheim, Germany	www.schall-messen.de/_s/control
May 25 – 27, 2004	Automotive Testing Expo Europe	Stuttgart, Germany	www.testing-expo.com
June 07 – 10, 2004	SEM – 10th International Congress and Exposition on Experimental Mechanics	Costa Mesa, California, USA	www.sem.org
June 21 – 5, 2004	AIVELA	Ancona, Italy	www.aivela.org
July 12 - 13, 2004	Multi-body Dynamics: Monitoring & Simulation Techniques	Loughborough, UK	www.lboro.ac.uk/mbd
July 12 – 16, 2004	Semicon West 2004	San Jose, California, USA	events.semi.org/ semiconwest2004
Sept 14 – 16, 2004	Nanofair	St. Gallen Switzerland	www.nanofair.ch
Sept 14 – 17, 2004	BIAS 2004	Milano, Italy	www.milanoenergia.it/ personal/bias_eng
Sept 20 – 22, 2004	ISMA 2004	Leuven, Belgium	www.isma-isaac.be
Sept 20 – 22, 2004	Diskcon 2004	Santa Clara, California, USA	www.idema.org
Sept 22 – 24, 2004	ALUMINIUM 2004	Essen, Germany	www.aluminium-messe.com
Sept 28 – 30, 2004	MeasComp 2004	Wiesbaden, Germany	www.meascomp.com
Oct 27 – 29, 2004	Automotive Testing Expo North America 2004	Detroit, Michigan, USA	www-testing-expo.com

Reference the web for the most up-to-date information on trade fairs and events!

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