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Efficient Quality Control by Using Optical Vibration Measurement

In production, objective quality controls directly on the production line are crucial to bringing safe, durable and high-quality products to market reliably and efficiently. Contact-free vibration measurement using laser vibrometry is an important tool here for testing quality features that can be clearly and easily evaluated using the vibration signature. The optical measuring method is thus the key to reliable, flexible and at the same time fast good/bad analysis in vibroacoustic quality control. Polytec's maintenance-free laser vibrometer measures contact-free and reliably even in demanding industrial environments and on almost all technical surfaces, thus contributing significantly to cost reduction and productivity by avoiding pseudo rejects.

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QUALITY CONTROL IN THE PRODUCTION LINE

In industry, the optimization of products and processes plays a key role in the commercial success of a company. Quality assurance in manufacturing is therefore based on fast, automated and robust testing techniques.

Vibroacoustic quality testing is a versatile, non-destructive process that manufacturers are increasingly using to ensure the quality and reliability of products and manufacturing processes. It provides information about the vibration characteristics and thus about impermissible deviations in the manufacturing process and the condition of the test specimens.

Companies have to deliver reliable product quality to succeed on the marketplace. 100 % final inspections are therefore mandatory in many fields in order to check product properties and detect possible errors. The demands made on the testing technology used for this purpose are constantly increasing, as the inspection often resembles a fine balancing act: defective products should be reliably detected, but pseudo rejects should be reliably avoided at the same time. Today, vibroacoustic quality control with special industrial laser vibrometers that can be integrated directly in the manufacturing process is a good prerequisite for the necessary precision measurements in the production area.

Laser vibrometers are an important test instrument wherever the dynamic and acoustic properties form part of the essential quality features of the product. Modern laser vibrometers avoid pseudo rejects and the consequential costs of errors in production control because of their accuracy and can help to optimize the design, layout or "sound" of the products, even at the product development stage.

For example, Wilo uses industrial laser vibrometers from Polytec for end-of-line test stands. The manufacturer of pumps for heating, cooling and air-conditioning applications, including automotive applications, can use them to identify loud motors on pumps during assembly checks, which are then repaired, **FIGURE 1**. The test stand assembly includes a control unit with a voltage input for controlling the speed of the motor to be tested. Polytec's QuickCheck software is used for the user interface and configuration of the test assembly. A manual process with piezo vibration sensors was used previously. With the newly developed test bench structure, the process could be simplified significantly, automated, and the cycle time reduced from 5 to 1 min. The measured values are automatically logged, which guarantees traceability. All in all, the switch to the laser vibrometer has paid for itself in less than three years.

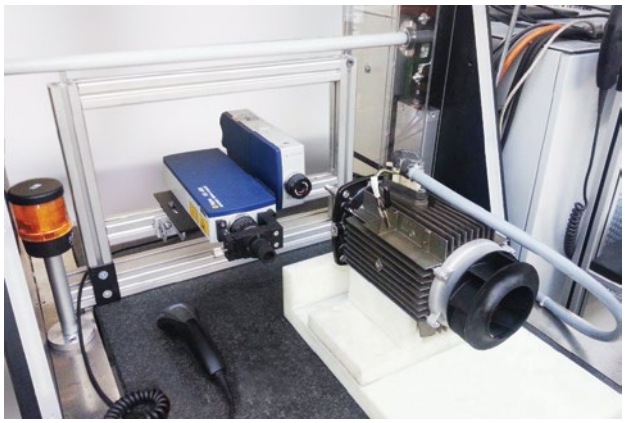

FIGURE 1 Two industrial laser vibrometers measuring on a Wilo heating pump (© Wilo)

VIBROACOUSTIC QUALITY CONTROL

Objective quality controls directly in the production line are a vital component of modern quality assurance. This is the only way for manufacturers to bring high-quality and long-lasting products to market and secure their corporate success in the long term. For example, the industrial vibrometer IVS-500 offers a reliable, flexible and at the same time fast pass/fail analysis in vibroacoustic quality assurance or structure-borne sound analysis, **FIGURE 2**. The laser vibrometer measures contact-free, even in demanding industrial environments and on almost all technical surfaces. It therefore makes a significant contribution to cost reduction and productivity by reducing pseudo rejects.

It checks the quality of semi-finished or finished products using the acoustic signature of the product as the basis for a precise and reliable pass/fail decision. When used in vibroacoustic quality testing, a vibrometer such as the IVS-500 offers a versatile, non-destructive testing method that also allows conclusions to be drawn about the product quality and potential optimizations in

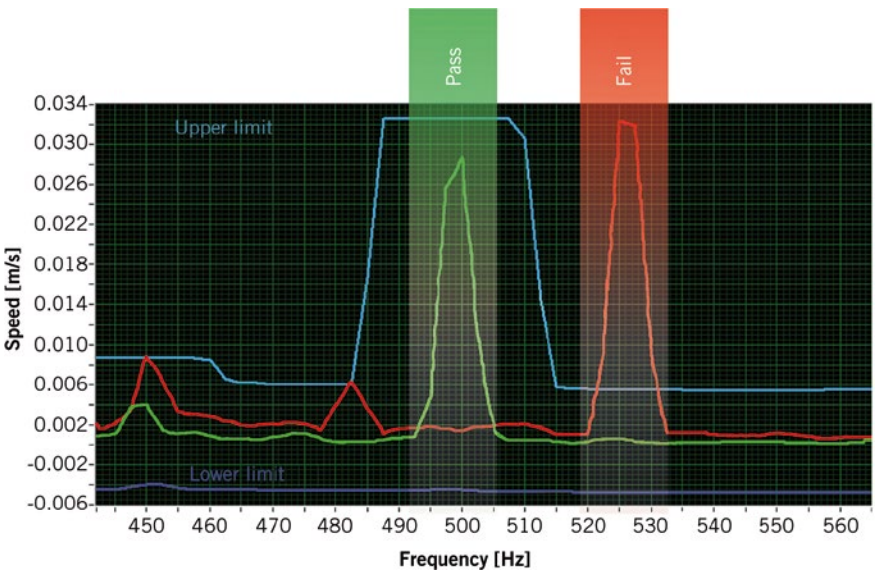

FIGURE 2 Pass/fail decision by means of a deviating acoustic signature (© Polytec)

the manufacturing process itself. In addition, it enables the classification of defects or material properties if the measurement results are outside the tolerance bands. Subsequent and thus costly complaints, as well as the associated loss of confidence, are avoided by preventing or reducing errors directly during production. 100 % inspections, zero-error tolerance and end-of-line tests are indispensable for a significant reduction or the elimination of such cases, especially for OEMs and Tier 1 and Tier 2 suppliers. For example, the acoustic signature can help to detect damage to or the incorrect assembly of bearings, cams, pinions or downstream components in the automated and reliable final production inspection of combustion engines. The versatility of the sensitive laser vibrometers means that they are very good measuring instruments for increasingly demanding measurement tasks in acoustically optimized transmissions, compressors, blowers and servomotors for modern motor vehicles. The IVS-500 provides contact-free testing with a laser beam and can therefore be easily and flexibly integrated in test stands and automated processes, even in confined spaces. It always measures with an optimum signal quality, even with changing component geometries, thanks to its variable stand-off distance and autofocus function. Preparation of the measurement, approach of tactile sensors or closure of the requisite sound insulation chambers for measuring microphones can be dispensed with. This keeps the actual measurement and processing time at an exceptionally low level.

LASER DOPPLER EFFECT

The process is based on laser Doppler vibrometry: If a light beam is reflected by a moving object, the frequency of the light changes in proportion to the velocity component in the beam direction, **FIGURE 3**. This effect is called the Doppler effect. The effect, named after the Austrian mathematician and physicist Christian Doppler (1803 to 1853), is also familiar from everyday life. For example, everyone knows that the sound of the siren of police or fire service vehicles is perceived at a higher frequency when they approach and a lower frequency when they move away.

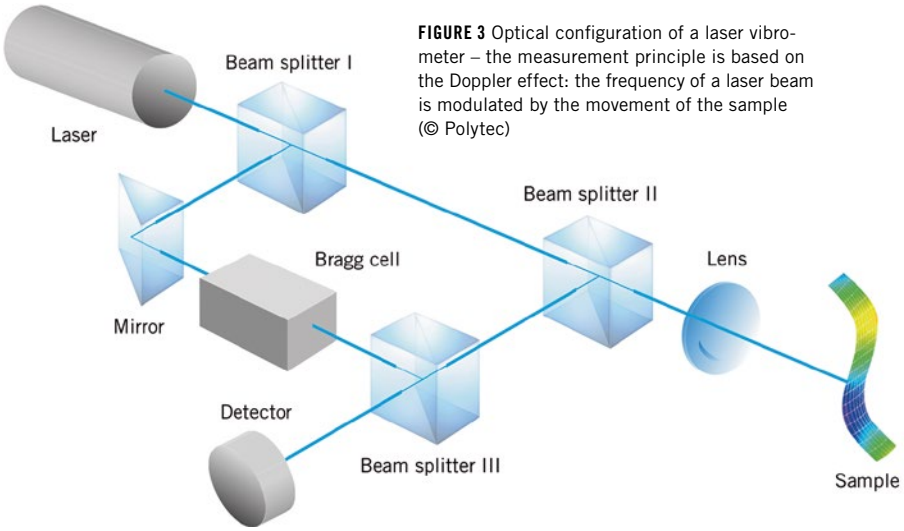

FIGURE 3 Optical configuration of a laser vibrometer – the measurement principle is based on the Doppler effect: the frequency of a laser beam is modulated by the movement of the sample (© Polytec)

The velocity information is coded in this frequency shift. It is used in laser Doppler vibrometry as a measurement signal. A precision interferometer and digital decoding electronics convert this frequency shift into a voltage signal in proportion to the vibrational velocity that can be processed by all conventional data acquisition systems. The velocity information is independent of the light intensity. This measurement principle is therefore also suitable for objects with a very low reflectance.

ADVANTAGES COMPARED TO OTHER MEASUREMENT METHODS

There are a number of advantages compared to conventional measurement methods: In contrast to measuring microphones or ultrasonic sensors, the laser vibrometer is insensitive to ambient noise and eliminates the need for an additional soundproof enclosure. The contact-free measuring industrial vibrometer can be easily integrated in existing systems without complex sound insulation. This not only simplifies the construction of the test stand but also accelerates quality control, since the test specimens do not have to be placed in a special sound-insulated test chamber for the test, which always comes at the cost of the cycle time.

Laser vibrometry can also score points against acceleration sensors. No mechanical, wear-prone adaptation units are required and the distance between the sensor and measurement point is variable. Contact-free measurement is possible at all optically accessible points and the test specimen is not affected by the mass or contact force of the sensor. This fast measurement principle makes very short cycle times possible. The measurement results are exactly reproducible. Laser vibrometers can be used universally and flexibly since they also work with high frequency bandwidths up to the ultrasonic range. They can determine material properties, errors or characteristic properties in a wide variety of test specimens on the basis of noise (structure-borne sound) or vibration characteristics. The measurement procedure has also proven itself in many industrial applications, even under harsh ambient conditions.

Vibroacoustic quality testing is a versatile, non-destructive method for optimization of the manufacturing process and the quality and longevity of the product and to identify defects or material properties outside the tolerance bands. The laser vibrometer can detect cracks and check material properties such as the Young's modulus.

LONG-TERM ECONOMIC EFFICIENCY

The Total Cost of Ownership (TCO) can provide information about the long-term economic efficiency of the various methods in the search for the right measuring method. **FIGURE 4** shows that the TCO can be higher over time in a conventional process that is susceptible to pseudo rejects and wear maintenance of the sensor than in laser Doppler vibrometry. Thanks to its technical advantages, such as a short cycle time and very good reproducibility, productivity can be increased and pseudo rejects reduced.

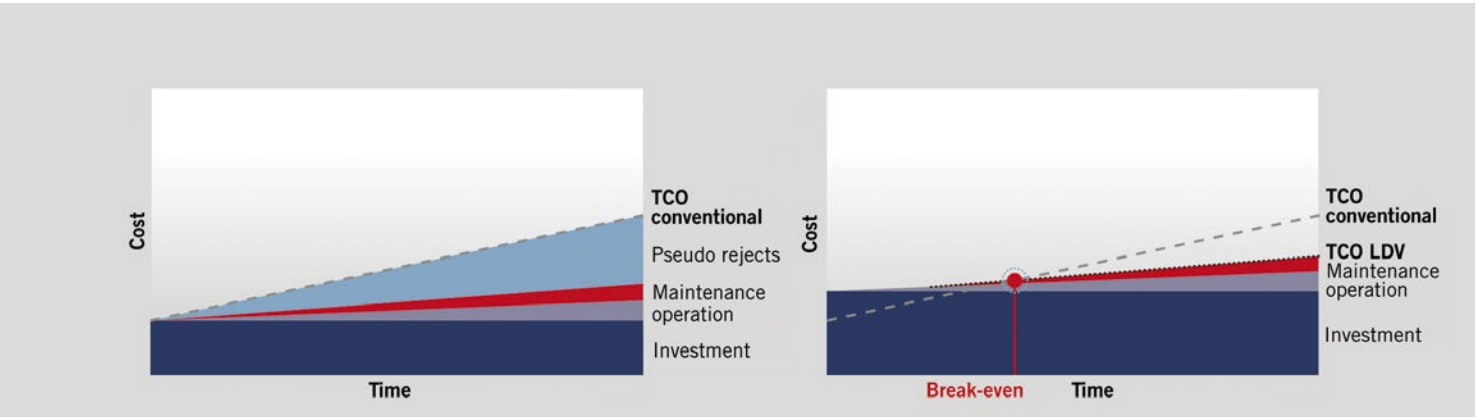

FIGURE 4 Comparison of the TCO using different measurement methods (left: TCO for conventional testing methods; right: TCO when using Laser Doppler Vibrometers (LDV)) (© Polytec)

It is therefore advisable to look at the total costs throughout the service life.

Polytec has been offering laser vibrometers for vibroacoustic quality control for several decades. The comprehensive product range offers solutions for almost every vibration problem in research, development, production and long-term monitoring, no matter whether it concerns single-point or differential measurements, the determination of rotational or in-plane vibrations, the visualization of vibrations on MEMS and microscopic systems or the complete, area-based graphic representation of structural vibrations.

The industrial vibrometer of the latest generation IVS-500 provides reliable measurement results on practically all surfaces, regardless of the ambient conditions, and can be flexibly adapted to different measurement tasks. It measures from distances of a few centimeters up to several meters. An integrated auto and remote focus function always ensures high signal quality even at varying distances, for example when measuring components of different sizes. Different models cover measurement frequencies up to 100 kHz, so that every user can find the right solution.

COMPLETE SOLUTION WITH USER-FRIENDLY SOFTWARE

The laser vibrometer can be easily integrated in a wide variety of automation environments in combination with the versatile inspection software QuickCheck from Polytec. The inspection software has been specially designed for vibroacoustic quality testing. It acquires the measurement signals of the laser vibrometer and other sensors, for example for speed measurement in engine tests, evaluates them, controls the test sequence, communicates with the production control system and offers user-friendly configuration and evaluation options. Limits in the frequency and time domain can be easily configured. Fully automatic testing of different test specimens and types on the same test bench is made possible and simplified by type-specific parameter and algorithm management. It also has a database for storing the test data, statistics functions and an export interface as well as operation security through hierarchical user rights. It helps to secure product quality in the long term and reduce pseudo rejects rates, thereby increasing the economic efficiency of the manufacturing process. Process-integrated vibroacoustic quality testing is enjoying increasing popularity in industry as a contact-free, flexible process, thanks to its performance, flexibility and reliability.

SUMMARY

The use of laser vibrometers on in-line or end-of-line test stands has proven itself in vibroacoustic quality testing. Their many technical advantages mean that productivity can be increased and pseudo rejects reduced compared to other measurement methods. They can be easily, flexibly and efficiently integrated into a wide variety of automation environments with economic benefits at the TCO level in combination with suitable software.