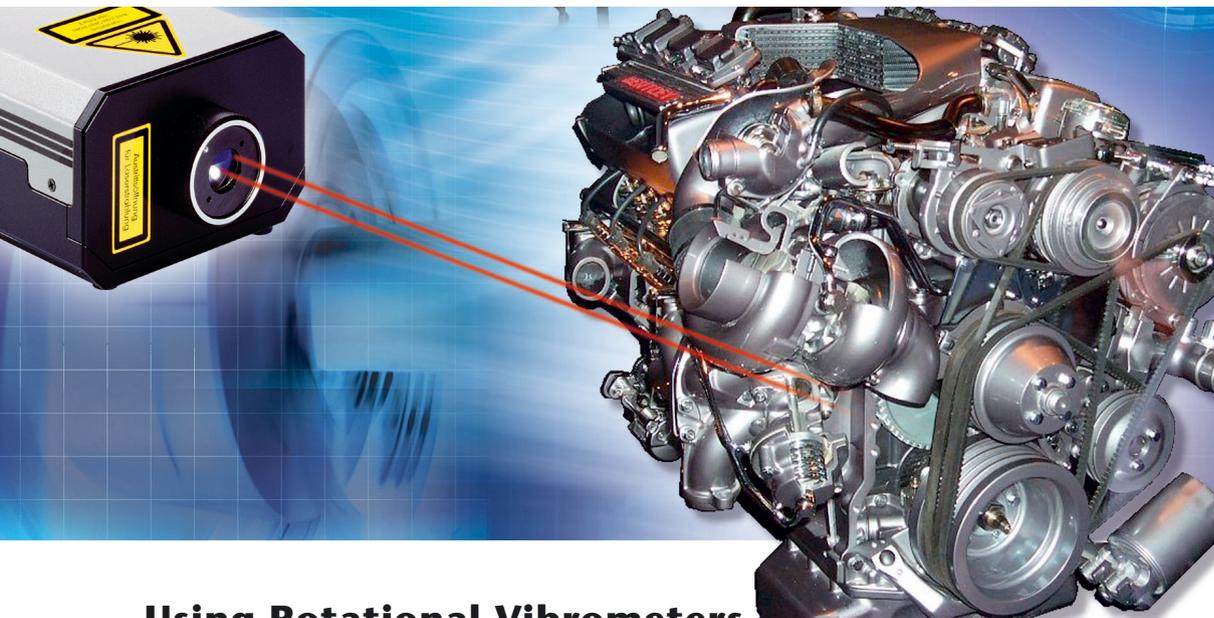


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FIELD OF APPLICATION

- A Aerospace
- B Audio & Acoustics
- C Automotive**
- D Data Storage
- G General Vibrometry
- M Microstructures &-systems
- P Production Testing
- S Scientific & Medical
- T Structural Testing
- U Ultrasonics

Using Rotational Vibrometers to Make NVH Measurements on Combustion Engines

An engine's combustion process induces rotational inhomogeneity and torsional vibrations in the drive shaft resulting in unwanted vibrations and noise emission. By examining the rotational movements of the different components, the drive train for the motor vehicle can be optimized to reduce the unwanted vibrations. Rotational vibrometers using non-contact measurement procedures allow for a quick and simple examination of the torsional vibrations during operation.

Components in the Combustion Engine

A combustion engine contains a large number of rotating parts, starting with the crankshaft, the camshaft, the drive shafts and differential shafts to the auxiliaries such as the starter, electric generator and turbo charger. In the following examples, measurements on the crankshaft pulley are shown.

Comparison of Measurement Procedures

The traditional method for measuring rotational vibrations uses the angular displacement encoder mounted to a pulley using an adapter. Apart from the mechanical effort involved, this technique loads the pulley causing a change in its mass and the moment of inertia. At best, these changes diminish the accuracy of the measurement; at worst, they can lead to completely false results.

The Polytec OFV-4000 Rotational Vibrometer makes a simple, non-contact measurement that preserves the original mass and moment of inertia. As a general rule, the surfaces to be measured do not need to be prepared, only on material which is highly light absorbent (black) it is necessary to increase the light scatter by applying reflective sticky tape (negligible mass).

Measurements with the Rotational Vibrometer

Rotational vibrometers measure angular vibrations on surfaces rotating from $-7,000$ to $+11,000$ RPM. They sense the rotation using the Doppler shifted laser light. The basic principles of rotational vibrometry are explained on www.polytec.com/usa/vib-university.

The example in Figure 1 shows simultaneous measurement of two movements of the pulley: the rotational vibrations are acquired using the OFV-4000 Rotational Vibrometer and the axial

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movements of the shaft are acquired with a Polytec Single-Point Vibrometer. The measurement data is used to perform an order analysis. The orders are multiples of the rotational speed. If the engine is turning at 3000 RPM (50 Hz) then the first order is at 50 Hz, the second order at 100 Hz and so on.

If the signal power of the rotational vibration is plotted against the rotational speed and frequency (spectrogram shown in Figure 2), then you can see that the maxima occur primarily at a resonant frequency of 490 Hz.

The corresponding order spectrum (Figure 3) shows that in the RPM range between 1000 RPM and 6000 RPM, primarily resonances of the 6th, 8th and 10th order are excited.

Signal Quality

The OFV-4000 Rotational Vibrometer offers you the option of conditioning the input signal using a tracking filter to improve the high-frequency carrier signal. It is particularly suitable for bridging short dropouts which can occur during rotational measurements due to the speckle effects of the reflected light. This effect is in principle better with a larger time constant (SLOW) but when tracking highly dynamic signals you have to switch to FAST. The most favorable setting is often found by trial and error and varies from case to case.

In Figure 4 the right picture shows how a smoother signal progression is attained using the filter setting FAST in which the discontinuities and disruptions shown in the example on the left side (Filter setting SLOW) are filtered out.

Summary

The Rotational Vibrometer is very easy to use, has a high optical sensitivity and maintains a large dynamic range. No adapter or flange is necessary for making measurements, leaving the object under examination unaffected.

The Rotational Vibrometer prevents stoppage time which occurs when using contact processes. In the car industry it supports the development of torsional vibration dampers and helps solve all kinds of rotational vibration problems.

For more information about the Rotational Vibrometer and about automotive applications please contact your local Polytec sales engineer or visit our web pages

www.polytec.com/usa/rotvib
www.polytec.com/usa/automotive



Figure 1: Measurements of rotational vibrations and out-of-plane vibrations on a crankshaft pulley

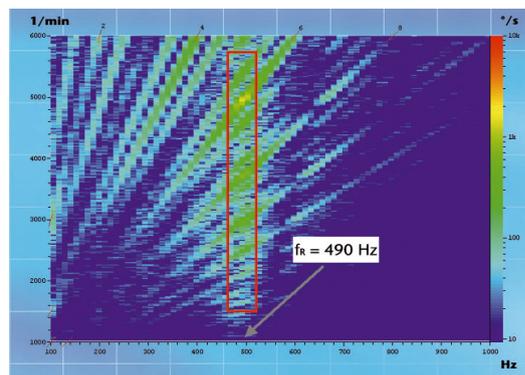


Figure 2: Spectrogram graph of the measurements on the crankshaft

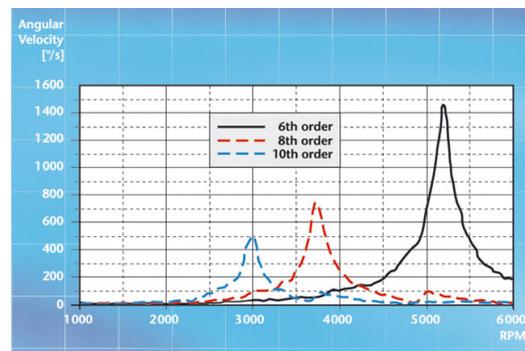


Figure 3: Order spectrum of the rotational vibrations

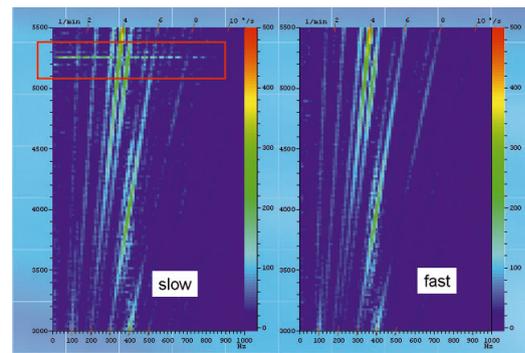


Figure 4: Application of the tracking filter

Polytec GmbH (Germany)
 Polytec-Platz 1-7
 76337 Waldbronn
 Tel. + 49 (0) 7243 604-0
 Fax + 49 (0) 7243 69944
info@polytec.de

Polytec-PI, S.A. (France)
 32 rue Délizy
 93694 Pantin
 Tel. + 33 (0) 1 48 10 39 34
 Fax + 33 (0) 1 48 10 09 66
info@polytec-pi.fr

Lambda Photometrics Ltd. (Great Britain)
 Lambda House, Batford Mill
 Harpenden, Herts AL5 5BZ
 Tel. + 44 (0) 1582 764334
 Fax + 44 (0) 1582 712084
info@lambdaphoto.co.uk

Polytec KK (Japan)
 Hakusan High Tech Park
 1-18-2 Hakusan, Midori-ku
 Yokohama-shi, 226-0006
 Kanagawa-ken
 Tel. +81 (45) 938-4960
 Fax +81 (45) 938-4961
info@polytec.co.jp

Polytec, Inc. (USA)
 North American Headquarters
 1342 Bell Avenue, Suite 3-A
 Tustin, CA 92780
 Tel. +1 714 850 1835
 Fax +1 714 850 1831
info@polytec.com

Midwest Office
 3915 Research Park Dr.,
 Suite A-12
 Ann Arbor, MI 48108
 Tel. +1 734 662 4900
 Fax +1 734 662 4451

East Coast Office
 25 South Street, Suite A
 Hopkinton, MA 01748
 Tel. +1 508 544 1224
 Fax +1 508 544 1225