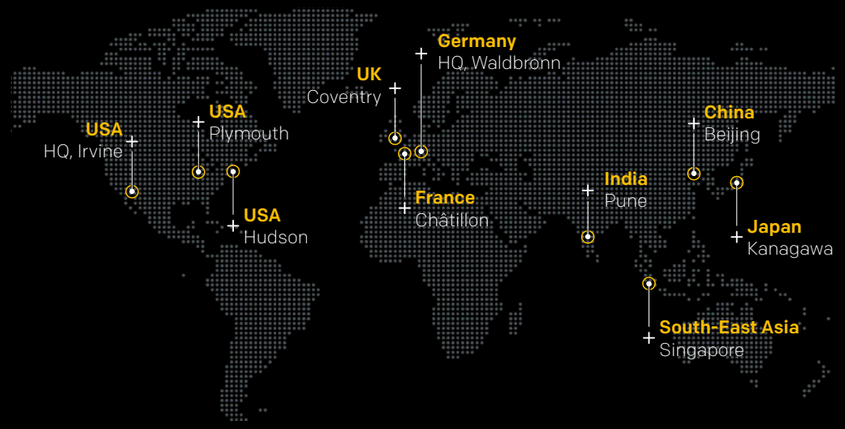

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Application //

Laser Doppler Vibrometry at extreme temperatures

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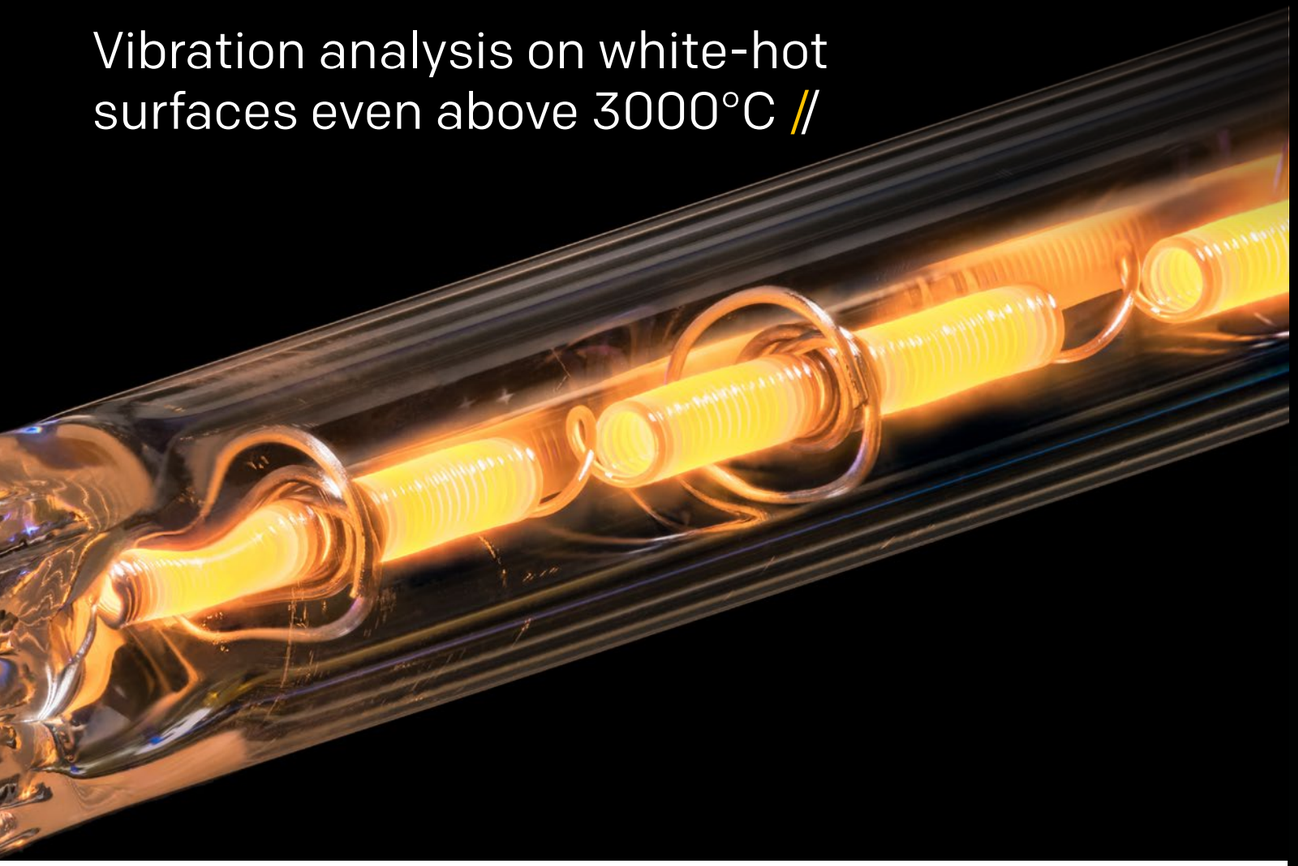
Vibration analysis on white-hot surfaces even above 3000°C //



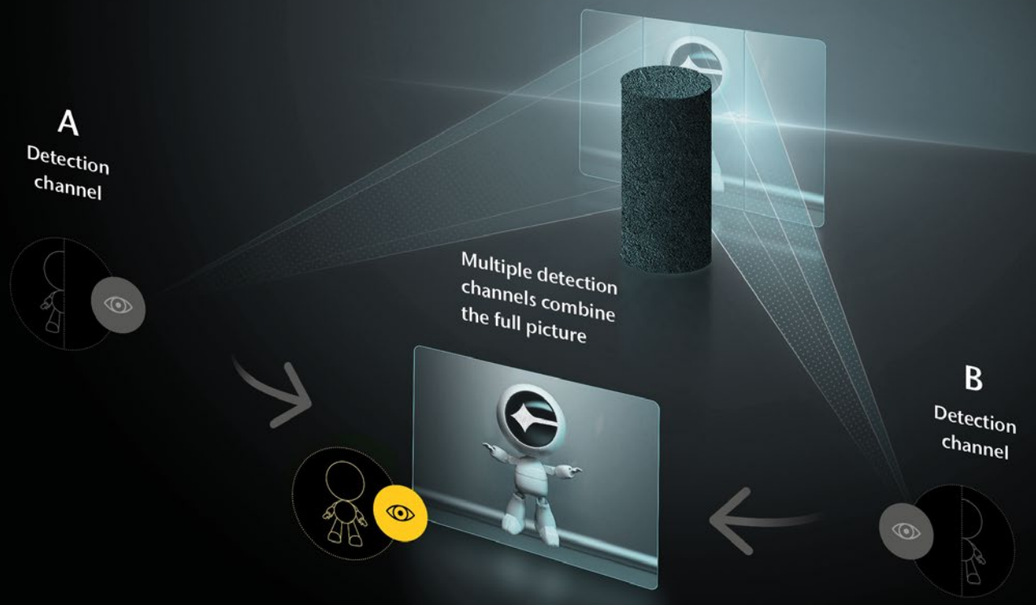
CHALLENGES OF VIBRATION ANALYSIS AT EXTREME TEMPERATURES

Non-contact vibration measurement on extremely hot components presents a particular challenge in modern test and measurement technology. Especially in aerospace, power generation and materials research, components are often exposed to extreme thermal loads where conventional vibration sensors fail or would distort the structural vibration due to mass loading.

Laser Doppler Vibrometers (LDV) with heterodyne interferometry and QTec® technology offer a unique solution here: They enable precise vibration measurements even on white-hot surfaces with temperatures well above 1000°C without any physical contact.

QTEC® TECHNOLOGY – REVOLUTIONARY NOISE REDUCTION

Polytec's patented QTec® technology effectively reduces noise in vibration measurements on technical surfaces and thus enables highest signal quality. For this purpose, QTec® vibrometers use an innovative multi-channel interferometer with diversity reception to recombine the best measurement signals from different perspectives into one consistent result. This drastically reduces the probability of dark speckles and thus signal dropouts.



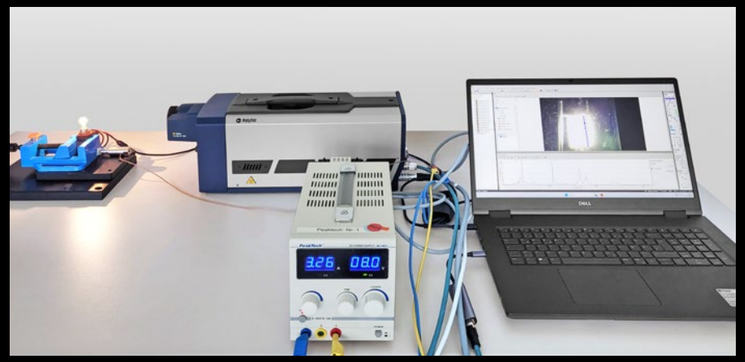
Measurement setup for high-temperature applications //

The example of a filament of a halogen bulb impressively demonstrates the performance of Polytec vibrometers at extreme temperatures. At nominal voltage, the filament reaches temperatures between 2700°C and 3000°C – even these intensely glowing objects can be measured without difficulty.

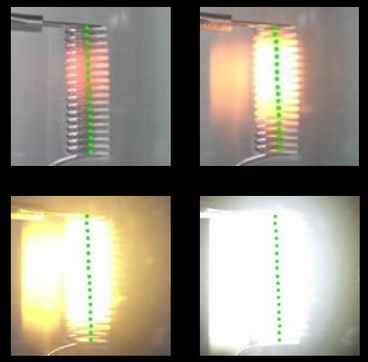
1 Filament of the measured halogen bulb. One measurement point per winding

THE MEASUREMENT SETUP COMPRISES:

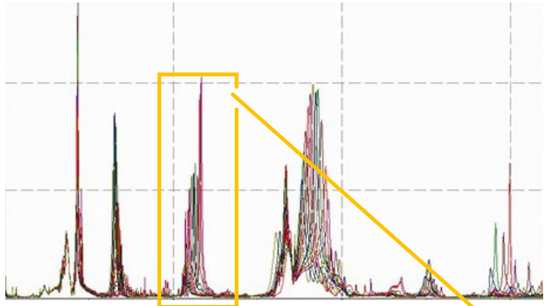
// VibroScan Xtra QTec® scanning vibrometer – for full-field vibration analysis
// Close-up Unit – with special lens for detailed measurements of small structures
// Stacked piezo excitation – driven by the built-in signal generator
// Non-contact laser focusing – on the glowing filament



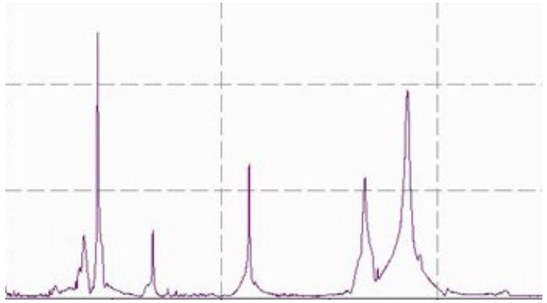
2 VibroScan Xtra QTec with Close-up Unit aligned to a light bulb



3 Vibrometer camera images at slowly increasing current



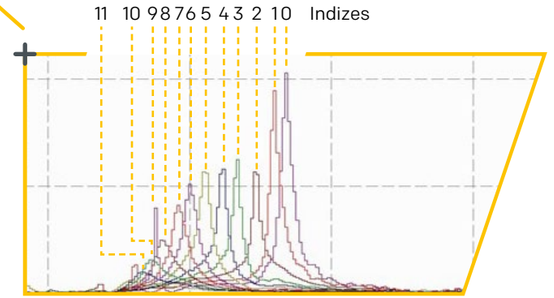
4 Changes in the spectrum as the surface temperature increases



5 Typical vibration spectrum in the energized, glowing state

EXPLANATION

The curves with indices 0-11 correspond to increasingly higher temperatures. It is clearly visible how the resonance frequency shifts to lower frequencies and, in addition, the damping (as the ratio of peak height to width) increases. This can be explained by the hot and thus softer material of the filament.



6 Zoom into the measured frequency spectrum in the range from 2 to 2.5 kHz

Measurement results and temperature effects //

As temperature rises, characteristic material changes become apparent:

1. Shift of resonance frequencies towards lower frequencies
2. Increase in damping (visible from the ratio of resonance peak height to width)
3. Change of mechanical properties due to thermal softening

These temperature-dependent properties can be analyzed and documented easily and reliably on such extremely hot surfaces using a QTec scanning vibrometer.

Summary //

Laser Doppler Vibrometry with QTec® technology is establishing itself as the standard method for vibration measurements under extreme thermal conditions. The non-contact and non-intrusive measurement technology enables precise analyses of samples with surface temperatures exceeding 3000°C and opens up new possibilities in high-temperature materials research, turbine technology, and quality assurance.