What if towers swing?

Reduction of gearbox tonalities with active or passive damping devices

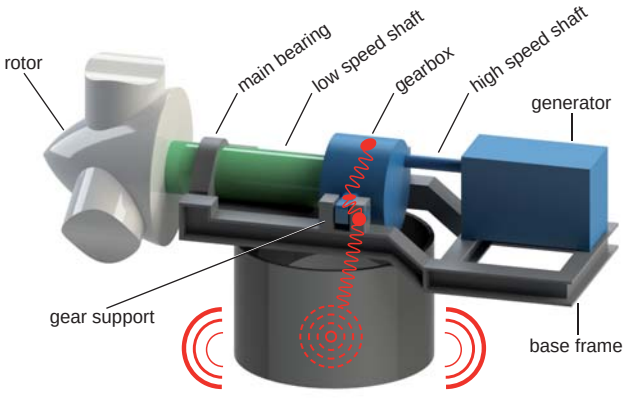
Wölfel

Tonalities affect the acoustic quality of the turbine

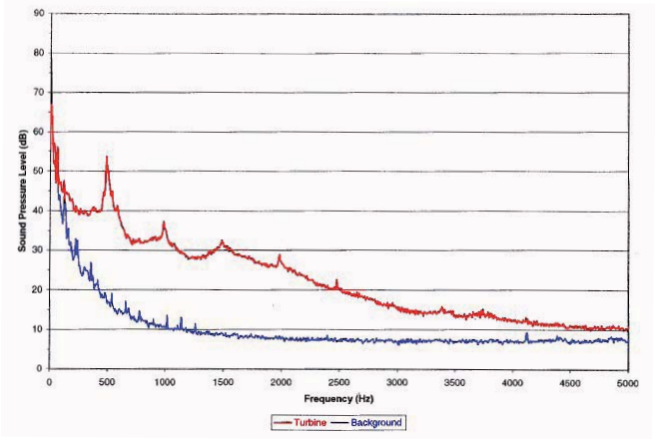
How are tonalities generated?

Tonalities have their origin in the gearbox:
The meshing forces of one or several gear stages vary periodically with the respective meshing frequency. This constitutes a dynamic vibration excitation in the audible frequency range, mostly from approx. 80 Hz up to several 100 Hz. In response to this excitation, the gearbox reacts with vibrations in the excitation frequency.

The gearbox vibrations are then transferred in the wind turbine and spread up to the rotor blades and the tower. During this transfer, they might be further increased by part resonances. In many cases, common gearbox supports cannot reduce the vibrations sufficiently, because the cutoff frequency of the isolation cannot be set low enough. With their huge surface, the tower and the rotor blades convert the mechanical vibrational energy into acoustic energy and emit this energy as audible sound: tonal airborne sound is produced.



Propagation and emission of tonalities in the drive train



Narrow-band spectrum with tonalities of a wind turbine during acoustic measurement in the free field

Why are tonalities a problem?

The acoustic quality of wind turbines is evaluated on the basis of the sound power level, which is to be determined according to IEC 61400-11. The noise of a turbine is mainly caused by air fl owing around the rotor blades. This leads to audible broadband noise consisting of many frequencies, none of which stands out particularly.

If gearbox tonalities occur, a noise with a fixed frequency, i.e. a tone, mixes with this broadband noise. It is known from psycho-acoustics that tonal noises (tonalities) are particularly unpleasant for people, which is why the standards assign a socalled tonality surcharge to the determined broadband sound power level for tonal components, which can be up to +6 dB. With this surcharge, the authorized limits for noise emissions or the contractually agreed noise levels are often exceeded.

How can tonalities be reduced?

Conventional solutions for tonality control are

- improvement of the meshing quality;
- softer supports at the torque arms; due to the huge static loads, however, this strategy has tight limitations.

Preventing propagation and emission with absorbers at the gearbox

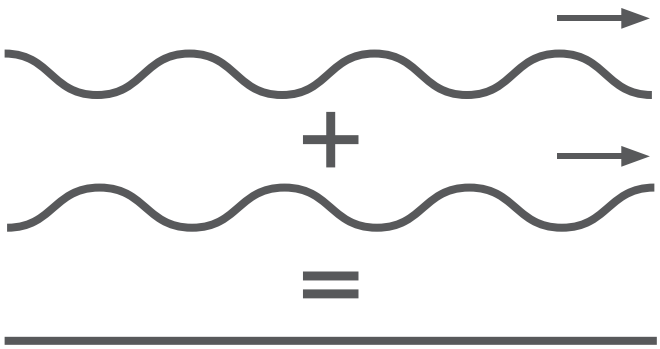
The innovative approaches of Wölfel are designed to prevent the propagation of gearbox vibrations – especially in the direction of the tower. This is achieved by compensating the present vibration by a precisely applied counter-vibration before it can spread.

For tonalities with fixed frequency: TMD.Sound

A passive slightly damped absorber compensates one order of tonal gearbox vibrations at one fi xed speed, mostly the rated speed of the wind turbine.

Application and effect

One passive absorber TMD.Sound each is mounted on both torque supports. The absorber is exactly adjusted to the tonality frequency at rated speed. Due to the adjustment, the absorber applies a force that is exactly opposite to the excitation, so that the tonal forces at the torque supports cancel each other out.
The transfer of the vibrational energy into the tower is prevented, it is "redirected" into the movement of the absorber mass of the TMD.Sound, which does not produce any noise emissions.



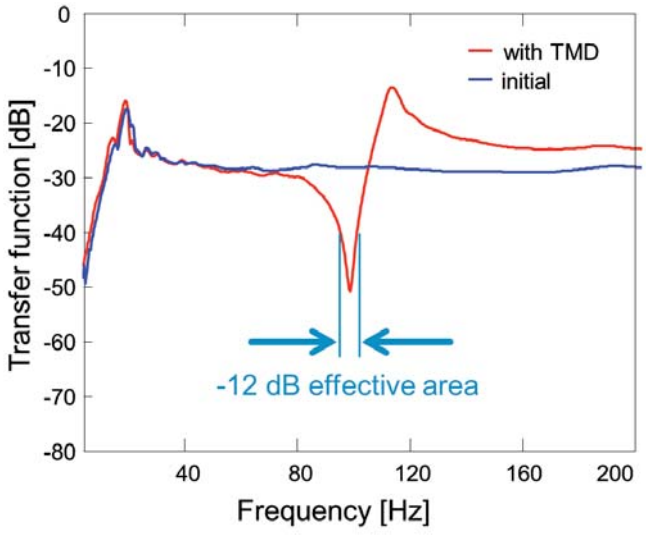
Elimination of tonalities with counter-vibrations

Advantages

- No energy supply required
- Low costs due to simple design
- Can be retrofitted (troubleshooting)

Disadvantages

- Higher mass → larger installation space
- Narrow bandwidth: only one fi xed frequency
- Limited frequency range



For tonalities with variable frequency: ADD.Sound®

An actively controlled absorber compensates several orders of tonal gearbox vibrations at variable speed over the entire speed range of the wind turbine.

ADD.Sound®

Application and effect

One active absorber ADD.Sound® each is mounted on both torque supports. A compact control cabinet is installed in the nacelle for the electronics. Due to the speed-adaptive control algorithm, the actuators integrated in the active absorber generate a force in the range of several kilonewtons and this force exactly eliminates the tonal excitation forces from the gearbox.

The transfer of the vibrational energy into the tower is prevented, it is "redirected" into the movement of the reaction mass of ADD.Sound®, which does not produce any noise emissions.

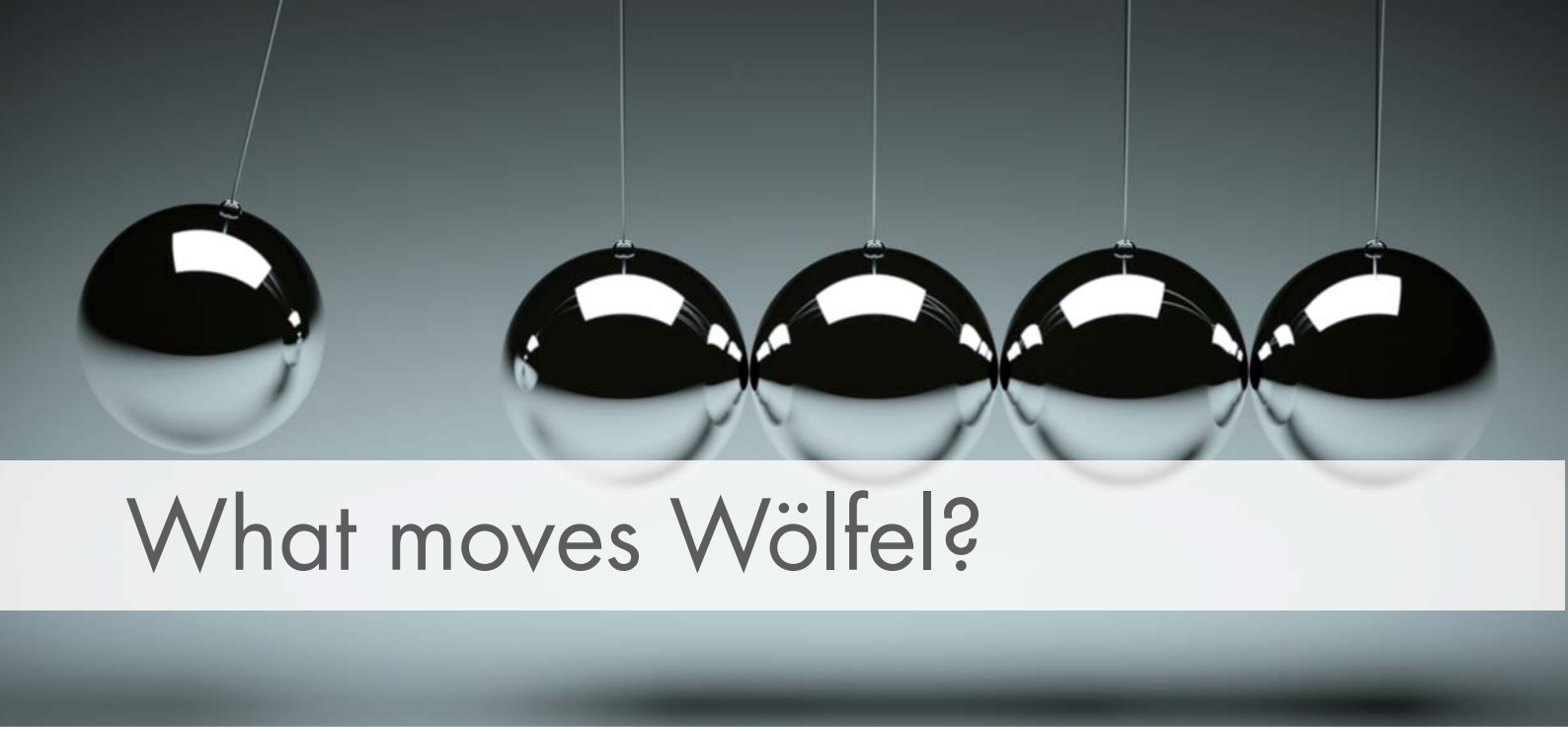
ADD.Sound® for the control of tonalities in wind turbines is used successfully in hundreds of installations.

Advantages

- Broadband effect
- Simultaneous compensation of several tonalities
- Lower mass → small installation space
- No adjustment required
- Can be retrofi tted (troubleshooting)

Disadvantages

- Energy supply required
- Higher costs than passive TMD.Sound



What moves Wölfel?

Vibrations, structural mechanics and acoustics – this is the Wölfel world. Here we are experts, this world is our home. More than 90 employees daily do their best for complete satisfaction of our customers. For more than four decades we support our customers with engineering services and products for the analysis, prognosis and solution of tasks in the fields of vibrations and noise.

Are vibrations really everywhere? Yes! That's why we need a wide variety of solutions!
Whether it is engineering services, products or software – there is a specific Wölfel solution to every vibration or noise problem, for example

- simulation-based seismic design of plants and power stations
- measurement of acoustic emissions of wind turbines
- universal measuring systems for sound and vibrations
- expert reports on noise immission control and air pollution forecasts
- dynamic occupant simulations for the automotive and aviation industry
- and many other industry-specific Wölfel solutions …

TÜV NORD DIN EN ISO 9001 · TAPA SCHALLSCHUTZPRÜFSTELLE NACH DIN 4109 · DAkkS Deutsche Akkreditierungsstelle D-PL-19254-01-00 · VBI · Bundesverband WindEnergie e.V. · §26 Mess-Stelle Gruppe: I Bereich: Q, R, S, T

Wölfel-Group
Max-Planck-Straße 15 / 97204 Höchberg
Phone: +49 931 49708 0 / Fax: +49 931 49708 150
info@woelfel.de / **www.woelfel.de**

Wölfel

PRO-BR-01-EN-08-2016