Extending the lifetime of your wind turbine

SHM.Tower® – Our intelligent and cost-effective tower vibration monitoring system. Valuable for a precise analysis of the lifetime of your wind turbine for its further operation
Vibration monitoring and further operation

Every wind turbine has its own individual structural and vibrational behavior while being in operation. The vibration load of wind turbines, especially that of the tower, can vary considerably depending on the location and operational mode of the wind turbine. In the design phase, these loads are determined by means of wind classes which derive the respective wind conditions from annual average values. Usually, data collected by neighboring metrological measuring stations are used during assessments regarding the lifetime extension of wind turbine towards the end of their operational life. That means that both the design and the assessment for further operation of the wind turbines are based on loads that may considerably deviate from the actual loads. Even two wind turbines in one and the same wind farm may differ significantly in their vibration loads. This may also be due to different balancing conditions or pitch angle errors.

Optimized operation

We recommend that the turbine settings should be optimized while taking the actual loads into account. This is necessary because of the strong vibrations that occur in case of insufficient balancing or incorrect pitch angles. The highest vibration amplitude values, which allow making direct statements about the global vibration level, occur at the head of the tower, the ideal installation position for SHM.Tower.

Remaining service life and further operation

To assess whether the operational life of a wind turbine can be extended, the remaining lifetime must be determined as best as possible. This requires that the design loads are compared with the actual fatigue loads. In this context, the full potential can only be exploited if the tower vibration data are collected using measuring equipment.
The SHM.Tower monitoring system has been developed for continuous measurement of the vibration loads of wind turbine towers. Since it issues warnings if threshold values are exceeded, the system provides considerable added value during ongoing operation. Wind turbines with excessive loads can be identified instantly to initiate immediate countermeasures.

During the entire life of the wind turbines, instantaneously evaluated and stored data provide valid statements about the lifetime that has already elapsed. With SHM.Tower installed in the tower, the assessment regarding lifetime extension of the wind turbine is based on actual fatigue loads rather than on mere estimates. In particular, extreme loads are measured directly. Since SHM.Tower registers structural loads using measuring equipment, the number of visual inspections can be reduced.

The system and particularly the software have been developed to meet the requirements of the industry from the very beginning and have been tested in a multitude of wind turbines. The calculated lifetime predictions have been verified and confirmed by validation measurements.

The SHM.Tower sensors and electronic components are accommodated in a compact housing and can be easily installed in the head of the tower. In the energy self-sufficient operating mode, SHM.Tower can register tower vibrations as early as during setup and without external power supply. In the operating phase, data are collected even during power failures. The system continuously measures and stores any fatigue loads.
Using its integrated acceleration sensors, the SHM.Tower monitoring system constantly registers the vibration status of the wind turbine. Since the system is installed in the head of the tower, the maximum amplitudes of the tower vibrations can be measured in either horizontal direction and, if necessary, vertically as well.

Alarms and warnings

The integrated processor directly evaluates the measured raw data, which can then be directly compared with the threshold values defined in ISO 10816-21 and VDI 3834. Any upward violation of the threshold values cannot only be documented but also be transmitted to your monitoring system through an Internet connection at any time as alarm or warning output.

Optimized wind turbine operating control system

The operating mode of the wind turbine can be analyzed at any time in combination with simultaneously measured operating data, such as wind speed, rotorspeed, power, pitch angle or azimuth angle. Acceleration data are output as averaged RMS values, allowing a precise analysis of the vibration load and operating mode as daily, monthly and annual variations. Special events, such as strong wind and its impact, can be identified and analyzed as time curves or frequency spectra.

Expandable sensor system

Optionally a 3-channel interface (4 ... 20 mA) allows the connection of external sensors, such as acceleration sensors, range sensors or strain gauges. These external sensors can be positioned in the wind turbine as desired, for example to monitor strains or relative shifts between the base and the foundation of the tower.
The integrated efficient processor evaluates measured data and monitors threshold values and, in addition, runs comprehensive calculation algorithms. These algorithms calculate the fatigue loads in each tower segment based on the vibration acceleration measured in the tower head. Due to the integrated algorithms, the consumed lifetime of the turbine can be shown at any time for each tower segment. The reserves for further operation can be optimally analyzed, especially before the design lifetime of 20 years is reached. The integrated lifetime evaluation algorithms use a structural model of the tower which is adjusted to your wind turbine in advance. The geometric data of the wind turbine and the material parameters are used to create a customized tower model. This ensures exact calculation results.

Installation before setup or retrofitting

If SHM.Tower is installed when the wind turbine is set up, the operating condition and the consumed lifetime are monitored during all life cycles of the turbine. Any extreme loads can be taken into account precisely. Particularly single events, such as strong wind, which significantly influence the remaining lifetime of the tower, are therefore included in the lifetime evaluation. This allows optimum utilization of the structure.

If retrofitted, SHM.Tower provides lifetime evaluations that are substantially better than the usual methods used for assessing lifetime extensions, although no vibrations were measured during the first years of operation. Extrapolations by means of the already measured loads allow evaluating the complete operating time of the wind turbine.

Individual lifetime evaluation in the wind farm

An individual lifetime evaluation of each wind turbine in a wind farm can be made when SHM.Tower is installed. If reserves are sufficient, operation of individual wind turbines can be continued beyond the end of their design lifetime. Since these reserves are documented and thus verifiable when a wind turbine is sold, this provides considerable financial added value.
Monitoring Intelligence Center

**MIC.Wind**

SHM.Tower has been developed for fully automatic and autonomous operation on wind turbines. With a direct interface to the turbine control system, the fatigue loads can be classified with respect to the operating data. In addition, our systems can be connected to our web-based monitoring portal MIC.Wind. This portal provides detailed information about the vibrations and the remaining lifetime of the tower. Today, such remote monitoring of essential components is standard for profitable operation. On request, all relevant data are transmitted and stored through the Internet.

All important indicators are available in graphical form on the web interface of Wölfel’s monitoring center MIC.Wind. Event-controlled messages and an automatic reporting feature ensure that any current information is available at any time. If the customer does not want a data interface for safety reasons or if a data interface is not available on site, all monitoring and data storage functions can be transferred to a central wind farm server.
SHM.Tower specifications

**General**

Dimensions approx. 180 x 150 x 90 (mm)
Weight approx. 2 kg
Temperature range -40°C to +55°C
Lightning protection Suitable for LPZ 1

**Measurement parameters**

Measuring value Acceleration
Direction 2D (3D possible)
Measuring range ± 2 g
Frequency range 0,1 … 10 Hz
Noise ≤ 50 μg/Hz
External sensor 3x (4 … 20 mA), only with external power supply

**Interfaces – hardware**

Power 110 … 230 VAC
Ethernet [PoE] Suitable for Power over Ethernet
LED indicators Low battery charge; external energy supply; storage overflow; status
Digital out Alarm output (if necessary)

**Interfaces – software**

Modbus TCP, OPC UA Transfer of operating data from the turbine control system (e.g., wind speed, azimuth angle)
FTP Data transfer
MIC.Wind Results and configuration
Local web server Configuration and data transfer

**Energy supply and data storage**

Energy-self-sufficient operation ≥ 2 months
Battery Lithium battery, low self-discharge for up to 10 years of use
(no storage battery)
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 …