CONCLUSIONS ON THE REDUCTION OF TOWER VIBRATIONS

ESM IMPACT DAMPER

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INTRODUCTION

Wind turbines are vibration-sensitive structures that can react to harmonic excitation from wind and water with large vibration amplitudes. The vibrations under resonance excitation can become so large that the loss of breaking strength and/or fatigue damage can be the result. If a classic tuned mass damper is installed, it can reduce the vibration response of the wind turbine under harmonic excitation to an acceptable level. The maximum deflections of the wind turbine due to non-harmonic extreme events are not reduced by a tuned mass damper. However, each stochastic deflection is followed by a harmonic oscillation of the wind turbine, which calms down faster if a tuned mass damper is used. A classic, viscously damped tuned mass damper reduces the operating loads and prevents excessive movement under resonance excitation.

As the tuned mass damper reacts to any vibration of the wind turbine, fatigue damage or wear in the damper accumulates quickly. Maintenance-free tuned mass dampers with a service life of 25 years are possible but may result in higher costs.

In general, tuned mass damper-systems react sensitively to frequency fluctuations on the turbine and tuned mass damper-side. The frequency fluctuations on the turbine-side can be large, as the foundation stiffness depends on the location. Also, the modal masses cannot be determined precisely or are different in different directions of turbine-movement. As a result, the tuned mass damper frequency usually has to be adapted to the turbine frequency measured on site or a larger tuned mass damper mass has to be provided in order to be able to compensate frequency deviations.

The above points have prompted ESM to develop a cost-optimized damping system that differs from a classic tuned mass damper in its operating mechanisms. In the following, this system is called impact damper.

OPERATING PRINCIPAL IMPACT DAMPER

ESM IMPACT DAMPER DESCRIPTION

As shown in Figure 1 and Figure 2, the ESM impact damper with its non-moving frame is bolted to the existing tower flange. The impact damper mass stands on friction pads that can slide inside the frame in the horizontal tower plane. If the impact damper mass impacts against the frame, elastomer stop elements, mounted on the frame and mass sides, absorb the impact and transfer forces into the tower that counteract the movement of the tower. Due to the rotationally symmetrical design, the absorber acts 360° in the horizontal tower plane.

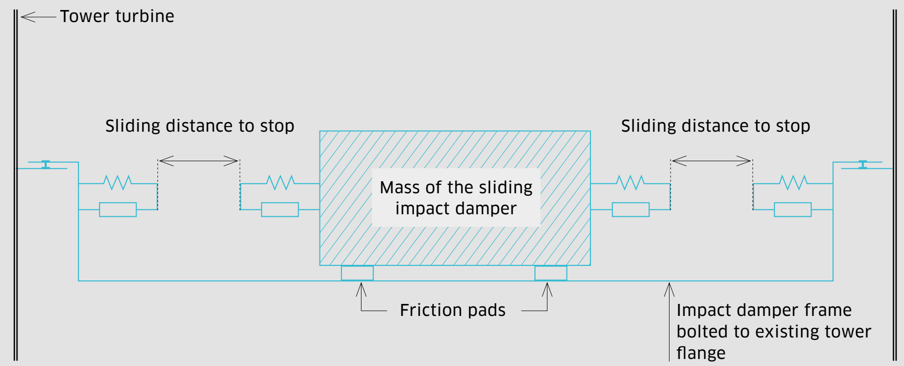

Figure 1: Substitute model impact damper

Friction is used to define a minimum system acceleration above which the damper mass starts to move. Typically, the friction value is defined in such a way that the impact damper mass only starts to move at higher vibration amplitudes of the wind turbine. Under this adjustment, the impact damper does not suffer any damage from normal operation of the wind turbine. However, larger vibration amplitudes are effectively damped.

As a result, the many small operating system movements do not lead to any wear on the damper side. In consultation with the end customer, a compromise can be found between performance at a low excitation level damper wear, and damper costs.

The innovative damping system has no natural frequency in the classic sense. This means that frequency adjustment on site is not necessary.

ESM IMPACT DAMPER CALMING PRINCIPLES

OPERATING EFFECT 1:
COUNTERFORCE

The impact damper mass can slide freely until it strikes on the frame side and emits a force impact counteracting the tower movement.

OPERATING EFFECT 2:
ENERGY DISSIPATION

Frictional energy is dissipated by the friction pads on the tower side of the ESM impact damper mass on its way to the frame-side stop. The frame-side and mass-side stop elements are made of elastomer. These also dissipate energy in the event of impact. This dissipated energy is removed from the initial oscillation of the tower, resulting in a smaller system oscillation.

OPERATING EFFECT 3:
CHANGE IN VIBRATION BEHAVIOR

At a low excitation level, the ESM impact damper mass is connected to the wind turbine. If the vibration amplitudes increase under resonance excitation, the impact damper mass starts to move. The change in the oscillation behavior of the turbine with the ESM impact damper leads to a reduction in the vibration level.

Figure 2: Installation of ESM impact damper in wind turbine

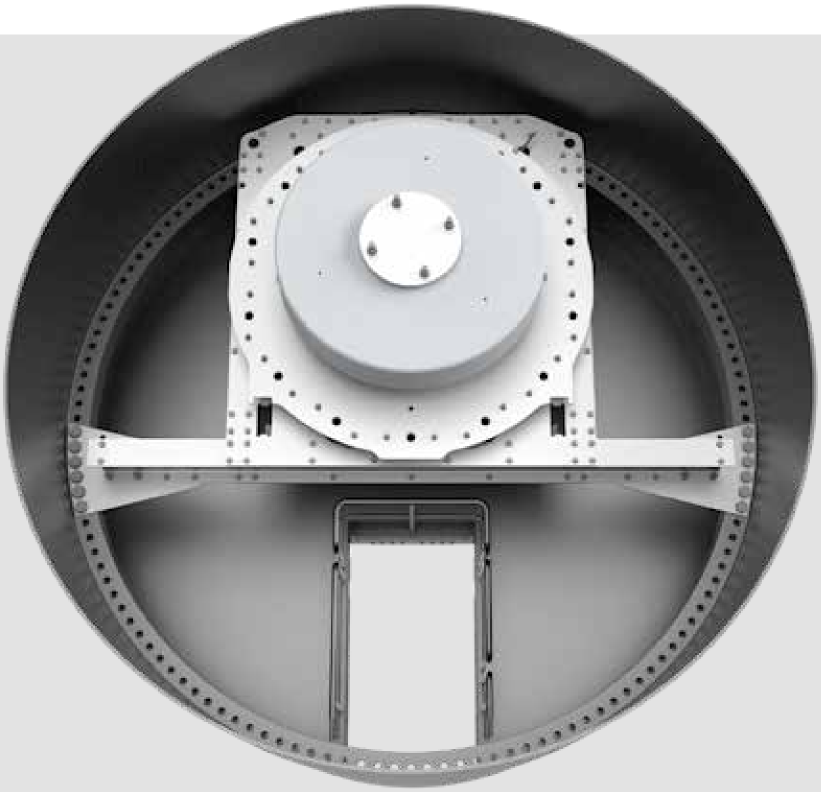

Figure 3: Fastening impact damper to existing flange bolted connection.

ADVANTAGES OF THE ESM IMPACT DAMPER

- Cost-optimized damping system, as impact damper contains no parts that need to be replaced over the service life.
- Cost-optimized system, as the service effort is limited to a visual inspection.
- Cost-optimized damping system by dispensing with mechanically machined parts. Use of concrete as a moving mass and simple friction and elastomer damping.
- Cost-optimized system, as no additional tower installations are required.
- Cost-optimized damping system due to simple installation of impact damper in the horizontal tower section on the installation site.
- Use of tower flange for impact damper fastening. Impact damper maintenance is possible via the existing flange platform. This means that no additional attachments are required.
- Impact damper makes less movement under resonance excitation than comparable tuned mass damper. This can be advantageous in confined spaces.
- The overall height of the impact damper is greatly reduced compared to classic tuned mass dampers.
- No frequency adjustment required from the impact damper on site.
- No power supply is required.
- Due to its design, the impact damper mass is “locked” in the frame and can therefore not strike the tower wall under extreme events such as (shutdown processes, earthquakes, etc.).
- Design, construction, drawing creation and strength calculation are largely automated, so that the impact damper concept can be quickly adapted to new specification requirements.
- A well-proven system (greater than 1000 impact dampers in field) that has been distributed by ESM for over 5 years.

Figure 4: Installation impact damper in horizontal tower section at installation site

LIMITATIONS OF THE ESM IMPACT DAMPER

- The current impact damper is designed for higher acceleration levels/frequencies higher than 0.5Hz. If performance is required at a low acceleration level, a “low-friction-unit” can be added to the current concept shown. This allows the impact damper mass to start sliding at any acceleration level.
- Typically, the coefficient of friction is set so that the impact damper mass does not slide in normal operation. As a result, the impact damper has low performance at a low excitation level.

SUMMARY

The ESM impact damper is a cost-optimized damping system that impresses with its low manufacturing, maintenance and installation costs.

Simple design and thousands of field applications reduce the probability of failure to a minimum. Depending on the customer’s specification requirements, the use of impact damper or classic tuned mass damper may make sense for the customer. ESM will be pleased to advise you in detail.

Figure 5: Impact damper in upright transport position

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