Description of rotor imbalance measurement at wind energy turbines performed by cp.max Rotortechnik

1 Basic measurement conditions

Wind conditions:

- constant wind speed (not gusty)
  - ° minimum 5 – 6 m/s during measurement without generator load
  - ° minimum 8,5 – 12 m/s during measurement with generator load (depends on the type of turbine)

Measurement duration:

- Depending on the type of turbine the count of rotor rotation should be chosen between 400 to 600. Thereby an evaluation as well as a measurement duration comes up which depends on the rotational speed and takes 15 to 60 minutes.

The setting of the turbine parameters for a constant rotational speed is done by a technician on-site or remote control as an alternative.

2 Vibration analysis procedure

2.1 Analysis of the rotor balancing condition

In principle the rotor balance measurement is done under guideline VDI 3834. In this case especially under attachment B.

A vibration measurement is done to evaluate the turbine and their fatigue behavior regarding rotor imbalances. For that, measurements are implemented in the nacelle by acceleration sensor, rotation sensor and measurement device. These devices measure the rotational speed and the vibration acceleration during a period of time. Tower-nacelle vibration, axial and radial to the rotation axis, is measured.

The acceleration sensor, in this case a capacitive acceleration sensor, is fixed at the main bearing or another adequate position inside the nacelle. It measures the rising axial and radial vibrations. As per VDI 3834 it should be fixed on a position which significantly reflects the effect of dynamic forces and describes the whole vibration condition of turbine and nacelle. The rotation and phase reference transducer is fixed on the slow-rotating shaft and the main shaft covering and measure the rotor rotation and phase of imbalance there. It takes normally 400 to 600 rotor rotations per measurement

and is started at least when the turbine has reached a firm adjusted rotation speed. The rated rotor speed is used most of the time to show operation with the highest rotor rotation speed. Measurements are usually made without generator load at a constant adjusted rotation speed to ensure reproducibility of them. Measurements made during the regular turbine operation are not intended due to rotation speed variations.

An order analysis is deduced from these vibration measurements. The order analysis shows the 1p-vibrations, which are relevant for the imbalance evaluation. 1p-vibrations in axial and radial direction in relation to the rotor axis are measured. Furthermore the phase angles of the rotor imbalances were measured as well. Afterwards the original vector is deduced from the 1p-magnitudes and the phase angles and is used for further calculation.

To reduce an imbalance it is decisive to eliminate the aerodynamic imbalance first and the mass imbalance afterwards. The reason for that is the influence of the radial vibration when it comes to an aerodynamic imbalance.

The procedures overview is attached to this document.

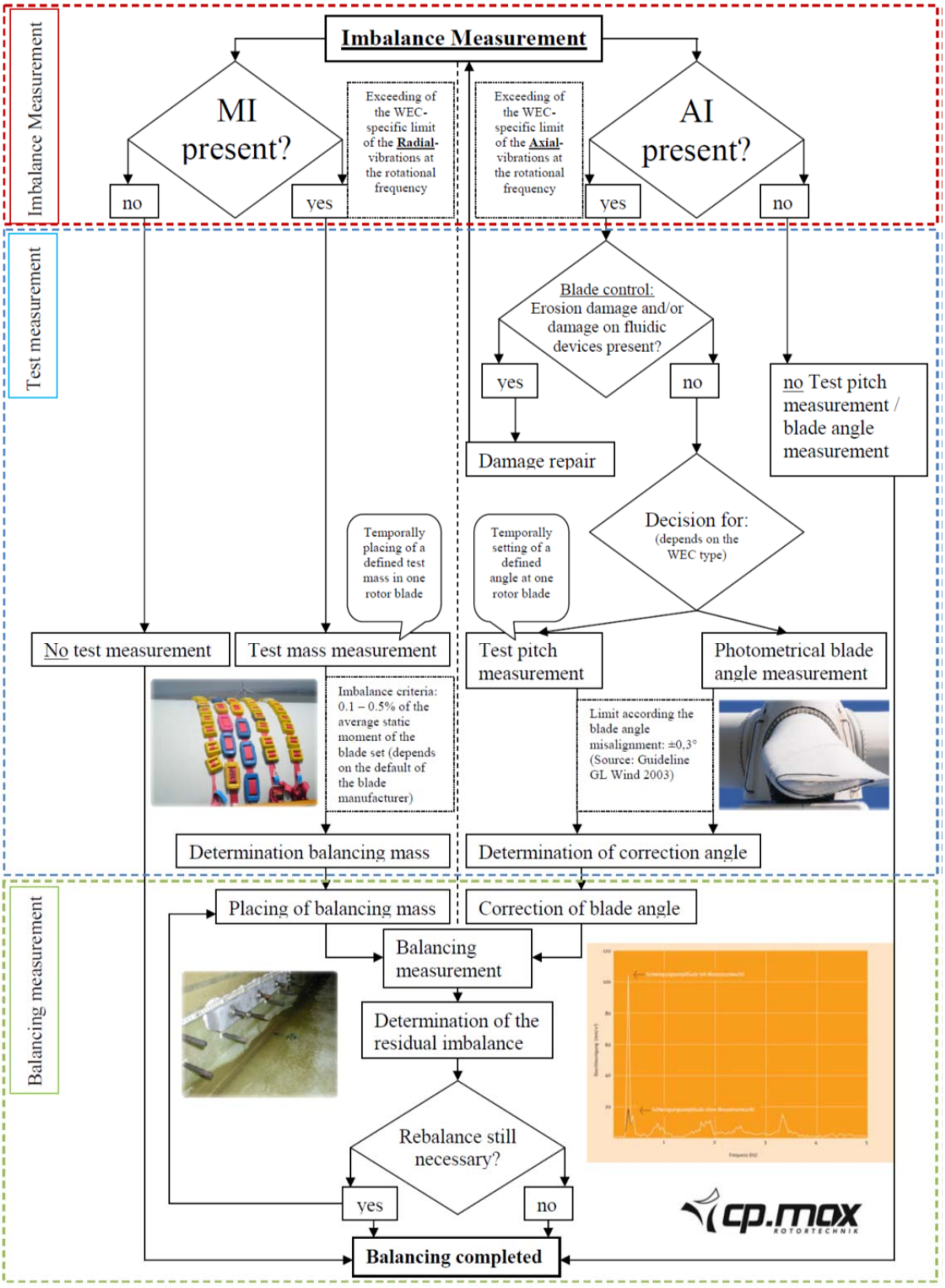
2.2 Detection of an aerodynamic imbalance

Reason for the aerodynamic imbalance is mostly, as described above, a non-synchronized blade pitch angle setting which leads to a performance decrease and vibration of the turbine. If the magnitudes value in axial direction is above the acceptable limit, a blade angle measurement or test-pitch-measurement is recommended/ implemented to assign influence of the aerodynamic imbalance.

If the appropriate twist angle is known it is possible to assign the total blade angle by a photometric blade angle measurement and afterwards verify the deviation of all blades to each other. In addition it enables the definition of the difference of the adjusted blade angle at a defined radius to the nominal angle which is deduced from geometric data of the blade type. Only by adjusting the accurate blade angle an optimal operation is possible. Another opportunity to lower axial magnitudes and to avoid the blade angle measurement is to do a test-pitch-measurement. This is a method to reduce vibrations by a test run with changed blade angles.

2.3 Detection of a mass imbalance

To recognize whether a mass imbalance occurs it is necessary to implement a test run with defined mass imbalance. For that it is needful to bring in a test mass with a defined mass into one of the rotor blades. This test mass is installed on a known radius (distance from the hub center) and thus, in most cases, tucked between trailing edge and spar web. The test mass position depends on the rotor blade construction. Afterwards the vibration measurement is done again, but with the test mass at this time. From the initial and the test run, definition of the original imbalance by using analytical software can be done. The mass imbalance is acceptable when the difference of the mean static moment of one blade set is from 0,1 % to 0,5 %. This difference depends on the blade manufacturer. The calculation of a turbine-specific limit for the 1p-magnitude is then possible by doing the test measurement. If the limit exceeds - the rotor needs to be balanced.


Imbalance Measurement
Imbalance Measurement
MI present?
no
yes
Exceeding of the WEC-specific limit of the Radial-vibrations at the rotational frequency
Exceeding of the WEC-specific limit of the Axial-vibrations at the rotational frequency
AI present?
yes
no
Test measurement
Blade control: Erosion damage and/or damage on fluidic devices present?
yes
no
Damage repair
no Test pitch measurement / blade angle measurement
Decision for: (depends on the WEC type)
Temporally placing of a defined test mass in one rotor blade
Temporally setting of a defined angle at one rotor blade
No test measurement
Test mass measurement
Test pitch measurement
Photometrical blade angle measurement
Imbalance criteria: 0.1 – 0.5% of the average static moment of the blade set (depends on the default of the blade manufacturer)
Limit according the blade angle misalignment: ±0,3° (Source: Guideline GL Wind 2003)
Determination balancing mass
Determination of correction angle
Balancing measurement
Placing of balancing mass
Correction of blade angle
Balancing measurement
Determination of the residual imbalance
Rebalance still necessary?
yes
no
Balancing completed