

Fan-wheel strength

Definition – testing – calculation

1. Introduction – general information

Fan wheels are technical products. Their ability to function and their suitability for certain applications depend on the guaranteed qualities and the types and conditions of use customers and other users expose them to.

Load conditions and resulting stresses on wheel bodies must be known before it is possible to specify fan wheel strengths. Complex conditions of use in practice, however, make the procurement of such information difficult. Application-specific designs and wheel recommendations – if no other special agreement has been concluded with customers – are therefore frequently founded on assumptions made on the basis of available statistics for the relevant application. Safety margins – particularly in regard to wheel strengths – based on statistics are usually incorporated into specifications to take account of effects that cannot be determined or specified.

Such safety margins are usually calculated for standard wheels designed for a variety of uses as depicted in the catalogue. Remaining risks may only be eliminated if customers test the wheels in real conditions. We expressly draw attention to the necessity of such tests to verify our recommendations.

2. Definition of sufficient strength

Fan wheels will be properly dimensioned if they fulfil the requirements outlined in Point 3 with sufficient probability during their intended life spans under the conditions we were made aware of and in the test conditions set out below.

3. Forces and loads

The forces and loads wheel bodies are exposed to may be divided according to the following causes:

3.1 During transport and installation

- Vibrations and shocks during transport
- Forces applied during installation, e.g. sliding on, pressing on, driving onto the shaft, etc.

3.2 During use through

- Centrifugal and pressure forces
- Switching on/off and acceleration/deceleration during the starting and slowing down procedures
- Plant vibrations and shocks
- Dynamic vibrations
- Temperature
- Medium handled
- Corrosion and wear during use and during stoppages etc.
- Remaining unbalance:
Initial wheel unbalance and its possible multiplication during installation (fitting unbalance) and during operation, e.g. distortion through the settling of material and temperature fluctuations, deposits of foreign bodies, wear, etc. As the residual unbalance may under certain circumstances change in operation, a regular examination is necessary and if need be the rebalancing of the wheel.
- Torsional oscillations during operation caused by drives or resonances
- Superpositioning of natural frequencies of other plant components

In principle, the above forces possess weakly stationary and dynamic characters and are therefore very difficult to determine or calculate in advance with any precision. A significant indication of the presence of such additional forces and loads is an increase of vibration. It is important to take measures to keep these forces and loads as low as possible.

4. Testing methods and strength studies

The strength of Punker's standard fan wheels is tested during centrifugal tests in combination with acceleration tests. Here, the fan wheels are fitted to shafts and run at constant speeds (which exposes them to centrifugal forces). The resulting speed-dependent deformations are then measured. Depending on their size, wheels may also be exposed to alternating acceleration and deceleration forces on a special machine for a specific amount of time.

The test results are then used to determine the so-called critical speed $n_{0.5}$ at which the wheel is deformed at some point by a maximum of 0.5 mm. This figure depends on wheel size and geometry. The maximum permissible speed indicated in the catalogue is based on this critical factor and a safety margin.

At this point, attention is expressly drawn to the fact that the maximum permissible fan-wheel speeds set out in the catalogue are for general applications regarded as „normal“ in the statistical sense. Uncertainties and unknown additional loads have been considered with the inclusion of a safety margin for such uses.

In applications with extreme loads, e.g. in rail vehicles, the information provided in the catalogue must be examined with a critical eye. This also applies to applications requiring the fulfilment of special standards and guidelines, e.g. explosionproof fans in accordance with CEN TC 305 or VDMA 24169 or fire-safety fans in accordance with EN 12101-3. Special studies must be carried out before safe statements may be made in regard to such applications. Punker would be glad to carry out such tests required by customers or have them carried out on the basis of a separate agreement and clarification of costs.

The above process may also be accompanied by numeric simulations/calculations using the finite element method (FEM), which provide insights into the deformation and tension fields of wheels under the assumed conditions of use.

For further general information see Sheet 0.0.0.01 – General Technical Information.