Field balancing

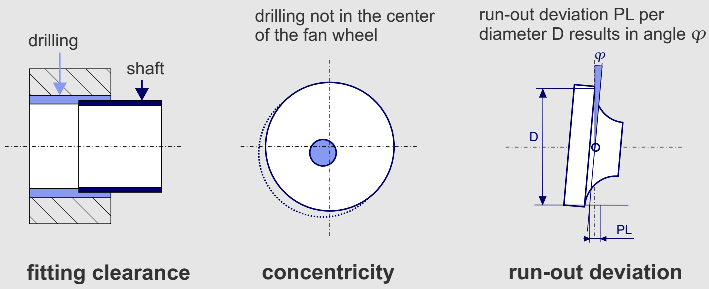
Fans, blowers, exhaust systems...

case study

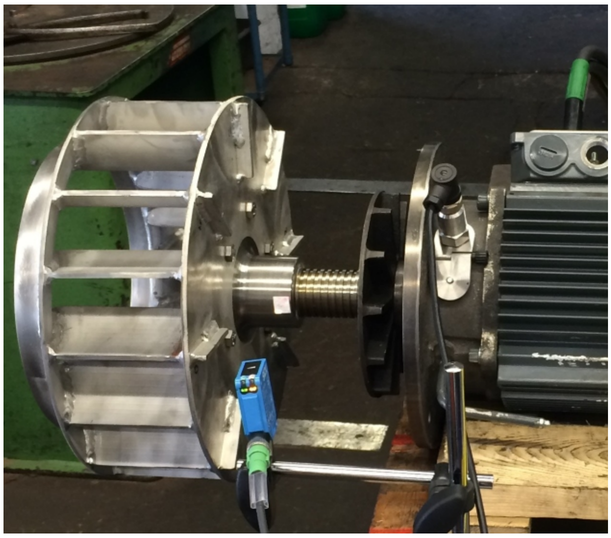
Every wheel needs a drive! In order for it to do justice to its intended purpose, in addition to the power adjustment of the drive, the storage and the running behavior are decisive for a durable and trouble-free use, often under rough conditions in the industrial environment.

Electric motors convert the electrical energy supplied into a rotary movement, which is transmitted to the impeller by direct mounting on the motor shaft or by means of a belt drive on the fan shaft. Masses that rotate and whose center of gravity is not on the axis of rotation generate centrifugal forces that rotate with the rotation frequency. As a result of unbalanced centrifugal forces, oscillating forces or oscillating movements occur, which are transmitted to the bearings and by definition (DIN ISO 1925) we are dealing with an imbalance.

In practice, additional, unavoidable errors occur during assembly due to fitting play. In addition, there are errors due to radial run-out and axial run-out deviations.



The individual imbalances of the impeller and drive motor resulting from the aforementioned influences add up vectorially to form a total imbalance during operation.



Pic. 1) Centrifugal fan mounted on the motor shaft.

For balancing, the vibrations on the bearing housing are measured with an accelerometer. The speed and angular position is detected by a light sensor with the help of a reflective mark on the impeller.

The balancing of all components in the operating condition offers the advantage that all influences from the fit clearance and residual imbalance of the individual components (motor, fan) are compensated. If you only rely on the permissible imbalance of the individual components, in the worst case these can add up after assembly so that the permissible total imbalance is exceeded.

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How can I determine what residual imbalance is permissible for my fans and whether this is also maintained after the assembly of all individual components?

The international standard DIN ISO 1940 gives recommendations for permissible residual unbalance of rigid rotors and defines so-called balance quality levels for different rotor types. The quality level directly indicates the value of the maximum permissible vibration speed in mm/s related to the weight of the rotor at a given speed. According to the following relationship:

$$G = e \cdot \omega = \frac{U}{m} \cdot \omega = \frac{u \cdot r}{m} \cdot \omega = \textit{balance quality grade} \left[\frac{mm}{s}\right]$$

u = Unwuchtmasse [g], [kg]
r = Radius zur Unwucht
$U = u \cdot r$ = Unwucht [g·mm]
m = Masse des Rotors [g], [kg]
e = Exzentrizität der Masse [mm], [μm]

$\omega = 2 \cdot \pi \cdot f = \frac{\pi \cdot n}{30}$ = Kreisfrequenz $\left[\frac{1}{s}\right]$

f = Drehfrequenz $\left[\frac{1}{s}\right]$

n = Drehzahl $\left[\frac{1}{min}\right]$

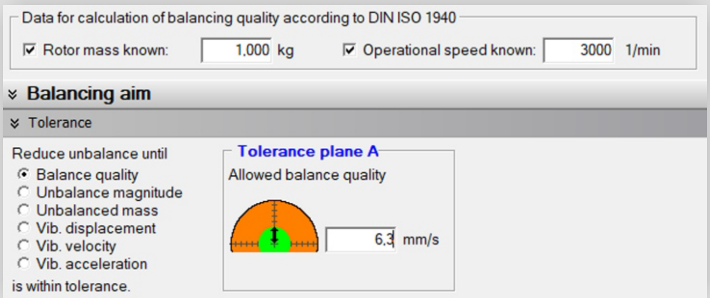
Fans, ventilators or blowers are usually classified as balancing grade 6.3.

How large is the permissible residual imbalance e_{zul} perm based on quality level 6.3 at an operating speed of 3000 rpm?

Solution: $e_{zul} = \frac{G}{\omega} = \frac{6{,}3}{314} = 0{,}020 \mu m$

or 20 gmm/kg.

This specification corresponds to the weight of a balancing mass with a rotor of 30kg (30.20gmm = 600gmm) on a balancing radius of 200mm (600gmm / 200mm) of 3g in order to theoretically completely cancel out the circulating centrifugal forces.



For quick and efficient work, the InnoBalancer ® Pro from the Vibromatrix® vibration measurement system offers you the option of specifying the permissible balancing quality. In this way, it is automatically checked during each control run whether the balancing quality has been maintained.

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Pic. 2) With the VibroMatrix® system, you not only measure machine vibrations on site, you improve running smoothness on site through dynamic balancing in 1 and 2 planes.

Can the specified balancing quality be achieved at all due to the given fit tolerances, axial and radial run-out deviations?

Let's assume the fan wheel was balanced by a contract balancer to a balancing quality of 6.3. At an operating speed of 3000 rpm, this corresponds to a permissible residual imbalance of 20 gmm/kg. The fan wheel has a weight of 15kg. The permissible residual imbalance is then 15 x 20gmm = 300gmm.

1.) Unbalance U_s from fitting clearance

A fit tolerance of H7/h6 (see ISO 286) for a nominal diameter of the electric motor shaft of 25 mm is specified for the assembly of the fan wheel. This results in a maximum play of 34 µm. The eccentricity es as a result of the game is 17 µm

$U_s = e_s$ m = 17 x 15 = 255 gmm

2.) Unbalance U_r from run-out deviation

The permissible concentricity deviation of 15 µm results in an eccentricity es of 7.5 µm and thus a maximum imbalance as a result of the displacement of the eccentricity:

$U_r = e_r$ m = 7,5 x 15 = 112,5 gmm

The individual imbalances from the clearance and the concentricity deviation add up vectorially, that is, in the worst case, the sum of the amounts. Then there is a maximum imbalance for the rotor at this point only due to the assembly, without further imbalances, e.g. due to axial run-out deviation of:

$U_p = e_p$ m =367,5gmm div 15kg = 24,5 µm or gmm/kg

The permissible center of gravity eccentricity of 20 µm is already exceeded by the fit-related imbalances. In order to comply with the required balancing quality of 6.3, the fan must be balanced in the operating state or the fit tolerance must be redefined.