

Basic knowledge
Fans

Fundamental principles of fans

Fans are turbomachines that are used to convey gaseous fluids such as air. A characteristic of fans is the pressure ratio Π , which indicates the ratio of the absolute final pressure to the absolute intake pressure. Fans are different from compressors because of their low pressure ratio of max. 2,5. At very low pressures up to about 1,1 they are also known as ventilators.

In a fan the energy is transferred to the fluid via aerodynamic flow forces. In this process the fluid is accelerated by the fan's rotor. Therefore, the rotor of the fan has to move with high velocity and

thus a high rotational speed. In this case, it can be said that the higher the pressure ratio, the higher the peripheral speed and rotational speed. The peripheral speed ranges from 15m/s in small domestic ventilators to more than 600m/s and speeds of more than 150,000 min⁻¹ in turbochargers. While the fluid at low pressures and velocities can still be regarded as incompressible, at higher pressures it must be considered compressible.

Characteristics of fans

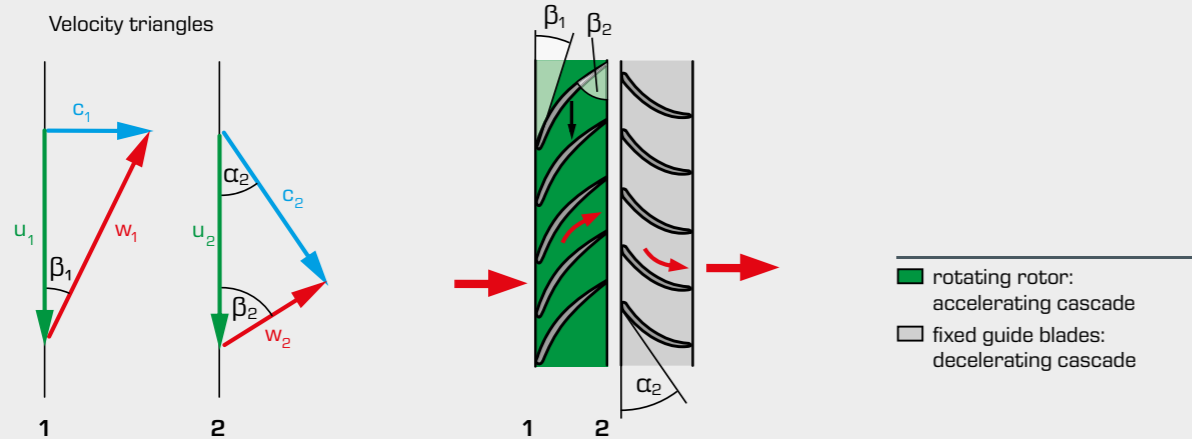
A fan is characterised by the specific speed σ . It is formed from the speed n , volumetric flow rate Q and specific hydraulic energy Y .

The ideal efficiency of a fan is achieved at a specific speed of $\sigma = 0,3-0,6$.

The specific hydraulic energy Y is the difference of the working capability of the fluid between the inlet and outlet of the turbomachine. It is calculated from the product of the head H and the gravitational acceleration g .

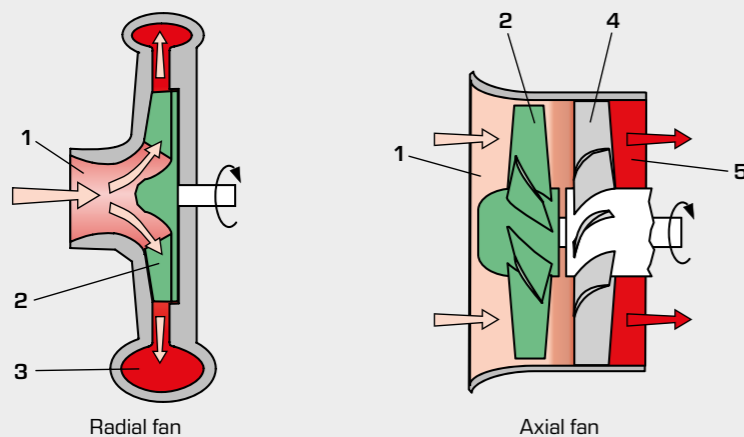
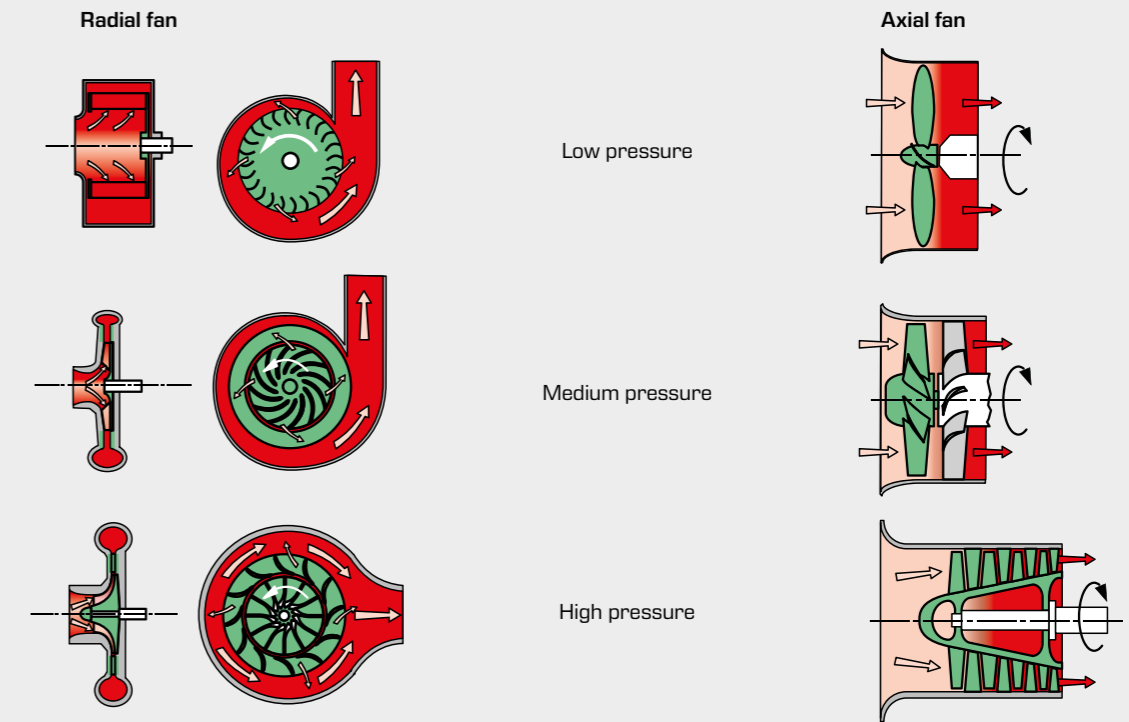
$$\sigma = n \cdot \frac{2 \cdot \sqrt{\Pi} \cdot \sqrt{Q}}{(2 \cdot Y)^{3/4}}$$

Velocities on the cascade using the example of an axial fan



c absolute velocity of the fluid, w relative velocity of the fluid, u peripheral speed of the rotor; 1 rotor inlet, 2 rotor outlet

Fan rotor shapes



1 inlet, 2 rotor, 3 spiral housing, 4 guide blades, 5 outlet

Types

As with other turbomachines, a distinction is made between radial and axial fans depending on the direction of flow.

Operating behaviour

The diagram shows the characteristic field of a high-pressure fan. The pressure ratio p_2 / p_1 is plotted against the mass flow rate for different speeds n_1 to n_8 in red. Green lines show the same efficiency η_1 to η_3 .

The operating range is restricted at low mass flows via the surge line (grey region). At small mass flows, the flow in the rotor becomes unstable, resulting in flow separation and partial return flows. In axial compressors in particular, this area should be avoided since the blades are placed under high stress.

