Impellers made by ebm-papst

Like pumps and compressors, fans and blowers belong to the category of aerodynamic and fluid work machines. A fan consists of an impeller, a drive motor and a housing for suspension and for guiding the air flow. The blades spaced along the circumference of the impeller are designed in such a way as to cause the flowing work medium to change direction, thus passing on pressure and speed energy.

ebm-papst construction designs

Depending on the geometrical shape of the impeller, there are different construction designs, with their names taken from the main flow direction in the impeller.

The most important designs are:
- Axial fans
- Centrifugal fans with backward curved blades
- Single or dual inlet centrifugal blowers with forward curved blades
- Diagonal (mixed flow) fans (a cross between axial and centrifugal fans)

Application-specific selection parameters

When selecting an application-specific fan or blower, the main parameters to be taken into account are these:
- Air flow at given back pressure
- Construcational design
- Speed/rpm
- Impeller diameter
- Ambient conditions governing suction and exhaust side

Relevant fields of application of the various construction designs

The different ebm-papst fan and blower designs correspond to the different fields of application:
- Small back pressures: axial fans
- High back pressures: centrifugal fans with backward curved blades and single or dual inlet centrifugal blowers
- Threshold between axial and centrifugal fans: diagonal fans

Characteristic curves of the various designs
**Operating range**

To the right of the "saddle" (right part of the air performance curve):
- Maximum efficiency
- Minimal noise
To the left of the "saddle" (left part of the air performance curve):
- Stall area
- Drop in efficiency
- Soaring noise
The optimum operating range of the fan is shaded in green in the curve given here.

**Direction of air flow**

The direction of air flow is given as follows:

- **Direction of air flow "V"**
- **Direction of air flow "A"**
Effects when mounted in wall ring or in the aperture
Mounting the fan in a wall ring can significantly increase the air performance in the operating range.

Effects with axial position in the wall ring
Axial position in the wall ring influences air performance and efficiency.
Effects with guard grilles
Mounting a guard grille reduces the air performance of the axial fan.

- Without guard grille
- With guard grille

The pressure drop in Pa can be roughly calculated according to the following equation:

\[ \Delta P_{\text{gr}} = \epsilon_{\text{gr}} \cdot 10^{-4} \cdot \dot{V} \quad \dot{V} \text{ in [m}^3/\text{h]} \]

For the guard grilles used at ebm-papst, the correction factor \( \epsilon_{\text{gr}} \) can be used depending on the impeller diameter \( D \) from the table to the right.

<table>
<thead>
<tr>
<th>Diameter D</th>
<th>Correction factor ( \epsilon_{\text{gr}} )</th>
</tr>
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<tbody>
<tr>
<td>130</td>
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<tr>
<td>143</td>
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<td>800</td>
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</tr>
<tr>
<td>910</td>
<td>1.5</td>
</tr>
<tr>
<td>980</td>
<td>0.9</td>
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</tbody>
</table>
Effects of obstructions on the suction or exhaust side
Disturbances or obstructions on the suction or pressure side reduce the air performance of the axial fan.

Obstructions on the inlet side
- $x / D = \infty$
- $x / D = 35 \%$
- $x / D = 18 \%$
- $x / D = 9 \%$
- $x / D = 5 \%$

Obstructions on the exhaust side
- $x / D = \infty$
- $x / D = 35 \%$
- $x / D = 18 \%$
- $x / D = 9 \%$
- $x / D = 5 \%$
### Operating range
Middle part of air performance curve:
- Maximum efficiency
- Minimal noise
To the right and the left of the middle part of the air performance curve:
- Reduced efficiency
- Increasing noise
The optimum operating range of the fan is shaded in green in the curve given here.

### Effects of nozzle gap dimension
The centrifugal air gap between the inlet nozzle and impeller cover plate influences the air performance and efficiency of the centrifugal fan.

1. \( s / D = 0.4\% \)
2. \( s / D = 1.0\% \)
3. \( s / D = 1.4\% \)
Effects of overlapping dimension
The axial overlap between the inlet nozzle and impeller cover plate influences the air performance and efficiency of a centrifugal fan.

Curve

1. \( x / D = 0.6\% \)
2. \( x / D = 0\% \)
3. \( x / D = -0.8\% \)

Effects of installation space
When mounting our product in a rectangular box, air performance might be reduced.

Curve

\( d_h = \) Hydraulic diameter

Formula: \( d_h = 2 \times B \times H / (B + H) \)

B = Width of box
H = Height of box
D = Outer diameter of the fan
Air flow measurement for inlet nozzles with pressure-measuring point

The differential pressure approach compares the static pressure before the inlet nozzle with the static pressure inside the inlet nozzle.

![Diagram of air flow measurement](image)

Air flow can be calculated on the basis of the differential pressure (difference in pressure of the static pressures) in keeping with the following equation:

\[ \dot{V} = k \cdot \sqrt{\Delta p_w} \]

\( \dot{V} \) in [m³/h] and \( \Delta p_w \) in [Pa]

If constant air flow control is used, then the nozzle pressure has to be kept constant:

\[ \Delta p_w = \dot{V}^2 \cdot k \]

\( k \) takes into account the specific nozzle characteristics.

One or four pressure measuring points are spaced along the circumference of the inlet nozzle. Connection on the customer side is accomplished via a pre-mounted T tube connector. This tube connector is suited for pneumatic hoses with an internal diameter of 4 mm.
The forward curved centrifugal impeller must always be operated inside a scroll housing.

A dual inlet centrifugal blower shows the same behaviour as two single inlet blowers operated in parallel: with size, speed and pressure being identical, double the air flow is achieved.

**Operating range**

Middle part of air performance curve:
- Maximum efficiency
- Minimal noise
- Higher performance density than with the backward curved centrifugal fan

To the right and the left of the middle part of the air performance curve:
- Reduced efficiency
- Increasing noise

The optimum operating range of the fan is shaded in green in the curve given here.

**Dimensioning of the scroll**

The dimensions of a typical scroll can be calculated with the following formulae, subject to the impeller diameter D:

- \( A = 1.002 \cdot D \)
- \( B = 0.992 \cdot D \)
- \( C = 0.922 \cdot D \)
- \( D = 0.853 \cdot D \)
- \( E = 0.784 \cdot D \)
- \( F = 0.715 \cdot D \)
- \( G = 0.646 \cdot D \)
- \( H = 0.612 \cdot D \)
- \( J = 0.720 \cdot D \)
- \( K = 0.689 \cdot D \)
- \( R = 0.073 \cdot D \)

Adjusting the dimensions to diminished mounting spaces is possible.
Effects of step diffusers
A diffuser mounted on the exhaust side with connected exhaust tunnel increases air performance and efficiency of the centrifugal blower.

- without step diffuser
- with step diffuser

Effects of obstructions on the intake side
Obstructions on the air intake side reduce the air performance of the centrifugal blower.

- $x/D = \infty$
- $x/D = 30\%$
- $x/D = 23\%$
- $x/D = 15\%$
- $x/D = 7.5\%$
Effects caused by obstructions on the inlet side for constant air flow
EC centrifugal blowers

Constant air flow is attained with unimpaired inflow only. An obstructed (e.g. asymmetrical or partially blocked) air flow can have a significant effect on the curve behaviour and cause large deviations from a constant air flow curve.

Examples of obstructed inflows

Instructions for designing a sufficiently unobstructed inflow:
- The distance $x$ between the blower intake and neighbouring walls or obstructions should be at least 25% of the impeller diameter.
- Inflows with angular momentum or asymmetrical rotation should be avoided.
- The inflow can be made more uniform using resistances such as those from filters or grilles.

On request, we offer calibrated blower designs that incorporate a specific installation situation.
Operating range

- Maximum efficiency
- Minimal noise

To the left of the “saddle” (left part of the air performance curve):
- Stall area
- Drop in efficiency
- Soaring noise

The saddle of the diagonal / mixed flow fan is slightly higher than that of the axial fan. This means that the technical ratings in the optimal operating range are better than those of the axial fan.

The optimum operating range of the fan is shaded in green in the curve given here.

Mounting information

The conical housing (part of delivery) makes sure the necessary gap dimension is kept.

Effects

The effects of the diagonal / mixed flow fan are similar to those listed for the axial fan (p. 577-580).
Dimensioning / change in speed

Influence of speed \( n \)
A change in speed influences:
- Air flow \( \dot{V} \)
  \[ \dot{V} \sim n \]
- Static pressure increase \( \Delta p_u \)
  \[ \Delta p_u \sim n^2 \]
- Requirement of energy \( P_1 \)
  \[ P_1 \sim n^3 \]

Influence of the speed \( n \) on the sound level \( L_w \)
When the speed changes, the approximate sound level can be determined using the diagram to the right and the following formula:

\[ L_{w_1} - L_{w_2} = 50 \text{ dB} \cdot \log \left( \frac{n_2}{n_1} \right) \]

- \( L_{w_1} \) = Sound level after speed change
- \( L_{w_2} \) = Sound level before speed change
- \( n_1 \) = Changed speed
- \( n_2 \) = Starting speed
**Influence of impeller diameter D**

A change in impeller diameter influences:

- Air flow \( \dot{V} \)
  \[ \dot{V} \propto D^3 \]
- Static pressure increase \( \Delta p_{st} \)
  \[ \Delta p_{st} \propto D^4 \]
- Requirement of energy \( P_1 \)
  \[ P_1 \propto D^6 \]

**Influence of width of air discharge b (only for centrifugal impellers)**

A change in width of the air discharge influences, in approximation:

- Air flow \( \dot{V} \)
  \[ \dot{V} \propto b \]
- Static pressure increase \( \Delta p_{st} \)
  \[ \Delta p_{st} = \text{const} \]
- Requirement of energy \( P_1 \)
  \[ P_1 \propto b \]