Press News

Airflow performance and speed at a glance:

Fan curves and optimum operating points

Fans create a flow of air, which they can then force through equipment that needs cooling. The necessary output is determined from the flow rate and the required static pressure. If the airflow through the equipment is restricted to any great extent by built-in components or bends and junctions, then this will lead to a loss of pressure; the fan will try to compensate for this by an increase in the static pressure, though the fan will have to work harder than in free air operation. The characteristic curve of the fan gives precise information about the flow rate at specific static pressures.

The whole airflow operation for cooling is often seen as very complicated, but this in reality is not the case. With a fan the flow rate decreases as the loss of pressure ('resistance') in the equipment increases. The actual construction and nature of the appliance leads to differing characteristics for the pressure loss depending on the flow rate. This is termed the characteristic curve of the appliance. It describes the progression in the static pressure necessary to force through the equipment a particular airflow against the resistance created by components within the equipment. This is calculated according to technical parameters concerning the flow.

Characteristic curves, the fingerprint of the fan

Even with the "active" components of the fan, one works with a characteristic curve. In contrast to the purely technical flow parameters of the device curve, here the influence of the drive motor must be taken into consideration. This additional parameter has a greater influence on the shape of the curve. Because of the limitations placed on them because of their construction, all small fans have relatively small low-performance drive motors. This means that depending on the different loads placed on them their speed and power consumption alter dramatically. With axial fans for example the maximum speed is achieved at the greatest flow rate but at the same time with the lowest power consumption. As the static pressure rises, so the power requirement increases, the speed of the motor falls until the power available from the motor once again matches the power demand of the fan impeller. If one observes the interaction between the appliance and fan it becomes clear that both curves have an intersection point. This is the so-called optimum operating point of the fan (Fig 1). Here the technical flow requirements of the appliance correspond with the "delivery possibilities" of the chosen fan. In order to be able to quickly assess this physical detail for the fan in question, the fan specialist ebm-papst shows these characteristic curves in its catalogue, together with other relevant fan data.

Axial fans are designed to move large quantities of air with low counterpressure. If the loss of pressure in the appliance increases, then the airflow quickly falls off (Fig 2). The saddle point in the fan curve is typical for axial fans. If the airflow is further restricted the flow round the impeller blades breaks away at the hub. This leads to a drop in pressure and a substantial increase in the noise level, caused by turbulence.

Radial fans however, thanks to their design, are able to transfer more energy to the air molecules. With radial fans the airflow always exits the impeller at its outer circumference and thanks to the higher circumferential velocities can thus achieve a higher pressure level. The speed curve has a distinct lowest point, but this can be at higher or lower airflow values (Fig 3). The efficiency achieved is at around the same level as with an axial fan.

Diagonal fans combine the extremes of axial and radial fans. Depending on their layout these fans can demonstrate either more axial or more radial characteristics. Special versions can even achieve an almost constant motor speed over the whole operating range. There is no longer any saddle in the fan curve, which overall is flatter than that of a radial fan (Fig 4).

The different shapes of the various fan curves are typical for a particular type of fan. However even fans of the same type of construction can show peculiarities - either because of their design or the motor with which they are equipped.

Dimensionless numbers

If one goes a step further when looking at different fans, the question often arises as to whether there is a simple way of comparing the different designs. This is where so-called dimensionless numbers can be of assistance. If one calculates the functional dependence of the static pressure and flow rate with reference to the circumferential velocity u, the outside diameter of the impeller wheel D and the density of the air, this gives the dimensionless volume number j and the pressure number Y.   Using these it is possible to calculate quickly the performance of geometrically similar fans having different speeds and sizes. It is also possible to show clearly in a diagram a comparison between various types of fans (Fig 5) and look at the effects of designs incorporating differing types of construction, size or speed.

Fan curves are thus meaningful diagrams that provide the user with the necessary information concerning the performance of a fan under different operating conditions. For this reason leading fan manufacturers such as ebm-papst show these diagrams in their catalogues. Using dimensionless numbers, standard characteristic curves offer the user a simple and quick way to compare the performance of the various types of fan on offer.

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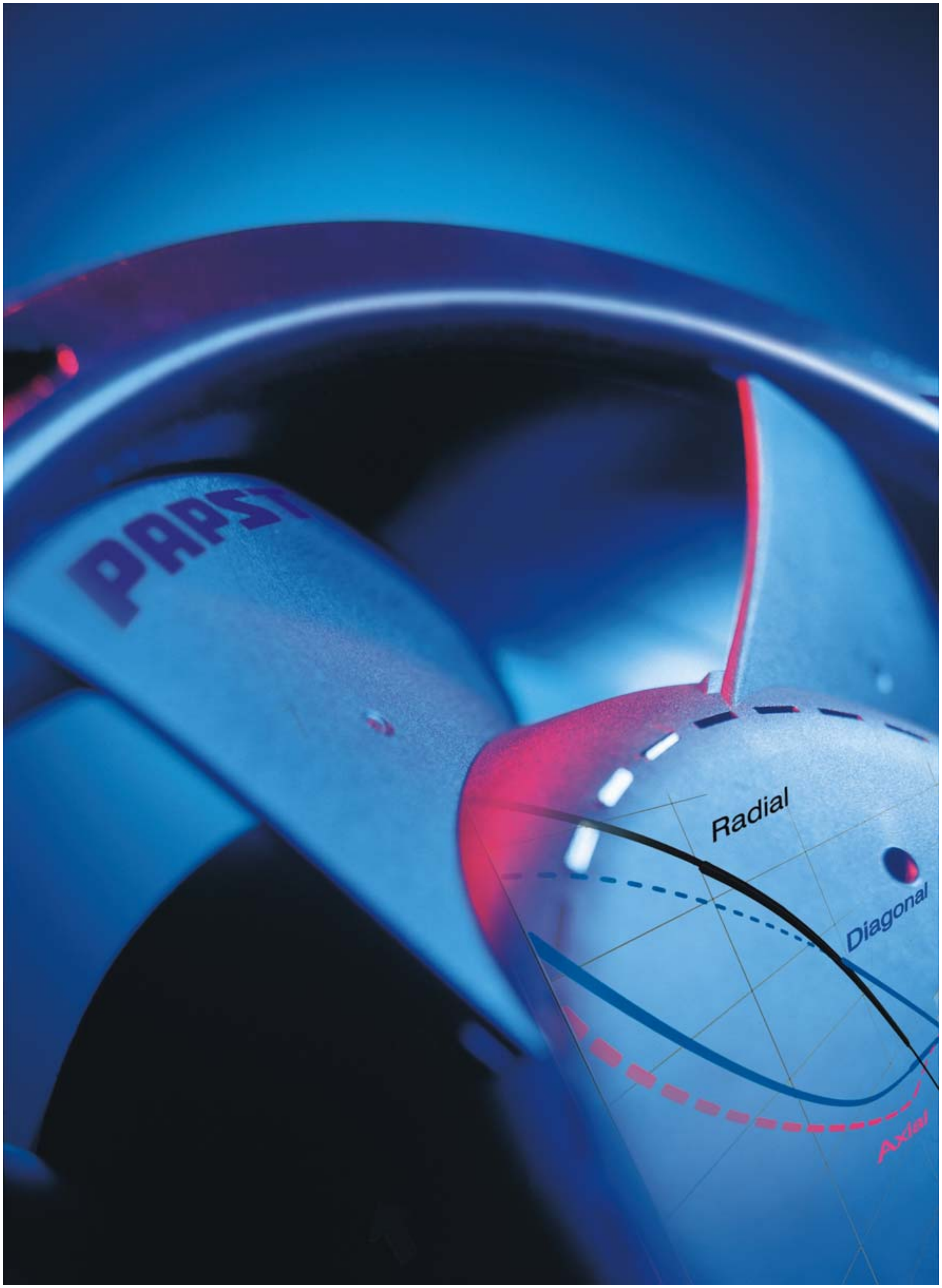

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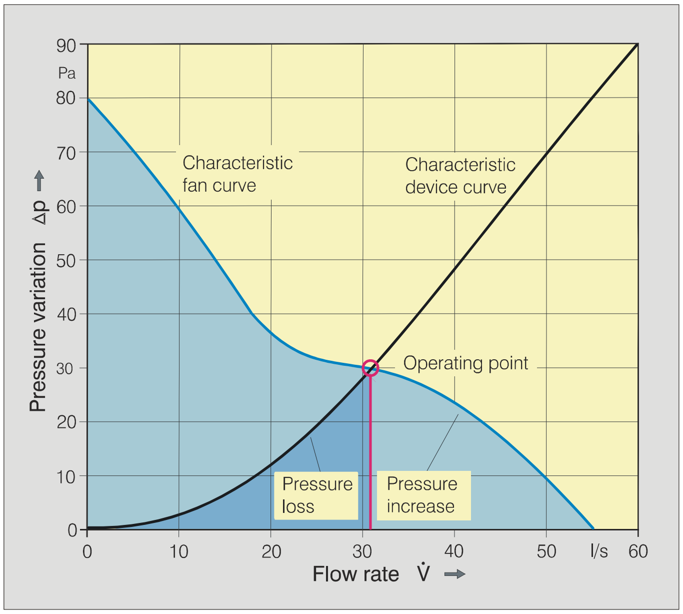

Fig 1: Calculation of the operating point

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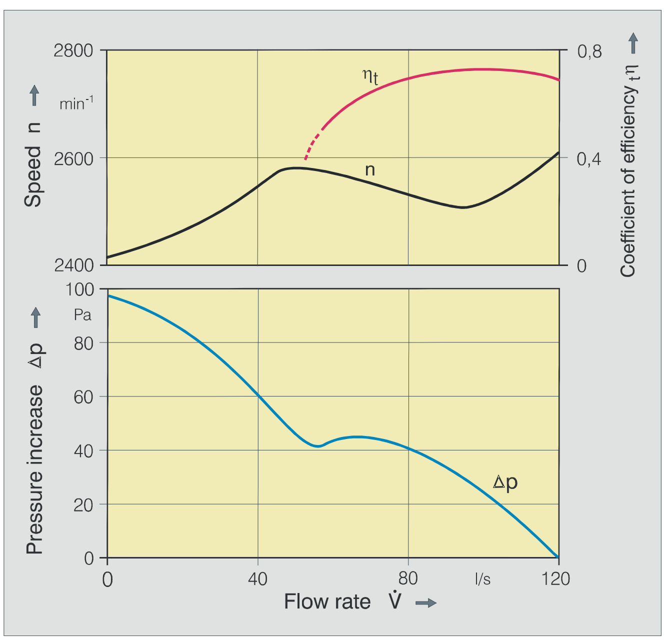

Fig 2: Change in speed and efficiency of an axial fan

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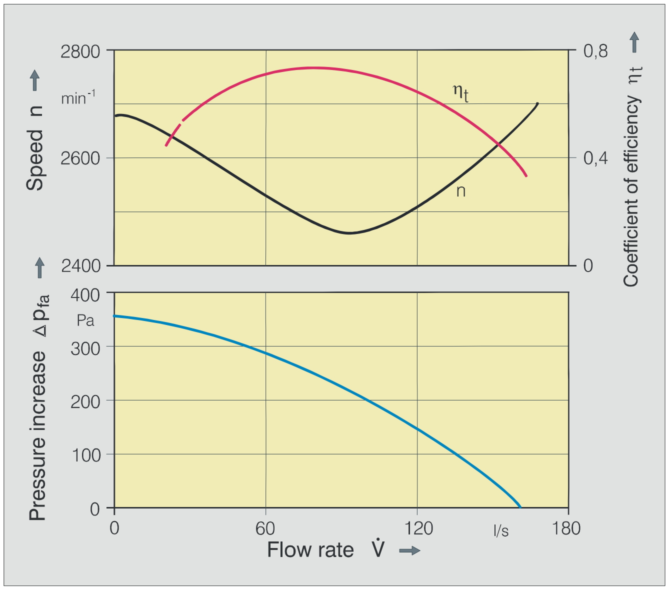

Fig 3: Change in speed and efficiency of a radial fan

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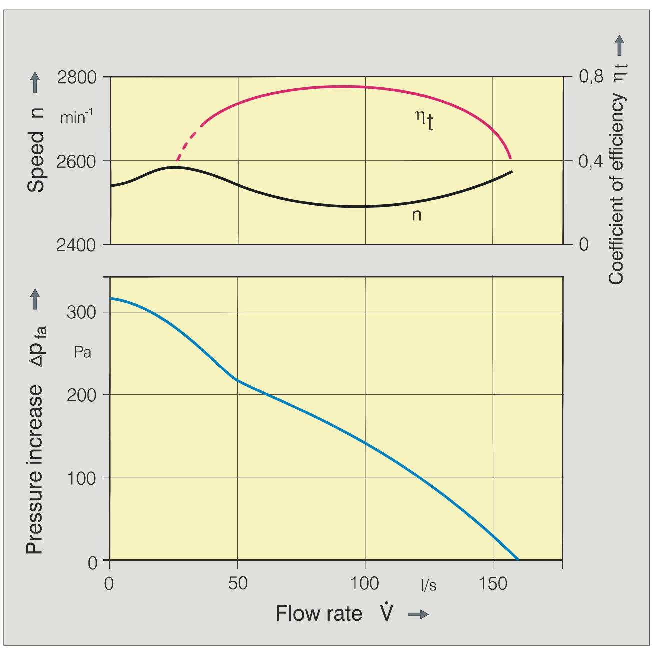

Fig 4: Change in speed and efficiency of a diagonal fan

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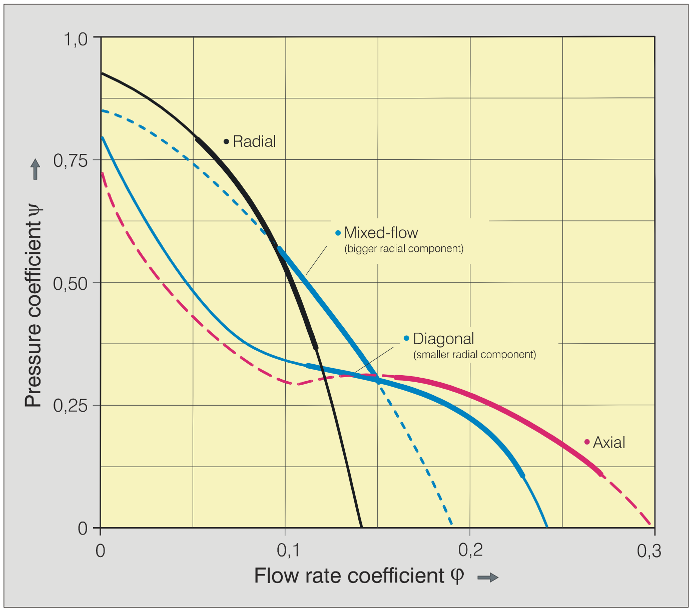

Fig 5: Comparison between the performance curves for different fan designs