

Using fans in series and parallel: performance guidelines

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When a single fan within a system cannot deliver sufficient airflow to provide the required level of cooling, and the physical size of the enclosure precludes the use of a larger fan, the concept of mounting fans in series or parallel is sometimes considered. In practice however, the only circumstances in which two fans of equal size can provide double the airflow is when they are operating in free air, i.e. no back pressure to restrict the airflow. This is a theoretical situation not found in practice.

The following article examines what really happens and how the performance of multiple fan solutions can be optimised.

Before examining the performance of series and parallel fan arrangements, it is worth considering the basic concepts of airflow characteristics in practical applications.

Fans are used to produce turbulent air currents which when forced through equipment enclosures, collect and remove heat from the internal components. Physical obstructions to this airflow not only provide a reverse pressure, which the fan must overcome, but can also mask components from the cooling air stream. The enclosure designer must therefore consider the cooling paths when the layout is being decided.

Densely packed enclosures exhibit airflow resistance, manifested as pressure loss in the direction of airflow. It's analogous to an electrical generator forcing current through a resistor - the resistor restricts the current flow.

In theory, weighting factors can be applied to determine the flow/pressure characteristics of systems. In practice, the variety of designs used in enclosures and the presence of internal cards, disk drives, power supplies or other elements that interfere with airflow, mean that it is impossible to calculate weighting factors using general formulae. Designers must rely on measurements or rough approximations.

For practical purposes, the pressure loss of an enclosure, Δp , is approximated by the formula:

$$\Delta p = R_v \times Q/2 \times V^2$$

where R_v is a weighting factor for pressure loss in dimensions of m^{-4} , Q is the density of the displacement medium and V is the velocity of air flow through the system. It can be seen that pressure loss increases as the square of flow rate.

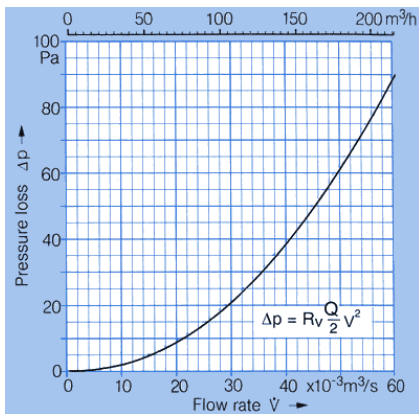
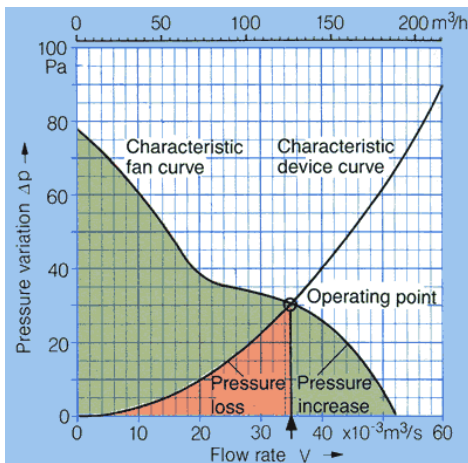


Figure 1 (above) shows the characteristic curve based on this formula where pressure loss is plotted as a function of flow rate. It describes the air flow characteristics of a given enclosure or other system.

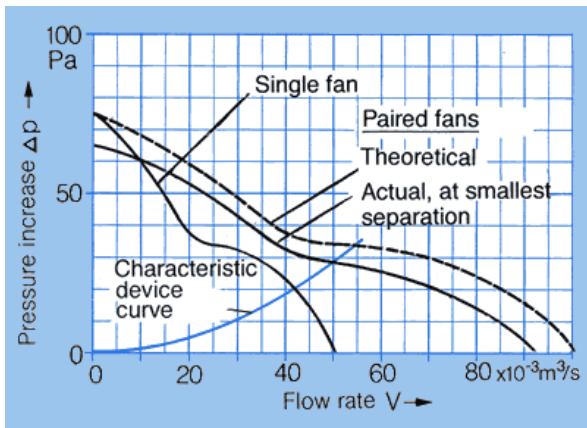


Fans operating in free air generate the maximum possible flow rates, but when fitted within an enclosure the fan is required to overcome the inherent airflow resistance. In order to achieve this the fan needs to produce a pressure increase which will in turn decrease the flow rate. A characteristic fan curve, as shown in Figure 2 (above), expresses the relationship between flow rate and pressure.

For a given enclosure and fan, the operating point of the fan is determined by the point at which the characteristic enclosure curve and characteristic fan curve intersect. At this point, the pressure loss of the enclosure is just compensated by the pressure increase of the fan and this point determines the flow rate that is available within that enclosure.

With parallel - side by side - mounting, the flow rate is multiplied by the number of fans but the results must be plotted over the entire characteristic fan curve. If fans are placed too close together, other interference effects come into play and reduce the overall flow. This is largely because the flow of air into a fan is usually laminar and smooth, while the exhausted air is much more turbulent. Even in an ideal environment, where interference effects could be ignored, a pressure

increase of four times would be needed to produce a doubling of air flow, as pressure loss increases with the square of flow rate. These differences and the effect of using fans in parallel are shown in **Figure 3** (below). Here, the airflow only increases by approximately 20 to 25% over that achieved with a single fan.



When fans are mounted in series - one in front of the other - the pressure increase, in theory, is doubled. However, if the fans are close together, results will again fall short of the theoretical performance due to the angular component of airflow introduced in the exhaust of the rear fan. This limits the suction effectiveness of the front fan. One solution is to direct the angular component back into the main air current using guide vanes, but this is a rather inelegant and space-hungry solution. A more commonly adopted and balanced approach is to use one fan on the intake and one on the exhaust side of the enclosure or cabinet. The presence of internal components and the large cross-sectional area between the individual fans will mean that airflow is essentially unidirectional. This provides effective airflow and relatively low noise levels.

The choice of series or parallel fan combinations will clearly depend on the individual application. Some solutions may even require a combination of both techniques. The key point to remember is that two fans never mean twice the air flow.