

## **ATS WHITE PAPER**

### **Performance Difference Between Fans and Blowers and Their Implementation**



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# Performance Difference Between

## Fans and Blowers and Their Implementation

### Introduction

Machines which deliver liquids are simply called pumps, but if gases are involved, like air, three different terms are in use, depending upon the pressure rise achieved. If the pressure rise is very small (a few inches of water), a gas pump is called a fan; up to 1 atm, it is usually called a blower; and above 1 atm it is commonly termed a compressor [1]. 25 mm of water, at 4°C, is around 249 Pa.

There are two basic types of pumps: positive-displacement and dynamic or momentum-change pumps. There are several billion of each type in use in the world today.

Positive-displacement pumps force the fluid moving by change in volume [1]. A cavity opens, and the fluid is admitted through an inlet. The cavity closes, and the fluid is squeezed through an outlet. The mammalian heart is a good example of a positive-displacement pumps. Gear and screw pumps are some of the mechanical designs available commercially.

Dynamic pumps simply add momentum to the fluid by means of fast-moving blades or vanes or certain special designs [1]. There is no closed volume: The fluid increases momentum while moving through open passages and then converts its high velocity to a pressure increase by exiting into a diffuser section. Dynamic pumps can be classified as follows:

### 1. Rotary

- Centrifugal or radial exit flow
- Axial flow
- Mixed flow

### 2. Special designs

- Jet pumps or ejector
- Magnetic pumps for liquid metals
- Fluid-actuated: gas-lift or hydraulic-ram

### Pumps in Electronics Cooling

For electronics cooling, dynamic pumps are most commonly used. These pumps would normally pump air at a pressure head of below 500 Pa; these pumps are normally referred to as fans or air movers. The fans can then be divided into axial and centrifugal or radial exit fans, as shown in Figure 1.

### Differences Between Axial and Centrifugal Fans

The difference between the axial and radial fans can be

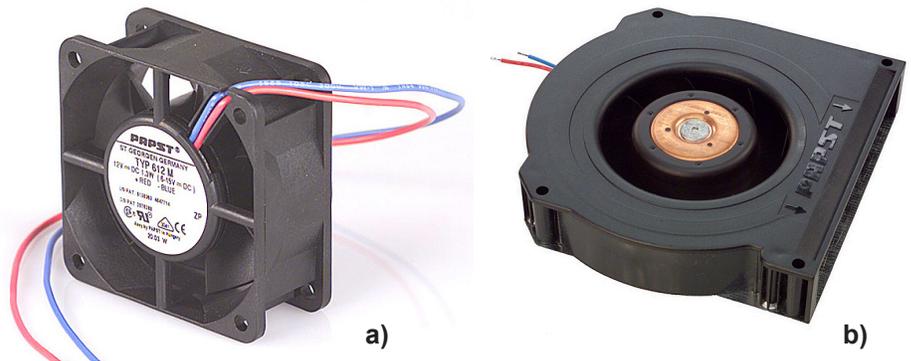


Figure 1. Photos of (a) Axial [2] and (b) Centrifugal Fans [3].

divided into two parts, namely geometry and fluid dynamics.

In general, a fan consist of a hub, housing and motor. Blades are mounted on the hub which is rotated by a motor. For electrical fans in electronics application, the motor is embedded inside the hub.

**Geometrical Difference**

An axial-flow fan has blades that force the air to move parallel to the shaft around which the blades rotate. For a centrifugal fan, the air flows in on a side of the fan housing. The air then turns 90° and accelerates due to centrifugal force as it flows out of the fan blades and exits the fan housing.

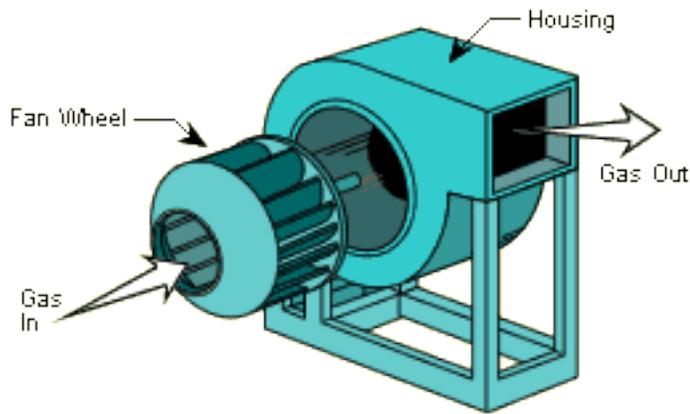


Figure 2. Centrifugal Fan Components Showing The Fan Housing And Hub (Fan Wheel) [4].

Due to the geometric differences between the axial and centrifugal fans, air flow through the fan differs, as stated in the previous paragraph. This difference in air flow direction has design implications for the electronic equipment. For example, in close circuit packs a blower might be preferable, since it can be placed on the PCB with the axial shaft perpendicular to the PCB and the flow exiting parallel to the PCB. An axial fan, on the contrary, has a large diameter and cannot be placed on the PCB in most telecom applications.

**Fluid Dynamics Differences**

To compare the fluid dynamics of a centrifugal and axial fan, the fan curves of the PAPST 8414 NH-221 axial fan and RL 48-19/12 ML radial fan were chosen. These fans have similar

power input and rotational speeds, as shown in Table 1.

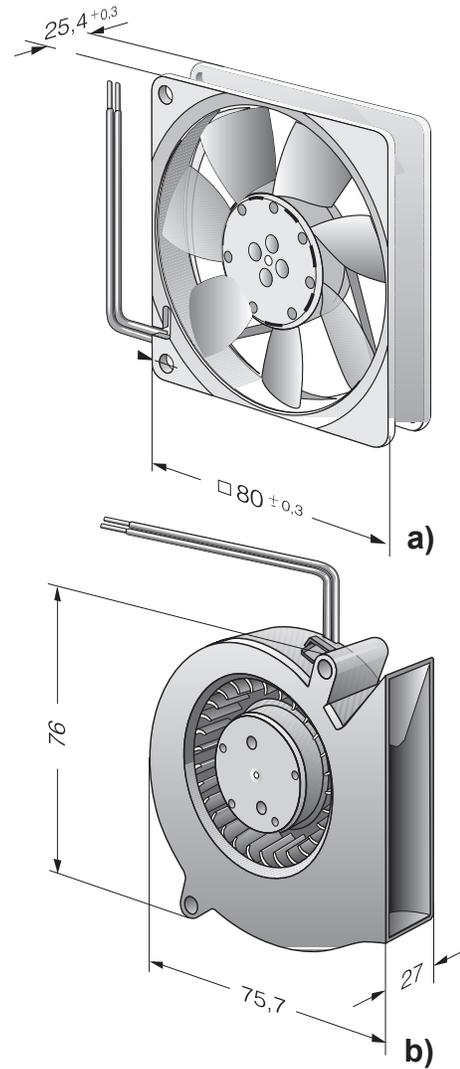


Figure 3. PAPST 8414 NH-221 (a) Axial Fan and (b) RL 48-19/12 ML Radial Fan [5].

Table 1. Data for the Axial and Centrifugal Fan Comparison [5].

Fan type	Part number	Nominal speed [min <sup>-1</sup> ]	Power input [W]	Noise [dB]
Axial	8414 NH-221	3600	3.2	50
Centrifugal	RL 48-19/14	3500	2.9	53

It is shown in Figure 4 (a) that the centrifugal fan has a higher pressure head at no flow than the axial fan, but the axial has a higher maximum flow rate. The flow rate through a system is determined by the intercept between the fan and system curve. Figure 4 (b) shows the system curves



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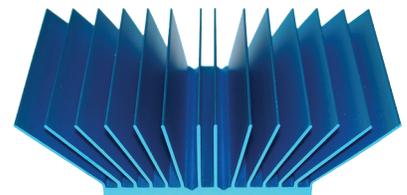
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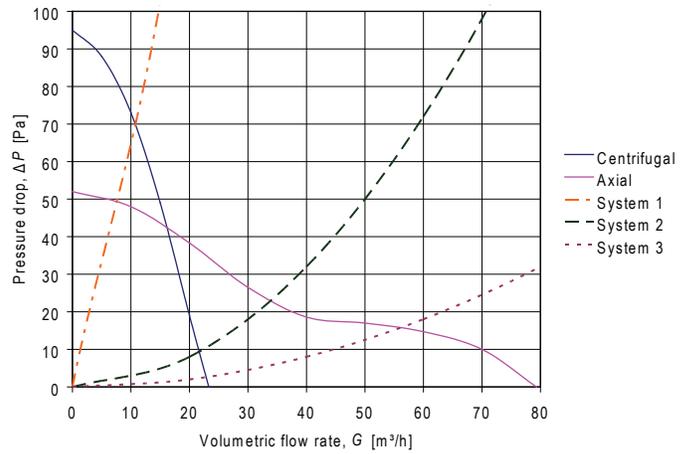
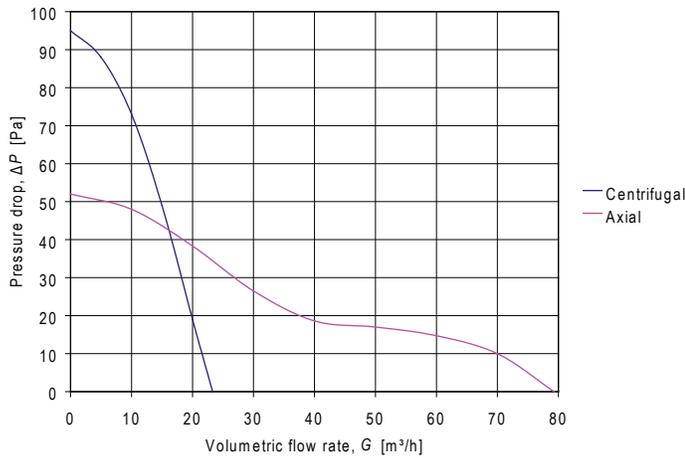


Figure 4. Fan Curves for the (a) Axial and Centrifugal Blowers, (b) Fan Curves and System Curves For Different System Configurations.

for three different systems. The intercept points between the fan curves and different system curves are shown in table 2. The system curve of a product may be relatively simple, such that it can be calculated using 1D fluid mechanics theory, or it may be sufficiently complicated so that the use of high performance CFD such as direct numerical simulation (DNS), or experimental data is necessary.

Table 2. Flow Rate and Pressure Drop In Systems 1, 2 and 3 For Different Fans.

Fan type	Value	System 1	System 2	System 3
Axial	G [m <sup>3</sup> /h]	10.9	34.0	55.4
	ΔP [Pa]	47.2	23.1	15.4
Centrifugal	G [m <sup>3</sup> /h]	12.4	21.7	22.7
	ΔP [Pa]	61.9	9.5	2.6

### Fans in Series and Parallel

In ideal situations, when using two fans in series, the maximum flow rate stays the same as for the single fan, but the maximum pressure head doubles. When using two fans in parallel, the maximum pressure head stays the same as for the single fan, but the flow rate doubles. In real situations, the fans may interfere with each other. The end results is a lower than expected performance. Centrifugal fans in series and parallel are shown in Figure 5 (a) and for axial fans in Figure 5 (b). The resultant flow rate and pressure drop is, again, the intercept between the fan curve and the system curve. Table 3 gives the flow rate and pressure drop for the centrifugal and axial fan in series and parallel.

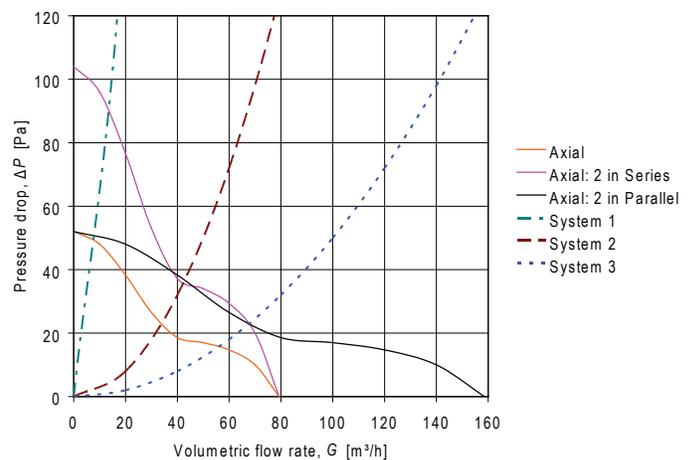
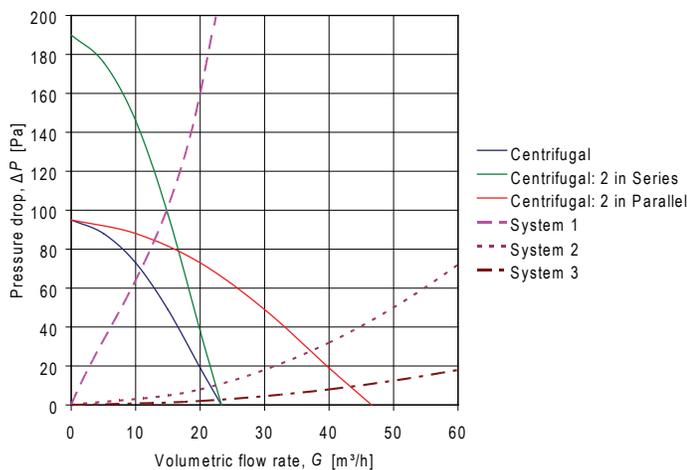


Figure 5. Fan Curves For (a) Centrifugal Fans and System Curves, (b) Axial fans with the System Curves.

Table 3. Flow Rate and Pressure Drop In Systems 1, 2 and 3 for Different Fans Combinations.

Fan type	Value	System 1	System 2	System 3
Axial	G [m <sup>3</sup> /h]	10.9	34.0	55.4
	ΔP [Pa]	47.2	23.1	15.4
Centrifugal	G [m <sup>3</sup> /h]	12.4	21.7	22.7
	ΔP [Pa]	61.9	9.5	2.6
Axial: 2 in Series	G [m <sup>3</sup> /h]	14.7	42.2	73.8
	ΔP [Pa]	86.8	35.6	27.2
Axial: 2 in Parallel	G [m <sup>3</sup> /h]	11.3	42.5	67.9
	ΔP [Pa]	51.0	36.1	23.1
Centrifugal: 2 in Series	G [m <sup>3</sup> /h]	15.4	22.4	22.9
	ΔP [Pa]	95.2	10.0	2.6
Centrifugal: 2 in Parallel	G [m <sup>3</sup> /h]	14.3	37.7	43.5
	ΔP [Pa]	81.4	28.4	9.5

### Summary

This article has discussed two types of fans used in electronics cooling, namely the centrifugal and axial fan. Their geometric and fan curve differences have been discussed. In general,

for the same power and rotation speed, the centrifugal fan can achieve a higher pressure head than an axial fan. However, an axial fan can achieve a higher maximum flow rate than a centrifugal fan.

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