Fan Basics and Selection Criteria (How to Use)

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1. Introduction

In recent years, the importance of cooling technology has become even greater due to an increase in heat emitted by equipment in line with a transition to high functionality and high speed.

When the heat of a device is cooled, the heat is transferred in one of the below three ways.

(1) Heat transfer through radiation
Release of thermal energy through electromagnetic waves.

(2) Heat transfer through thermal conduction
Heat is directly transferred to components and chassis.

(3) Heat transfer through convection
Releases heat from the component surface to the surrounding air and from the air vent into the atmosphere.

Heat transfer by convection plays an important role in the cooling of devices. Heat transfer by convection can either be natural convection, which occurs from the buoyancy caused by temperature difference, or forced convection, which forcibly moves fluid using fans, etc.

Forced convection is extremely effective towards the cooling of devices.

Customers have a diverse range of equipment, and as such, there is a diversity of requirements for cooling fans.

In order to respond to this, Sanyo Denki has commercialized fans such as the axial flow fan and centrifugal fan which are available in various sizes and exhibit aerodynamic performance and electrical performance.

In order to choose the right fan for your equipment out of a diverse lineup, it is important to understand the characteristics and operating condition of each fan.

This report explains about fan basics and selection criteria (how to use).

2. Fan Basics

2.1 Fan types

Depending on drive power and airflow, fans can be categorized in the following way.

Categorization by drive power separates AC fans which operate on alternating current (utility power) and DC fans which operate on direct current. (This report gives an explanation on DC fans)

Categorization by airflow broadly separates fans into axial flow fans or centrifugal fans. Table 1 shows the features of each fan.

Sanyo Denki has commercialized the axial flow fan and centrifugal fan.

In recent years there has been an increase in axial flow fans with high static pressure due to the benefits of high speed drive in accordance with higher motor performance, and a transition to counter rotation. This has led to increased usage of axial flow fans on equipment with large ventilation resistance due to high mounting density.

2.2 Main applications

In addition to our standard “axial flow fan”, Sanyo Denki offers a diverse lineup of products including a high static pressure “counter rotating fan”, an environmentally-resistant “splash proof fan”, “oil proof fan” and “wide temperature range fan”, “centrifugal fan” and “blower” which blows air perpendicular to the inlet direction, “ACDC fan” which drives by DC power internally converted from AC power, “reversible flow fan” which can blow air in both directions by changing the direction in which its moving blades rotate.

Table 2 shows the characteristics and applications of the various fans available.

Table 1: Fan types

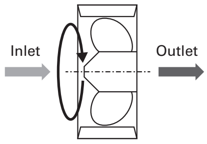
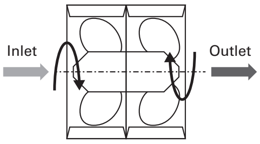
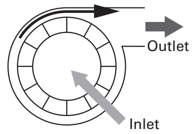
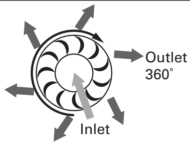
Fan type	Appearance	Airflow	Features
Axial Flow Fan (Counter Rotating Fan)			· Easy to obtain high airflow · Easy to reduce SPL (sound pressure level) · Suitable for equipment with small ventilation resistance due to low/medium mounting density.
			· High static pressure · Suitable for equipment with large ventilation resistance due to high mounting density.
Centrifugal Fan (Blower)			· High static pressure · Suitable for equipment with large ventilation resistance due to high mounting density.
			· The airflow and static pressure is between those of an axial flow fan and blower. · Discharges in a full radius direction. · Effective in the ventilation of large equipment.

Table 2: Fan characteristics & application examples

Model	Characteristics	Application examples
Axial Flow Fan	A wide lineup (fans come in various sizes and with different characteristics such as low power consumption, low noise, high airflow and high static pressure)	Home electric appliances, OA devices
Counter Rotating Fan	Higher airflow and static pressure than if two conventional products of the same size were used in series.	Servers and other high mounting density equipment
Splash Proof Fan	Optimal for equipment used in environments exposed to water spray. The levels of water protection are IP54, 55, 68 (differs depending on model)	Outdoor equipment
Oil Proof Fan	For equipment used in environments exposed to oil mist.	Machine tool control units for FA
Long Life Fan	Has an expected life of up to 200,000 hours.	Used in ICT equipment and other devices which need to be maintenance free for prolonged periods
Wide Temperature Range Fan	A guaranteed operating temperature range of -40˚C to +85˚C.	Equipment used in environments with a broad ambient temperature range
Centrifugal Fan	A high static pressure fan which blows air perpendicular (360˚) to the inlet direction.	Ventilation of large equipment, air purification devices
Blower	A high static pressure fan which blows air perpendicular to the inlet direction (has directivity).	Flat/high mounting density equipment Paper sorbing for printers and photocopiers
ACDC Fan	Drives by DC power internally converted from AC power. Longer life and lower power consumption than the conventional AC fan.	Able to replace AC fans.
Reversible Flow Fan	Can blow air in both directions with only one unit. Can control forward/backward switchover speed with one control cable.	Household ventilation, cool beverage vending machines, food showcases

2.3 Understanding main specifications

Various fans are introduced in catalogs and websites. Figure 1 shows the specifications provided in Sanyo Denki fan catalogs and the meaning of each item.

	<1>	<2>	<3>	<4>	<5>	<6>		<7>		<8>	<9>	<10>
Model No.	Rated voltage [V]	Operating voltage [V]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow		Max. static pressure		SPL [dB(A)]	Operating temperature [°C]	Expected life [h]
						[m^3/min]	[CFM]	[Pa]	[$inchH_2O$]			
9GA0412G7001	12	7 to 13.8	0.17	2.04	13,100	0.36	12.7	192	0.77	42	-20 to +70	40,000/60°C (70,000/40°C)
9GA0412H7001			0.06	0.72	7,300	0.2	7.1	59.6	0.24	28		

<1> Rated voltage ········ The voltage necessary to drive fans. There are 12 V, 24 V, 48 V, etc.

<2> Operating voltage ········ The voltage range which can be applied without problems when the fan is operating.

<3> Rated current ········ The current when the fan is operating at rated voltage (at free air).

<4> Rated input ········ The power value when the fan is operating at rated voltage (at free air).

<5> Rated speed ········ The speed when the fan is operating at rated voltage (at free air). The common unit used is [min^{-1}] and means the same as [rotations/min]. Expresses the rotating speed per minute.

<6> Maximum airflow ········ The maximum airflow obtainable when the fan is operating at rated voltage. The static pressure is zero at this time. Airflow is the volume of air propelled by a fan in a set period of time.

<7> Maximum static pressure ········ The maximum static pressure obtainable when the fan is operating at rated voltage. The airflow is zero at this time. Static pressure is the power which propels air by pushing against the flow path resistance inside equipment (obstructions, etc.) using the fan when air is discharged. Fans with high static pressure are suitable for the cooling of equipment with high mounting density and ventilation resistance.

<8> SPL ········ Sound level when a fan is being driven at the rated voltage (at free air, the value 1 meter from inlet). Fans with small SPL help to make equipment quieter.

<9> Operating temperature range ··· The allowable temperature range as an ambient environment for fan operation.

<10> Expected life ········ The life which can be expected when a fan is continuously operated under certain conditions. Measurement conditions differ between manufacturers.

Fig. 1: Understanding main specifications (E.g.: 40 sq., 15 thick GA type)

2.4 Fan airflow characteristic

The airflow characteristic of a fan is expressed by the airflow vs. static pressure characteristic. This characteristic is unique to a fan.

The maximum airflow is obtainable when there is no airflow resistance (zero static pressure). This is a condition with nothing around the fan and is not achievable if the fan is built into a device.

If a device does not have an air outlet vent and air cannot escape, the fan will not be able to propel air (zero airflow). At this time the device internal pressure is maximum static pressure. When a fan is actually used, it operates at a medium between maximum airflow and maximum static pressure.

Figure 2 shows the airflow vs. static pressure characteristic, maximum airflow, maximum static pressure, and device mounting condition.

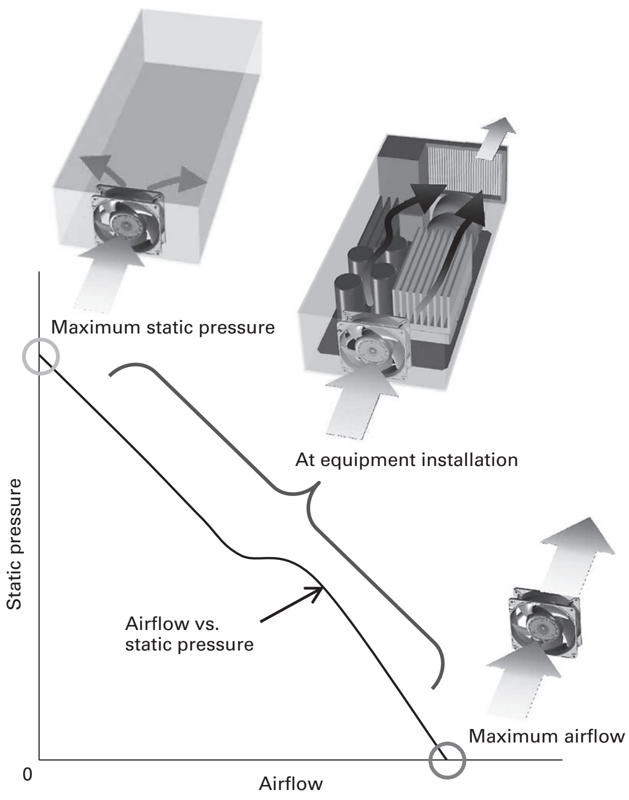


Fig. 2: Airflow vs. static pressure

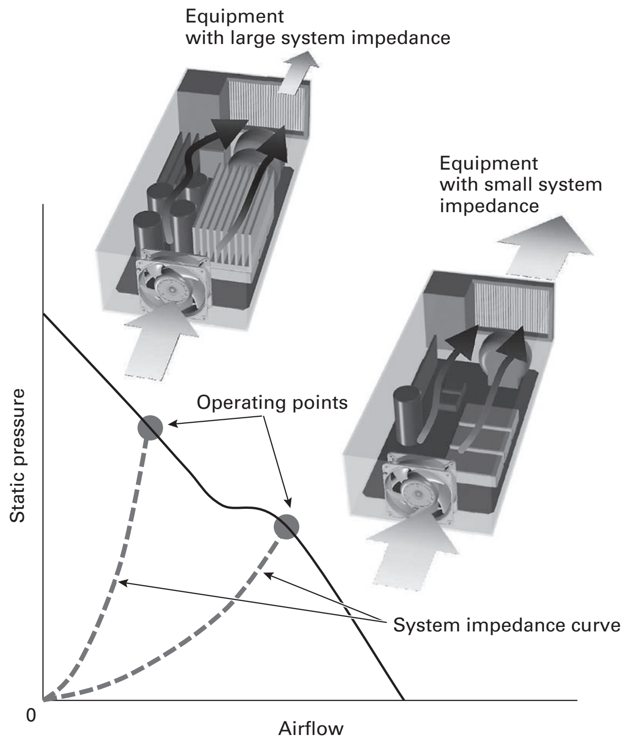


Fig. 3: Airflow vs. static pressure characteristic and system impedance

3. Operation of Fans Mounted on Devices

The “degree of airflow difficulty” differs depending on the device. This “degree of airflow difficulty” is referred to as ventilation resistance, or system impedance.

Devices in which airflow is difficult have large system impedance. Devices in which airflow is easy are said to have small system impedance.

System impedance can be approximated using a quadratic curve. The point where this curve intersects with the airflow vs. static pressure characteristic is the operating point of the fan. Figure 3 shows the relationship between system impedance and the fan operating point.

Fans mounted on devices will have a reduced airflow due to system impedance. Moreover, such fans tend to display different speed, power consumption and sound pressure level to what is stated in the catalog specifications. Figure 4 shows the relationship between the fan operating point and speed, power consumption and sound pressure level.

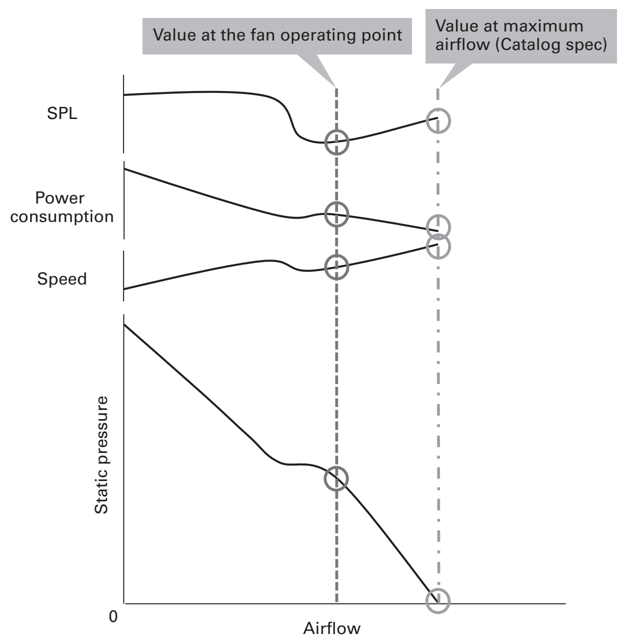


Fig. 4: Operating point and fan characteristic examples

4. Fan Selection Criteria (How to Use)

When equipment is cooled using fans for forced air cooling (forced convection), most of the heat inside equipment is released via the following route.

Component heat
↓
Transfer from components to air inside the device … <1>
↓
Discharge outside of the device … <2>

The following three methods can be used to increase the effect of <1>.

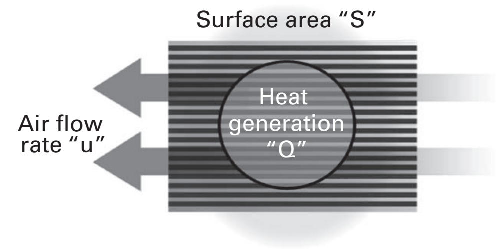
(1) Widen the surface area of components which generate heat.
(2) Increase the airflow rate in the area.
(3) A combination of (1) and (2).

The concrete method for (1) is to increase heat dissipation by attaching a heat sink.

The concrete methods for (2) are increasing the airflow rate around components by rearranging component layout, installing a flow rectifier plate or modifying the chassis opening.

Moreover, in addition to the above, it is possible to increase cooling effectiveness by adding another fan and directly aiming the discharged air to components.

If the surface area and heat generation amount of the object being cooled are fixed, the relationship between the flow rate of air passing the object and temperature elevation will be as shown in Figure 5.



Heat transfer formula

Heat generation amount "Q" [W] = h x S x ⊿T

h: Heat transfer ratio [W/m² · K]

S: Surface area [m²]

⊿T: Temperature elevation [K]

Fig. 5: Heat transfer formula

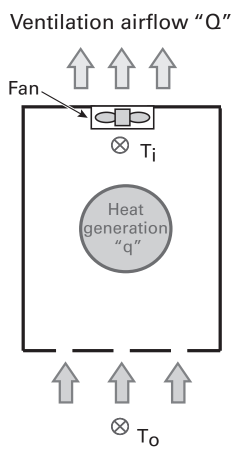
With heat emission "Q" and surface area "S" remaining constant, heat transfer ratio "h" will change if airflow rate "u" changes. The relationship between heat transfer ratio "h" and airflow rate "u" is;

$h \propto u^{0.5}$ (laminar flow heat transfer)

$h \propto u^{0.8}$ (turbulent flow heat transfer)

For example, to halve the temperature elevation of the targeted object, it would be effective to find an airflow rate "u" which doubles the heat transfer ratio "h". Therefore, it would be effective to multiply the airflow rate "u" by 4 times in the case of laminar flow and by 2.4 times in the case of turbulent flow. Normally it is common to think in terms of laminar flow when making calculations.

The ventilation airflow required at <2> can be calculated once the heat which should be taken from the heat source (device heat generation amount) and allowable temperature elevation for the device interior have been determined. Figure 6 shows the calculation formula.



$$Q = \frac{60 \times q}{\rho \times Cp \times \varDelta T}$$

q : Equipment heat generation [W]

⊿T : Chassis inner allowable temperature elevation [K]
⊿T = Ti − To

ρ : Air density [kg/m³]
1.20 kg/m³ at room temperature

Cp : Specific heat at constant pressure [J/(kg·K)]
1007 J/(kg·K)

Q : Necessary ventilation airflow [m³/min]

Fig. 6: The amount of heat which should be taken and necessary ventilation

For example, if the device heat generation was 100 W, the chassis internal typical temperature was 65°C and the chassis ambient temperature was 50°C (chassis inner allowable temperature elevation: 15 K), then the necessary ventilation airflow would be as per the below formula.

$$Q = \frac{60 \times 100}{1.20 \times 1007 \times 15} \fallingdotseq 0.33\ [\mathrm{m}^3/\mathrm{min}]$$

To increase the effect of <2>, it would be useful to raise fan ability and increase ventilation airflow. (Increase speed, increase no. of fans, change fans)

One must note that the calculated required ventilation airflow is not the maximum airflow stated in catalogs. As mentioned in section 3, it must be taken into consideration that the operating airflow declines due to system impedance.

5. Conclusion

This report has introduced fan basics and selection criteria (how to use).

Sanyo Denki wishes to continue accurately identifying the needs of our customers to achieve new development, customization and technical support of products which ensure customer satisfaction.

Reference

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