Development of the "San Ace Airflow Tester" - A Measuring Device for System Impedance and Operating Airflow of Equipment

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1. Introduction

In recent years, devices have improved functionality and increased speed. Meanwhile, from an environmental perspective, there is great emphasis placed on low sound pressure level (SPL) and low power consumption. Under such circumstances, the thermal design of equipment is becoming increasingly important. An important element of thermal design is selecting the optimal fan. Generally, fans are selected through a process of estimation and simulation based on past results, then an evaluation on an actual machine. If the system impedance and operating airflow of a device could be more easily identified, the operating point of the fan specific to that device could then too be identified, so that the search for the optimal fan could be refined even further. In other words, it would be possible to select a fan which is optimal not only in terms of cooling performance, but also in terms of power consumption and SPL.

Although ways to measure system impedance and airflow do already exist, it was difficult to use these to help with fan selection due to issues such as the measuring device being too large or the measuring accuracy being poor.

For this reason, SANYO DENKI developed the "San Ace Airflow Tester" (hereinafter "new product") to easily and accurately measure the system impedance and operating airflow of a device.

This paper will first introduce the features of this new product. Then, an example will be provided of how this new product can aid fan selection.

2. Outline of the New Product

2.1 External view and dimensional overview

Figure 1 shows an external view of the new product, while Figure 2 provides an overview of its dimensions.

Table 1 shows the specifications for the new product.

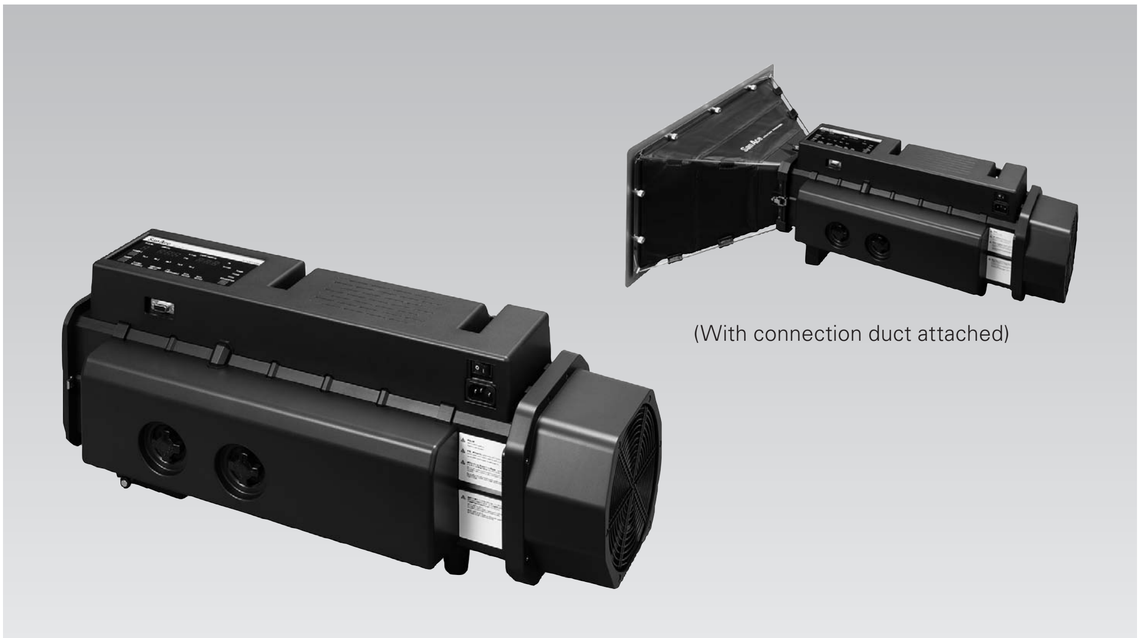

Fig. 1: External View of the "San Ace Airflow Tester"

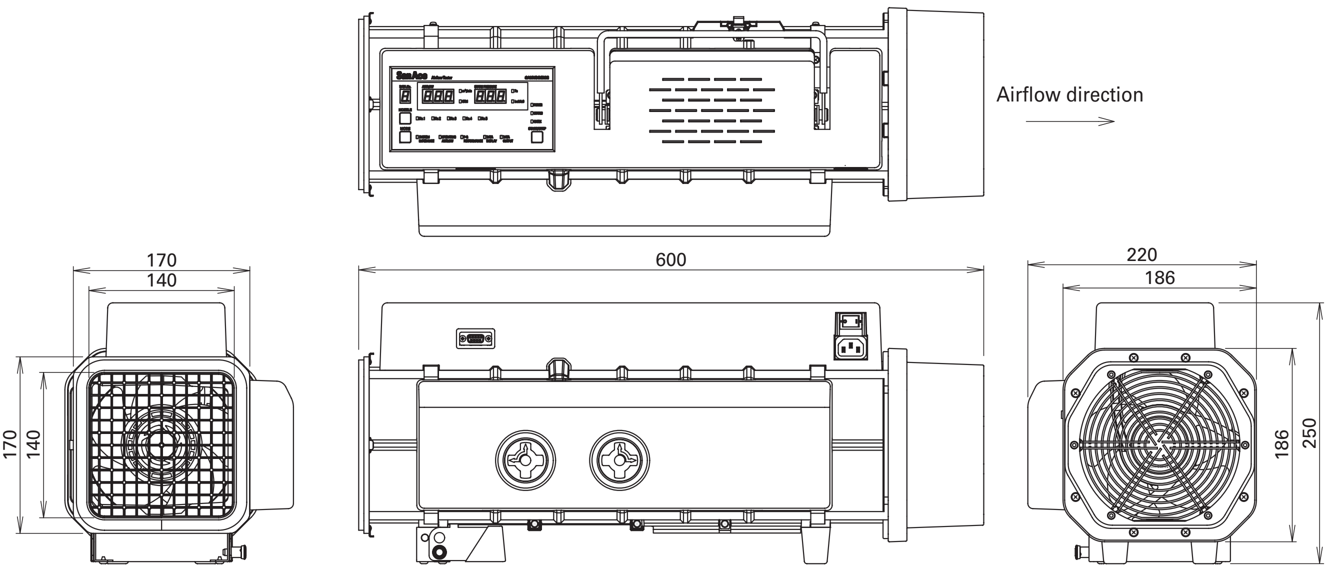

Fig. 2: Dimensions of the "San Ace Airflow Tester"

Table 1: Specifications of the new product

Item		Specifications
Measurement functions		System impedance, operating airflow, P-Q performance
Measurement range	**Airflow**	0.2 to 8 m^3/min (7 to 282 CFM)
	Static pressure	0 to 1,000 Pa (0 to 4.01 inchH_2O)
Measurement accuracy	**Airflow**	±7% of the maximum airflow measured with each nozzle
	Static pressure	±10 Pa in relation to a measurement value of less than 200 Pa
		±50 Pa in relation to a measurement value of 200 Pa or more
Display/output data	**Main unit display**	Airflow, static pressure (standard atmospheric pressure conversion: 20˚C, 1013 hPa)
	Data output	Airflow, static pressure (standard atmospheric pressure conversion: 20˚C, 1013 hPa), atmospheric pressure, ambient temperature, humidity
Interface		RS-232C-USB serial converter
Operating/storage environment	**Ambient temperature**	0 to 40˚C
	Humidity	20 to 85% RH (non-condensing)
Power supply	**Input voltage**	100 to 240 VAC, 50/60 Hz
	Power consumption	260 VA Max.
Dimensions		600 (W) x 250 (H) x 250 (D) mm
Connection duct opening		500 x 250 mm
Mass		Main unit: Approx. 6 kg, connection duct: Approx. 1.5 kg

3. Product Features

3.1 Compact and lightweight

The new product is compact and portable, measuring 600 mm (width) by 250 mm (height), by 250 mm (depth) and weighing 6 kg. Its lightweight structure is due to it being made primarily from injection molded plastic components. Moreover, the compact size is attributed to its integrated design, whereby the power source and control components are arranged on the top face of the main unit, while the sensors, etc. are on the side of the main unit. In addition, to increase further portability, it comes with a handle which can be stored away when the device is not being carried around. So for large equipment, it is possible to take measurements easily without moving from the location where the equipment is installed.

3.2 Measurement accuracy

3.2.1 Double chamber method

The Airflow Tester uses the double chamber measurement method which is based on JIS and AMCA standards. When measuring highly turbulent air such as airflow from a fan, the double chamber method provides higher measurement accuracy than measurement using a pitot tube or calculating from wind velocity. As such, virtually all fan performance testers use the double chamber method.

Figure 3 shows a model diagram for the “San Ace Airflow Tester”.

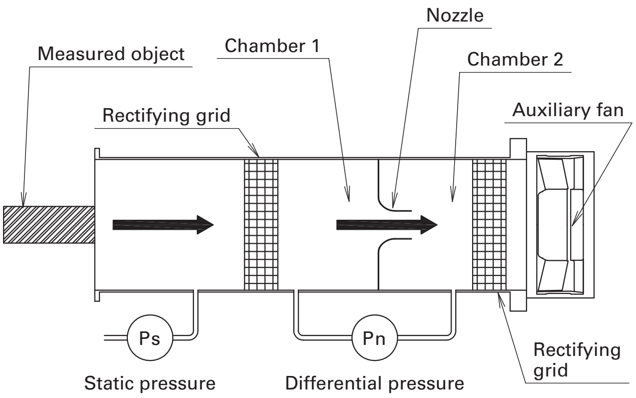

Fig. 3: Model diagram of the Airflow Tester

Chamber 1 and chamber 2 are separated by a nozzle, through which air passes. At this time, a pressure difference occurs between chamber 1 and chamber 2 (= differential pressure). Airflow can be calculated by measuring this differential pressure. Moreover, since the pressure difference (= static pressure) between the inside of the chamber and the atmospheric pressure can be measured at the same time, system impedance and operating airflow can be measured. An auxiliary fan is used to forcefully blow air into the object being measured, thus creating differential pressure and static pressure, and enabling system impedance to be measured. For operating airflow, the auxiliary fan controls the static pressure of chamber 1 so it becomes zero and airflow is calculated from the differential pressure at this time.

3.2.2 Nozzle

Using the double chamber method, airflow is calculated from the differential pressure generated by the nozzle. However, if airflow is low and the nozzle opening diameter is large, the differential pressure between chambers 1 and 2 will be too small, causing a greater airflow deviation. As such, SANYO DENKI designed five types of nozzles that can be used within the airflow measuring range of the Airflow Tester. The right nozzle to suit the airflow can be used to enable highly accurate measurement throughout the entire measuring range. Figure 4 shows external views of the nozzles while Table 2 gives their respective specifications.

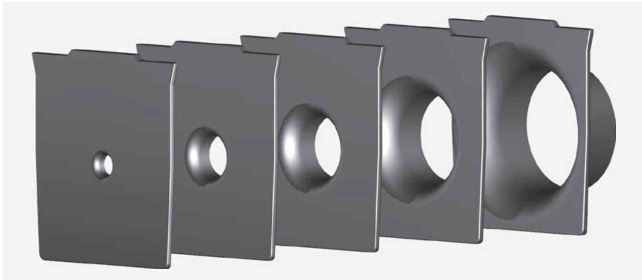

Fig. 4: External view of the nozzles

Table 2: Nozzle specifications

Nozzle no.	Internal diameter ø [mm]	Airflow measuring range [m³/min]
No. 1	18	0.20 to 0.42
No. 2	28	0.42 to 0.90
No. 3	42	0.90 to 1.90
No. 4	60	1.90 to 3.90
No. 5	82	3.90 to 8.00

Any of these five types of nozzles can be attached to the Airflow Tester to suit the airflow being measured. The new product features a guidance system to guide the user if he or she chooses a nozzle for an airflow outside of its measurement range, providing advice on which nozzle type to use to enable highly accurate measurement within the appropriate range.

3.3 Data Viewer Software

The measured data can be confirmed on the operating panel on the top face of the main unit or as a graph on a computer when an RS-232C - USB serial convertor is used. Figure 5 shows a screenshot from the Data Viewer Software, specialized software used to convert measurement data into graph format.

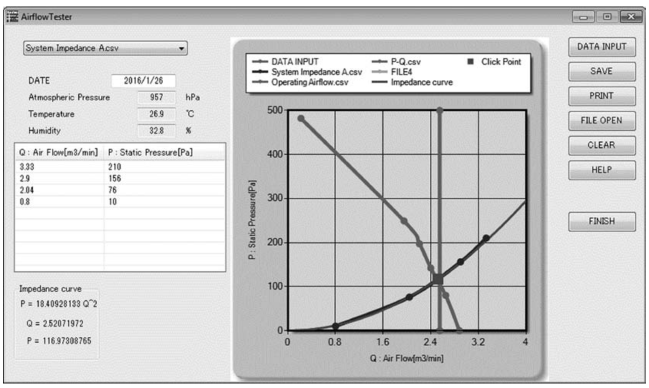

Fig. 5: Screenshot from the Data Viewer Software

Data on system impedance, operating airflow, and the fan's P-Q performance are shown in a layered format, and the airflow and static pressure values are displayed when the user selects an arbitrary point on the graph (for example where the graph intersects). For this reason, the operating point of the fan when it is installed in a device can be easily found. Moreover, a quadratic curve passing through the selected point can be drawn and its inclination (pressure loss coefficient) also automatically calculated. The information displayed on the graph can be saved in CSV format and also utilized with spreadsheet calculation software, etc. Moreover, if the saved CSV data is loaded, the same display as when the measurement was taken can be reproduced and displayed together with data measured afterwards.

4. Example of Fan Selection Using the Airflow Tester

An approximation of system impedance can be obtained from the quadratic curve and expressed in the following formula from static pressure (Ps) and airflow (Q).

$$Ps = C \cdot Q^2$$

Here, C is referred to as the pressure loss coefficient and it is a coefficient determined by load from the equipment, etc. If the pressure loss coefficient is large, so too is the system impedance, making it difficult for air to flow. On the other hand, air will flow easily if the pressure loss coefficient is small.

Here, we will provide an example of selecting the optimal fan for a device by utilizing data measured on the Airflow Tester and this relational expression.

4.1 Fan selection by measuring the system impedance of a device

This section will explain how to measure system impedance, then select the optimal fan from the measured values and airflow required to cool the device.

First, measure the system impedance of the device and, as shown in Figure 6, draw an approximation of the quadratic curve. Next, identify the required operating point from the intersection with the formula-derived minimum airflow necessary to cool the device. Select fans which have P-Q curves that pass close to the top right of this operating point. Of the possible candidates, select the fan with the lowest SPL and power consumption at the operating point.

In the case of Figure 6, since Fan A and Fan B meet the required operating point, they would create no problems insofar as cooling performance. However, of the two fans, Fan B has lower SPL (4 dB(A)) and lower power consumption (4.2 W) at the operating point, so it can be said that Fan B is the best choice. In this way, the optimal fan for the device can be selected accurately and easily.

4.2 Fan selection by measuring the operating airflow of a device

This section will explain how to select an even better fan by measuring operating airflow when a device is already equipped with a fan.

First, use the Airflow Tester to measure the operating airflow of the device. Next, as Figure 7 shows, plot the P-Q performance curve of the mounted fan, then find the intersection of the measured operating airflow. This is the operating point of the current fan. Next, draw a quadratic curve ($Ps=C \cdot Q^2$) passing through this operating point to obtain the system impedance curve. Find the minimum airflow needed to cool the device through calculation or lowering the speed of the current fan. The point where the quadratic curve, $Ps=C \cdot Q^2$, and the necessary airflow intersects is the operating point. Select fans which pass closely to the top right of this operating point. Of the possible candidates, select the fan with the lowest SPL and power consumption.

As Figure 7 shows, the currently installed Fan A actually has higher airflow than necessary to cool the device. By changing to Fan B, the cooling performance requirement can still be satisfied, but with an SPL reduced by 5 dB(A) and power consumption reduced by 5.4 W; therefore, Fan B is the optimal fan for this device. In this way, the Airflow Tester significantly contributes to the optimal design of a equipment.

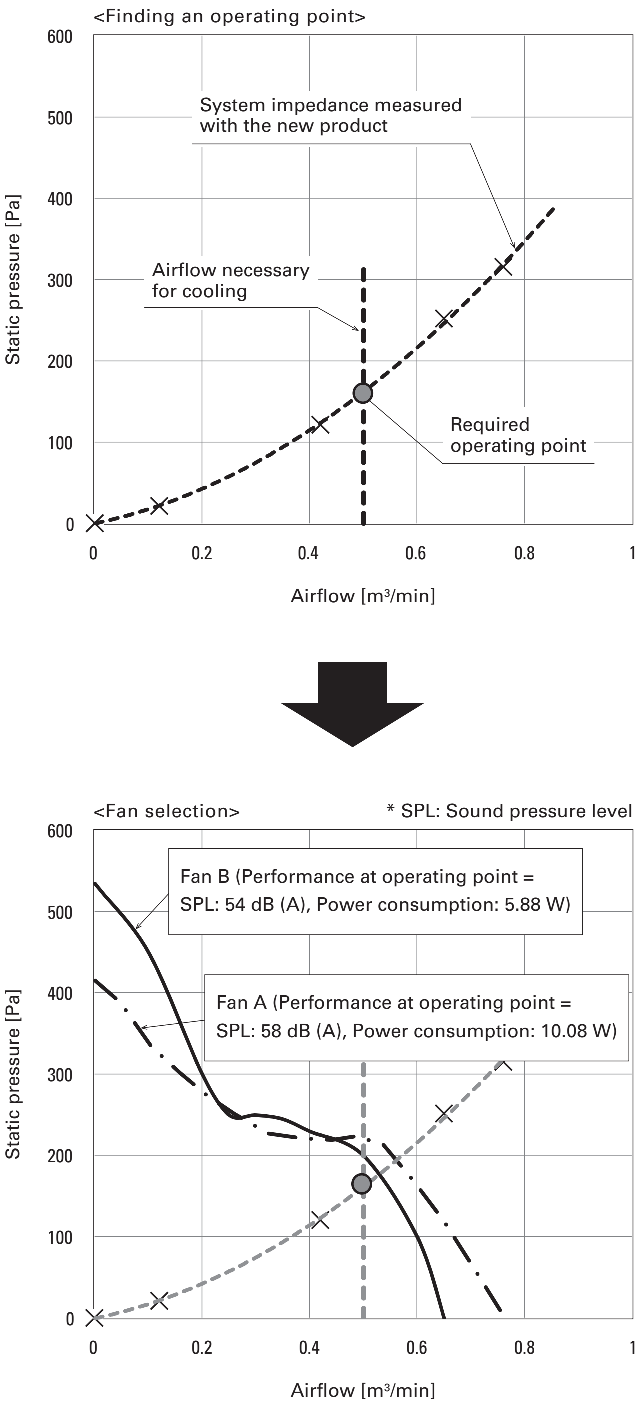

Fig. 6: Optimal fan selection from the system impedance of a device

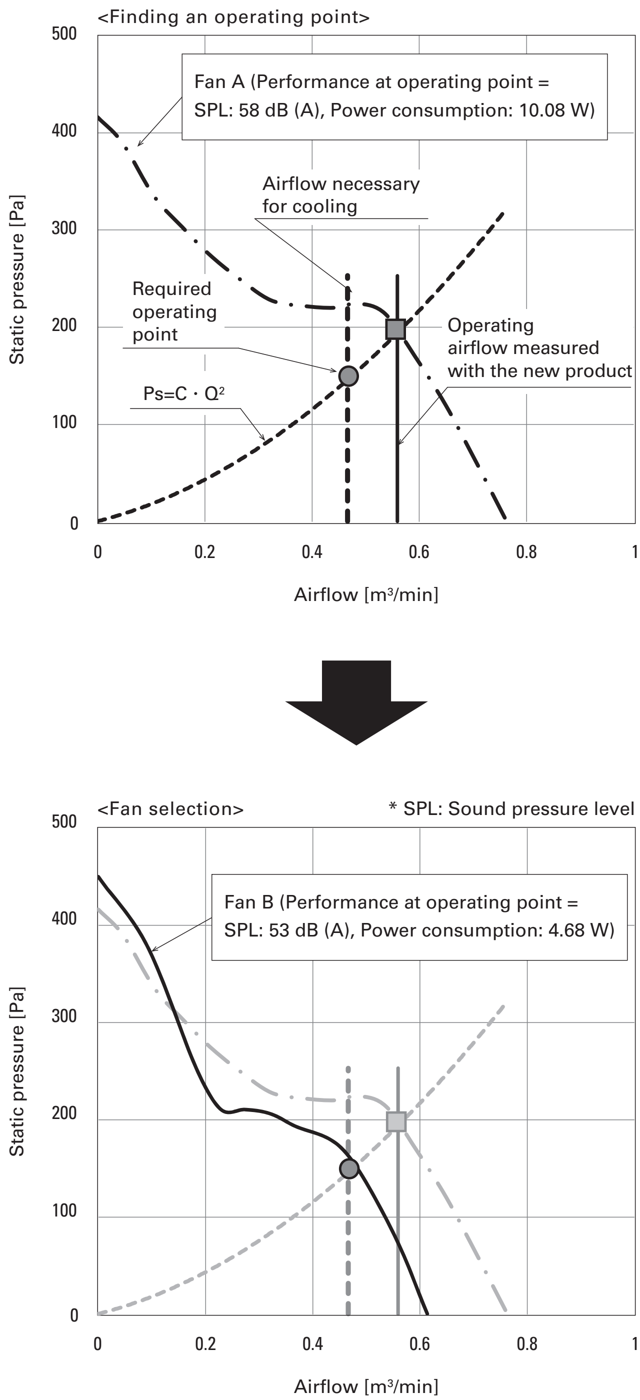

Fig. 7: Fan selection from the operating airflow of a device

5. Conclusion

This paper introduced the features of the "San Ace Airflow Tester" developed by SANYO DENKI. This product enables the measurement of system impedance and operating airflow in order to select the optimal fan. The new product is the first in the industry* that is compact and portable, and enables easy measurement of system impedance and operating airflow. With the "San Ace Airflow Tester", for the first time ever it is possible for our customers to clearly see the system impedance and operating airflow of a device during its development, greatly contributing to the optimum selection of fans and shortening development cycle times.

We wish to continue engaging in product development from the viewpoint of our customers and offer products which match our customers' needs.

* Current as of Sept. 14, 2016 in accordance with SANYO DENKI's investigation

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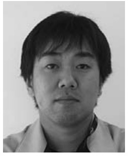

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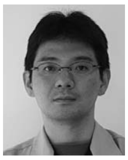

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