Cooling Systems Specialty Technologies for Achieving High Airflow and High Static Pressure

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1. Introduction

Under our corporate philosophy of "Aim to help all people achieve happiness," SANYO DENKI has set three technical concepts. These are (1) technologies for protecting the global environment, (2) utilizing new energy, and (3) conserving energy. Based on these concepts, we have always developed *San Ace* cooling fans with a certain goal in mind. The goal is to realize a quiet fan with a long lifespan, minimal power consumption, and the highest airflow vs. static pressure characteristics possible.

This article will introduce our specialty technologies used in the development of *San Ace* fans to achieve high airflow and high static pressure products.

2. Background to the Demand for High Airflow and High Static Pressure

In recent years, driven by the advancement of cloud services, demand has been growing for rack mount servers (Fig. 1) used in data centers. Our fans are used in many of these servers, which are representative of ICT equipment. Generally speaking, rack mount servers are designed to be mounted in 19-inch wide racks, as standardized by the American Electronic Industries Alliance. Heights are standardized in multiples of U (44.45 mm), such as 1U, 2U, and 4U. Racks are the mainstream for server shape, and can accommodate stacks of up to forty two 1U servers so space in data centers can be used efficiently.

As with regular servers used in offices, rack mount servers have a CPU, memory, HDD, and power supply. To ensure stable operation, it is necessary to not exceed the manufacturer's guaranteed temperature for each device, and using fans for cooling is a common approach. Figure 2 depicts an example of a 1U server. There are eight 40 × 40 mm fans in the center of the device, and there is also a 40 × 40 mm fan in the power supply, as shown in Figure 3.

With the spread of the internet, the processing speed and data volume handled by servers have been rising year by year, and the heat generation of each device has increased along with these changes. Moreover, the density of components inside devices is increasing, so fans must be compact while also having high airflow and high static pressure.

Fig. 1 Example of a rack mount server
(Photo courtesy of Super Micro Computer, Inc.)

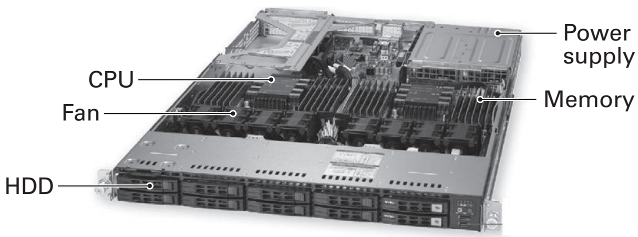


Fig. 2 Example of a 1U server
(Photo courtesy of Super Micro Computer, Inc.)

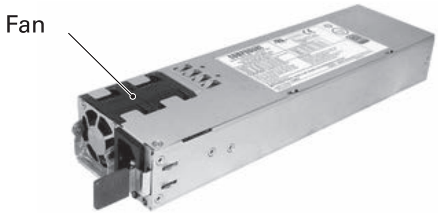


Fig. 3 Example of a 1U power supply
(Photo courtesy of Compuware Technology Inc.)

3. Specialty Technologies

3.1 Specialty technology (1): Axial fan with static blades

Let me explain the transition to high airflow and high static pressure demanded from fans used in rack mount servers. Generally speaking, to increase fan airflow, it is necessary to either increase motor speed or increase blade size. Moreover, to increase static pressure, it is necessary to either increase motor speed or alter the shape of the blades and frame to ones where static pressure can be easily secured. Meanwhile, for 1U servers, there is the aforementioned height restriction of 44.45 mm, so fan height cannot exceed 40 × 40 mm.

1U servers released in the late 1990s were equipped with our 40 × 40 × 28 mm 9P type axial fans (hereinafter 40 × 40 × 28 mm fan). Since then, whenever a new server model was developed there was a demand for higher airflow. This could be handled by increasing fan speed through minor changes such as changes to the drive circuit.

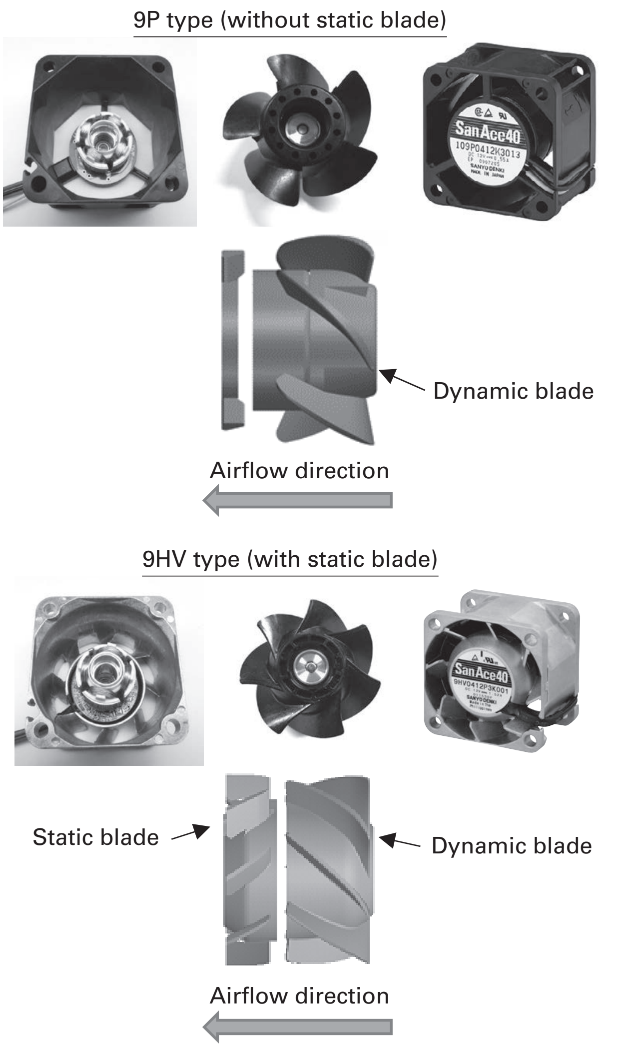


Fig. 4 Example of structures for our 40×40×28 mm fans

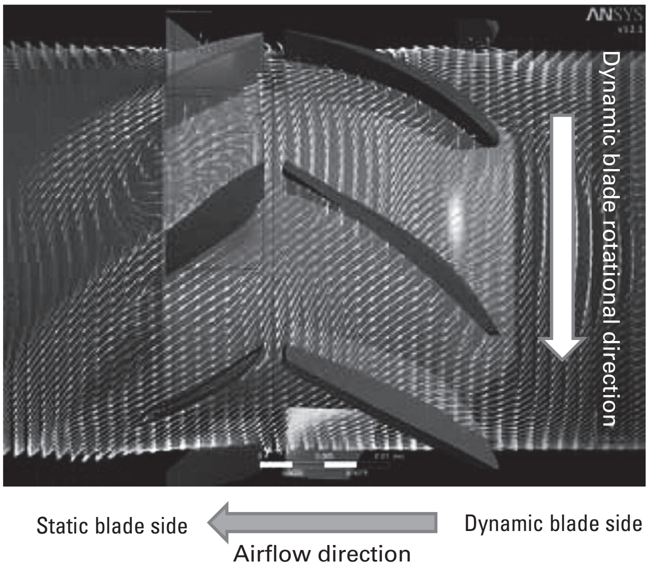


Fig. 5 A vector diagram of the air in a fan with static blades

However, by 2003, it had become difficult to effectively achieve the target airflow vs. static pressure characteristics simply through increased motor speed. We believed one of the reasons for this was that the rotating air from the dynamic blades was not contributing to axial airflow, but rather causing the flow created by the dynamic blades to lose energy.

Hence, as shown in Figures 4 and 5, we placed backward static blades in front of the dynamic blades to change the rotating air flow to the axial direction and suppress energy loss. The angle of the rotational component created by a dynamic blade varies between the area near where the blade is attached and the area near the blade tip, so we designed a static blade that match these angles. Moreover, because the overall frame thickness was 28 mm, which was insufficient to secure enough thickness of static blades in the axial direction. As such, we increased the number of static blades with the aim of increasing the rectifying effect.

Furthermore, we optimized the overall blade/frame shape, magnetic circuit, and drive circuit to minimize power consumption and noise level while maintaining the target airflow vs. static pressure characteristics.

Regarding this axial flow fan with static blades, we developed the 9GV type, 9GA type, and 9HV type for the 40 × 40 × 28 mm size in 2008, 2012, and 2015, respectively. The performance of these is shown in Table 1 and Figure 6. Compared to the 9P type (109P0412H3013) developed in 1987, the 9HV type developed in 2015 has a maximum airflow around 2.6 times greater, and a maximum static pressure around 10.7 times greater.

Table 1 Example of general specifications of our typical 40 × 40 × 28 mm fans

Model no.	Speed [min^{-1}]	Max. airflow [m^3/min]	Max. static pressure [Pa]	Power consumption [W]	SPL [dB(A)]
109P0412H3013	8,700	0.32	102.9	2.34	37
109P0412K3013	15,500	0.59	340.0	6.6	50
9GV0412K301	16,500	0.76	415.0	10.08	58
9GA0412P3K01	22,000	0.81	799.0	11.04	61
9HV0412P3K001	25,000	0.83	1,100	18.3	65

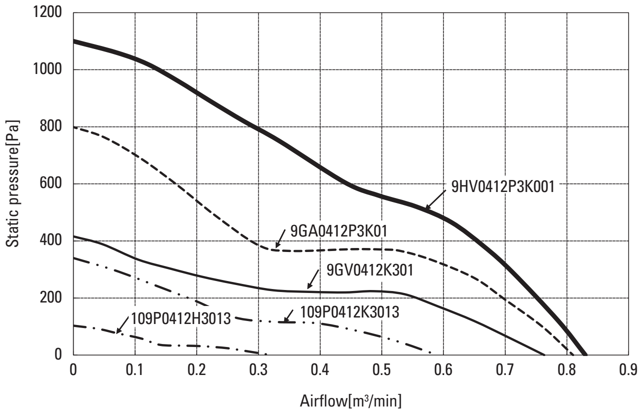


Fig. 6 Example of airflow vs. static pressure characteristics of our typical 40 × 40 × 28 mm fans

3.2 Specialty technology (2): Counter Rotating Fan

With the higher heat generation and higher component density shift in 1U servers, the cooling performance of the 40 × 40 × 28 mm fan was no longer sufficient, and cases emerged where two fans were being used in series. When two axial fans are arranged in series in the same rotational direction, similarly to the axial fans without static blades discussed in Section 3.1, rotational components remain. Hence, collision loss is caused by the flow produced by the inlet fan's dynamic blades and that of the outlet fan's dynamic blades. As a result, airflow vs. static pressure characteristics improved slightly, but it could not sufficiently satisfy the performance requirement.

In light of this, we developed the Counter Rotating Fan in 2004 as a counter rotating axial flow fan comprising an inlet fan and an outlet fan where the respective dynamic blades rotate in opposite directions. As shown in Figure 7, by installing static blades shaped to smoothly receive the flow from the inlet dynamic blades, we achieved a configuration in which the rotating flow was converted to axial flow by the outlet dynamic blades. Consequently, as Table 2 and Figure 8 show, the airflow vs. static pressure characteristics were significantly improved and we were able to solve the issue of static pressure drops in specific zones characteristic of axial flow fans.

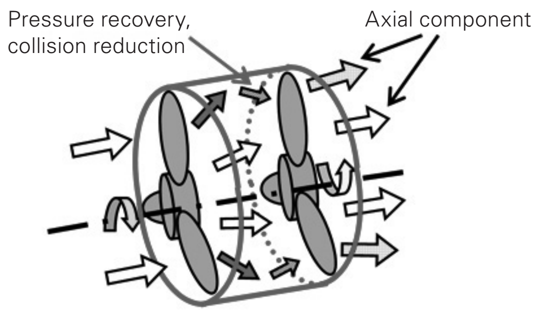


Fig. 7 Illustration of Counter Rotating Fan flow

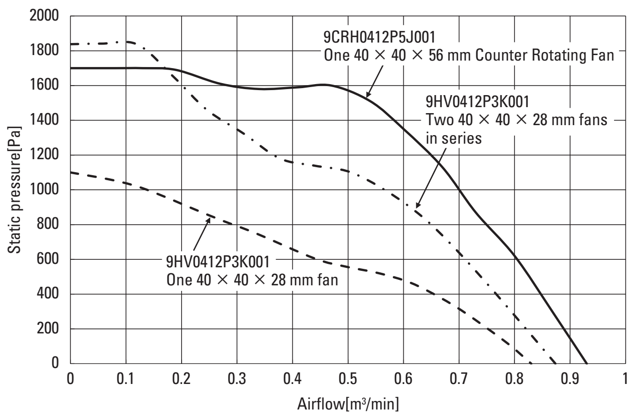


Fig. 8 Example of airflow vs. static pressure characteristics of our typical 40 × 40 mm fans

The 40 × 40 × 56 mm Counter Rotating Fan 9CRH type developed in 2017 (shown in Figure 9), has a maximum airflow 1.3 times greater and maximum static pressure 3.3 times greater than those of the 9CR type developed in 2004. Furthermore, as shown in Figure 10, flow straightness is dramatically improved compared to when an axial fan is used in isolation or in a series of two. By releasing these Counter Rotating Fans, we could offer customers unprecedented new solutions to meet their needs for higher airflow and higher static pressure.

Table 2 Example of general specifications of our typical 40 × 40 mm fans

Model no.	Speed [min^{-1}]		Max. airflow [m^3/min]	Max. static pressure [Pa]	Power consumption [W]	SPL [dB(A)]
	Inlet	Outlet				
9HV0412P3K001 **One 40 × 40 × 28 mm fan**	25,000		0.83	1,100	18.3	65
9HV0412P3K001 **Two 40 × 40 × 28 mm fans in series**	25,200	30,900	0.87	1,840	28.0	77
9CRH0412P5J001 **One 40 × 40 × 56 mm Counter Rotating Fan**	29,500	25,500	0.93	1,700	30.24	70

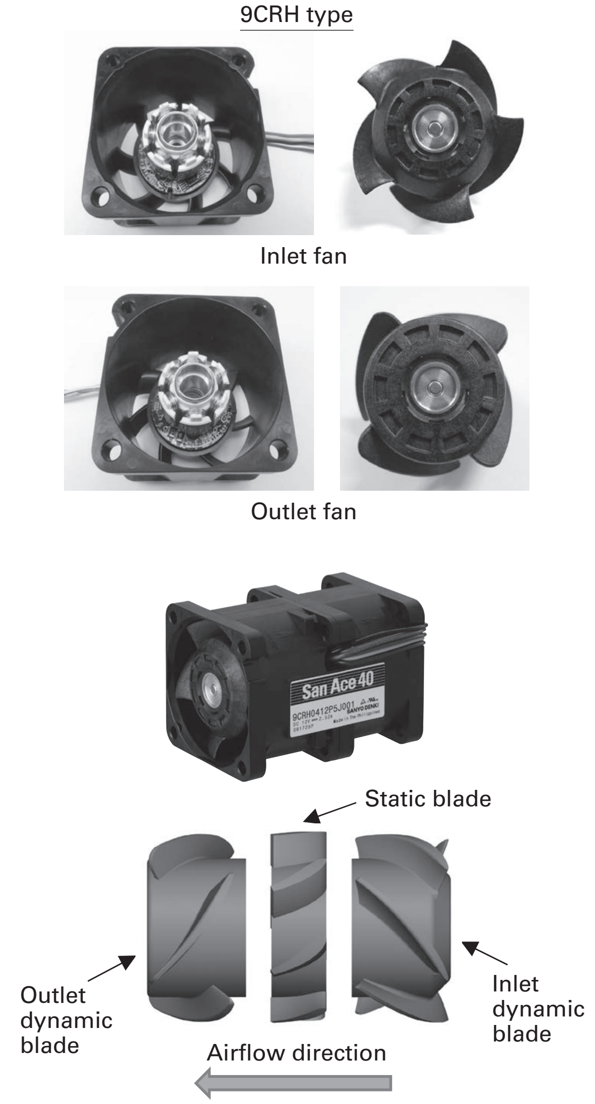
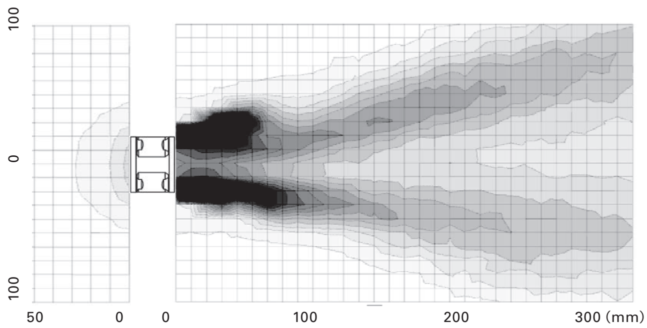
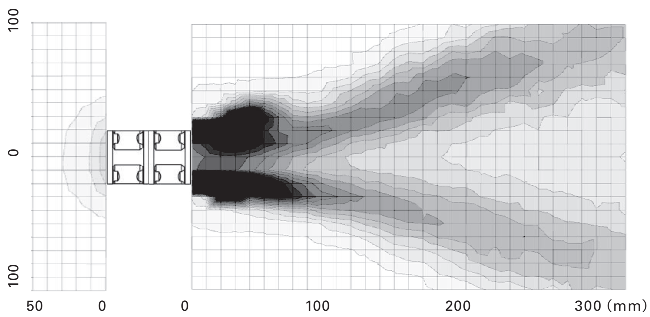


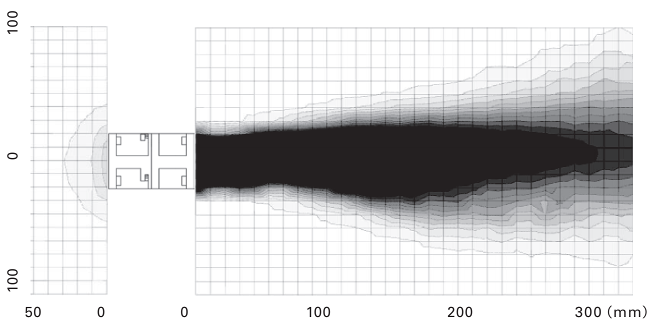
Fig. 9 Example of structure for our 40 × 40 × 56 mm Counter Rotating Fan



40 × 40 × 28 mm 9HV type fan (25,000 min^{-1})



Two 40 × 40 × 28 mm 9HV type fans in series (Inlet fan 25,200 min^{-1}/outlet fan 30,900 min^{-1})



40 × 40 × 56 mm Counter Rotating Fan 9CRH type (Inlet fan 29,500 min^{-1}/outlet fan 25,500 min^{-1})

Fig. 10 Wind speed distribution (in free air and at rated voltage)

Furthermore, in addition to the 40 × 40 mm size, our current lineup has 36 × 36 mm, 60 × 60 mm, 80 × 80 mm, 92 × 92 mm, 120 × 120 mm, and ø172 mm Counter Rotating Fans. These are being actively adopted in a variety of industrial equipment, such as ICT equipment requiring compact fans with extremely high operating airflow.

4. Conclusion

This article introduced our specialty technologies for achieving high airflow and high static pressure used in the development of our *San Ace* fans, with a focus on the technologies used for fans with static blades and Counter Rotating Fans. The development of these technologies enables us to deliver optimal solutions to our customers who face cooling issues. SANYO DENKI will continue to strive toward technological development so that we can keep offering solutions matching our customers' concerns.

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