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SANYO DENKI AMERICA

Factors to consider when strategically integrating 1U high performance cooling fans for efficient thermal management

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1. Introduction

The onrush of high-performance processors, such as CPU and GPUs, are ever-increasing in applications such as 1U servers, internet switches, and information and computer technology (ICT) equipment. The amount of data being processed is increasing, larger heat densities are becoming the norm, while the allotted device packaging space is shrinking. As a result, thermal management becomes a crucial aspect of these systems. One method of thermal management is increasing airflow by optimizing the system's cooling fan.

To satisfy these requirements, Sanyo Denki developed and launched the High Static Pressure Fan San Ace 36 9HV type, 9HV3612P3K001, with PWM control function.(1) Building onto the recent product release, this article will introduce strategies to mitigate heat – putting two fans in parallel and clearing obstructions to the inlet airflow.

2. Product Overview

Table 1 shows the product features of the fan. The fan's size is 36 x 36 x 28 mm, which fits perfectly in 1U cooling rack applications and allows for a bit of extra space compared to the traditional fan size of 40 x 40 x 28mm for 1U server applications.

Table 1: Characteristics of High Static Pressure Fan, San Ace 36 9HV Type.

Model No.	Rated voltage	Operating voltage range	PWM duty cycle	Rated current	Rated input	Rated Speed	Max. airflow		Max. static pressure		SPL:	Operating temperature range	Expected life
	(V)	(V)	(%)	(A)	(W)	(min^{-1})	(m^3/min)	(CFM)	(Pa)	(inchH_2O)	(dB[A])	(°C)	(h)
9HV3612P3K001	12	10.8 to 13.2	100	1.75	21.0	32500	0.72	25.4	1400	5.62	67	-20 to +60	30000/60°C 53000/40°C
			20	0.05	0.6	6000	0.12	4.2	47.2	0.19	26		

3. Operating Two Fans in Parallel and Spacing

A straight-forward method of increasing airflow through a system is to mount another cooling fan. The positioning of a second fan is an important consideration - whether the fans would run in parallel, in tandem, or in different mounted locations in a system. In theory, putting two fans in parallel would double the total airflow. For parallel fans in compact systems, there is a demand for reducing the space between the two fans, as showcased in **Figure 1**.

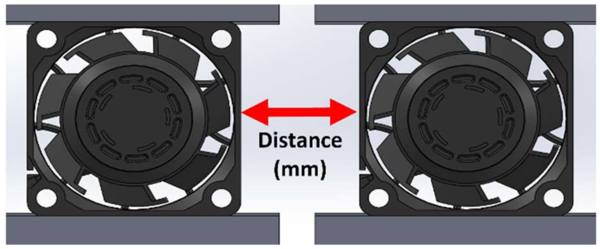

Fig. 1: Parallel fan setup. To save space in a system, the distance between the two fans needs to be minimized.

However, when two fans are placed too close together, it is also important to account for possible interference from turbulence on the fan outlet side. Therefore, the spacing between two fans in parallel was studied, from large separation distance to small separation distance, and compared to a single fan. The static pressure (P) and air flow rate (Q) performance[2] is shown in **Figure 2** (P-Q curve). The dotted red, purple, and blue lines represent system impedance examples, ranging from high impedance to low impedance.[3] The yellow dotted circle is the operating zone where Sanyo Denki recommends running the fans for highest efficiency.

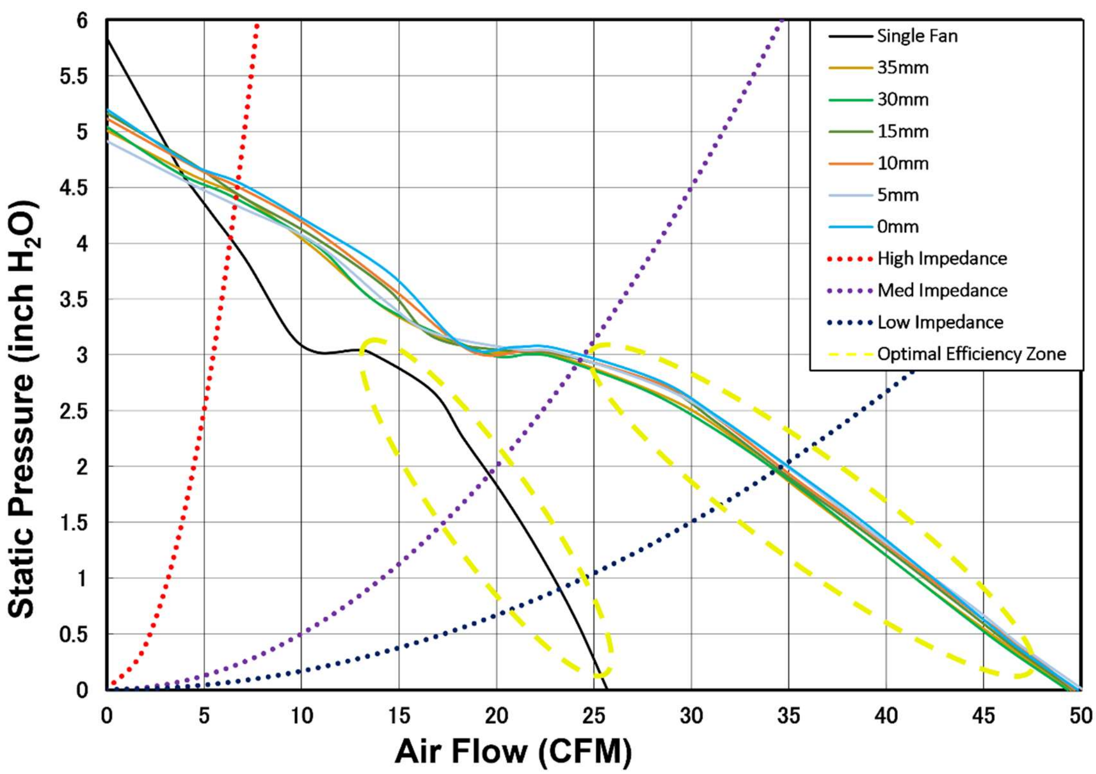

Fig. 2: P-Q curve of the San Ace 36 9HV type fan. Single fan and parallel fan setups with various spacing are shown (ref. **Fig. 1**).

From the data set, all the parallel fan setups with distances from 0mm up to 35mm appear to have similar P-Q performance. Due to the 36mm 9HV type fan's particularly small size, the distance between parallel fans has negligible performance impacts. It is also observed that in the parallel setup, the airflow rate does double, up to 50 CFM when compared to the single fan setup, which has an airflow of 25 CFM. Therefore, placing the 9HV3612P3K001 fans in parallel allows for great design flexibility as the fans can be placed close together to save space, or further apart to target different areas of the system to cool.

4. Effect of Obstruction Experiment

Another placement variable that can be detrimental to fan operation is whether the inlet of the fan has obstructions. The distance between a flat sheet of metal and the inlet side of a single or parallel fan setup was studied, and the setup is shown in **Figure 3**.

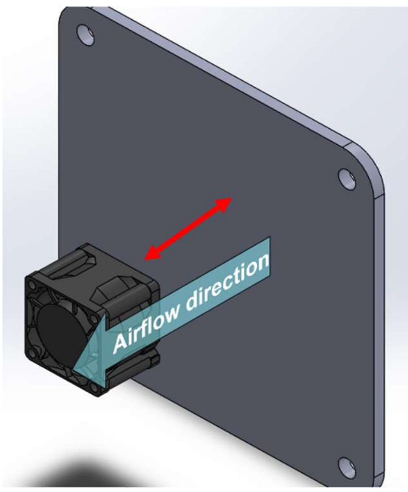

Fig. 3a: Single *San Ace* fan and inlet obstruction.

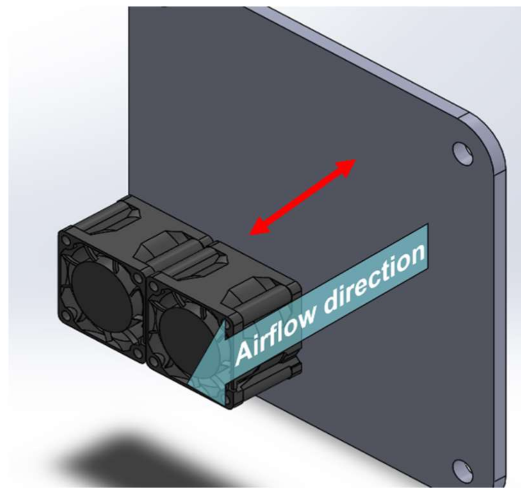

Fig. 3b: Parallel *San Ace* fans (0mm distance between the two fans) and inlet obstruction.

4.1 Single Fan and Obstructions

Initially, a single fan and its inlet obstruction distance was studied (**Figure 3a**). The P-Q curve is shown in **Figure 4**.

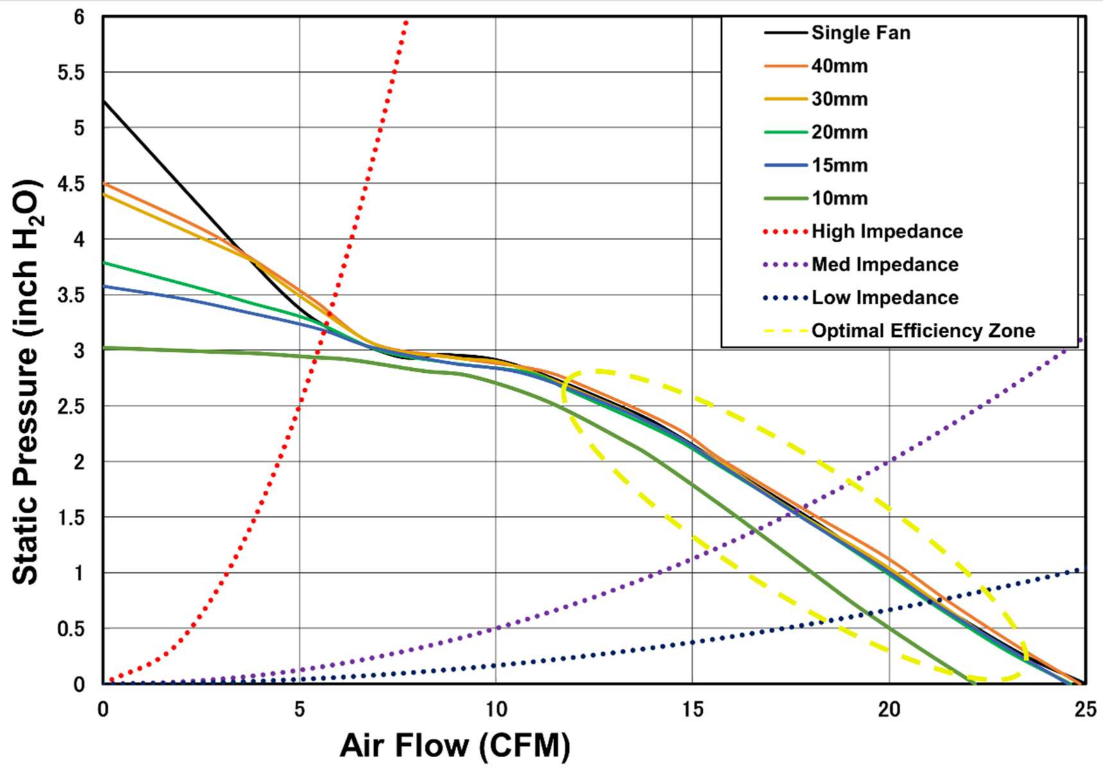

Fig. 4: Single fan 9HV3612P3K001 P-Q performance curve at various outlet blockage distances (ref. **Fig. 3a**).

As a baseline, the single fan data was also included. It was found that inlet obstruction distances of 40mm, 30mm, 20mm, and 15mm had negligible impact on the performance of the fan. When the inlet obstruction was placed within 10mm of the fan inlet, there was a noticeable reduction in the air performance of the fan.

4.2 Parallel Fan and Obstructions

Following the single fan test, parallel fan inlet obstruction was tested. From the findings in **Figure 2**, parallel fans with 0mm spacing were selected for the obstruction evaluation because the airflow performance was stable, and the configuration has the most space-saving potential for a system. The setup is shown in **Figure 3b**, and the accompanying results are shown in **Figure 5**.

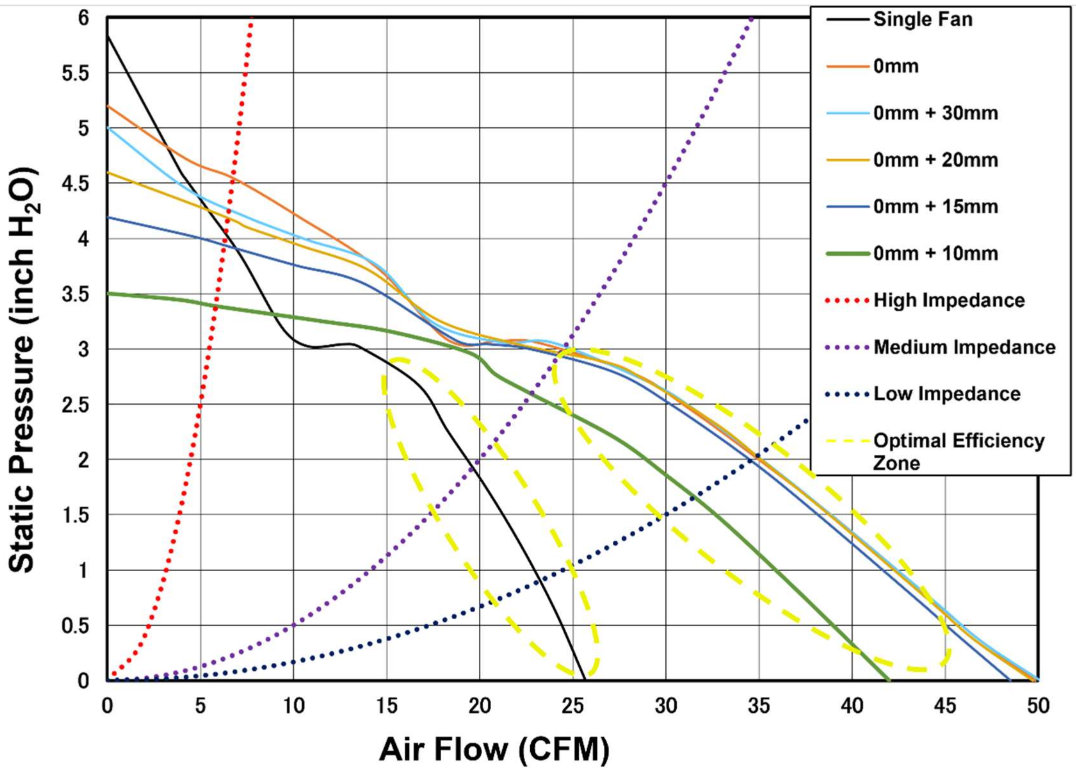

Fig. 5: Parallel fans of 9HV3612P3K001, space 0mm apart. P-Q performance curve at various outlet blockage distances (ref. **Fig. 3b**).

Mirroring the trend found in the single fan and obstruction setup, for the parallel fan setup, there were negligible performance effects from inlet obstructions at 30mm, 20mm, and 15mm. However, once the inlet obstruction got closer at 10mm, there was reduction of the airflow performance for the parallel setup. To maximize airflow performance of a single or parallel fan setup, it is recommended to keep inlet obstacles at least 15mm away from the fan.

5. Conclusion

Smaller form factors and higher performance fans can contribute to new energy efficient ICT equipment, which has broad-ranging applications that can protect the environment and people's health and safety. Some examples of the applications include green infrastructure, advancement of healthcare research such as cloud computing for infectious diseases, vaccine development, and biomolecular modeling. Other usage cases could lead to increasing healthcare access and availability of information, improving remote work access, and bolstering virtual learning and education.

This article has overviewed the space limitation and thermal management challenges in a high-performance system, and introduced San Ace 36 9HV type fans, which address these challenges. 9HV3612P3K001 has an innately small form factor at 36 x 36 x 28mm while delivering high static pressure and high airflow performance on par with its 38 x 38mm and 40 x 40mm San Ace counterparts.

Sanyo Denki studied compact fan placement and found that incorporating a parallel fan setup at any spacing and keeping obstructions at least 15mm away from the inlet would optimize the cooling performance of a system, while saving space in that compact system.

There are future studies that Sanyo Denki plans to conduct. Some include investigating the performance of parallel fans in an actual system and studying the distance between inlet obstruction versus sound performance.

(1) Akira Nakayama and 5 others: “High Static Pressure Fan San Ace 36 9HV Type.” *SANYO DENKI* Technical Report No. 47, pp. 11-15 (2019.05). Retrieved from <https://www.sanyodenki.com/archive/document/corporatedata/technicalreport/2019/TR47E_p11_SanAce36.pdf>.

(2) “Session 4 – Airflow and Static Pressure.” *SANYO DENKI* Training – Fan Basics. Accessed July 2021. Retrieved from <https://techcompass.sanyodenki.com/en/training/cooling/fan_basic/004/index.html>.

(3) “Session 7 - System Impedance of Devices.” *SANYO DENKI* Training – Fan Basics. Accessed July 2021. Retrieved from <https://techcompass.sanyodenki.com/en/training/cooling/fan_basic/007/index.html>.