MPU Cooler "SAN ACE MC-HX"

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1. Introduction

The recent progress in MPU (microprocessor) technology is remarkable as MPU, the brain of the computer, continues to become faster, more sophisticated, and more integrated. This trend brings with it the increasing amount of heat generated by the microprocessor, making it increasingly more important to use a highly efficient, high-performance and low noise cooling device to keep the MPU cool.

To meet such a demand, we have developed MPU cooler "SAN ACE MC-HX" for Pentium® 4.

This article outlines the product and describes its features.

2. Background to Development

It is not only the amount of heat generated but also the heat density that is increasing with microprocessors that are becoming faster and more sophisticated, making it necessary to develop a cooling device designed to diffuse effectively the localized heat.

Sanyo Denki has developed the MPU cooler “SAN ACE MC Series” for cooling microprocessors.[1],[2],[3] With some exceptions, the "SAN ACE MC" Series use a heat sink of aluminum base material as the most cost effective way to obtain optimum performance. In contrast, our new product “SAN ACE MC-HX” for Pentium® 4 developed with our main focus on its performance rather than cost, comes with a characteristic spiral heat sink made of copper to provide a dramatically higher cooling performance than that provided by any conventional type.

3. Product Overview

Fig. 1 shows the newly developed "SAN ACE MC-HX" for Pentium® 4., and Fig. 2 shows its dimensions. Table 1 shows its performance specifications.

With its cooling fan and heat sink built into one "SAN ACE MC-HX" is a cooling device developed specifically for the Pentium® 4 microprocessor. "SAN ACE MC-HX" for Pentium® 4 features:

(1) Fanning structure of Sanyo’s original fan and heatsink
(2) High cooling performance
(3) Characteristically shaped heat sink
(4) Low noise
(5) High reliability and long life

Fig. 1 "SAN ACE MC-HX" for Pentium® 4

3.1 Structure

The structure of the newly developed "SAN ACE MC-HX" for Pentium® 4 is characterized as follows:

(1) The fan is located on the air intake side with the heat sink on the outlet side to improve the length of service life as well as cooling performance.
(2) The frame is shaped such that the airflow will least affected even if the obstruction is moved closer toward the fan's intake. With "SAN ACE MC-HX" for Pentium® 4 actually incorporated into equipment, the volume of air produced by the fan will be kept from dropping to ensure that the cooling performance is least affected.
(3) The heat sink is built of copper, a material known to have excellent heat conductivity.
Furthermore, the fins are arranged to form a spiral that allows the air discharged from the fan to flow effectively into the fins.

3.2 Performance

(1) Heat sink

Fig. 3 shows the heat sink adopted for the new product.

This heat sink consists of fins, fin base, and heat sink base. These three components are built of copper, which is known to have excellent thermal conductivity. The parts are jointed by soldering.

Sanyo Denki has traditionally primarily used aluminum as the heat sink material. Heat sinks are built using either of the following two processes; ① Die cast and ② Extrusion. The characteristics of the conventional heat sinks are as follows:

Model No.	Rated voltage [V]	Operating voltage range [V]	Rated current [A]	Rated rpm [min^{-1}]	Thermal resistance [K/W]	Sound Pressure level [dB(A)]	Weight [g]
9H9912G5016	12	9 - 13.8	0.23	5200	0.37	39	410

Table 1 "SAN ACE MC-HX" for Pentium® 4 Performance Specifications

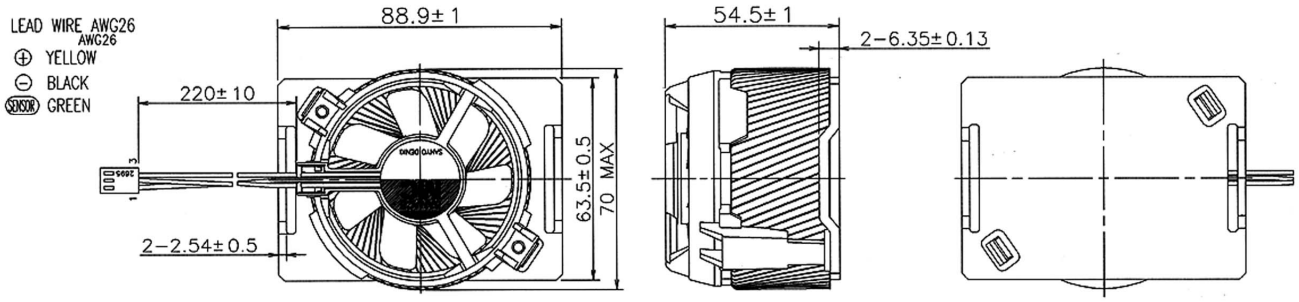

Fig. 2 "SAN ACE MC-HX" Dimensions

①Aluminum die cast heat sink

- Less geometrical restriction because of its conformity to any shape
- Fins can be arranged to suit the airflow, making it easier to obtain high cooling performance and reduce noise.
- Fins can only be perpendicular to the base, making it difficult to arrange the fins slanted with respect to the axis rotation of the fan.
- The building material is required to possess high fluidity (ex. ADC-12). However, such materials are usually poor heat conductivity rather than that of genuine aluminum, not so suitable if cooling performance is your first priority.

②Aluminum extrusion heat sink

- Easy to produce, hence, the low production cost.
- Fins will be arranged in a straight line due to its extrusion method, making the heat sink produced not so effective in providing the best cooling performance and reduced noise.
- Many restrictions on the design of the heat sink, such as on the fin shape, fin height, and fin pitch.

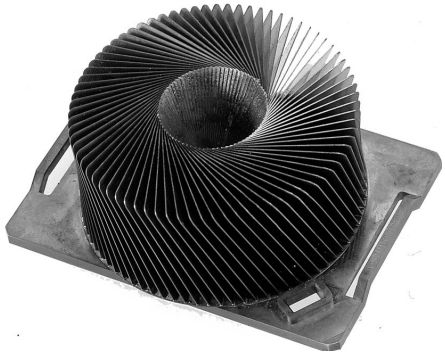

Fig. 3 Heat Sink

In sharp contrast with this, the heat sink for "SAN ACE MC-HX" has 77 fins that form the heat radiator, all slanted with respect to the axis of rotation and arranged in a circle around the axis of fan rotation. This configuration allows the largest possible radiation area and the airflow from the fan to be effectively discharged as it is blown against the fins. The slanting angle of the fins has been determined through experiments to suit the airflow from the fan so the optimum cooling performance can be obtained.

Thus, the new heat sink inherits all the advantages from conventional types and has overcome their disadvantages to provide high cooling performance and low noise.

(2) Fan motor

The fan motor used in "SAN ACE MC-HX" is specially designed to match most of the performance of the heat sink discussed above. Fig. 4 shows the fan motor.

To achieve optimum performance, particularly when "SAN ACE MC-HX" is built into equipment, the venturi is provided one step lower than the label on the boss to secure the air flow passage even if the obstruction is moved closer to the upper part of the fan, thus maintaining good cooling performance. In addition, the blade shape, distance between blade and spoke, distance between blade and fins, and the shape of the spoke root have been optimized to provide a large air volume and low noise operation.

Fig. 4 Fan Motor

(3) Cooling performance

A Comparison has been made between the cooling performance of "SAN ACE MC-HX" and an conventional model.

Assuming the heat generated by the microprocessor (MPU) is 60W and the ambient temperature is 45℃, the surface temperature of the MPU is as follows: (see Fig. 5)

①"SAN ACE MC-HX"

The thermal resistance being 0.37 K/W, the increase in MPU surface temperature Δt can be given as follows:

$\Delta t=60(W)\times 0.37(K/W)$
$=22.2(K)$
Therefore, the MPU surface temperature T_c is given as follows:
$T_c=45(℃)+22.2(K)$
$=67.2(℃)$

②An conventional model
Take "SAN ACE MC" 109X9612S5016 (Heat sink: Aluminum extrusion) for example. The thermal resistance being 0.44K/W, the increase in the MPU surface temperature Δt is given as follows:

$\Delta t=60(W)\times 0.44(K/W)$
$=26.4(K)$
Therefore, the MPU surface temperature T_c is given as follows:
$T_c=45(℃)+26.4(K)$
$=71.4(℃)$

It is clear from this that the increase in surface temperature can be reduced by some 4℃ for as high as 60W of heat generation.

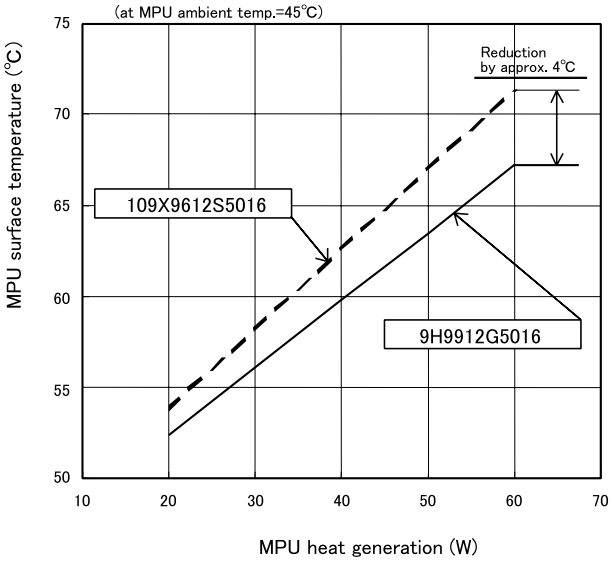

Fig. 5 MPU Temperature Comparison

(4) Noise characteristics

The level of the noise generated by "SAN ACE MC-HX" is 29 dB [A] for the same cooling performance as yielded by the above-mentioned "SAN ACE MC" 109X9612S5016 model whereas the level of the noise generated by "SAN ACE MC" 109X9612S5016 model under the same condition is 40 dB[A]. The result represents reduction in noise level by as much as 11dB[A] for the same cooling performance. (see Fig. 6).

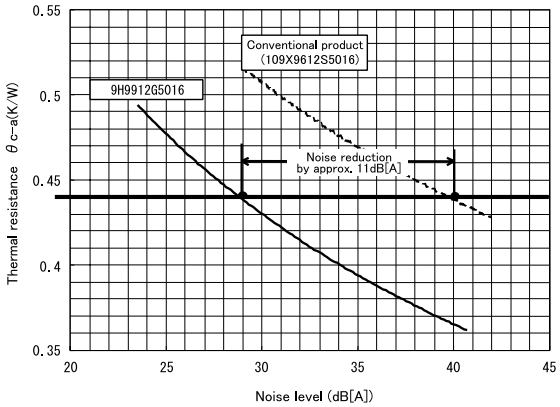

Fig. 6 Noise vs. Cooling Characteristics Comparison

Such a significant noise level reduction for an MPU cooler can be attributed not only to the superior cooling performance but also to the fins arranged in a spiral circle that reduces the fluid noise.

4. Conclusion

We have introduced some part of the structure and performance of the newly developed "SAN ACE MC-HX" for Pentium® 4.

The heat generated by microprocessor and heat density are expected to increase as microprocessors continue to develop just as they have, becoming higher performance and faster.

Under such circumstances, there will continue to be demand for more compact and higher performance cooling devices with lower noise level.

* Pentium® used in this article is a trademark of Intel Corporation.
* "SAN ACE MC-HX" pending patent application

References

(1) Development of MPU cooler "SAN ACE MC" (by Ogawara et.al)
SANYO DENKI Technical Report, No.1 p.9 - p.14 (May 1996)
(2) "SAN ACE MC note" (by Watanabe et.al)
SANYO DENKI Technical Report, No.4 p.23 - p.25 (May 1997)
(3) Development of "SAN ACE MC" for Pentium® Ⅲ & Pentium® 4 (by Ogawara et.al)
SANYO DENKI Technical Report, No.11 p.5 - p.8 (May 2001)

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