MPU Cooler for Pentium®4, "SAN ACE MC"

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1. Introduction

In recent years, technical progress of the microprocessor (MPU), which is the brain of a computer, has been remarkable, and its high speed, advanced features, and high integration are being enhanced. In connection with this, the heating value from a microprocessor has been also increasing quickly. The product with a heating value (Thermal Design Power) exceeding 80W has appeared in the Pentium®4 processor from Intel Corp.

In order to maintain stability while operating a microprocessor with a high heating value, a cooling device which has high cooling performance and high reliability compared with the conventional product is been needed.

In our company, in order to meet such a demand, the MPU cooler for Pentium®4, "SAN ACE MC", was developed and produced commercially.

Its product outline and its feature are introduced in this document.

2. Background of the Development

Until now, in our company, the MPU cooler "SAN ACE MC" series has been produced commercially as a cooling device for Pentium®4 microprocessors from Intel Corporation.(1)(2)(3) However, in the conventional product series, the performance was insufficient for cooling the microprocessor of the heating value of 80W class.

Then, the development of "SAN ACE MC", which has much higher cooling performance than before, was started. Diffusing heat efficiently by using copper, which has high heat conductivity, in addition to the conventional aluminum was examined. Moreover, the surface area of a cooling fin of a heat sink was examined to expand as much as possible, satisfying the conventional size and mass spec, in order to raise a cooling performance. The form of a fan motor was also designed in consideration of cooling performance and noise.

In this way, the MPU cooler was developed.
"SAN ACE MC" for Pentium®4.

3. Outline of the Product

The MPU cooler "SAN ACE MC" for Pentium®4 produced commercially is shown in Fig. 1, and its size specifications are shown in Fig. 2. Also, the performance overview of the product is shown in Table 1.

Fig. 1 MPU Cooler "SAN ACE MC" for Pentium®4

This product is the cooling device developed for Pentium 4 processors, which unified a cooling fan and a heat sink. The feature of the product are indicated below:

(1) Sanyo original structure for the fan and the heat sink
(2) Heat sink inserting copper pillar in the aluminum extruded hollow fin
(3) High cooling performance
(4) Low noise
(5) High reliability and long life

Table 1 Performance Overview of the MPU Cooler for Pentium®4, "SAN ACE MC"

Model	Rated Voltage [V]	Operating Voltage Range [V]	Rated Current [A]	Rated Rotation Speed [min^{-1}]	Thermal Resistance [K/W]	Sound Pressure Level [dB[A]]	Mass [g]
109X9912S0016	12	9～13.8	0.48	5400	0.295	45	450
109X9912T0S016*Note1	12	9～13.8	0.48	5400	0.295	45	
				2610	0.420	28	

*Note1.This model is a thermally speed control type. It operates slow for intake air of a fan being 32℃ or lower and faster for 40℃ or higher.

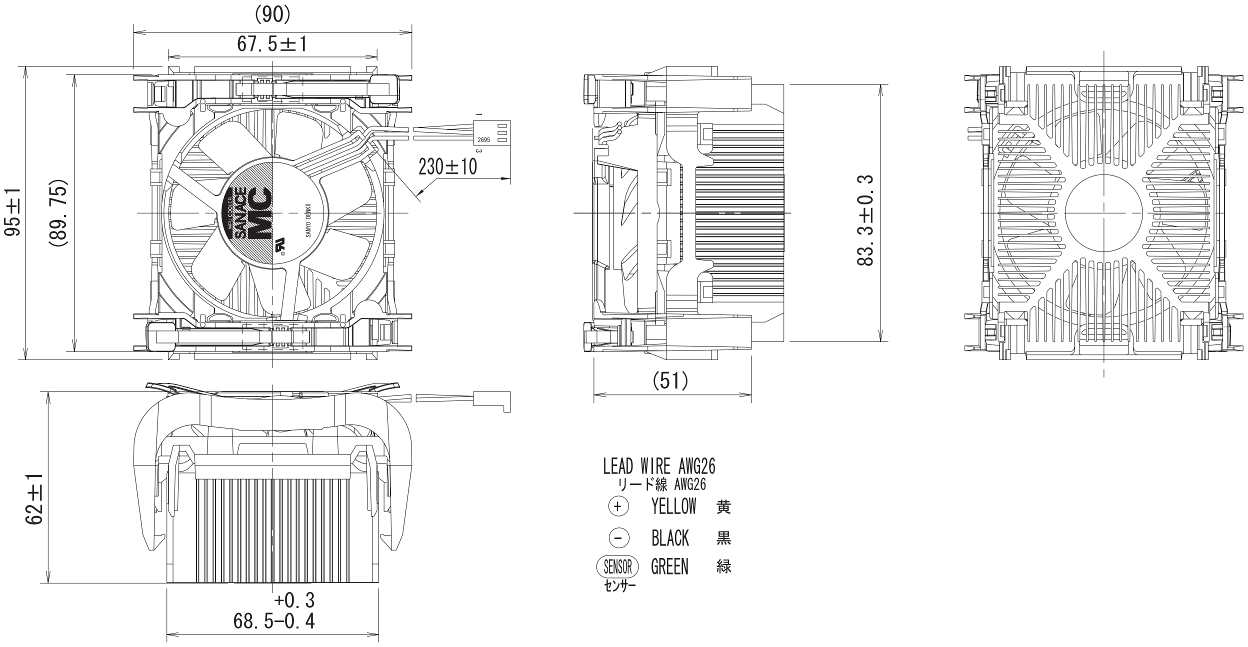

Fig. 2 Dimensional Overview of the MPU Cooler for Pentium®4, "SAN ACE MC"

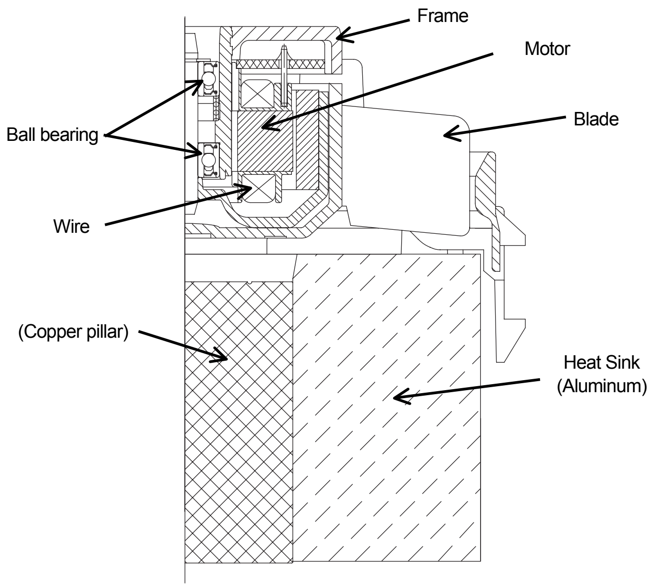

Fig. 3 Structure Drawing of "SAN ACE MC" for Pentium®4

3.1 Structure

The features of the structure of the "SAN ACE MC" for Pentium®4 are listed below. The structure drawing is shown in Fig. 3.

(1) The fan is located on the intake side, and the heat sink is located on the exhaust side. This structure contributes to the improved life of the fan and to increased cooling performance.

(2) It adopts a unique form for the heat sink by inserting a copper pillar into the aluminum extruded hollow fin. A high cooling performance is realized by this structure, while suppressing an increase in mass.

(3) Even if mounted in comparatively thin equipment, the frame shape is improved so that even if an obstruction stands close to the fan intake side, there is still sufficient intake area. This reduces the loss of cooling performance.

3.2 Performance

(1) Heat Sink

The heat sink consists of two parts and has put the creativity for realizing a high cooling performance. Copper, excellent in heat conduction, was adopted as the base, and the form was made into a pillar shape. In addition, the structure, which uses an aluminum extrusion material for a hollow cylinder and extends a fin to the four quarters, was used for the fin. It increases the surface area, while suppressing an increase in mass. The copper pillar is inserted into the hollow of the aluminum structure, creating the heat sink shown in Fig. 4.

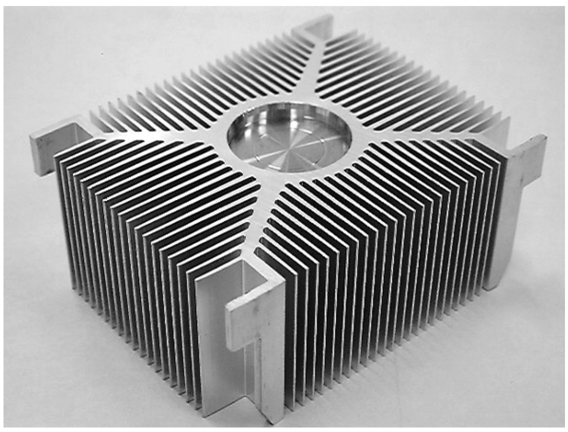

Fig. 4 Heat Sink

In this product development, one of the goals was to attain a high cooling performance within the mass restrictions of 450g. Generally, as cooling performance increases, mass tends to become heavy, due to designs that increase the number of fins in an attempt to make the heat dissipation area of a heat sink expand, or that thickens the base of a heat sink in order to raise the thermal conductivity, etc. Moreover, if copper, which excels in heat conductivity, is used for a material of a heat sink, performance will improve, but mass will increase similarly. Therefore, not all heat sinks are constituted from copper material, but copper is used only for the heat sink's central part, and it was determined to use aluminum for a fin part. However, a target cooling performance is unrealizable only by embedding copper material in the central part of the conventional aluminum extruded heat simply.

The performance of a heat sink is determined by the heat dissipation area and amount of exhausted air, which passes over the heat dissipation. Therefore, it is necessary to reconcile the opposite conditions of securing the opening area for the air sent by the fan passing and increasing the heat dissipation area of a fin. Therefore, it was not made to extrude and arrange a fin part perpendicularly to a fan's axis of rotation like the conventional extruded heat sink, but it was made to extrude a fin to a fan's direction of the axis of rotation. And it was considered as the composition, which spreads a fin from a center to the four quarters. Thereby, the surface area of a fin was increased about 16% to the conventional extruded heat sink, and the opening area for ventilation could be secured. Moreover, heat is quickly diffused in the height direction of the heat sink central part, and it enabled it to conduct heat to each fin by inserting heat conductive high copper pillar in this fin hollow part. By these, the high cooling performance of heat resistance of about 0.3 K/W was attained, suppressing the increase in heat sink mass to about 20% of the conventional product.

(2) Fan

The fan that carried in the product was designed to exclusive use in consideration of a cooling performance and noise. The fan is shown in Fig. 5.

Fig. 5 Fan

Since larger air volume was needed in comparison with the former to attain high cooling performance, the size rise of fan size and the motor size was carried out. In addition, the venturi part was designed to be lowered one step from the motor part so that performance is demonstrated when fan is actually put in apparatus. It secures a path of air even if the obstruction approaches the upper part of the fan.

Furthermore, the shape of a blade, the distance of a blade and a fin, and the direction of a spoke to blade etc., were optimized, and large air volume and low noise levels were attained.

(3) Comparison With the Conventional Product

The result of comparing the size, the cooling performance, and the mass of this product and the conventional product is shown in Table 2.

Even though the size of this product is equivalent and the mass is increased approx. 80g (approx. 22%) compared with the conventional product, heat resistance has been improved sharply by 0.125 K/W (about 30%) as a result of an exclusive design so that the performance of a fan and a heat sink can be pulled out to the maximum extent as mentioned. This degree of improvement shows that temperature rise reduction of 10K can be attained as compared with the conventional product, when the heating value for cooling is 80W.

Table 2 Comparison Table

Model	Size of Exterior [mm]	Mass [g]	Thermal Resistance [K/W]
109X9912S0016	95 × 74 × 62	450	0.295
109X9812H0016	95 × 71.3 × 62.5	370	0.420

Moreover, the noise in the same cooling performance was compared in Table 3. Consequently, about 10dB[A] of noise reduction was attained compared to the conventional product, and equipment noise can be reduced by using this product.

Table 3 Comparison Table of Noise at the Same Cooling Performance

Model	Thermal Resistance [K/W]	Rotating Speed [min^{-1}]	Sound Pressure Level [dB[A]] *Note2
109X9912T0S016	0.420	2610	28
109X9812H0016	0.420	3900	39

*Note 2. Sound pressure level is the value at1 m from fan intake side

4. Conclusion

A part of the structure and performance of the MPU cooler for Pentium®4, "SAN ACE MC" were introduced. Heating value increases with performance improvement, and speed increases of microprocessors continue to be expected. In such a situation, it is thought that smaller size and greater cooling performance of a cooling device will be demanded.

* Pentium® in the text is the registered trademark of Intel Corporation

Reference

(1) Ogawara and others :"SAN ACE MC" for Pentium®III & Pentium®4
SANYO DENKI Technical Report, No.11 pp5-8 (2001-5).
(2) Watanabe and others : MPU Cooler "SAN ACE MC-HX"
SANYO DENKI Technical Report, No.12 pp25-28 (2001-11).
(3) Ikeda and others: "SAN ACE MC" for Pentium®4 1U Server
SANYO DENKI Technical Report, No.14 pp20-23 (2002-11).

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