High Performance Liquid Cooling System "SAN ACE MC Liquid"

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1. Introduction

Microprocessor units (MPU), the brains of any computer, are becoming faster, with more functionality and greater capacity. The heating value from microprocessors is increasing rapidly as a consequence. Some microprocessors have a heating value that exceeds 100W, leading to growing demand for better cooling performance from cooling devices.

Another requirement that has recently become more critical is for computer equipment to generate less noise. This has in turn made important to reduce the noise made by cooling devices.

In response, SANYO DENKI has developed a high performance liquid cooling system called San Ace MC Liquid. This is a cooling device that simultaneously achieves both high cooling performance and low noise.

This paper describes the product and introduces its features.

2. Background to the Development

SANYO DENKI has been releasing air-cooling MPU coolers in the SAN ACE MC series, which integrate a cooling fan and heat sink, as cooling devices for microprocessors. [1], [2], [3], [4]

The following improvements needed to be made for air cooling MPU coolers to achieve high cooling performance:

- Increase the surface area of the heat sink
- Use material with high heat conduction for the heat sink
- Use a high air volume fan

These improvements in turn involved issues with the enlargement and mass increase of the heat sink as well as the increase in noise caused by the high air volume of the fan motor. We were testing the limits of air cooling.

We then started developing a liquid cooling system as a new cooling device to replace the air cooling MPU cooler.

The liquid cooling system we have developed has improved cooling performance and is also designed to produce less noise compared with conventional air cooling MPU coolers. In addition, the radiator, reserve tank, pump, and fan were integrated to improve ease of installation, maintainability, and flexibility.

The result is a product known as San Ace MC Liquid.

3. Product Features

Fig. 1 shows San Ace MC Liquid, a liquid cooling system.

Fig. 1 Liquid Cooling System: SAN ACE MC Liquid

The features of the product are as follows:

(1) High cooling performance

Cooling performance has been improved approximately 32% at the same sound pressure level compared with air cooling MPU coolers.

(2) Low noise

The sound pressure level has decreased approximately 23dB(A) at the same cooling performance compared with air cooling MPU coolers.

(3) Ease installation in information devices

The same ease of installation as that of the air cooling system has been realized by integrating the radiator, reserve tank, pump, and fan.

(4) High reliability and long life

An expected life of 40,000 hours was achieved without the need to replenish cooling liquid. This is thanks to the reliable and durable components (radiator, pump, connection tube, fan, and cold plate).

(5) Flexibility

A diverse array of microprocessors and other electronic parts can be cooled by preparing unique installation metal fittings for the cold plate.

4. Introduction to the Product

Fig. 2 is a cross-section look at the SAN ACE MC Liquid.

Table 1 shows a performance overview of the product.

4.1 Structure

The features of the structure and components of this new liquid cooling system are as follows.

This product consists of a cold plate, radiator, pump, tube, and fan. Fig. 3 shows the parts that make up this product.

The cooling method used by SAN ACE MC Liquid is explained below.

The heat originating from the MPU is absorbed by a cold plate and is transmitted to the cooling liquid which flows around the cold plate. After depriving the cold plate of its heat, the cooling liquid itself becomes warm. So it is sent to the radiator and cooled using the air generated by the fan. The cooled cooling liquid circulates around the cold plate, and once again deprives the cold plate of its heat. An electric pump is used to circulate the cooling liquid.

(1) Cooling Liquid

Long life coolant (hereafter, LLC) is used for the cooling liquid. For the LLC, we looked at ethylene glycol and propylene glycol, choosing propylene glycol because it has less toxicity and is therefore superior in environmental terms. A corrosion control solution to protect parts from corrosion was also added.

The freezing temperature changes depending on the density, although the LLC is used with a solution. The freezing temperature of the propylene glycol solution is about -35℃ with a 50% solution and -15℃ with a 30% solution. In addition, the cooling performance changes depending on the density. Since the higher the density, the lower the cooling performance, we chose a 50% solution, taking into account the actual operating environment and cooling performance.

Fig. 4 shows the relationship between the density and cooling performance of the cooling liquid.

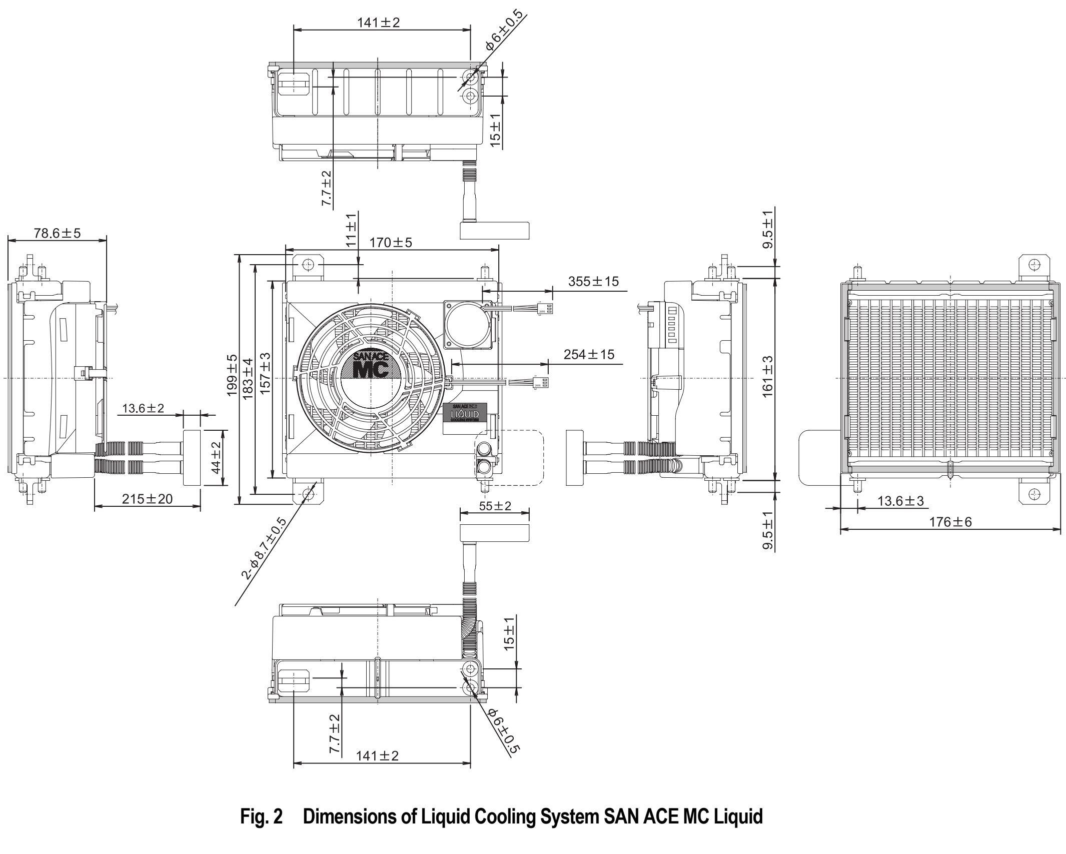

Fig. 2 Dimensions of Liquid Cooling System SAN ACE MC Liquid

Table 1 Performance Overview of Liquid Cooling System "SAN ACE MC Liquid"

Model	Rated Voltage (V)	Operating Voltage Range (V)		Rated Current (A)		Rated Rotating Speed (min^{-1})		Thermal Resistance (K/W)	Sound Pressure Level (dB[A])	Mass (g)
		Fan	Pump	Fan	Pump	Fan	Pump			
109-LC1-001	12	7-12.6	7-12.6	0.25	0.12	2400	2000	0.22	42	1150
						1300	2000	0.255	28	

* The fan in this product is a thermally speed controlled fan. It operates at low speed when the temperature of the air flows into the radiator is lower than 25℃ and at high speed when the temperature is higher than 35℃.

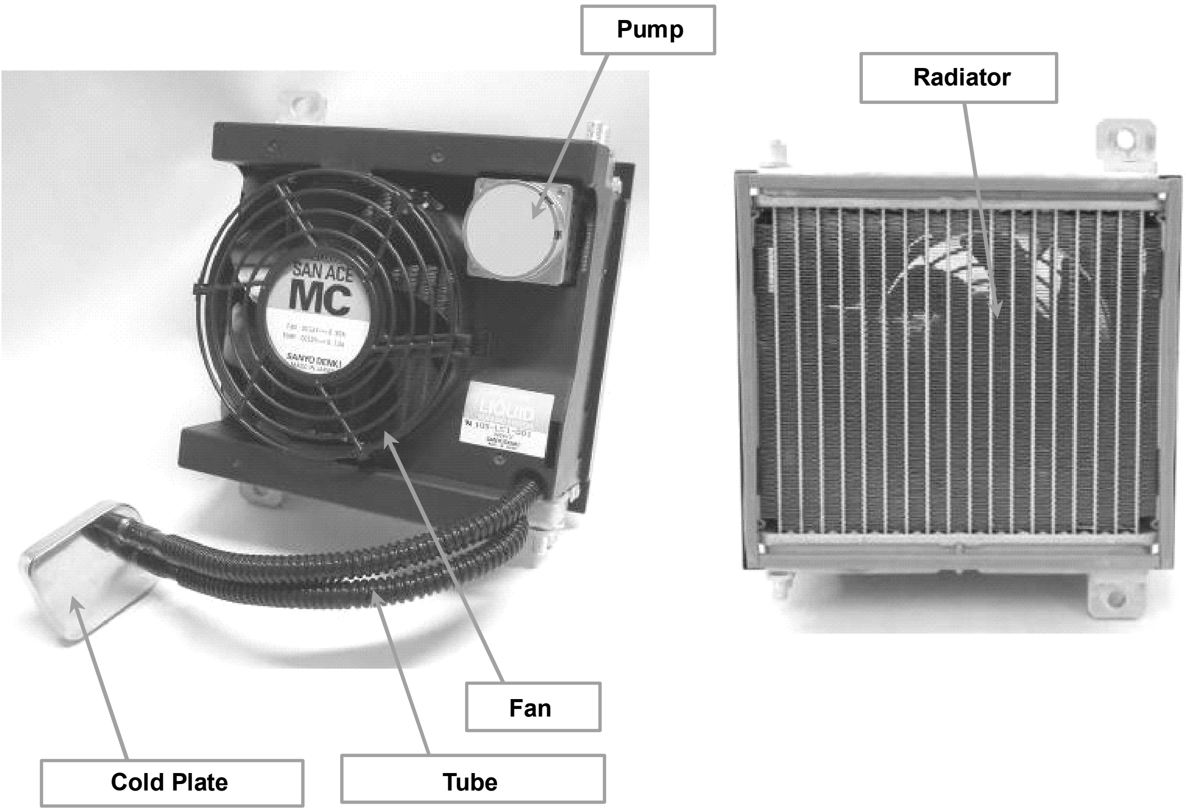

Fig. 3 Component Structure of the Liquid Cooling System "SAN ACE MC Liquid"

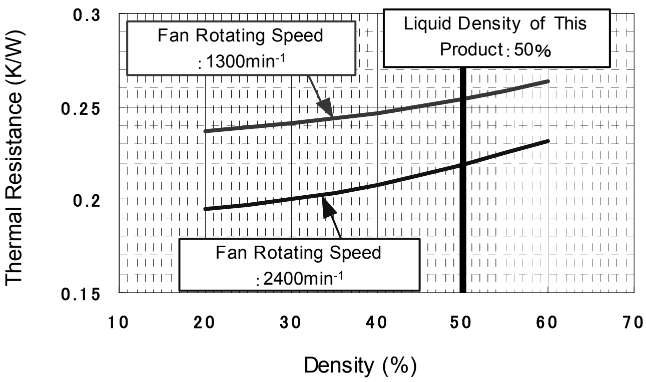

Fig. 4 Relationship Between Density and Cooling Performance of the Cooling Liquid

(2) Cold Plate

To improve cooling performance of cold plate, increment of radiation area and speed of cooling liquid are required. In other words, it is necessary to increase the number of fins to increase the heat radiation area and narrow the pitch (width of the flow path of the cooling liquid) of each fin to speed the cooling liquid flow.

In developing SAN ACE MC Liquid, our focus was to optimize the thickness of the base and the fins and the fin pitch, given the limited size.

To achieve higher cooling performance, copper was used as the material for the cold plate, as it has excellent heat conduction. Since copper oxidizes and discolors, the exterior was nickel plated. We have also optimized the type and thickness of the nickel plating to minimize its thermal resistance.

(3) Radiator

Increasing the area of the heat radiation fin and the volume of the ventilation that passes through the heat radiation can raise the cooling performance of the radiator. In reality, the load of the radiator (ventilation resistance) rises when the number of heat radiation fins is increased excessively, and the volume of ventilation decreases compared with a radiator with few heat radiation fins. In addition, when the load is large, the noise also tends to increase. The radiator of this product is designed to achieve the right balance between cooling performance and noise by optimizing the thickness of the core and the fin pitch.

The space was saved by using the radiator tank also as a reserve tank.

Multi layer aluminum—which is light, highly reliable and corrosion resistant—was used as the material.

(4) Tube

We chose the fluorinated resin tube.

Fluorinated resin has a low liquid penetration percentage. It also has advantages with its excellent chemical resistance, heat resistance, weather resistance and minimal deterioration after years of use, not only under a variety of environmental conditions but also with any chemical or temperature.

We also adopted a bellows shape for a tube to prevent a tube collapse in which the flow of the liquid was obstructed when it is bent. The tube, as a result, became flexible enough to make it easier to set up the cold plate at a time of installation.

(5) Small Pump

The small pump installed in this product was developed for exclusive use in consideration of high performance, low noise, low power consumption and long life. The basic form of the pump is a centrifugal type. Fig. 5 shows a structural chart of this pump.

This pump uses a magnet pump structure to completely separate the pump and motor. The sealing of the pump has been improved using an O ring together with seal material, and it has a highly reliable structure with absolutely no liquid leakage outside or into the motor.

The motor for the pump drive has the same design as the BLDC fan motor, which has produced excellent results in our company. The motor achieved low power consumption while retaining adequate water supply capabilities, in this system with a radiator with a high load and a cold plate.

A unique underwater bearing is used in the pump that circulates the cooling liquid and it is a long-life type suitable for maintenance-free liquid cooling system.

(6) Fan

A thermally speed controlled-type BLDC fan is employed, given its strong track record in our company.

Sufficient ventilation volume was secured while lowering the rotating speed to decrease the noise by making an impeller the size of the maximum diameter that can be installed in this product. We have achieved even better noise reduction by optimizing the distance between the radiator and the fan, and designing the fan frame for exclusive use.

The piping tube was installed in the fan frame to look refined and simple.

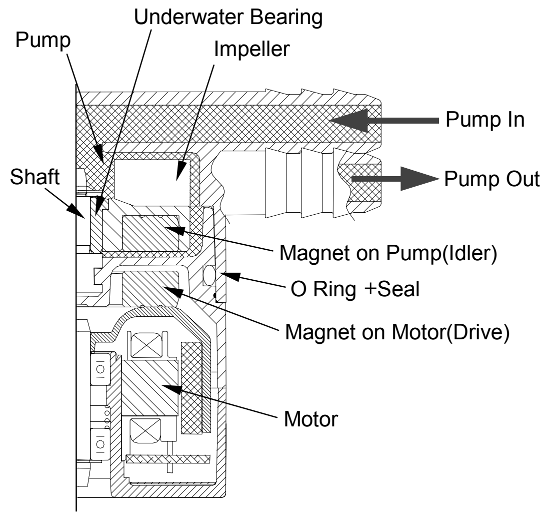

Fig. 5 Structural Diagram of Small Pump

4.2 Performance

(1) Comparison with conventional products

The result of a comparison of the cooling performance and the sound pressure level between SAN ACE MC Liquid and a conventional product (air cooling MPU cooler) is shown in Fig. 6.

This product achieved a decrease of 0.12 K/W (approx. 32%) in thermal resistance compared with the conventional product at the same sound pressure level (28dB [A]). This improvement is equal to a temperature difference of 12K assuming the heat to be cooled is 100W and it signifies an improvement over the conventional product.

In addition, compared with the same cooling performance (0.28K/W), this product achieved a noise reduction of approx. 23dB[A]. This corresponds to a sound pressure level of approx. 2000min^{-1} minutes in a 120 square fan.

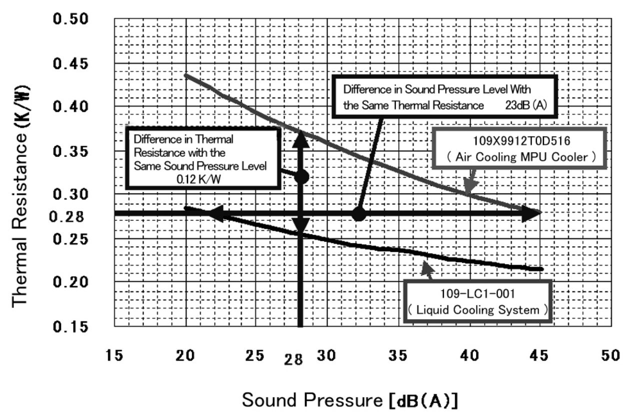

Fig. 6 Comparison of Performances Between the Liquid Cooling System and Air Cooling System

With this new liquid cooling system, all components were designed for exclusive use and optimized, so this system achieved high cooling performance and low noise as described.

We have also realized an expected life of 40,000 hours with no maintenance requirements, by leveraging our conventional technology and carefully examining the reliability of each component.

4. Conclusion

This paper introduced the structure and performance of the SAN ACE MC Liquid high performance liquid cooling system. Demand for reduced noise is likely to continue to grow as microprocessors improve their performance and become faster. Heating values will likewise continue to rise.

The liquid cooling system has the potential to comprehensively meet these needs compared with air cooling MPU coolers, the most commonly used product today.

The liquid cooling system also has potential application not in the computer equipment sector but also in the digital home electric appliance industry, is ease of installation in information instruments and reliability are improved, and costs are reduced.

References

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