New Cooling Technology for a Projector with a High Brightness of 3,000 lumens (lm) and the World Beating Light Weight of 1.6kg

TAKAMATSU Hiroaki, MASUDA Naoki, LEE Junsi, NISHIMURA Yoshifumi, SAKAI Shigenori, TANI Yusuke

Abstract

In its efforts to increase luminance and decrease the size of projectors, NEC has developed a new cooling technology that supports high-density packaging and also features an industry-first use of a small air pump.

The latest projector models have incorporated this technology achieving a luminance of 3,000lm from a lightest-in-the-class 1.6kg body weight.

Keywords

projector, high luminance and light weight, compact air pump, new cooling technology

1. Introduction

This projector has been made available for use in fields where a magnified projection of video is required, such as in enterprises and education facilities. While the keys to competition success are the high luminance and high resolution, the reduction in size and weight is also an important factor in the context of the recent expansion in mobile use.

In general, increasing the luminance requires a lamp with a higher output. As this tends to increase the cooling system size, there is a conflict with the need for size and weight reduction.

This paper introduces a new cooling technology developed to support compatibility between the two issues outlined above by taking our new projector (model NP60, see **Photo**) as an example.

2. Measures for Luminance Improvement and Size Reduction

In our development of a projector model with higher luminance and smaller size we placed emphasis both on improving its packaging density and on reducing the cooling system size

Photo NP60.

Table Main product specifications of NP60.

Item	Details
Method	1 Chip DLP®/color separation by color filter rotation
Pixels	1,024 × 768 (768,432 pixels)
Light source	220 W AC bulb
Luminance	3,000 lm
Contrast ratio	1,600:1
Screen size	33” to 300”
Power consumption	285 W
Dimensions	246(W) × 72(H) × 177(D) mm (without projections)
Weight	1.6 kg

by improving the cooling efficiency.

With regard to the improvement of the packaging density, we applied a lamp cooling system using a small diaphragm air pump and intra-system spot cooling using small sirocco fans with high static pressure and air ducts.

In the context of cooling efficiency improvement we achieved thermal diffusion via heat sinks, etc. by adopting a new technique combined with spot cooling.

Table shows the main product specifications of the NP60.

3. Lamp Cooling Using a Small Diaphragm Air Pump

3.1 Differences from Previous Cooling System

The lamp of the DLP® (Digital Light Processing) projector uses an elliptical reflector so that the light flux is concentrated at the extremities of the lamp bulb. As this increases the temperature of the lamp bulb extremities, cooling by high velocity blown air is essential.

The lamp cooling system of the previous design used a sirocco fan. As this type of fan must be installed in close proximity to the lamp in order to obtain high air velocity, the options for the installation location tended to be limited. In addition, the necessity of installing an air duct adjacent to the lamp bulb also required a large space.

For the design of the new lamp cooling system, we adopted a small diaphragm air pump (hereinafter simply referred to as "the air pump"). The air pump offers 500 to 1,000 times higher static pressure than the sirocco fan, so a high air velocity can be obtained at the outlet even after the air has passed through the high drag environment of its tubes. This enables the installation of the new system to be optimally located and even at some distance from the lamp bulb. By installing the air pump in a space in the projector that is relatively unoccupied and by effectively utilizing the space previously occupied by the sirocco fan and air duct, we have achieved improvements in the packaging density and in the size reduction of the projector system (**Fig. 1**).

3.2 System Configuration

The air space is installed in the unoccupied space on the left side of the projector. The air from the air pump is supplied via a tube to the distributor in the lamp unit. The air is then blown out of the very small hole in the distributor to cool the lamp bulb (**Fig. 2**).

The air velocity output from the very small hole in the distributor is as high as 5 times that of the air used by a sirocco cooling fan.

3.3 Vibration Countermeasures

The new air pump vibrates more than the sirocco fan, and the vibration of the air pump that is used for the new projector model is about twice that of the sirocco fan. In order to eliminate the impact of the vibration on the noise characteristics of the projector, we have developed a design that insulates the air pump vibration from the projector (**Fig. 3**).

As a result, we have succeeded in reducing noise during the air pump operation by 10dB compared to the measurement without insulation. The projector now boasts the lowest noise level of its class while at the same time offering higher luminance and a more compact size.[*1]

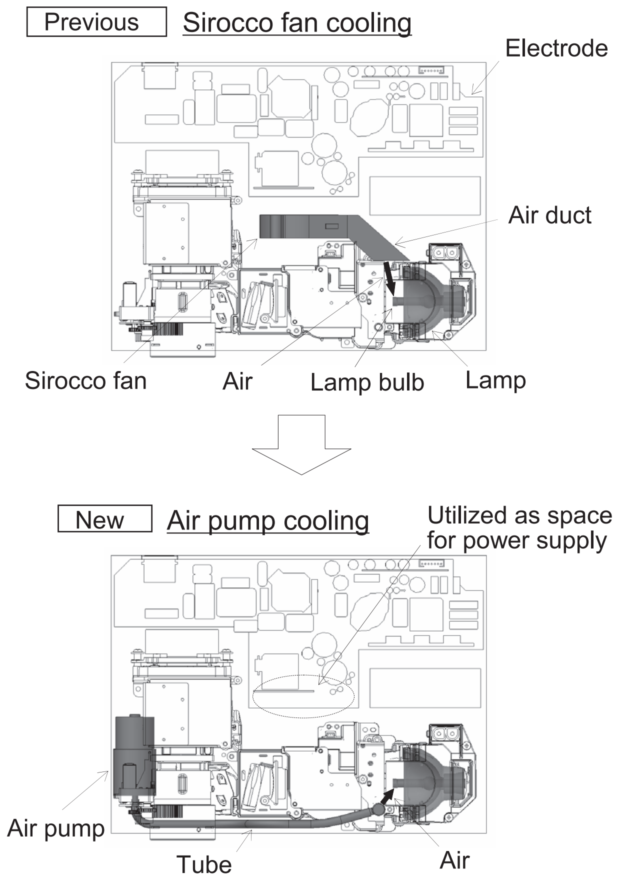

Fig. 1 Differences from previous cooling system.

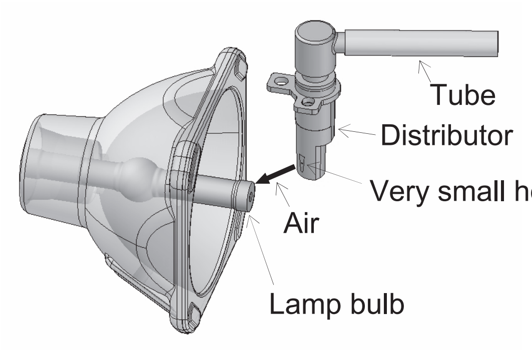

Fig. 2 Cooling of lamp bulb.

[*1] The noise of 40/35dB (normal/eco) is the lowest in the market for projectors of smaller than 3000lm/2kg class (researched by NEC Display Solutions, Ltd. in 2006).

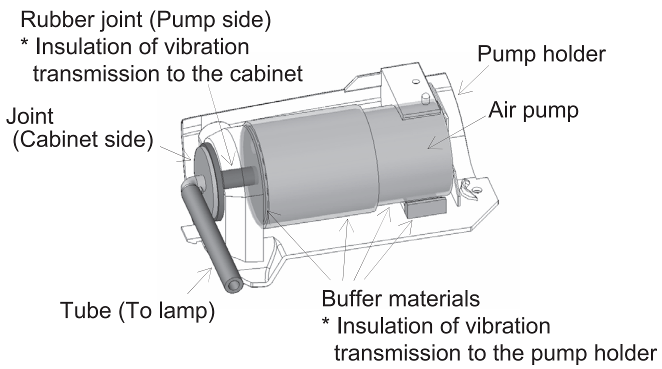

Fig. 3 Vibration insulation structure.

4. Intra-System Spot Cooling Using Small Sirocco Fans with High Static Pressure and Air Ducts

4.1 Differences from Previous Cooling System

Previous projectors have been cooled internally by using an axial fan to feed as much air as possible all over the insides of the projectors. However, as the axial fan has a low static pressure characteristic and its air flow drops when it encounters any drag, it is necessary to provide as much air flow space as possible inside the projector, including in the spaces before and after the axial fan.

The spot cooling system of the new design that uses small sirocco fans with high static pressure and air ducts has made it possible to reduce the required unoccupied space compared to the axial fan cooling system, thereby improving the packaging density and reducing the size of the system (**Fig. 4**).

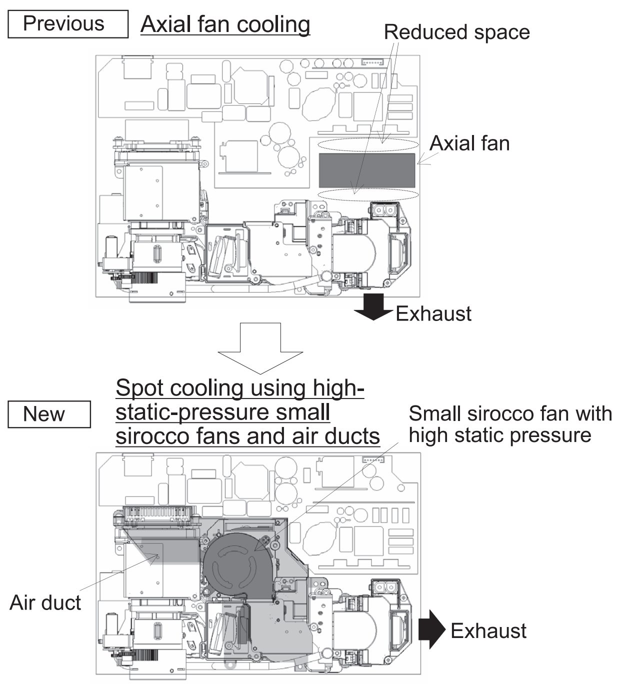

Fig. 4 Differences from previous system.

4.2 System Configuration

The new cooling system mounts three sirocco fans inside the projector.

The first sirocco fan, fan A, is located below the optical engine. The intake side of this fan cools the surroundings of the lighting components of the optical engine and the exhaust cools the lamp bulb and the components that surround it.

The second sirocco fan, fan B is located at the center of the projector. This fan has the first air duct, air duct A, on the intake side so that the heat sink used for the DLP® chip cooling and power supply are cooled via this air duct. On the exhaust side, air duct B is installed for use in cooling the power supply, etc.

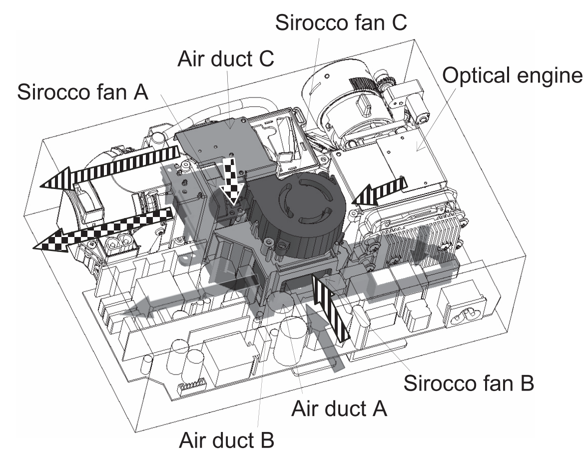

Fig. 5 Intra-system spot cooling.

The third sirocco fan, fan C, is installed above fan B, on its intake side, this fan has another air duct, air duct B, for use in cooling the power supply and optical components. On its exhaust side, an air duct C is installed for use in cooling the surroundings of the lamp (**Fig. 5**).

5. Utilization of Thermal Diffusion

The new design utilizes thermal diffusion in a different manner than previously. It is combined with the spot cooling system described above in order to improve the cooling efficiency and thereby allows the cooling system size to be reduced. The new cooling system can cool the projector with about 75% of the air amount compared to the previous design.

5.1 Cooling the Power Supply

The power supply of the previous projectors was cooled by a heat sink installed on the component mounting side of the circuit board. As a result, when air is fed toward the heat sink, the electrical components mounted there formed drag and deteriorated the heat sink cooling efficiency. To deal with this problem, the new design installs only electrical components with high heat generation and locates the heat sink to the rear of the circuit board (**Fig. 6**).

Together with the spot cooling system described above, this design has contributed in significantly improving the cooling efficiency. Also, the reduction in the heat generation on the component mounting side of the circuit board has made high-density packaging of the power supply circuitry.

5.2 Cooling of the DLP Chip

Previously, the DLP® chip of DLP® projectors have been cooled by installing a heat sink to the rear of the DLP® chip and by radiant heat. In the new design, we also installed a heat sink at the front of the DLP® chip to enable heat radiation from the front side also and have thus succeeded in reducing the DLP® chip temperature by 5%. Together with the spot cooling system described above, this design has significantly improved the cooling at the rear of the DLP® chip by 60% compared to the previous design (**Fig. 7**).

5.3 Cooling of Cabinet

Usually, the temperature of the exhaust air has been as high as nearly 90°C because of the rise in the lamp bulb temperature. The exhaust outlet grid also used to become very hot due to exposure to the exhaust air.

In order to reduce the temperature of the exhaust outlet grid by better diffusing the heat, the new design installs a metallic material on the inner side of the exhaust outlet grid, which is made of a resin material (**Fig. 8**).

This design has reduced the temperature at the exhaust outlet grid by nearly 30% compared to the previous design, thereby enabling cooling with a reduced quantity of air.

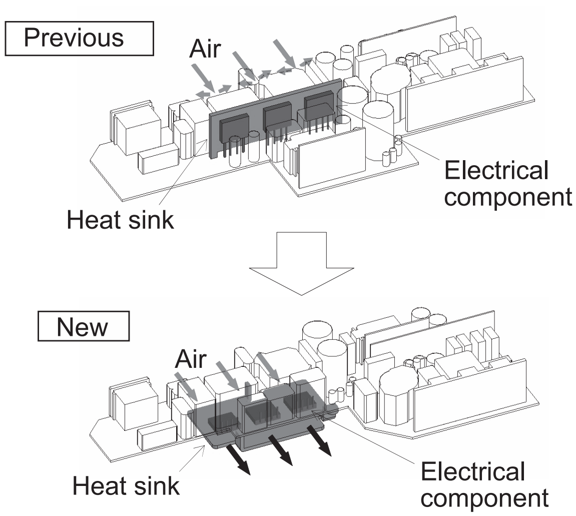

Fig. 6 Cooling of power supply.

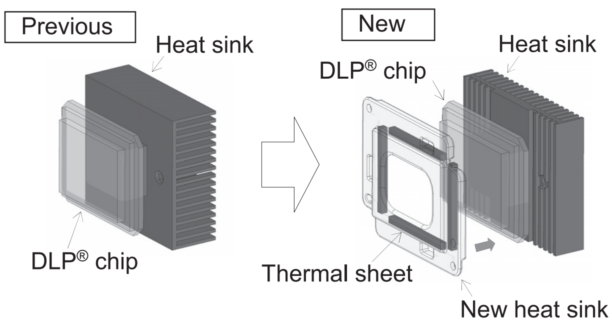

Fig. 7 Cooling of DLP chip.

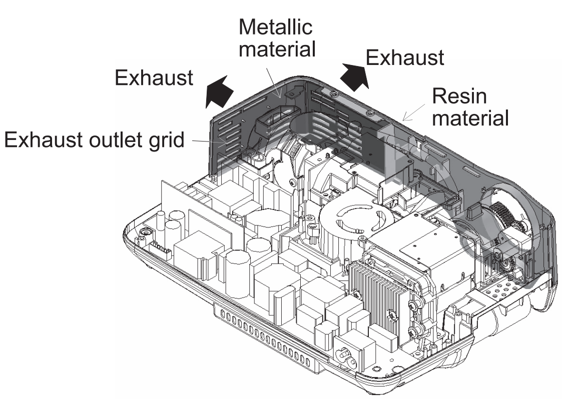

Fig. 8 Cooling of cabinet.

6. Conclusion

We have recently established an innovative cooling technology that enables an increase in luminance while at the same time permitting a decrease in the size of the projector.

In the future, we will pursue further performance improvements in endeavoring to both impress and satisfy our customers so that we may further expand our share of the projector market.

* DLP is a registered trademark of Texas Instruments Incorporated.

Authors' Profiles

TAKAMATSU Hiroaki
Manager,
Development Division,
Projector Operations Unit,
NEC Display Solutions, Ltd.

MASUDA Naoki
Assistant Manager,
Development Division,
Projector Operations Unit,
NEC Display Solutions, Ltd.

LEE Junsi
Staff,
Development Division,
Projector Operations Unit,
NEC Display Solutions, Ltd.

NISHIMURA Yoshifumi
Staff,
Development Division,
Projector Operations Unit,
NEC Display Solutions, Ltd.

SAKAI Shigenori
Staff,
Development Division,
Projector Operations Unit,
NEC Display Solutions, Ltd.

TANI Yusuke
Staff,
Development Division,
Projector Operation Unit,
NEC Display Solutions, Ltd.

● The details about this paper can be seen at the following.
Related URL:
http://www.nec-display.com/products/projector/index.html