Development of Power Saving Thermal Print Head

Tsuneyuki Sasaki,Toshifumi Nakatani,Taishi Numata,Hisashi Hoshino,Hirotoshi Terao;ALPS ELECTRIC CO., LTD.,Osaki, Miyagi,Japan

Abstract

We examined a power saving on thermal printing.Development of Power saving thermal print head by 3D thermal analysis.

Thermal printer is a simple structure, and it is small suitable. Therefore, it is widely used for a direct, thermal printer and a mobile printer of the built-in type. The power saving of a thermal head have to achieve for the battery longevity in a mobile printer and the speed-up of the Thermal printing.

We looked into thermal head structure, energizing condition and medium structure suitable for power saving. The numerical analysis by the finite element method was applied to the examination.

It reports on the content that optimizes the structure to make the printing quality united to the power saving.

1. Introduction

The thermal print technology is a technology where an excellent print in a simple mechanism can be achieved. Moreover, the chance for it to become easy to acquire digital data recently and to print by all scenes increases. Thermal printing that uses the thermal paper is a technology that has been generally used for some time, however, there is full-color paper like new, full-color thermal paper method print medium Zink, too. It is possible to downsizing it because of an unnecessary Ink ribbon. Achieving a mobile Products and all equipment built-in Products becomes possible by using this small size and thin mechanism.

The power saving of a thermal head is indispensable aiming at on a further, mobile inclination and speed-up in Zink and the printer of the sublime type. Moreover, the heat countermeasure is also important in mobile products. Decreasing the turning on Input Energy becomes a reduction of the heat load.

The device development of a thermal head was executed by uniting the processing technology and the Computer Aided Engineering technology in ALPS. As a result, it succeeded in the power saving glass material development. Thermal head that used this glass material has the power-saving feature. It reports on the development method and a current printing characteristic and the problem this time.

2. Structural basic study by CAE Analysis

2-1. Thermal head unit

A thermal head is a device of the process of the thin film.

* Alps Electric Co., Ltd. HMI Business Unit The 5th Engineering Dept.
6-3-36 Nakazato furukawa Osaki-City
Miyagi, Pref, 989-6181 Japan
e-mail: sasakits@alps.co.jp

A lot of time and the cost hung in the trial manufacture and the evaluation so far. Therefore, development by the Computer Aided Engineering is a very effective device. The optimization design of a thermal head with power saving and robustness.. Characteristics by using the Computer Aided Engineering and the quality engineering in ALPS are done (Figure1).

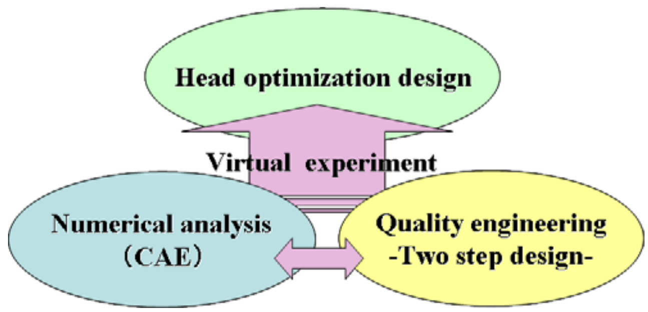

Figure1. ALPS optimization design image

CAE is executed by 2stages, ①whole analysis, and ②part analysis. 1st Stage in this development is an analysis of the entire thermal head unit. The purpose of 1st Stage is a thing to select an effective part to the power saving.FEM software (Ansys10.0) was used for the CAE. The analysis was executed by two dimensional analyses (Figure2).

It executed it on the following conditions as Analytical flow.

- An arbitrary electric power[W/dot] is supplied to the heater
- It energizes during the fixed time(65sec:One piece Corresponding at printing time (width of 6Inch))
- The head surface temperature is measured including it after it energizes.

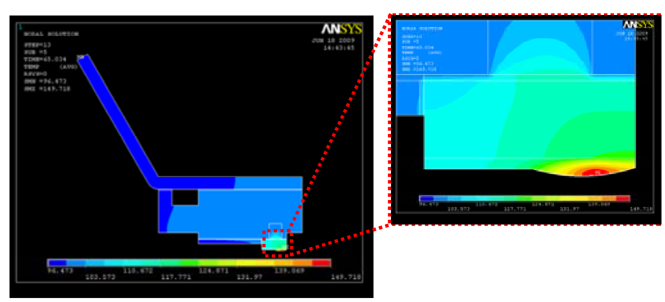

Figure2. Thermal Head Unit Analysis Model

The characteristic differences are compared for each model as an evaluation method to the analytical result by the curve of the Heater Temperature with the following time point (Figure3).

- Temperature rising curve at power on at once.
- Thermal storage temperature rise curve.

- Cooling curve after Power off is done.

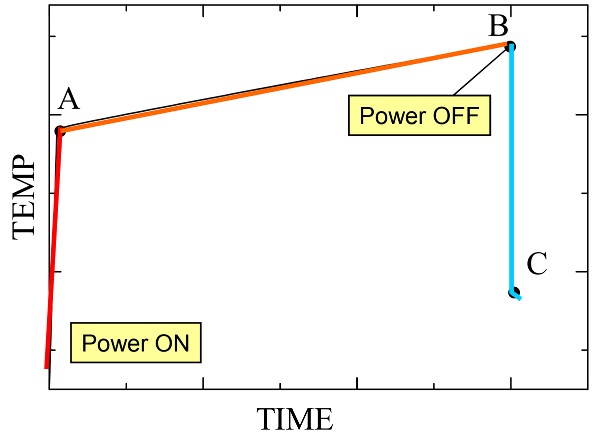

Figure3.Image of method of evaluation of characteristics (Relation between energizing time and head surface temperature)

Application of quality engineering

The quality engineering also did application of using together to this study when the power saving thermal head structure was examined. This study used two step design technique in the quality engineering. Two step designs is a technique of approaching a target function after the characteristic difference in the error condition making is improved.

Table 1. control factor level list

	Control Factor	1	2	3	
A	Hollow position	adhesive	Al board	—	
B	Hollow width	S	M	L	
C	Substrate thickness	L	M	S	mm
D	Substrate thermal conductivity	S	M	L	W/mK
E	Al board thickness	L	M	S	mm
F	Adhesive thickness	S	M	L	μm
G	Adhesive thermal conductivity	S	M	L	W/mK
H	Air thermal conductivity	S	M	L	W/mK

Table 2. Error condition

	Control Factor	N0	N1	N2
A	Hollow position	—		
B	Hollow width	—		
C	Substrate thickness	0%	+	-
D	Substrate thermal conductivity	0%	-	+
E	Al board thickness	0%	-	+
F	Adhesive thickness	0%	+	-
G	Adhesive thermal conductivity	0%	-	+
H	Air thermal conductivity	0%	-	+

The level list with the control factor used by this research and the crack is shown in Table1. And, the error condition in each parameter is shown in Table2. Moreover, the error factor was set within the range of ±2-10%. This error condition is given within the range where it can happen by real Products.

Figure4 shows the factor effect Figure of the signal-to-noise ratio. The influence level from this Figure to the system to the difference of each parameter is understood. The best level in each parameter to the difference can be found.

Next, the sensitivity to the power saving of each parameter is arranged. The sensitivity of each parameter is calculated in the above-mentioned time of three points. Figure5 shows the factor effect Figure concerning the sensitivity of each parameter in Temperature rising curve. As for the result and which time point, the substrate thermal conductivity and the Al board thickness are large and the influence is large in the power saving.

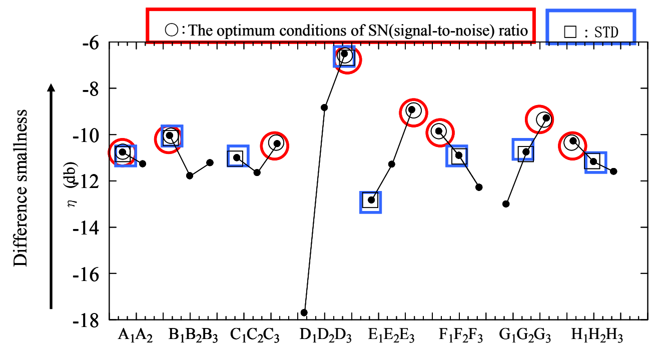

Figure4. The factor effect Figure of the signal-to-noise ratio

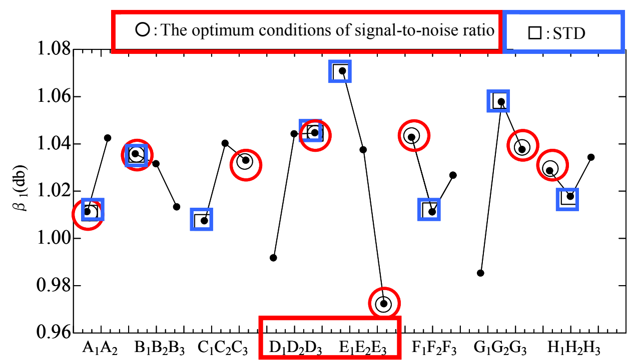

Figure5. The factor effect figure of Sensitivity of rising: β1

Moreover, even if the comparison sensitivity is made good, the parameter that the difference influence under the error condition is small and effective is a substrate thermal conductivity. We thought the substrate physical properties to be an effective parameter, and decided the development target of a power saving thermal head.

2-2. Thermal head Substrate

We used FEM software (ANSYS10.0), even this study. Assuming a model simulating relative motion of the head and paper, the analysis employed Mass Transport function of the software (Figure6). Heat conduction equation of the model is given as in Equation (1).

The focus of development is squeezed to the thermal head substrate and a detailed CAE is executed. Concretely, the optimization investigation; study of the heat physical properties value (The thermal conductivity: λ[W/mK] ,specific heat: c[J/KgK],density: ρ[Kg/m^3]) that seemed that it related to the power saving it was done. Moreover, the substrate thickness was optimized as an element that did not ruin the image quality from the cooling curve.

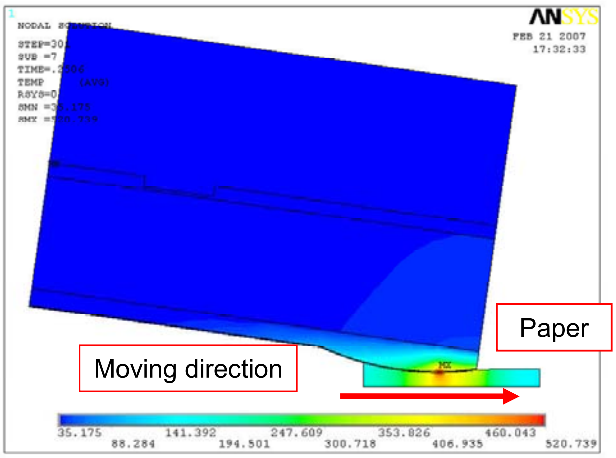

Fig6. Thermal Head Substrate Analysis Model

$$\rho c\left(\frac{\partial T}{\partial t}+vx\frac{\partial T}{\partial x}+vz\frac{\partial T}{\partial y}+vz\frac{\partial T}{\partial z}\right)+\lambda\frac{\partial^2 T}{\partial x^2}+\lambda\frac{\partial^2 T}{\partial y^2}+\lambda\frac{\partial^2 T}{\partial z^2}=Q \qquad (1)$$

ρ:	*Density*
c:	*Specific Heat*
T:	*Temperature*
t:	*Time*
vx, vy, vz:	*Velocity of a moving fluid*
λ:	*Thermal conductivity*
Q:	*Generation of heat*

First of all, one factor experiment to each heat physical properties value was executed. Moreover, the relation to the substrate thickness was investigated. The direction of reducing of effective heat physical properties value the thermal diffusivity rate to the power saving in the thermal head substrate has been understood from the result. The definition of the thermal diffusivity rate is shown in Equation(2). The thermal diffusivity rate is a function of three physical properties values(c, ρ, λ). It is understood that it is a physical properties value in which Speed where heat is transmitted.

$$a=\frac{\lambda}{c\rho}\quad\left[m^2/\mathrm{sec}\right]\qquad(2)$$

a : **Thermal diffusivity** (=Speed where heat is transmitted)

λ :Thermal conductivity(=Thermal performance)

c :Specific heat
ρ :Density
} **=Thermal storage ability**

Next, the printing condition is presumed from the heat response curve. We paid attention to the defective printing especially generated by remaining heat. It is assumed that the phenomenon to draw the sign in the blank Department by remaining heat is called "Obiki" in this study. Figure7 shows "Obiki" image Figure. The power saving is a direction of a thermal diffusivity minimum rate as was done ahead. The device is thought to be insulation or a state of thermal storage UP. When it is such a state, "Obiki" is direction of deterioration. The relation of the trade-off of power saving and "Obiki" is understood, and it is important to decide the design of the system.

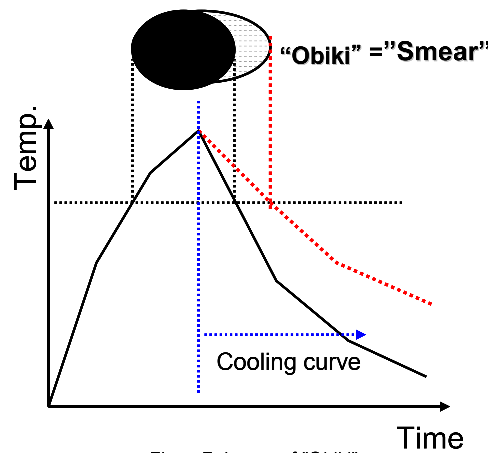

Figure7. Image of "Obiki"

Figure8 shows a related Figure at the effect of the power saving and "Obiki"level. "Obiki" levels were compared from the heat response curve requested from the numerical analysis by the number of presumption "Obiki" Dot. More "Obiki" Dot is, the worse the image quality level is. A horizontal axis shows the need electric power. 100% of the ratio is STD. It is a power saving by small the numerical value. Each color in graph point shows the substrate thickness difference.

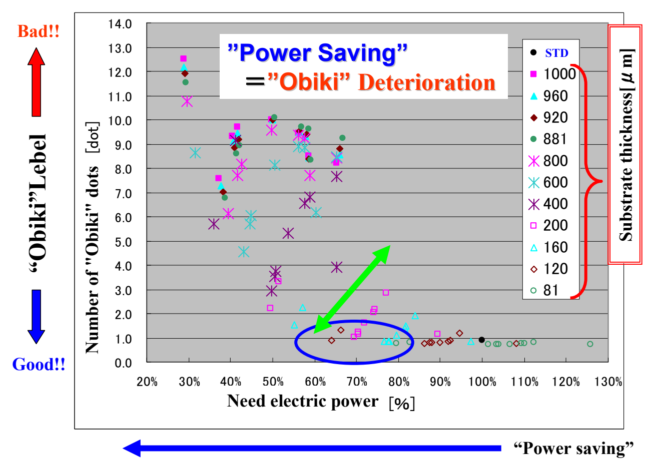

Fig8. ***Power saving and "Obiki" relation***

Result, power saving, and "Obiki" show the relation of the trade-off. Moreover, the substrate thickness of the power saving is effective. However, some adjustment is possible according to the heat physical properties value. In a word, the optimization design of each system (printing speed, need electric power, and image quality level, etc.) is possible.

3. Experimental Confirmation

We mixed by the physical properties value optimized more than CAE, and developed the low thermal diffusivity rate glass material. The device that used the glass for the substrate of a thermal head was evaluated. For instance, the relation between the effect electric power and the printing density was evaluated as a printing evaluation. Figure9 shows what arranged to the relation between the substrate thickness and the power saving. Figure10 shows what arranged to the relation between the substrate thickness and “obiki”Lebel.The power saving and the printing level equal with CAE result were obtained.

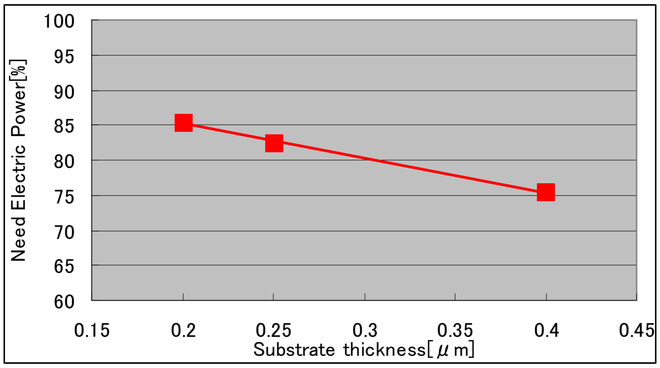

Figure9. Relation between substrate thickness and power saving (New HD)

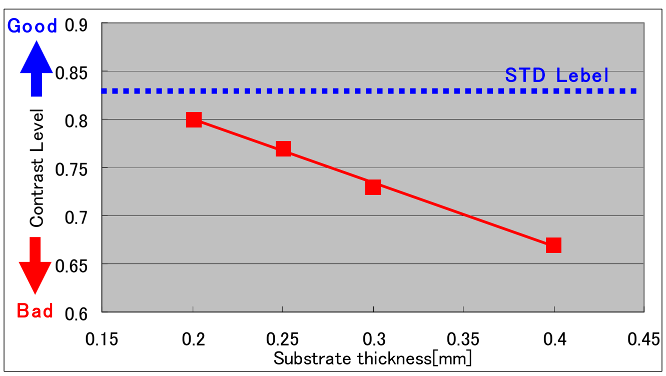

Figure10. Relation between substrate thickness and contrast Level (New HD)

4.Conclusion

We developed "Power saving thermal head" and "Low thermal diffusivity rate glass material" this time. As a result, further, mobile, and achieving the miniaturization become possible the thermal printer. When developing, the following finding was obtained.

1. The optimization design of the thermal head who unified CAE and the quality engineering is effective. As for the evaluation load reduction by two dimensional analyses, two stage approaches of a whole analysis and a partial Analysis is effective.
2. The power saving of a thermal head and "Obiki" level are the relations of the trade-off. The thickness of the substrate and the influence of the thermal diffusivity are large in the power saving of a thermal head.
3. The method to evaluate from the heat response curve of CAE by the number of presumption "Obiki" Dot is effective.

References

[1] H.Terao and N.Tsushima, T.Shirakawa, and I.Hibino, “Study of a Thin Film Thermal Print Head for High Definition Color Imaging Use”, IS&T’s NIP15:1999 International Conference on Digital Printing Technologies, p227 (1999).

[2] H.Terao, T.Nakatani, N.Tsushima, and I.Hibino, “Study of a Thermal Print Head for Multi-level Tone Printing”, IS&T’s NIP16:2000 International Conference on Digital Printing Technologies, p227 (2000).

[3] H.Terao, T.Nakatani, N.Tsushima, and I.Hibino, “Study of 1200dpi High Resolution Thermal Print Head”, IS&T’s NIP17:2001 International Conference on Digital Printing Technologies, p504 (2001).

[4] H.Terao and T.Nakatani, “Study of Thermal Print Head for High-Speed Print”, IS&T’s NIP19:2003 International Conference on Digital Printing Technologies (2003).

[5] H.Hoshino and H.Terao, “Development of Low-power Thermal Printing Technology”, IS&T’s NIP22:2006 International Conference on Digital Printing Technologies (2006).

[6] E.Sakai, J.Yoneda, and A.Igarashi, “Image Stability of TA Paper”, IS&T’s NIP15:1999 International Conference on Digital Printing Technologies, p235 (1999).

[7] Stephen J. Telfer and William T. Vetterling, “A new, Full-Color, Direct Thermal Imaging System”, IS&T’s NIP21:2005 International Conference on Digital Printing Technologies, p181 (2005).

[8] Hirotoshi Terao and Hisashi Hoshino, “Development of Development of a thermal print head by 3D thermal analysis Low-power Thermal Printing Technology”, IS&T’s NIP24:2008 International Conference on Digital Printing Technologies (2008).

Author Biography

Tsuneyuki Sasaki received his master of engineering degree in graduate school of Mechanical engineering, Iwate University in 2000.

He has worked at ALPS Electric Co.,Ltd.System devices Division since 2000,and is currently an engineer in the engineering department.

He is developing and designing a thermal print head,and Key technology of small and making to thin type printer system.

His interests are in research and development of Saving Energy system like power saving technology.