Development of High Efficiency Thermal Printhead

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Abstract

Recently, a large portion of product development is focused on environment protection. Especially, the reduction of carbon dioxide is targeted to prevent global warming. For the thermal printhead, the way to address this is to improve the heat efficiency in order to realize reduced energy consumption. Our newly developed printhead achieves significant improvement in heat efficiency. Two approaches are taken during this development; (1) control the heat flow in the heater, so that heat can be concentrated at the heater and (2) increasing glaze thickness in order to utilize heat accumulation more efficiently. Previously, to make better heat response with high speed printing, utilization of thinner glaze was adopted to prevent an "Obiki" phenomenon which is 'trailing print' on the media. However, this thinner glaze dissipates the heat quickly and as such can result in lower heat efficiency. This paper will describe how to use the heat accumulation by thicker glaze without significant print quality degradation by Obiki. In this way high heat efficiency is achieved.

Heat efficiency and print speed

Recently, reduction of energy consumption is required in many industries. This activity reduces carbon dioxide emissions, and in doing so it will contribute to environmental protection.

In the thermal printing industry, this requirement is becoming stronger than before as well. To satisfy it, thermal printhead heat efficiency improvement is required. On the other hand, thermal printing method has a history to increase print speed by heat response improvement using thin glaze technology. Figure 1 shows the heater glaze construction. By reducing the thickness of this glaze layer, heat accumulation is also reduced and heat response is improved. This can be referenced in a conference paper publication available at [1]. However, a result of reduced glaze thickness is that heat efficiency has been sacrificed. In order to achieve heat efficiency improvement while also achieving high speed printing, this dilemma needs to be solved.

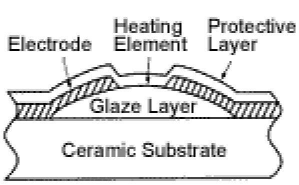


***Figure 1**. Glaze construction*

In this paper, how to improve the heat efficiency will be described first. And, also how to improve the dot reproduction will be discussed later.

Heat efficiency improvement

To improve the heat efficiency, two kinds of methods are considered.

One method is to use accumulated heat efficiently. Increasing glaze thickness is one way to accomplish this - it gives us better efficiency easily. However, it also makes print quality worse as compared with thinner glaze. The reason is that time constant of temperature falling curve is longer than thinner glaze. It may be cause of "Obiki" phenomena which is remaining color at the trailing edge even after stop printing by excessive remaining heat in the heater area of the printhead. It can be significant print quality degradation with high speed printing.

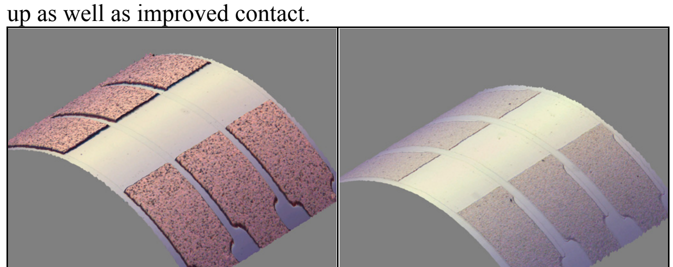
The other is heat flow control. It is the method to transfer heat from heater to media efficiently. There are two ways to control heat. The first is better contact between heater and media. The second is to optimize the inside of the heater by printhead construction. Our EcoGeneration Technology, which will be described later in this paper, can provide both features. The significant thing is that it helps to improve print quality as well as heat efficiency.

Heater glaze construction

The relationship between suitable glaze thickness and print speed is defined in the publication of conference paper at [1]. At this time, the target application is 'high speed' barcode which requires print speeds from 4ips (ips = inch per second) up to 10ips. Originally, achieving this speed required 35um~55um thickness of glaze to provide satisfactory heat response. In this paper, two versions of glazes will be referenced. One is 35um thickness and 0.7mm width. The other is 55um thickness with 0.8mm width. Both of them are widely used in the thermal printing industry.

EcoGeneration Technology

EcoGeneration Technology provides heat flow control. One of the features is better contact between heater and media due to no electrode step, which regular heater has. Figure 2 shows the surface difference between regular and EcoGeneration heaters. Electrode step height of regular heater is about 1um. This surface construction can have other effects such as reduced residue build up as well as improved contact.



Regular heater surface	EcoGeneration heater surface

***Figure 2**. Surface comparison between regular and EcoGeneration heaters.*

The other feature of EcoGeneraion Technology is heat flow control in the heater itself. Specifically, heat is concentrated at the heater area. Because of this, the heat can be used for printing more efficiently.

When combined, both features make synergy effect to provide heat efficiency much better than regular heater construction.

Overcoat thickness

Another heat flow control factor is the thickness of the overcoat. This overcoat thickness is the meaning of distance between real thin film heater element and the media surface. If this distance is small and result is 'thinner' overcoat, media should receive heat more freely than with 'thicker' overcoat. In this paper, 9um and 4.5um thickness overcoat is used for the experiment.

Heat efficiency comparison

Heat efficiency comparison between various samples has been done as per the following procedure.

1. Sample preparation as Table 1.
2. Full black printing with four kinds of speeds from low density to high density. Pulse method is single pulse without any history control.
3. Measure the OD (optical density) of each printout by Macbeth type densitometer.
4. Read the applied energy at optical density 1.3 as a comparison point (Ref. Figure 3.)

Sample	Heater construction		Glaze thickness		Overcoat thickness	
	Regular	E.G.	35um	55um	9um	4.5um
Reference	X		X		X	
A	X			X	X	
B		X	X		X	
C	X		X			X
D		X		X	X	
E		X		X		X

Table 1. Sample spec.

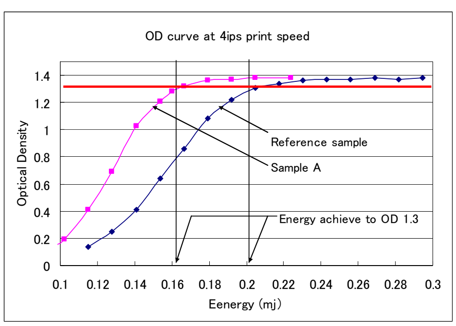


***Figure 3**. How to read the comparison point of OD 1.3.*

Figure 4 shows the energy comparison to achieve OD 1.3 by typical thermal sensitive paper for label application. This energy is the applied energy for each line printing.

This chart includes Reference sample, Sample A, Sample B and Sample C. From it, Sample A used the least amount of energy to achieve OD 1.3 This effect is very much known as usage of heat accumulation in the glaze layer. Sample B is the sample which EcoGenearion technology is added onto Reference sample. The only difference between A and B is without and with EcoGeneration technology, respectively. Obviously, EcoGeneration printhead shows better heat efficiency. Also, Sample C is the sample which is half thickness overcoat of Reference sample. This difference is from the overcoat thickness only. It may not be significant, but still some heat efficiency effect improvement is observed.

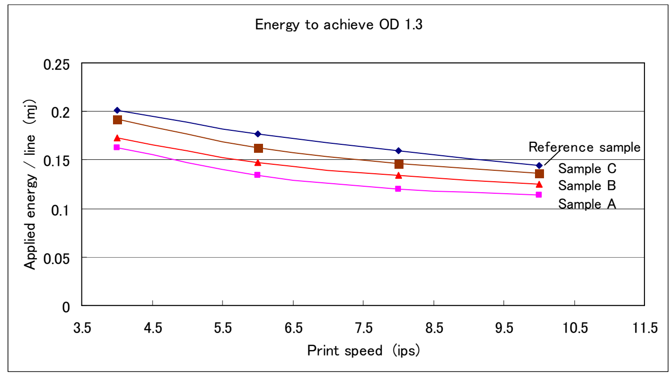


***Figure 4.** Energy comparison to achieve OD 1.3 (Reference sample, Sample A, Sample B and Sample C)*

From this result, we can conclude following inequality for the effect to heat efficiency.

(Sample A) > (Sample B) > (Sample C)
Glaze thickness > EcoGeneration > Overcoat thickness.

To maximize the heat efficiency, 55um thickness glaze and EcoGeneration technology are combined into Sample D and Sample E. Sample D has 9um thickness overcoat and Sample E has 4.5um. Result is in Figure 5. Both of them show quite good heat efficiency. But, three is almost no difference between Sample D and Sample E. Originally, the effect of glaze thickness and EcoGeneration is quite significant. Also, measurement error may be included in it. Then, there is the possibility of migration of the overcoat thickness effect in it. From this result, we may be able to conclude that it's not necessarily to consider including thin overcoat to gain the high heat efficiency.

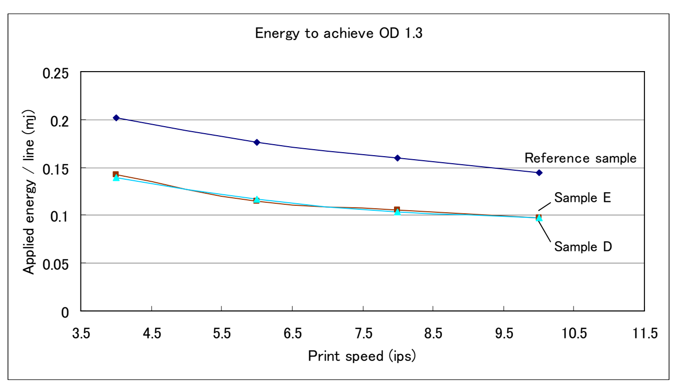


***Figure 5.** Energy comparison to achieve OD 1.3 (Reference sample, Sample D, and Sample E)*

55um glaze and EcoGeneration printhead heat efficiency is improved about 30%~33% from reference printhead.

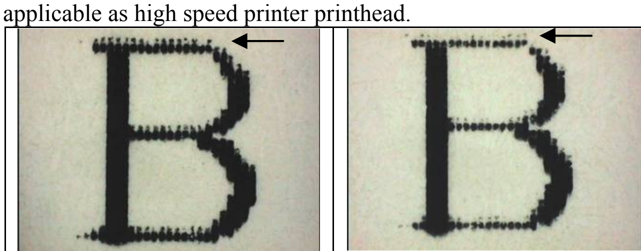
Print quality

To improve print quality, we must target three things as below:

1. Achieve a sharp leading edge.
2. Have dot connection in parallel direction as heater line.
3. Minimize Obiki phenomena.

If thin glaze is used, number 1 and 3 can be improved compared to thick glaze. It is known as in the publication of conference paper at [1]. However, our interest is heat efficiency improvement maintaining the print quality. Then, it requires the thick glaze instead of thin glzaze. The key point is that how to improve the print quality if utilizing thick glaze.

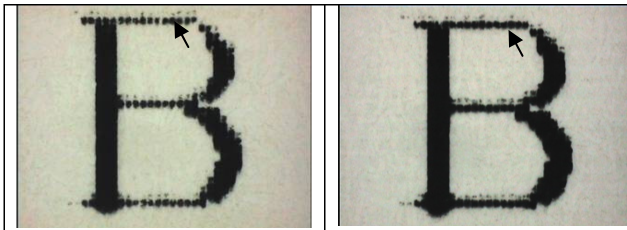
Figure 6 shows printouts of character “B” by reference printhead and Sample A on the direct thermal sensitive paper. This is available as commercial label. All printouts of print speed are 6ips without any history control and applied energies are reduced for high efficiency construction printhead as well as Sample A below, which ratio is same as the energy ratio to achieve OD 1.3. Reference printhead shows better leading edge and dots connection than Sample A. Printout of Sample A shows very faint leading edge which almost no print at first line. Thick glaze absorbs the heat to accumulate in it. This is the reason not to print clear leading edge with 55um glaze sample. It may not be applicable as high speed printer printhead.



Reference Regular heater (35um glaze)	Sample A Regular heater (55um glaze)

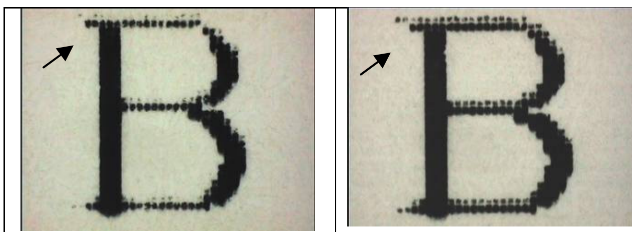
***Figure 6** Printout comparisons (35um glaze and 55um glaze)*

EcoGeneration heater construction makes better contact between heater and media than regular heater. It has been mentioned in above paragraph. Result is in a Figure 7. It shows the printouts difference between Sample A (Regular heater) and Sample D (EcoGerenation heater). Sample D shows slightly better leading edge than Sample A. And, second line is much better. However, it is still far from the Reference printhead result which is high speed printer printhead.



Sample A Regular heater (55um glaze)	Sample D EcoGeneration (55um glaze)

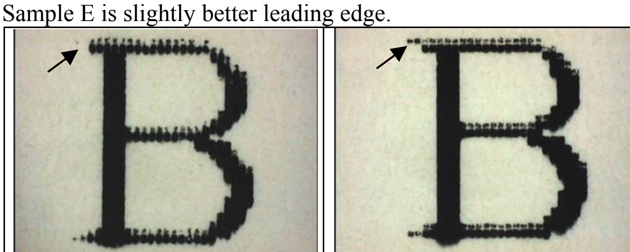
***Figure 7** Printout comparisons (with and without EcoGeneration)*



Sample A Regular heater, 55um glaze 9um overcoat	Sample Regular heater, 55um glaze 4.5um overcoat

***Figure 8** Printout comparisons (with and without EcoGeneration)*

Then, this 4.5um overcoat is added onto 55um glaze with EcoGeneration heater construction. It is Sample E. Figure 9 shows the printouts comparison between Reference printhead and Sample E. Those printouts are almost equivalent quality or Sample E is slightly better leading edge.



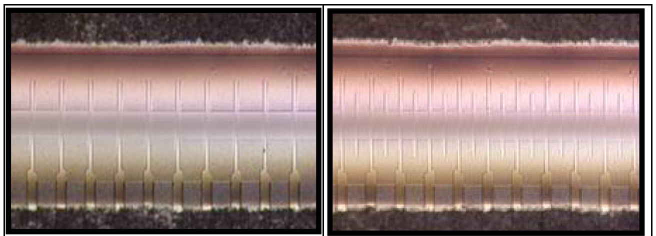
Reference, Regular heater 35um glaze, 9um overcoat	Sample E, EcoGeneration 55um glaze, 4.5um overcoat

***Figure 9** Printout comparisons (with and without split heater)*

The other hand, adoption of this thin overcoat needs to be done carefully as it cam be a cause of short printhead life. It must be confirmed by reliability testing in advance. Or, new overcoat may need to be developed to compensate for the overcoat thickness and achieve the required printhead life.

Split heater construction

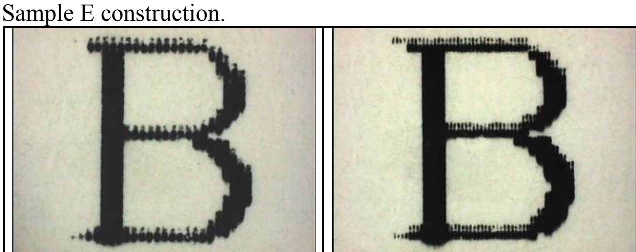
To improve the dots connection of parallel direction as heater line, one of the ways is to apply split heater method. High resolution heater makes high quality image. It is know as in the publication of conference paper at [2]. This is the way to apply high resolution printhead advantage in to low resolution printhead. The way is to split the one heater to two. Then, heater resolution itself will be doubled. However, two heaters must be energized always together due to the construction. Figure 10 shows the difference between single heater and split heater.



Single heater construction	Split heater construction

Figure 10 *Heater construction*

The feature of split heater is that temperature between heaters is higher than single heater. This is the reason of better dots connection as parallel direction as heater line. Figure 11 shows the difference between Reference printhead and split heater onto Sample E construction.



Reference (35um regular) Without split heater	Sample E with split heater. 55um glaze, EcoGeneration 4.5um overcoat

Figure 11 *Printout comparisons (with and without split heater)*

From this result, we found the way to improve printout of leading edge and dots connection by EcoGeneration construction, thin overcoat and split heater even with 55um thick glaze.

Least Obiki phenomena

Printout of leading edge and dots connection has been discussed. However, least Obiki phenomena haven't been discussed. To minimize the Obiki, still history control is required. It is discussed in the publication of conference paper at [1].

As the other effect of EcoGeneration and thin overcoat, those constructions make better heat transfer from heater to media. It may change the ratio of usage of generated heat by heater. Theoretically, better heat transfer construction may have higher ratio of the heat to the media than heat dissipation to the ceramics through glaze layer. It means also improvement of heat response of the heater. It might help to reduce Obiki phenomena as well.

Conclusion

To improve heat efficiency from 35um thickness glaze with regular heater construction, adoption of 55um glaze and EcoGeneration construction is most effective. Improvement is about 30~33% less energy under 4ips~10ips speed condition.

55um glaze print quality is less than 35um glaze. To improve it, adoption of EcoGeneration construction, thin overcoat and split heater is effective. This high print quality construction makes almost equivalent or better quality than 35um glaze regular heater construction.

To use those printhead construction to gain more than 30% heat efficiency improvement maintaining the print quality with 35um glaze regular heater printhead, there are still two issues. One is optimized history control to minimize Obiki phenomena. The other is printhead life by thin overcoat. Once those will be solved, it will be the most eco friendly thermal printhead in the world.

References

[1] Hidekazu Akamatsu , Maximum performance of printhead (IS&T, Anchorage , AK, 2007) pg. 142.

[2] Youichi Moto, Development of ultra high density thermal printhead (IS&T, Louisville, KY, 2009) pg. 770

Author Biography

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