Technological direction for Thermal Print Head

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Introduction

Recently performance requirement concerned of Thermal Print Head (hereafter TPH) is not only unique but also diversified into various kinds because of new applications and its performance requirement. For example, industrial photo printer requires high print quality and stability, but home use printer does not require them. Additionally bar-code printer, which is one of the retail uses, requires more durability and more stability.

As above, TPH performance is usually deiced based on the application segment, and requirement became more unique year by year.

However, panorama tic view of history of TPH development, it is easy to fine that TPH development has been driven by print quality, high speed, durability and cost.

Since several years ago, Toshiba Hokuto Electronics Corp. proposed NE-type TPH, and added new function and improved performance to optimize each application segments.

I would like to explain about technical direction for NE-type TPH.

1. NE-type TPH

NE-type means heater was located near edge of substrate less. Normal TPH design had a common area and/or common pattern on the edge side of substrate.

NT-type TPH had U-shape heaters in its heater array; U-shape heater was one of the essential technologies for NE-TPH, because there was no common area. U-shape heater was designed that a heater was divided; one lead was connected to switching IC, the other was connected to the common near the IC side, the common bus patter was made on the print circuit board. This means both leads were patterned same direction (see figure1a).

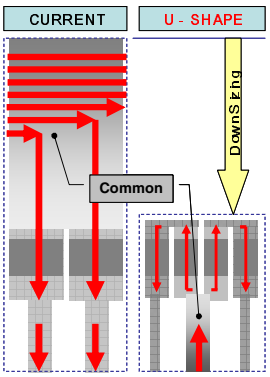


Figure 1 concept of U-shape heater

U-shape heater had 2 heating element, so its space frequency was 2 times higher than heater resolution. Then U-shape was highly praised by many photo printer producers.

Also, its heater length became 2 times higher than normal heater design. Therefore it was easy to get high resistance products, which helped to save current consumption. Additionally the common bus was located print circuit board, so its resistance was decreased. Then the common drop was decreased.

Recently, U-shape design was improved by optimizing heater location against glaze top. Generally the distance between heater and IC bonding resin was closer by shrinking substrate therefore platen roller was closer to IC bonding resin by shrinking substrate. So the paper pass gap between platen roller and IC bonding resin was closed. By this improving, there were possibilities of coexistence between larger platen diameter and small substrate.

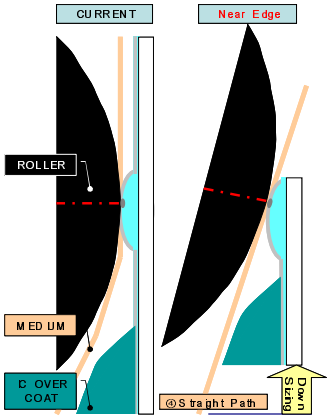


Figure 2 Concept of Straight pass TPH

To keep the clearance between the bonding resin and the platen roller, heater line was located on the slop of the convex glaze. To optimize substrate width, convex height and heater offset, paper pass was made straight. For example card printer used hard medium made of plastic, but straight pass is suitable for it without increasing substrate width.

2. Print quality improving

To get a photo like print quality, high resolution and uniformity were necessary for TPH heaters.

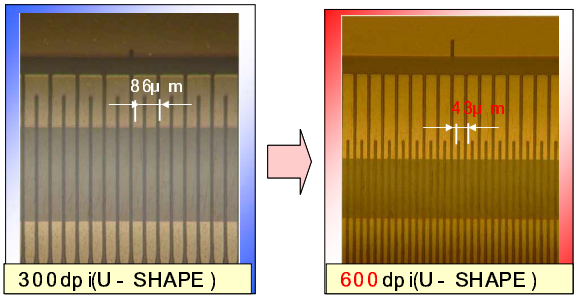


Figure 3 600dpi U-shape heaters

Toshiba Hokuto Electronics Corp. will mass-product 600dpi U-shape model shortly. This heating element pattern was corresponding to 1200dpi.

The other hand, uniformity had two concepts. One was heat value uniformity, and the other was heat conductivity uniformity. Especially, glaze undulation at convex slop was one of the most important parameter. This undulation often made bandings caused by unequal mechanical touch. Figure 3 shows there was a strong correlation between banding and glaze undulation in card printer application.

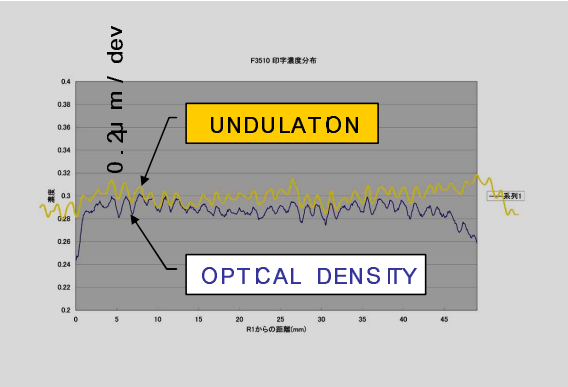


Figure 4 relations between undulation and optical density

To keep ID card photo print quality, we estimated the glaze undulation should be controlled less than 0.1um. It was difficult to keep undulation less than 0.1um by current glazing process, so we improved the process. But it was not enough for mass-production. Therefore we added “undulation polish” process around heater area to keep the undulation less than 0.1um.
Figure 5 shows the result of undulation polish. The undulation was controlled less than 0.1um even if convex slope, which undulation was estimated worse than glaze top area.

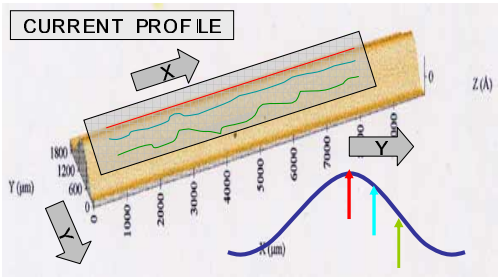


Fig .5a undulation measurement point on glaze

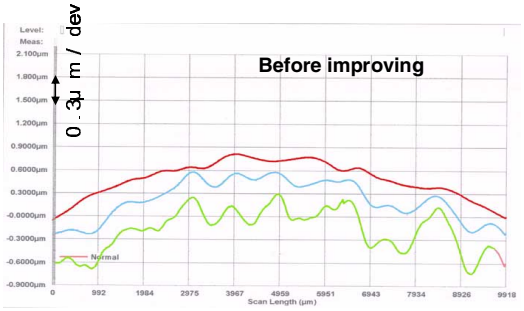


Figure 5b glaze undulation result (previous process)

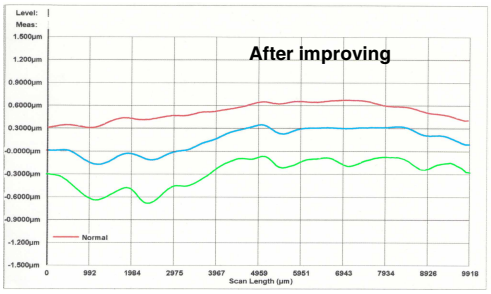


Figure 5c glaze undulation result (new process)

Additionally, we are testing if this new process has a possibility to make a narrow width partial glaze, which was estimated impossible historically.
In Figure 7, upper and middle figures were current wide width glaze, the other hand, lower was narrow width partial glaze. Generally partial glaze has a large undulation because of ceramic surface.

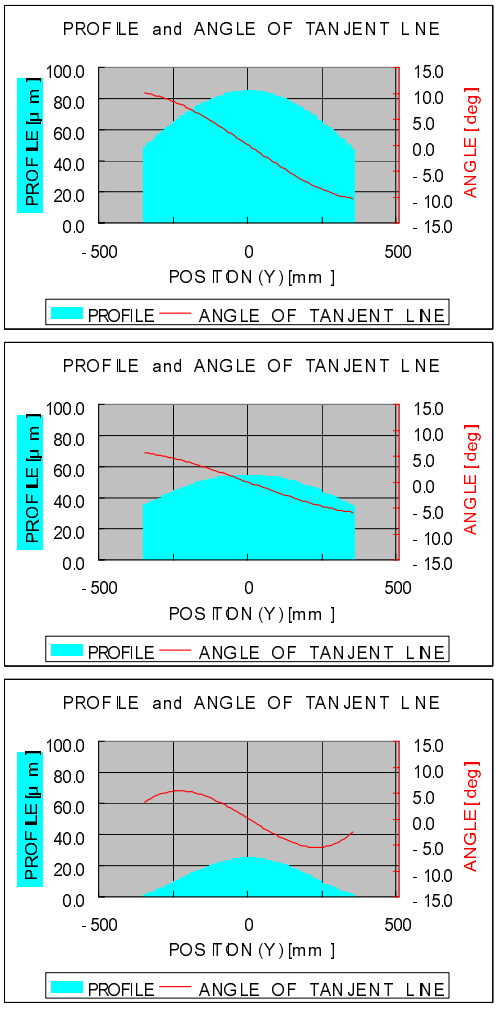
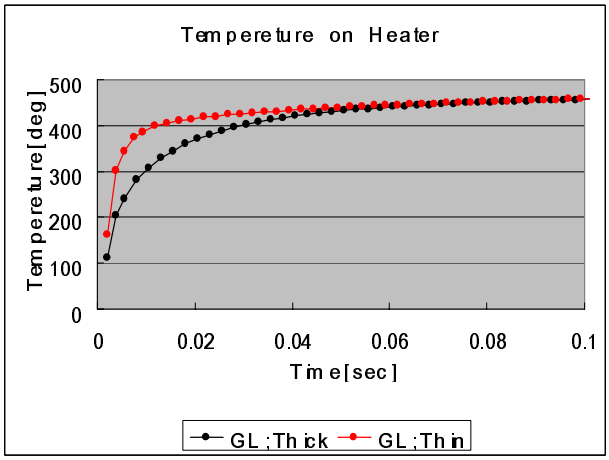


Figure 6 Glaze profile and tangent line

3. High speed printing

Generally it is important to optimize the balance between heat accumulation and heat radiation. This is corresponding to improving heating response and heat efficiency. Especially, glaze thickness is decreased by increasing print speed.



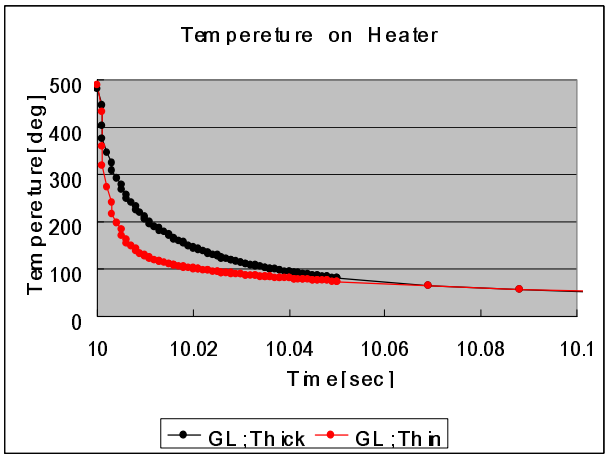
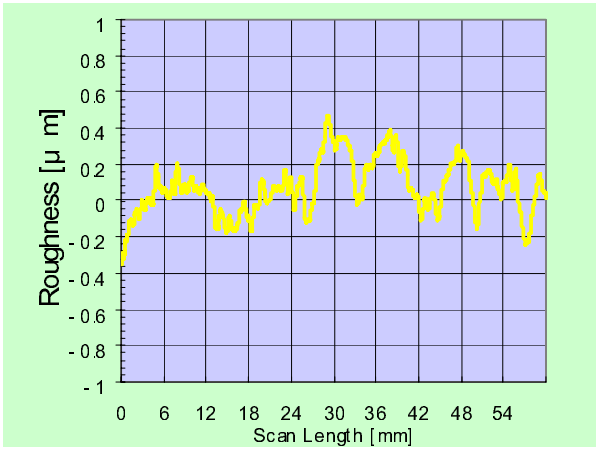


Figure 7 heating and cooling response by glaze thickness

This is corresponding to small heat capacity heater system. Therefore, thinner glaze process was required for a long period. Historically, current glazing process was difficult to make a thinner glaze and/or a small radius convex glaze because of crystallization around boundary between glaze and alumina. Described previously new glaze process solved this problem. Small radius convex glaze helped to increase heat transfer to medium, the other hand thinner glaze helped to decrease accumulation and heating response.

We succeeded to mass-product 40um thickness convex glaze without increasing undulation by optimizing glaze material and new process. Please see figure 8, left figure showed previous process glaze that had worse and high frequency. The other hand new process (right figure) showed also undulation, but its frequency was low. It meant new process glaze would not make banding at photo print.



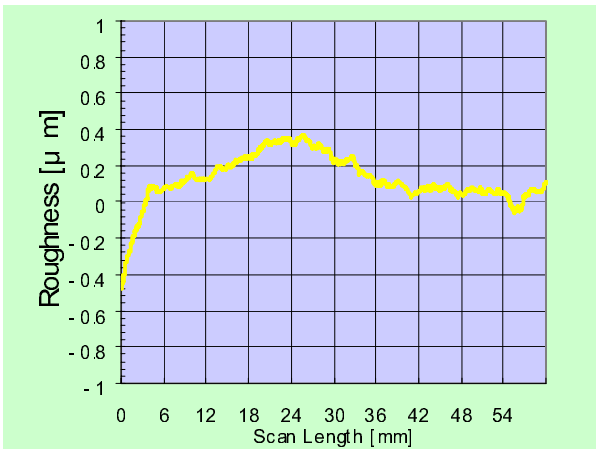


Figure 8 40um thickness glaze undulation
Upper: current process
Lower: new process

4. High durability

High durability implies some concept, for example heater stability, wear resistance, wire bonding durability, etc. Especially as result of failure analysis caused in the field, scratch was one of the major failure modes. Almost scratch is caused by particle from outside system. As tentative test result that was used lapping tape instead of thermal paper, the frequency of scratch fail ratio increased by decreasing protective layer thickness.

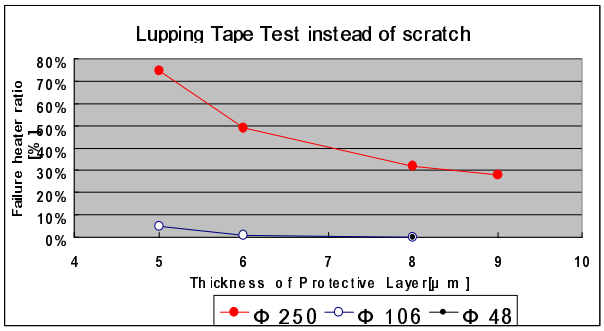


Figure 8 Lapping test instead of scratch

The protective layer stiffness shall be estimated by Young's modulus and section modulus, which is corresponding to protective layer thickness. It is sure protective layer will be worn by medium after long use. Therefore possibility of scratch will increase by increasing running distance. Toshiba Hokuto Electronics Corp. succeeded to optimize to select protective layer material and thickness to keep stability during printer life

5. Conclusion

TPH is printing devise that generates Joule heat and transfers Joule heat to medium. Therefore TPH design shall be defined by degree of heat generation uniformity and heat transfer uniformity. So Toshiba Hokuto Electronics Corp. thinks it is important to find vital control parameter for many kind of demand. Glaze and/or protective layer are vital parameter, so Toshiba Hokuto Electronics Corp. will improve current design and/or process by them for more high performance

Author Biography

Yoshinori Muya received his BS degree in electronics engineering from Kanagawa University in 1983. He worked at Toshiba Hokuto Electronics since 2002. He has designed thermal print head.
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