Novel Approach to Thermal Transfer Ribbon Residual Security Problem

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Abstract
Thermal transfer printing is a well-established, reliable, economical, durable, and quality printing method. However, the transfer ribbon residual image contains all the information of the printed matter (the "reverse" image of the printed information). This can be a tremendous security issue if the third-party gets hold of the used ribbon, especially if the printer is used for privacy-sensitive matters. The information can be safeguarded by destroying the ribbon in conventional ways such as shredding. However, such methods involve removing the ribbon from the printer equipment and processing it externally.

What we developed is a new heating head that is ideal for this application as it can be built into the printer or attached as an external unit of an existing printer. The heating head maintains a constant temperature suitable for melting the ink on the ribbon so that the original information is rendered unrecognizable. The startup time for the heating head from cold to operating temperature is a few seconds, a feature that is also attractive no energy is wasted while the unit is on standby. The construction of the head is unique and it is virtually free of heating surface abrasion problems.

Introduction
Thermal printing methods can be divided into two major categories: thermal transfer and direct thermal.

The direct thermal method, in essence, utilizes a print medium (paper in general) which is impregnated with a chemical (dye) that changes color in reaction to heat. Probably this is the simplest form of printing technology today and is most widely used for point of sales and bar-code labels as well as in the fax printing of yesteryear. The major drawback of this method is that the printed image is not permanent and if the medium is re-heated at the coloring (imaging) temperature, the non-imaged portion (background) will color and the original images will disappear as they merge with the background color.

The thermal transfer method utilizes a medium that does not contain any dye (plain paper, label or card in general) and a transfer ribbon that is permeated with the "ink" (wax or resin-based material). The thermal printhead heats the ribbon, the "ink" on the ribbon melts and moves (transfers) to the print medium. Images created by the thermal transfer method are more stable and "permanent" than those produced by the direct thermal method.

Problem of Residual Image
One of the drawbacks of thermal transfer method is that the ribbon has the residual image that contains all the information in the printed matter ("reverse" image of the printed information, analogous to the negative film of the conventional photographic process) as depicted in the Fig.1 illustration. This is a tremendous potential security issue if a third-party gets hold of the used ribbon, especially if the printed information contains any personal information such as the medical and personal records on a drug bottle label or prescription sheet, license or membership card, and so on.

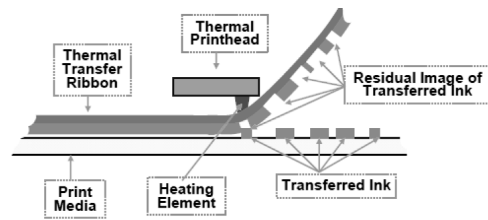

Fig. 1
Illustration of Residual Image on Ribbon

The residual information can be purged by shredding, melting or burning the used ribbon. However, the purging process is easier said than done, since typical thermal transfer printers on the market do not have provisions to deal with the residual image on used ribbons. If the ribbon is to be destroyed, the process will be done outside the printer and there is a high possibility that the ribbon could be lost in the process and the information leaked.

Alternative to Ribbon Purging Externally
One way to avoid information leakage due to mishandling the used transfer ribbon is to neutralize the ribbon prior to removal from the printer. If the used ribbon is heated to the ink's melting point so that the residual information is no longer readable while the ribbon is within the printer, it accomplishes the objective of purging residual ribbon information.

The ideal heating device for this purpose should have minimum impact on the printing function; it should not contribute to raising the temperature of the printer's internal structure and should consume minimum energy while the printer is not in use, yet there should be no waiting time for warm-up when the printing to start.

The Proposed Heating Device
We developed a heating device (heating head) that will be well-suited to this application as it is very close to the specifications for the ideal device described above [1]. It consists of a heating element and temperature-sensing element on the ceramic substrate as shown in Fig. 2.

The heating and sensor elements are made with the material which has a temperature coefficient of resistance (TCR) of plus 0.15%/°C. This makes it possible for this device to monitor the temperature in real time while it is in use through the change of resistance of the sensing element [2].

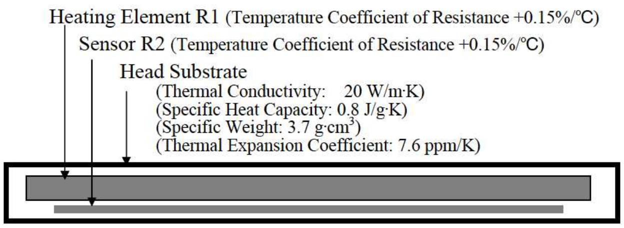

Fig. 2
Substrate structure of heating device
(Top view)

The temperature measurement can be made through the following process using the sensor element R2.

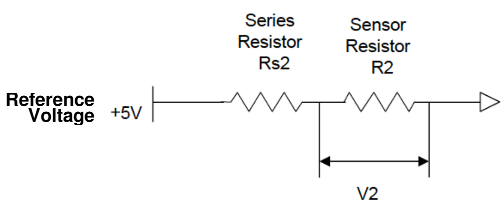

Fig. 3
Temperature measurement

The following is an example of temperature measurement.

- The temperature sensing element R2 has a temperature coefficient (TCR) of plus 0.15%/°C.
- Add a reference resistor Rs2 with high precision (+/- 1%) and temperature coefficient of +/- 25 or 50 ppm (parts per million)/°C in series with the sensor resistor R2.
- For this example, the reference voltage of +5V is applied to the sensor element R2 and the reference resistor Rs2 as shown in Fig. 3.
- The sensor resistance R2 at a given time is defined by measuring the voltage V2 across as:

$$R2 = Rs2 \times V2 / (5 - V2)$$

- Temperature change is found as the ratio of the percentage change of sensor R2 to the temperature coefficient (0.15) from the original resistance value of R2 at 20 °C.

$$\text{Temperature change (°C)} = \text{\% change of R2} / 0.15$$

With a positive TCR, the heating element gives the device a self-regulating capability as shown in Fig. 4. This is because the resistance of the heating element goes up as the temperature goes up. As a result, the current that goes through the heating element goes down and the power generated by the heater also goes down since the driving voltage remains constant. This is very important for the heating application as thermal runaway (temperature keeps going up as the heater is fed with more power since the resistance of the heater decreases) can have a devastating effect such as burning the ribbon or catching fire in the case of a typical heating device with the negative TCR.

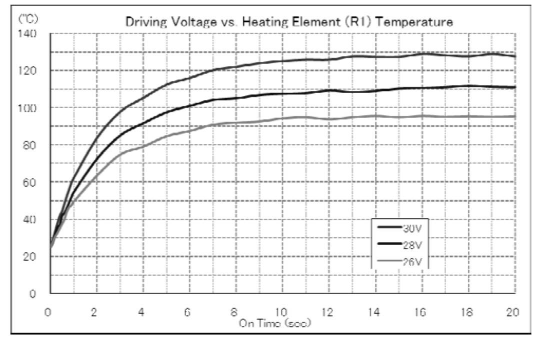

Fig. 4
Drive Voltage vs. Head Temperature

In addition to the ability to monitor the real-time operating temperature of the running process, the heating head is configured to withstand mechanical wear and tear as the heating surface is not on the same side of the actual heating element as shown in Fig. 5 and 6.

The head substrate selection is an important factor for the device since it determines the capability and functionality as well as the marketability.

From the performance point of view, aluminum nitride (AlN) which has the thermal conductivity of 60 W/m·K or silicon (Si) of 150 W/m·K may be better than alumina (Al_2O_3) of 20 W/m·K. However, the cost figures make it impossible to use the former two materials.

The ceramic (95% alumina) substrate with thickness of between 0.5 to 1 mm is a good compromise for this application as the thermal response time is in the second order and the thermal resistivity loss due to the heat going through substrate is about 1%. The same ceramic material is used in thermal printhead as well as hybrid IC industry, there is a definite scale of economy advantage.

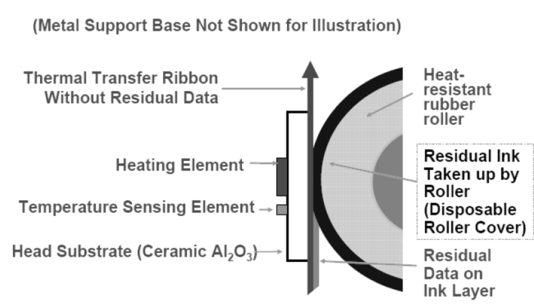

Fig. 5
Side View of Heating Head

An alternative heating head configuration is shown in Fig. 6; this is called a “true-edge” type, as the heating is done on the edge of the head. The advantage of this type is the flexibility of the placement and space saving in the printer unit.

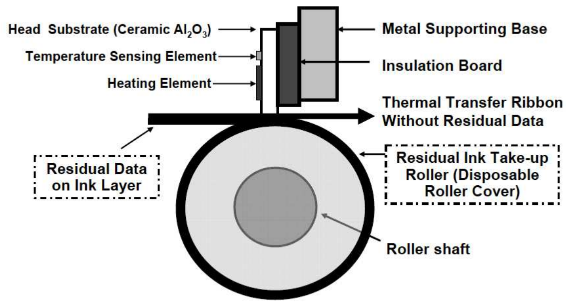

Fig. 6
Alternative Heating Head Configuration

The typical heating devices suffer abrasion issues, as when the material is heated when in contact with the heating surface. The new device, however, has no problems since the side on which the material being heated is facing is made of ceramic. So, even if hard particles such as metal or sand debris come through with the ribbon, no damage will be done to the heating surface.

Why New Heating Head Is the Best Fit?

As discussed, the new heating head has characteristics suitable for purging the residual image on the thermal transfer ribbon. The summary points are:

- The heating head requires no warm-up time and no "stand-by" pre-heating state as it can reach the operating temperature in a few seconds. This is an attractive feature from the energy conservation point of view.
- Heating head real-time temperature can be monitored while the thermal transfer ribbon is touching the heating surface for precise heat control.
- There is a saturation temperature for the heating element that will self-regulate the peak temperature for safety measures and will not cause the thermal runaway.
- Since the heating side of the head is made of ceramic, it is impervious to abrasion and wear and tear and the durability of the device is much higher than the typical thermal printheads.
- The production process is more cost-effective as the heating element does not need to have an anti-abrasion overcoat requiring secondary or multiple coating and firing steps.
- Heat distribution can be fine-tuned by trimming or adding extra materials on to the heating element since it does not become in contact with the ribbon.
- Temperature distribution of the heating head is more gradual and less localized with fewer hot spots as the heat comes through the ceramic substrate from the heat generating side to the ribbon contact side.
- The heat generating element is not on the ribbon heating side, so an alternative configuration of the heating head is possible as shown in Fig. 6. This will give more flexibility to printer manufacturers to incorporate the heating head.

Experimental Result

An example of the residual image on a thermal transfer ribbon is shown in Fig. 7. The residual information on the ribbon is exactly the same as on the printed media (paper, card, label, receipt, and etc) except it is the "negative" film format of conventional photography (i.e., the white part on the media is black on the ribbon and black part is white). There may be some specific information which is confidential or should not to be made public.

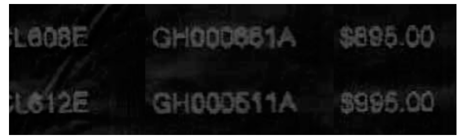

Fig. 7
Residual Image on the Thermal Transfer Ribbon

As shown on the example in Fig. 7, residual images on the used thermal transfer ribbon is clearly visible opening up the risk of information leak to the third-parties or competitors.

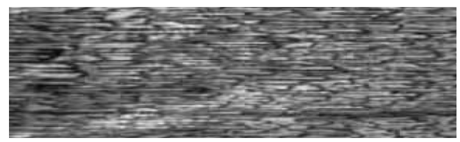

Fig. 8
Example of Purged Ribbon Residual Image

The example in Fig. 8 shows how the residual image on the thermal transfer ribbon is purged beyond recognition using the heating device. With this process, even if the used ribbon is obtained by a third-party, the data cannot be retrieved and information cannot leak out. The purging process was done at a temperature of 85 °C for this ribbon, but the temperature and purging speed depends on the thermal ribbon sensitivity and other specifications.

Implementation of Device Placement

The actual implementation of the heating device is up to the printer manufacturer and their design philosophy/policy dictates how the post-printing process is performed.

Fig. 9 is one example of heating device placement for the process. The printing process is the traditional thermal transfer method in which the transfer ribbon and the paper come onto the printhead pressing against the print roller. When the data for printing is supplied to the printhead, selected heating elements are energized and heated, making the "ink" (wax or resin) on the ribbon melt and transfer to the paper. The used ribbon with the printed information visible goes to the heating device and roller and the information is purged.

Since the ribbon handling mechanism (such as in cassette or rollers, for example) is different from one printer manufacturer to another, specific implementation of the heating head will be different. However, the basic idea of its operation should be the same.

Another implementation possibility is to have the heating device as an add-on unit to the existing printer rather than a new printer model. An advantage of the add-on ribbon purging unit is more cost related than technology since the process is virtually the same whether the device is built-in or external (add-on).

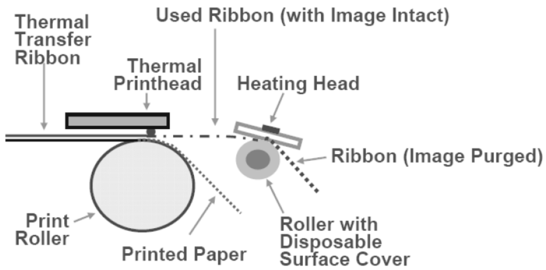

Fig. 9
One Implementation Example

The example of the setup uses a heating head and roller with a disposable surface cover, but here again, how the residual ink is absorbed will depend on the printer manufacturer and it can be in the form of a belt or scraping blade.

Conclusion

We demonstrated that for the application of purging the residual image data of used thermal transfer ribbons, the heating head we developed is a perfect device to be implemented when the process has to be done within the printer unit.

The process will give thermal transfer printing the benefit of secure printing and easy disposal of used thermal transfer ribbon data without the risk of information leaking to unintended parties.

References

[1] H. Taniguchi, S. Sunada & J. Oi, "Development of New Multi-Purpose Heating", Proceeding 2010 IS&T's NIP26, pg.693
[2] U.S. Patent # 7206009 B2

Author Biography

Before founding HIT Devices Ltd., in Kyoto, Japan, Hideo Taniguchi worked for ROHM Co., Ltd. for over 40 years where he was responsible for the products including items relevant to the printing industry like thermal printheads (printhead with partial glaze layer, development / implementation of driver ICs on substrate for printhead) and development/mass-production of LED printheads. He received his BS from Ritsumeikan University in Kyoto (in the field of Applied Chemistry) with additional study in Electrical Engineering.

Shigemasa Sunada joined HIT Devices Ltd., in 2007 and has been working in various heating head projects for design and development. Prior to his current work, he worked for ROHM Co., Ltd. in Kyoto as a design and development engineer for such products as LEDs and various diodes. He graduated in mechanical engineering at Rakuyo Technical High School in Kyoto.

Jiro Oi works for HIT Devices Ltd., a Kyoto-based electronic component manufacturer. A native of Hokkaido, Japan now he resides in Brentwood, Tennessee. Prior to joining HIT Devices, he worked with ROHM Co. Ltd. for more than 15 years specializing in thermal printheads and other electronic components. He received his BSEE from California Polytechnic State University in San Luis Obispo, California and MBA from Thunderbird School of Global Management in Glendale, Arizona.