Novel Approach to Plastic Card Overcoating Process

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Abstract

Plastic cards are widely used in various industries all over the world. Many on-demand non-embossed pictured cards require overcoating (also referred to as laminating) processes for surface protection from fading, abrasion, alteration and counterfeiting. There are several lamination types, such as wet lamination, dry lamination, hot-melt lamination and extrusion lamination. The focus on this paper is the hot-melt lamination type which utilizes heat and pressure to adhere the film on the card. The laminating / overcoating layer material can be clear material with anti-abrasion capability or hologram material for authentication. Typical overcoating process in the thermal transfer card printer is done by thermal printhead or heat roller. This paper suggests the heating head for this process. The heating head works on a very similar principle as the thermal printhead. The heating resistive element and temperature sensing element are placed on the alumina head substrate. When power is applied, the resistive element generates heat for the overcoating material to thermally adhere to the plastic card surface. Unlike the thermal printhead, however, which has hundreds of tiny heating elements, the heating head has one contiguous heating element. The construction of the heating head gives more robust thermal performance and even heating capability across the overcoating material on the card surface. In comparison to a heat roller, the heating head can be used on-demand and does not require the constant pre-heating while the unit is on stand-by (more "eco-friendly" efficiency and safety).

Background

We have been working with the thermal heads for over four decades for various purposes. The usage of the thermal heads became popular in the '70 and remained as a main stream of printing technology for the applications starting such as thermal pen recorder, direct thermal printer, bar-code printer, transportation ticket printer, fax machine, photo color printer, office printer, thermal rewritable printer and evolved into package sealer and laminator. Even inkjet printer (thermal bubble jet) is utilizing the thermal head. Our recent development was the heating head[1]. Originally, our heating head was designed for thermal rewritable application – to erase the image on the rewritable media.

The importance of erasing device for the thermal rewritable application was the ability to heat the rewritable media within the narrow window of the erasing temperature requirements set forth by the specific rewritable media. Our heating device met the requirements, because it was able to monitor the real-time device heating element temperature while the erasing media was in contact with the element.

We found that our heating head would be an excellent match for the plastic card overcoating applications. There are some specific requirements for this application and we addressed the issues. Since there are different methods to do the overcoating, this device may not fit all situations. If the process is done with thermal printhead which is used to print the image, for example, the separate heating head such as this device will not work. So this is a more application specific product.

Application Requirements

The application is for a very specific segment of the thermally printed plastic card overcoating process. Currently, the majority plastic card color printing is done with the process known as the dye diffusion thermal transfer (or some manufacturers refer to as dye sublimation thermal transfer) technology. The most popular card material is Polyvinyl Chloride (PVC) mainly because it is the most cost-effective material, although there are other materials available in the market.

The printed cards often contain useful information and/or personal data with picture, but they are often subject to counterfeiting, alteration, duplication and forgery. Overcoating is done to help reduce these problems.

Protection of a card with overcoats and laminations prolongs the life of the card by shielding the printed image from UV light (image fading), preventing dye-migration, reducing normal wear and abrasion due to handling, and reducing wear to the card image caused by frequent swiping of card through magnetic stripe readers.

Since our approach for the laminating/overcoating is the hot-melt method, our discussion will be limited to the specific materials which consist of clear and/or holographic varnish overlays and patches which are specifically formulated for card protection. Application of the overcoating material to the card is usually done by heat and pressure. Currently common methods are either to use the thermal printhead or heat roller. The importance for this process is for the overcoating material to be well fused to the card substrate without the air voids from edge to edge.

Heating Methods

When the thermal printhead is used for the process, the overcoating/lamination material is intermingled with the printing ribbon of different color panels. There are several combinations, but the common one is known as YMCKO (Yellow, Magenta, Cyan, blacK, Overcoat). Yellow, magenta and cyan are the primary colors in printing (or subtractive color) system. The three colors are combined in varying degrees to make a full spectrum of colors. Black (K rather than B to avoid confusion with blue) is usually a black resin panel for printing text, and clear overcoat or (O) is a thin, protective layer.

Merits for using the printhead for overcoating are:

- No added hardware for overcoating
- Smaller unit size

Typical shortcomings with this method are:

- Slow process speed
- High stress on printhead
- Potential uneven heating
- Limited ribbon selection

Another popular method is to use the heat roller. The overcoating material ribbon on for this method usually is separate from the printing color ribbon(s). For higher output printers, this has been a choice as the overcoat layer can be applied independent of printing process. The structure of the heat roller usually consists of the core heating element and the outer roller layer of some high-temperature synthetic material.

Pros for the heat roller method are:
- Smaller unit size
- Even heating
- Higher speed process

Cons for the method are:
- Slow start-up from OFF state
- Wasted energy on stand-by state
- Difficulty in precise temperature control

Heating Head

The new approach for this process is to use the heating head. The heating head was originally developed for the thermal rewritable media erasing process. The requirements for that application were the ability to start quickly from complete off state, on-demand heating, maintain the constant and precise process temperature throughout the operation. Those requirements happened to be almost identical to those factors required for the overcoating process with minor differences.

The heating head basic makeup consists of a heating element and temperature-sensing element on a ceramic substrate as shown in Fig. 1.

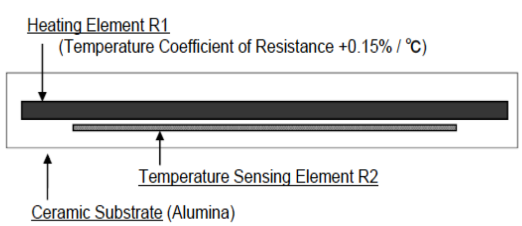

Fig. 1Substrate structure of heating head (Top view)

Though it does not show in the figure, the surface of the elements is covered by a protective glass layer. The substrate is mounted on the aluminum heat sink. The elements are connected with lead wires and the final configuration is shown in Fig. 2. Although the structure and appearance are similar to the thermal printhead, the operation of the heating head is very different. The heating head element (whole element as one continuous heater) is either ON or OFF and it does not require the data-in and enable (or strobe) signal like typical thermal printhead of this width range.

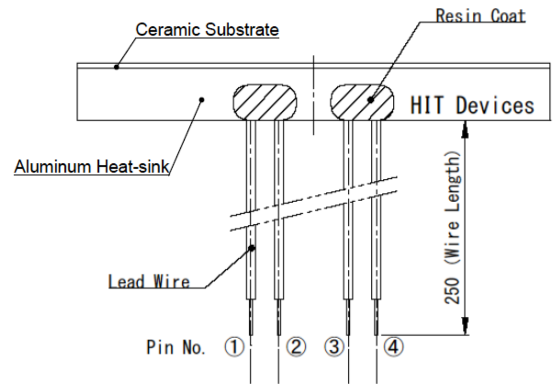

Fig. 2 Heating head configuration

Unlike the heat roller which requires a warm-up time when it starts from the OFF state or a constant heating to reduce the starting time when the roller is on stand-by, the heating head can be heated up on demand. That contributes to energy saving and efficiency as well as keeping the unit cooler. Also, it is safer as the heating device does not have to be kept at a high temperature on stand-by state.

Temperature Sensor

Existing heating device, be it thermal printhead or heat roller, has the temperature sensor, but it is to monitor the heating substrate or heat-sink (macro-temperature) and the reaction time is not very fast because it is mounted away from the heating element.

What makes this heating head different from other similar devices is the heating and sensing elements are located very close to each other (less than 1 mm) and the temperature change of the heating element can be picked up in real time even if the overcoating material and card are in contact with the heating element.

The temperature sensing element (R2) is made with the material which has a positive temperature coefficient of resistance (TCR) of 0.15%/°C or 1500 parts per million per Celsius degree (PPM/°C)[2]. In another words, the element's resistance changes according to the temperature. This makes it possible to monitor the temperature in real time while it is in use through the change of resistance of the sensing element. The example of temperature sensing and control circuit is shown in Fig. 3.

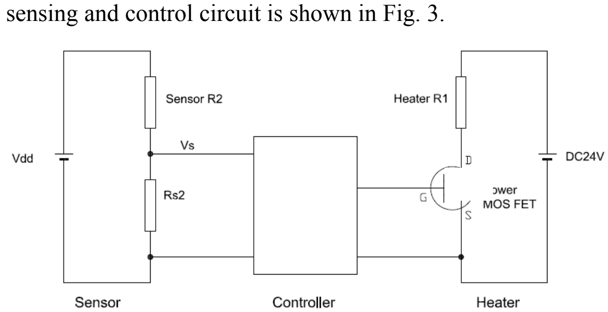

Fig. 3 Example of temperature control

The example circuit is to sense the temperature change which translates to the ohmic change of the sensor element R2 and to control the heater power supply to the heat element. The voltage fed into the controller Vs is defined as:

$$Vs = Vdd * (Rs2)/(R2 + Rs2)$$

Similar control circuit is to incorporate the Resister Bridge as shown on Fig. 4.

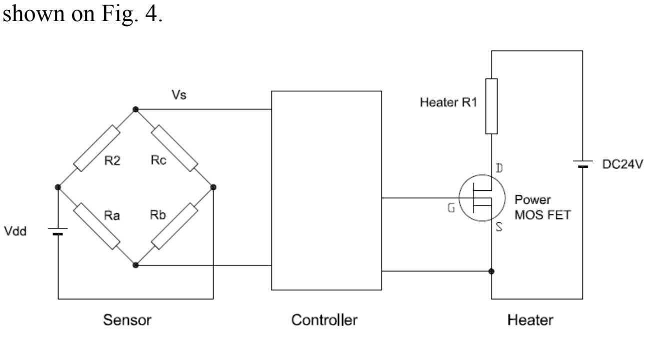

Fig. 4 Example of temperature control with Resister Bridge

The voltage fed into the controller Vs is defined as:

$$Vs = Vdd * (Rc/(R2 + Rc) - Rb/(Ra + Rb))$$

The temperature measurement can be made through the sensor element R2, since the TCR is known as positive 0.15%/°C and the 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.

Temperature change (°C) = % change of R2 / 0.15

Unique Feature of Heating Element

Typical heating devices have heaters with negative temperature TCR, but this heating head is equipped with the heating and sensor elements which have a positive TCR of 0.15%/°C.

What is unique about the heating head is the positive TCR heating element since it gives the heating head the "self-regulating" thermal characteristic. With the positive TCR heating element, if the temperature goes up when the power is applied, the heating element resistance goes up as well. With higher resistance, the current and power go down and eventually the heat is reduced.

The device in general with the negative TCR heating element has the characteristics of current increase as the resistance goes down when the temperature goes up, phenomenon known as the thermal runaway – eventually the device will suffer irreversible damage unless proper power management is employed. Therefore, the positive TCR heating head has the built-in safety feature.

Along with the basic characteristics of heating element self-regulation, the temperature control of heating head becomes easy when the control circuits such as shown in Fig. 3 or Fig. 4 are employed as the part of heating head driver unit. One example of actual temperature controlled heating profiles is shown in Fig. 5. The saw-tooth-like wave form is due to the driver voltage ON-OFF by the controller and not the characteristics of the heating head.

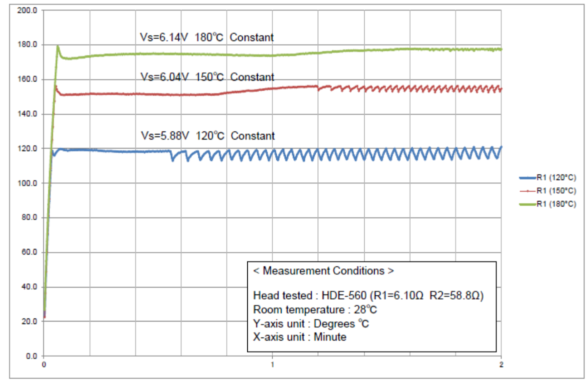

Fig. 5 Temperature Profile with Driver Controller

Requirements for Overcoating Process

The development of heating head for the typical rewritable media erasing was based on the most common card size CR80 (standard credit card size) of 54 mm width since the printing is contained within the card edges. For overcoating/lamination application, however, it is required to accommodate the requirement sometimes referred to as "Over-the-Edge" printing which is to print the card without white spaces on the card edges. If the card is printed up to the edges, then the overcoating has to be done same way. So, the heating element effective width was increased to 57 mm for this application. This will ensure the coating layer on the card is fused securely from edge to edge.

Implementation

The overcoating process by heating head is most likely done after the card printing is complete (vs. as a part of the printing process) similar to the heat roller process, though this will be completely up to the manufacturer of the equipment.

The output from the temperature sensing element (R2) should be fed into the control unit for proper driving signal in order to maintain the predetermined temperature level for the overcoating process.

The same care should be taken for handling the heating head as the thermal printhead as they are susceptible to the mechanical (physical) as well as the non-physical damages such as electro-static discharge (ESD) damage on the elements.

Common problems

This is not a unique problem to the heating head usage, but when the overcoating material is heated and fused together with the card substrate, then they tend to warp due to the different thermal expansion coefficient of two materials. This is a similar phenomenon to "bi-metal" effect.

One of the ways to solve the problem is to apply the opposite force to the card before it cools off completely. So by the time the card comes out of the unit it will be flat. Again, the implementation will be up to the equipment manufacturer. One possible solution is to incorporate the anti-warping bar which doubles as the liner material peeling bar just after the fusing is completed as shown in Fig. 6.

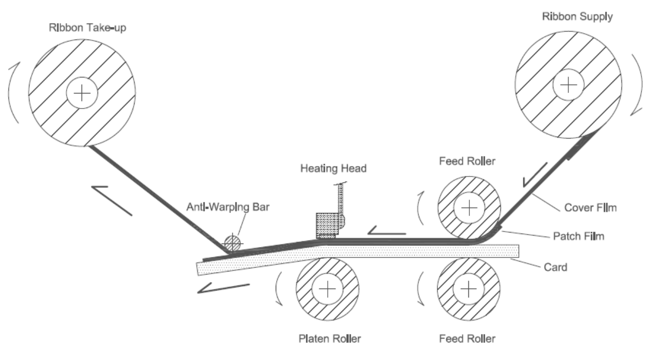

Fig. 6Concept of Anti-warping Mechanism

The best process conditions between the overcoating and card material has to be determined experimentally. Some of the common problems such as inadequate overcoating adhesion, air bubbles between the overcoating layer and card, streaking and overcoating material wrinkles can be solved by adjusting the process speed, temperature and head pressure.

The overcoating and card materials along with the thicknesses also change the processing parameters, so through compatibility testing under various conditions and combinations are needed.

Conclusion

We believe that the demand for the plastic card overcoating continues and the heating head proposed is an energy saving and safer alternative to a heat roller. With the proper temperature control circuit, the operation will be simpler and faster than other heating devices for laminating/overcoating operation.

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.