On-demand Transcript Foil Print Technology for In-Molding and Hot Stamp

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Abstract

We have developed totally dry, environment-friendly and small-footprint digital printing machine for In-mold and Hot stamp which is characterized by its Foil printing. Recently, digitalization of foil printing system such for In-mold is attracting strong attention since the variety o f exterior parts for consumer products, such like laptop PC, is increasing to provide different decorations accordingly to the personalization trend. We adopted thermal transfer method which has unique feature that it could print regardless of transferring material such like pigment for this application and made best use of it during commercialization. We report the content of study and measures against variety of problems such as heat radiation design etc required for speeding up the machine to meet the requirement of business use product.

1. Introduction

Thermal transfer printing is totally dry process and is the printing technology with simple structure and high reliability. It doesn't choose the transfer material such as pigment. Likewise, it could utilize the material used in gravure printing which is the most major method of In-mold and Hot stamp foil printing and reproduce the output in dry process without loosing the characteristics. In addition, Metallic ink such as Foil which is mandatory for exterior parts decoration could be printed. We have developed seven colors tandem system also capable to print spot colors aiming to achieve both productivity and versatility which is required in business use product while making best use of these characteristics of thermal transfer. In order to design this machine, Heat radiation design for small-footprint and high speed, Highly accurate film feeding and positioning technology, Various measures for vibration, Highly accurate thermal head heat controlling technology to achieve gravure-like high quality printing, Highly accurate color simulation technology etc were needed and this report will discuss our approach to part of these.

2. Mechanical Design and Mechanical Control

2.1. Outline structure

First, Fig.1 explains outline structure of printing system we developed this time. Printing film will be fed in roll form and winded after passing drum platen. Seven printing heads are allocated radially on drum platen Drum platen rotates and film will be fed. Printing head will be applied one by one accordingly to the transferred film and print on it. Print result is shown in Fig. 2. It realizes equal print quality with the offset printing shown as comparison.

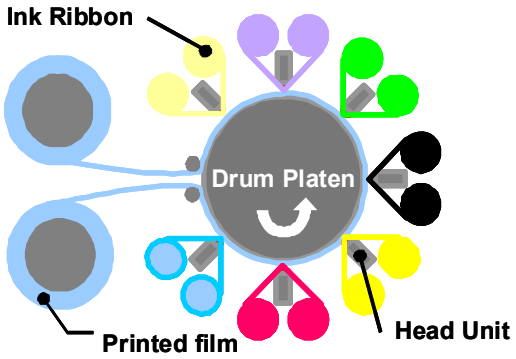


Fig.1

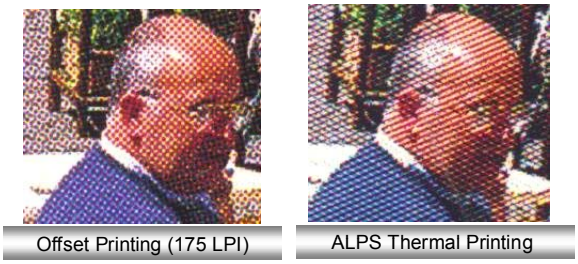


Fig.2

The exterior part produced with the output from this digital thermal transfer printing machine is shown in Fig.3

Fig.3

2.2. Heat Radiation Design

Temperature rise of system is a big problem for printing stabilization where heat is given as principle of thermal transfer printing. Especially this time, with this 7 channel tandem system, heat accumulation around the printing head became serious problem. We have adopted water cooling method which provides excellent cooling capacity for its compact size in order to cope with this problem. Schematic diagram of two different cooling method is shown in Fig.4. Since heat radiator can be separated from heat source with water cooling system, it allows you to design the head surrounding area compact as well as eliminate the limitation of cooling performance caused by space factor. Comparison of temperature rise between water cooling method and conventional air cooling method is shown in Fig.5.In case of thermal transfer method, precise heat control will become difficult if the temperature around the thermal head exceeds 55 Deg C. Water cooling method keeps the temperature 50 Deg C while air cooling method reaches 55 Deg C in about 15 minutes.

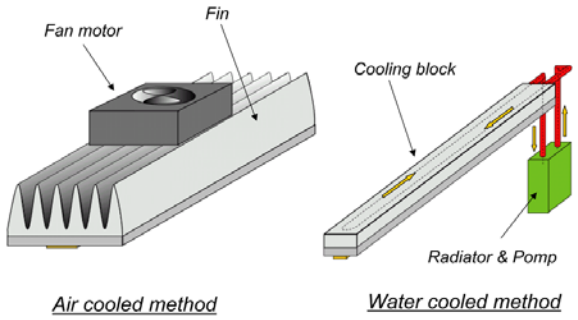


Fig.4

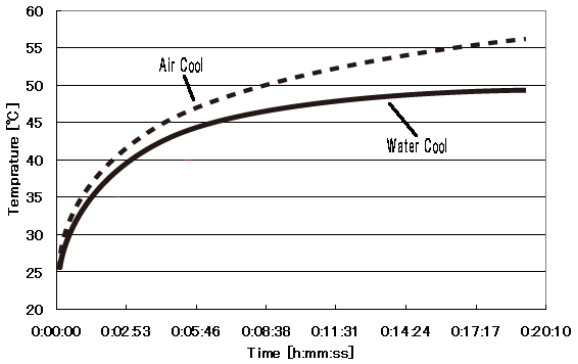


Fig.5

2.3, Film feeding technology

Since the vibration on film feeding system will cause irregular print, measures for vibration become indispensable to achieve print image stabilization. Especially with tandem system, since irregular density from each print head will interfere to be strong irregular color, the problem is more serious.At the beginning stage of development, strong irregular color appeared which was caused by the vibration of printing film winding system.The data is shown in Fig. 6. Horizontal axis is spatial frequency and vertical axis is strength of density error. Before applying the countermeasure, there were several strong peaks including the one exceeding 4 % density error. Analysis of spatial frequency helped to identify the vibration source and we have applied proper countermeasure on those sources based on the analysis data. We could lower the density error caused by vibration within 1%.

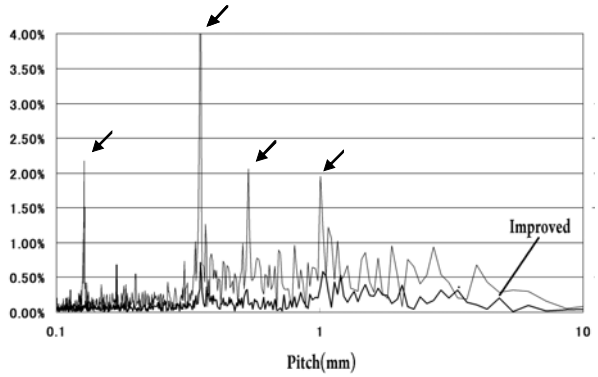


Fig.6

2.4. Stable ink ribbon tension control technology

In printed image stabilization, it is also important apply stable tension to the ink ribbon which is used in thermal transfer method. Irregular Density will be generated by jitter if the ribbon tension is too high, instead, wrinkle will be generated if it is too low. Ink ribbon tension depends on diameter of ink ribbon and diameter of ink ribbon changes continuously depending on used amount. Therefore it is necessary to detect the condition and control it in real time. We have adopted the combination of encoder feedback and PWM (Pulse Width Modulation) control since the servomechanism which is suitable for this intended purpose is expensive. PWM control is a method to modulate the output by changing the duty ratio of pulse wave and it is possible to use general DC motor.

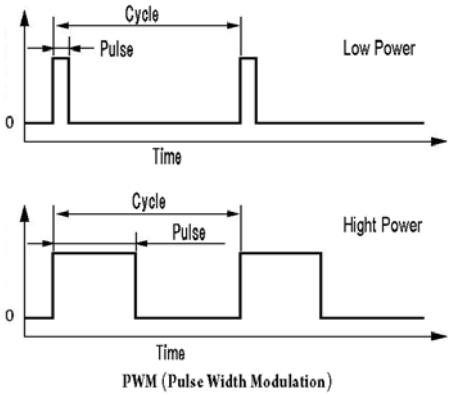


Fig.7

It is possible to control the ribbon tension in real time by controlling the PWM duty continuously accordingly to the ink ribbon rotation speed calculated by linear encoder. Concept of

PWM control is shown in Fig. 7 and Duty - Output relation chart is shown in Fig. 8. The power to DC motor is provided by pulse and therefore it is possible to control the average output by changing the pulse width per cycle as a duty.

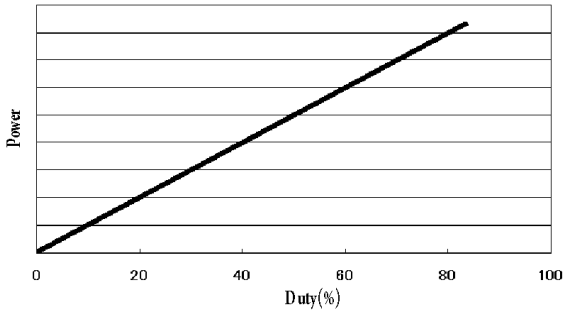
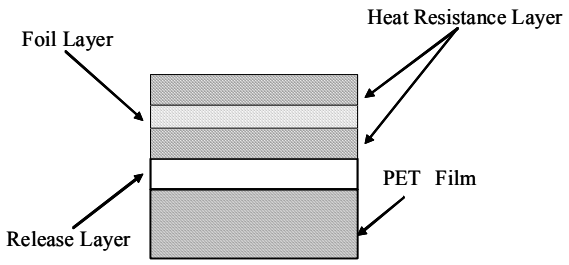


Fig.8

2.5. High luminance Foil printing technology

Luminance is the most important feature of Foil printing and it is important to suppress heat deformation of Foil in order to achieve high luminance. There are two factors of heat deformation, one is heat resistant physicality of Foil (Ink Ribbon) another is heat of print head.In order to improve the heat resistance of Foil, we have adopted sandwich structure which put the Foil layer in between heat resistance layer. (Fig. 9)It is desirable to keep the thermal head driving temperature low against heat deformation. The relation between thermal head pulse control and temperature is shown in Fig. 10. With conventional energizing method, printing and gloss was incompatible since it reached the heat deformation beginning temperature of Foil (T1) if the electric power required to transfer Foil is applied. We have solved this problem by adopting chopping control for energizing which could provide enough amount of heat to transfer Foil while limiting the peak temperature low. The surface of printed Foil by each method is shown in Fig. 11. There is no heat deformation on chopping control result while conventional method shows heat deformation per dots.



Foil Layer Cnstitution

Fig.9

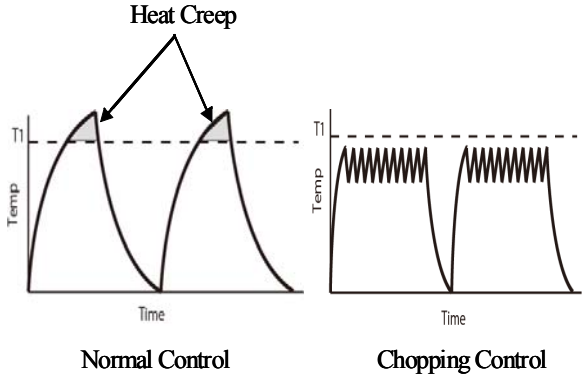


Fig.10

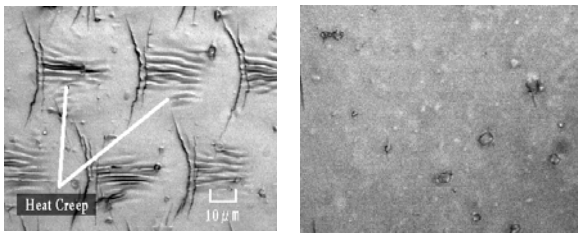


Fig.11

4.Conclusion

We have developed totally dry, environment-friendly and small-footprint digital printing machine for In-mold and Hot stamp which is characterized by its Foil printing. Recently, High mix – Low volume is becoming a trend of exterior parts decoration. Digital printing is capable to print from 1 sheet and we believe the system we developed will contribute to this needs.

References

[1] 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)

[2] 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)

[3] T. Asada, H.kobayahi and, H.Terao ” Study of D2T2 printing for high-speed print”,IS&T’s NIP20:2004

[4] T. Asada, H.kobayahi and, H.Terao ” Study of D2T2 printing for high-speed print”,IS&T’s NIP20:2004

[5] T. Sasaki, T. Nakatani, N. Numata, H. Hoshino and H. Terao “ Development of Power Saving Thermal Print Head”

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