Toner Based Direct Color Printing on Plastic Boards

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Abstract

Toner based direct color printing on plastic boards has been investigated using a color laser printer. The color toner for the printer consisted of polyester resin, color pigments, a charge control agent, and wax. The transfer and fusing conditions in the printer, which used an intermediate transfer method and a fusing roller method, were optimized to obtain color images on six types of plastic boards such as these made from polymethl methacrylate (PMMA), polycarbonate (PC), and polyethylene terephthalate (PET). The fused polyester color toner was found to adhere to the plastic boards, with results for the PET, PVC, and ABS boards being particularly good.

Introduction

Printing on plastic boards is important for making many kinds of packages, cards, CD-ROMs, photo masks for printed circuits, and so on. Moreover, the demand for direct printing on plastic boards, which is easier than the traditional offset method, is increaseing.[1,2] Toner based direct printing using electrophotographic technology is one candidate for this. Electrophotographic printing has become one of the most widely used techniques in copiers and printers to form images ranging from monochrome to full color ones. However, the status of electrophotographic technology for direct printing on plastic boards is still being investigated. Never the less, the future is bright, and it is predicted that this method will become more common than traditional printing techniques.

The aims of this study were two fold. One was to optimize the transfer and fusing conditions in an experimental machine to obtain toner based color images on several kinds of plastic boards such as PMMA, PC, and PET. The other was to evaluate the adhesive ability between the fused polyester color toner and the plastic boards.

Experimental Machine and Materials

The experimental printing machine used in this study is shown in Fig. 1. The machine was equipped with a diode laser scanner assembly, an organic photoconductor belt, four color developing units using a non-magnetic mono-component developing method, an intermediate transfer drum, a corona charger for pre-charging, a transfer roller, and a heat roll fuser.[3] This printing machine successively transferred four color toner images (yellow, magenta, cyan, and black) from the developing units to the intermediate transfer drum via the organic photo-conductor belt in a way that caused the images to overlap one another. A complete color image was thus formed by the four color toner images on the intermediate transfer drum. This was then transferred to a plastic board by the transfer roller. Before this transfer process, the corona charger charged the surface of the plastic board. Next, the color toner particles on the board were fused with the heat roll fuser. Then, the toner particles adhered to the board.

The fuser's surface material was silicone rubber. The processing speed of this experimental machine without the fusing process was 100 mm/s. It was 35 mm/s with the fusing process. This latter approach resulted in good toner adhesion.

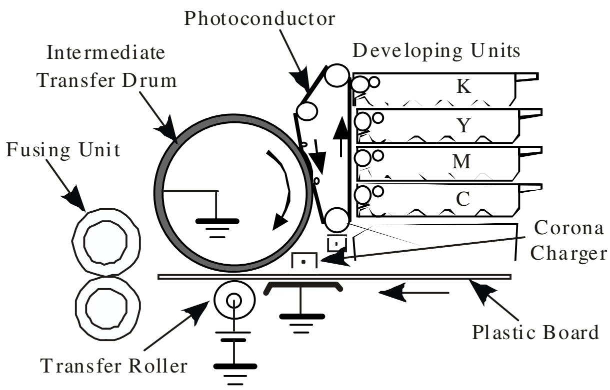

Figure 1. Construction of experimental printing machine.

Table 1. Basic Properties of Plastic Boards.

No.	Name of Plastic Board		Specific Gravity	Specific Heat (KJ/g°C)	Volume Resistivity (Ω • cm)	Thickness (mm)
1	Polymethyl Methacrylate	(PMMA)	1.17	0.00207	$6x10^{16}$	1
2	Polycarbonate	(PC)	1.23	0.00172	$4x10^{17}$	1
3	Polyethylene Terephthalate	(PET)	1.27	0.00268	$6x10^{17}$	1
4	Rigid Polyvinyl Chloride	(Rigid PVC)	1.4	0.00175	$2x10^{16}$	1
5	Plasticized Polyvinyl Chloride	(Plasticized PVC)	0.7	0.00172	$3x10^{16}$	1
6	Acrylonitrile Butadiene and Styre	(ABS)	1.05	0.00212	$4x10^{16}$	1

The color toner for the printing machine consisted of polyester resin, color pigments, a charge control agent, and wax. The glass transition and melting temperatures of the toner were 60°C and 104°C, respectively. The six types of plastic board shown in Table 1 were used in this study.

Transfer Conditions

The thickness of the plastic boards was 1 mm, and their volume resistivity was very high at over $10^{16}\,\Omega$cm. Therefore, it was difficult to transfer the toner particles from the intermediate drum to the plastic board using only the transfer roller. That is, the pre-charging technique was important to obtain good transfer efficiency. Figure 2 shows the relationship between the transfer efficiency and surface charge on the plastic board (PMMA board in this case). The transfer efficiency was determined using the ratio of the toner mass amounts on the intermediate transfer drum before and after the transfer process. It was found that charging at over 10^{-8} C/cm^2 was necessary to obtain good transfer efficiency.

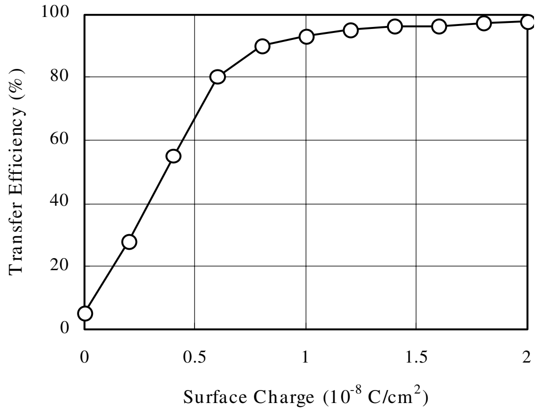

Figure 2. Transfer efficiency and surface charge.

Fusing Conditions and Toner Adhesion

Figure 3 shows the relationship between the toner adhesion and fusing temperature. Toner adhesion was determined using the tape-peel method. In the tape-peel test, adhesive tape was stuck on the printed surface for five minutes, after which the tape was pulled off at a 180 degree angle. Toner adhesion was measured in percentages, which equaled the ratio of the densities of the printed areas before and after the test.

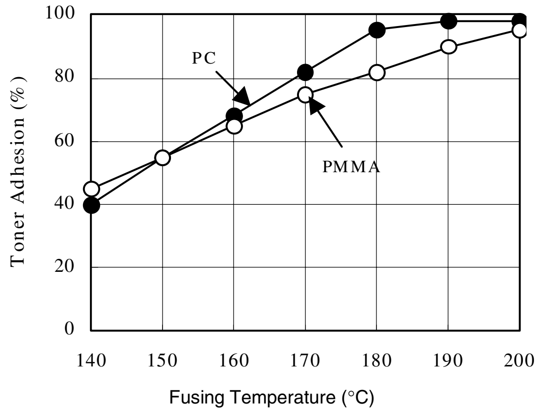

Figure 3. Toner adhesion and fusing temperature.

From the results in Fig. 3, it was found that a fusing temperature over 180°C was necessary to obtain good toner adhesion over 80%.

Table 2 shows the results of toner adhesions for fusing at the temperature of 200°C. From the results, it was found that the polyester toner used in this study adhered well to the PET, PVC, and ABS boards.

Table 2. Toner Adhesions for Fusing at the Temperature of 200°C.

PMMA	PC	PET	Rigid PVC	Plasticized PVC	ABS
90 ~ 95%	93 ~ 98%	95 ~ 100%	95 ~ 100%	95 ~ 100%	95 ~ 100%

Conclusion

Toner based direct color printing on plastic boards has been investigated using a color laser printer. The transfer and fusing conditions in the printer, which used an intermediate transfer method and a fusing roller method, were optimized to obtain color images on six types of plastic boards. It was found that the fused polyester color toner adhered to the plastic board. In addition, the following results were noteworthy.

1) The pre-charging technique was important to obtain good transfer efficiency.
2) Fusing temperature over 180°C was necessary to obtain good toner adhesion with plastic boards.
3) The polyester toner adhered particularly well to the PET, PVC, and ABS boards.

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Biography

Akira Shimada received a B.E. degree in electronics from the Shinshu University, Japan, in 1977 and an M.E. degree in electronic physics from the Tokyo Institute of Technology, Tokyo, Japan, in 1979. Since 1979, he has been engaged in the research and development of electrophotographic processes at Hitachi Ltd., Japan. He is a member of the Imaging Society of Japan.