A Method for Increasing Fusing Latitude of Liquid Toner

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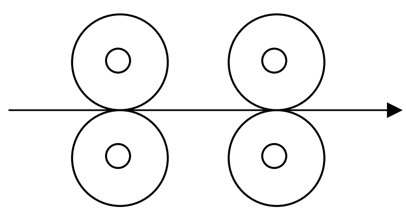
Abstract

A method is described which increases the fusing latitude of liquid toner in an electrophotographic printer. A two stage fusing system with different coverings on the first and second stage fusing rollers has been found to produce fused toner images with good durability without low or high temperature fuser offset. The first stage nip temperature is just high enough to vaporize most of the liquid toner carrier fluid. The first stage roller covering is selected to resist low temperature fuser offset. The temperature of the second stage fuser nip is sufficient to adequately fuse the toner to the receiving media and is generally higher than the temperature of the first stage nip. The covering on the second stage fusing roller is selected to resist high temperature fuser offset. The coverings on both the first and second stage rollers must have good release properties.



Introduction

Toner images produced by electrophotographic printing must exhibit good durability, blocking resistance and crease resistance. Image durability is accomplished by passing the printed media through a heated nip. This melts and fuses the thermoplastic polymer within the toner particles to the media. A persistent problem that can occur during the toner fusing process is preserving image integrity. Any toner that adheres and transfers from the receiving media to the fusing roller or belt will compromise image integrity. The term "fuser offset" is commonly used to describe this unwanted toner transfer. Fuser offset can occur if the fusing nip temperature is either too low or too high. Low temperature fuser offset (cold offset) is the result of solid toner particles, that have not reached the molten state, transferring to the fuser roller surface. High temperature fuser offset (hot offset) occurs when the viscosity and /or cohesive force within the molten toner has been sufficiently reduced to allow adhesive transfer to the fuser surface. For successful image fusing an operating temperature window must exist between the low and high offset temperatures.

A liquid toner is a dispersion of toner particles in a dielectric carrier fluid. Generally, the carrier fluid is hydrocarbon based and selected so that the vapor pressure is sufficiently low to minimize increase in toner solids from evaporation prior to toner deposition onto the imaged photo receptor but is sufficiently high to allow some evaporation during transfer and preferably prior to actual fusing of the toner particles onto the final receiving media. Vapor pressure of the carrier fluid is even more critical when multiple layers of toner are sequentially deposited and transferred to form colored images on the receiving media. The fusing offset temperature window generally increases as the residual carrier fluid in the toner image decreases.

Experimental

A series of fusing experiments were run to define and quantify the advantages of fusing with the two stage system.

Description of Fuser Configurations

Figure 1 depicts a single stage fuser apparatus that is typically used for fusing dry toner. This apparatus has an upper fusing roller and a lower backup roller. Both rollers are hollow and have an internal thermostatically controlled halogen lamp to heat the rollers.

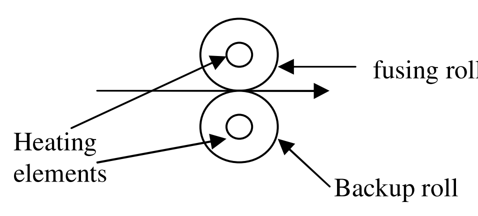


Figure 1. Typical fusing for dry toner

Figure 2 depicts the two stage fuser apparatus used for fusing liquid toner. The first stage rollers are used to absorb and/or vaporize at least a portion of the carrier liquid. The temperature of the first stage rollers is set low enough to prevent hot offset of molten toner but high enough for carrier fluid evaporation. After passing through the first stage nip the residual carrier fluid in the toner image is low enough to allow acceptable toner fusing in the second stage nip. In these fusing tests the upper roller for both the first and second stage nips had a durometer of 10 Shore A and the lower rollers had a durometer of 20 Shore A.

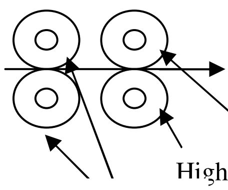


Figure 2. Liquid Ink Fuser

Fused Image Abrasion Test

Toner images 5 inches long by 1 inch wide were printed and fused with each fuser test configuration. An AATCC Crockmeter Model CM1 manufactured by Atlas Electric Devices Company, Chicago, IL was used to measure the abrasion resistance of the various fused images. A 1.76 cm^2 linen cloth was mounted onto the Crockmeter head and the cloth cycled back and forth 5 times (a total of 10 passes) on the fused toner image. A constant load of 934 grams on the head was used during the abrasion of each fused sample. The fused ton toner images were large enough so that the cloth contacted only the fused toner image during cycling.

The abrasion resistance of the fused image is determined by measuring the optical density of the initial fused toner image and the optical density of toner abraded onto the cloth. The following formula is used to calculate abrasion resistance with results reported as a percentage:

Fused Toner Abrasion Resistance =

$$((OD_{print} - OD_{cloth}) / (OD_{print})) \times 100$$

A grade of 95% is considered acceptable.

Fuser Offset Test

Fuser offset occurs when part of the toner image on the printed media is transferred from the media to a fusing roller during fusing. In this evaluation both cold offset and hot offset were investigated. The following rating scale was used to grade image integrity of fused images from the various fuser configurations:

Image Integrity Ratings

Rating	Description
0	Image integrity preserved; acceptable
1	Very small areas of fused image are missing but
	the frequency is very rare
2	Small areas of fused image are missing every 10-12 prints
3	Small areas of fused image are missing every 4-5 prints
4	Large areas of fused image are missing on some prints
5	Large areas of fused image are missing on consecutive prints

Single Stage Fusing (One Roller Pair)

The following results were obtained from a fusing device configured as shown in Figure 1 in which the toner images were made with liquid toner. This is a single stage fuser which is similar to that used in printers that use dry toner.

All of the fuser rollers used in this test were covered with a silicone elastomer.

Fused Liquid Toner Image Evaluation with Single Stage Fusing

Type of Fuser Roller Covering	Fuser Roller temp.-C	Abrasion Resistance	Offset
Absorptive silicone elastomer	75°	No data	Cold offset: 5
	100°-110°	85%	Hot offset:1
	120°-130°	95%	Hot offset:3
	145°-160°	97%	Hot offset:4

These results indicate that acceptable abrasion resistance is only obtained at a temperature that causes hot fuser offset. An operating temperature window for acceptable image fusing does not exist when using a single stage fuser configuration with the liquid toner used in this test.

Two Stage Fusing (Two Roller Pairs)

The two stage fusing system has two pairs of rollers as shown in Figure 2. The covering on the first roller pair is a carrier fluid absorbent silicone elastomer. This covering has good release properties, has good resistance to cold fuser offset and is efficient in the removal of a significant amount of carrier fluid from the toner image. The second roller pair is covered with a fluoropolymer which has good release properties, has good resistance to hot fuser offset and is durable for extended usage at relatively high temperatures.

Fusing trials were again run with the two stage fuser system and with the same liquid toner that was used above with the single stage fuser. Results are given in the following table:

Results and Discussion

From these results and from observations made during testing, carrier fluid evaporation takes place at the first stage rollers which removes much the of the carrier fluid from the toner image. This allows the second stage rollers to adequately fuse the image without fuser offset. Acceptable fused toner abrasion resistance is now obtained without fuser offset as shown in trial 4.

The fusing performance of the system is improved even at lower temperatures, when the first stage fusing roller was covered with a carrier fluid absorbent release coating. This results in a further decrease of the residual carrier fluid in the toner image. Careful selection of the fuser roller coverings can therefore increase fusing latitude with liquid toner.

To determine the efficiency of carrier fluid removal with two stage fusing, toner images were printed, fused and placed inside a clear polyethylene/polyester sleeve. This sleeve is known to be affected by exposure to and contact with hydrocarbon fluids and vapors. The presence of a hydrocarbon causes wrinkling of the sleeve.

Toner images were passed through the fuser at various first stage fuser nip temperatures. These prints were then inserted into the polyethylene/polyester sleeves to determine the presence of hydrocarbon carrier fluid. The following table is a summary of results:

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Carrier Fluid Content vs. First Stage Fuser Roller Temperature

First Stage Nip Temperature	Wrinkling of Polyethylene Sleeve
Control – Not passed through the first stage nip	Yes – Unacceptable
150	Yes – Unacceptable
160	Yes – Unacceptable
165	No - Acceptable

These results indicate that most of the carrier fluid in the toner image is removed if the first stage nip temperature is above 165 degrees C and the second stage roller is set at 180C for all conditions.

Conclusion

A combination of mechanical configuration of the fuser and proper selection of fuser roller coverings has been shown to increase the fusing latitude of liquid toner images in an electrophotographic printer.

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Cond.	Roller(s) used	Roller Temp.	Abrasion Resistance	Offset
1	Roller 1 only	95°C	77%	0
2	Roller 2 only	180°C	90%	5
3	Roller 1 & Roller 2	90°C/180°C	98%	1.5
4	Roller 1 & Roller 2	95°C/180°C	98%	0
5	Roller 1 & Roller 2	50°C/180°C	90%	0

Biography

Chuck Simpson received a B.S. in Chemical Engineering as part of an Engineering Assistance Program at 3M Company in 1982. He has worked in imaging science with both the 3M Company and Imation. He is currently working with the Digital Printing Solutions Lab of Samsung Electroncis in Woodbury, Minnesota and can be contacted at 651-209-4938 or at *cw.simpson@samsung. com.*