Duplex Color Radiant Fusing

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Radiant fusing in the wavelength range between 500 nm – 10 μm (visible – far infrared (IR C)) with continuous radiation or pulsed radiation has been used in copying and printing since the early days of commercial application of electrophotographic technology. We have evaluated the use of high intensity continuous and flash radiation for color independent radiant fusing and have chosen the UV range from 200 nm – 380 nm (UV-C – UV-A) of the spectrum which combines high intensity and low color dependency. We discuss matching of emission spectra of lamps with absorption spectra of the toners by fuser modifications, process and toner material optimization. In duplex fusing of prints for two-pass duplex electrophotographic engines, the paper goes through the fusing station twice, with the risk of reheating the first image above the softening point. Radiant fusing requires non-contact paper feeding in the heating zone followed by a non-contact paper feeding in the following cooling zone. In flash fusing we demonstrated that backside temperature of the substrate stays well below critical temperature so that conventional contact paper transport means like Kapton® belts are sufficient for duplex color flash fusing of sheet materials. Finally we discuss the potential of the technologies for future toner based high speed color production printers.

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Introduction

Definition

Fusing is the fourth step of the electrophotographic process consisting of the steps:

1. imaging,
2. inking,
3. toner transfer,
4. fusing,
5. cleaning.[1]

We concentrate in this paper on fusing of dry toner. Fixing of the toner powder is a process that includes liquefaction, sintering, spreading, penetration into the paper and re-solidification (Fig. 1). Most common materials having these characteristics are based on thermoplastic resins.

Toner is not only fixed to the paper but additionally the surface quality has to match the gloss and other print quality specification. The complete process of fixing and matching the image quality as far as it is fuser related we call fusing. Other digital printing technologies like electrographic, ionographic or magnetographic printing use toner as well. The teaching of this paper is valid for them analogously if they use color toner.

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History

A variety of technologies have been used to apply energy to the toner (and the paper) which cause the toner to fuse on the surface of the paper.

In early days of electrophotography and related processes non-contact heating, vapor fusing or cold pressure fixing were used.[3] The non-contact heating methods used were mainly flash (Fig. 2)[5], IR, or convection fusing (see Ref. 4).

For more than 20 years the most common fusing technology has been hot roller fusing where toned paper passes through a pair of rotating rollers, at least one of which is heated. The heat melts the toner and the roller pressure pushes it into the paper[6] (Fig. 3).[7] Nowadays hot roller fuser is the dominant technology in low and medium speed printing.

The principles of black and white[8] and process color[9] (mostly 4 color) fusing technology have to be distinguished. Spot color (two color) printing is assigned to black and white printing as it is done by modified one color printers. The main differences are shown in Table I.

Widely used in the field of high speed black-and-white production printers is the use of "hybrid" fusers which are combinations of more than one technology, e.g., a contact paper preheater with a roller fuser in high speed web electrophotographic printing above ca. 0.75 m/s, or pressure transfixing combined with flash or radiant fusing used in high speed web ionography.[11]

For industrial color printing machines (digital presses) the demands regarding paper processability are further widened and include paperweight up to ca. 300 g/m² as well as a broad variety of substrates including coated and textured papers.

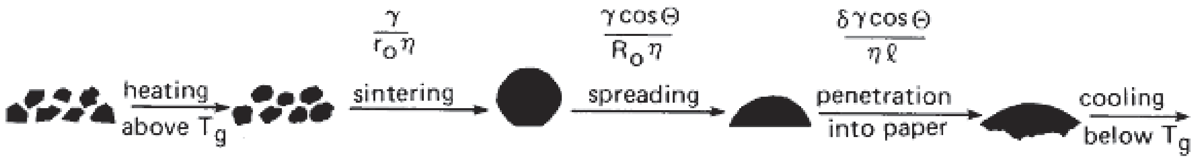

Figure 1. Processes involved in fixing[2]

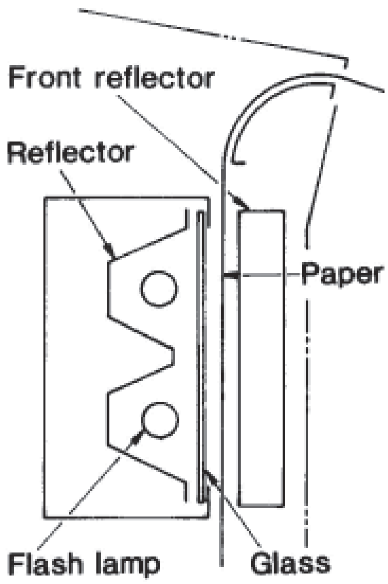

Figure 2. Structure of color flash fuser[3]

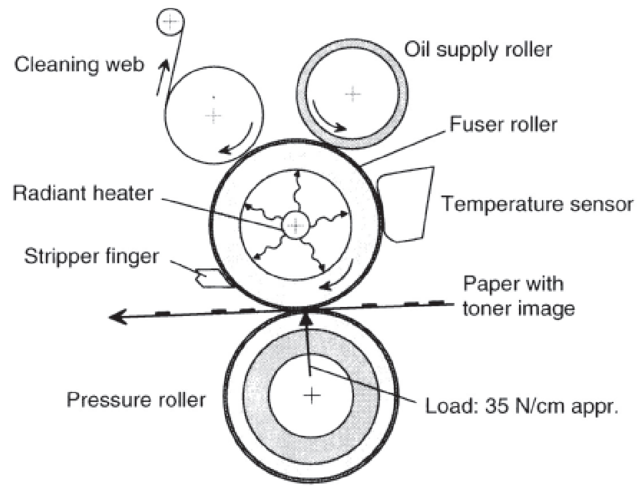

Figure 3. Example of heat roller fusing unit[7]

TABLE I. Main Differences Between Black and White and Process Color Printing

	Black & white	Process color
Max. toner layer	100%	400% (290% using under color removal[10])
Preferred gloss	Matte	Glossy
Paper stock	Small range	Wide range

TABLE II. Characterization of the Optical Spectrum

UV-C	100 nm – 280 nm
UV-B	280 nm – 315 nm
UV-A	315 nm – 380 nm
Visible	380 nm – 780 nm
IR A	780 nm – 1400 nm
IR B	1400 nm – 3000 nm
IR C	3000 nm – 106 nm

In production printing a variety of non contact fusing technologies are used beside roller fusing like IR and flash fusing. For dry toner based color printing hot roller fusing is still dominant with a single exception where long wavelength IR radiation is used.[12]

Motivation

Contact fusers, like hot roller fusers, have been widely used. However their failure rates and associated maintenance and the use of silicone oil as release agent have driven a search for more reliable technologies, which have lower costs over the lifetime of the machine and show better fusing quality as well. Thus we have evaluated the non-contact radiant fusing methods using flash or continuous radiation for their potential as future fusing technologies for color production printing.

Absorption Characteristic of Color Toner and Paper

IR radiation is used so far for non-contact fusing of toners. For single color (black) printing IR A and IR B radiation have been used for a long time (Table II).

For color toner, so far only IR C radiation is used where the paper and the toners absorb nearly 100% of the IR radiation. The absorbency of the toners in the three process colors cyan, magenta and yellow on one hand and that of black toner on the other hand differ significantly in the wavelength range <5 μm (Figs. 4 and 5).

The paper absorbs typically less than 10% in the visible, more than 60% above 2.5 μm and nearly 100% of the IR radiation above 10 μm. The process color pigments absorb in limited wavelength regions in the visible, and absorb typically less than 10% in the IR range below 2.5 μm. Black toner absorbs about 90 – 95% in the wavelength range between 0.8 μm and 10 μm.

These different absorption characteristics cause non-uniform fusing behavior with IR A and IR B radiation, which may be seen as non-uniform fixed toner, non-uniform gloss, partial blistering of toner (so called micro-blistering) on coated paper, or partial overheating of the paper with color change.

This effect is most significant between the three process-color toners, which absorb slightly differently and very selectively in the wavelength range between 0.8 and 4.5 μm, and the black toner, which absorbs about 95% over that wavelength range. Due to this unequal absorption of black toner, color toner and paper, non-contact IR fusing of full color prints is so far only pos-

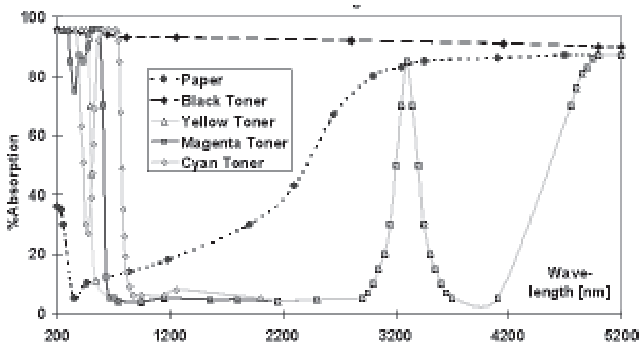

Figure 4. Absorbency of paper and process color toner in the wavelength range from 200 – 6200 nm (schematically)

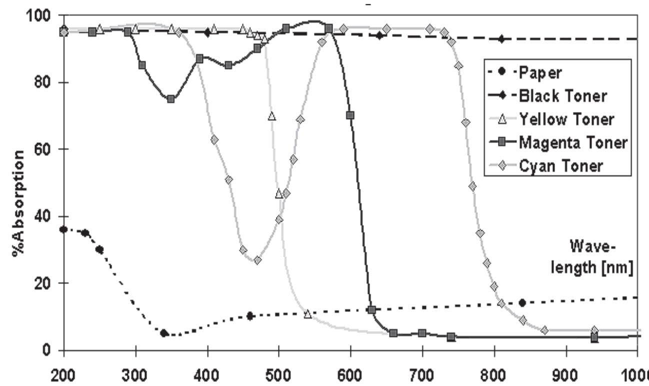

Figure 5. Absorbency of paper and process color toner in the wavelength range from 200 – 6200 nm (schematically)

sible by using IR radiation above ca. 5 µm, where toner and paper absorb basically all IR radiation. In this wavelength range the energy density of the IR light is relatively low, so that the time for fusing is long. To realize a long fusing time the size of the fusing area has to be very large or the speed of the printer is limited.

Alternatively IR absorbers may be added to the process color toners to match the absorbency characteristic of the black toner in the wavelength range between 800 nm and 2 µm.[13] These kind of absorbers are so far much too expensive to be used in consumables like toner, and are not completely colorless in the visible range so that they may have a negative influence on the color reproduction.

Concept Selection

We have concentrated our work on light sources that have a significant part of the emission in the UV-C and UV-B range of the electromagnetic spectrum (200 – 315 nm), as these lamps have a relative high intensity, and the toners of different colors absorb similarly in this range. The absorption of paper in this range is 15 – 40%. The lamps have emission in the visible range as well, which has to be taken into account.

Experimental Procedure

For both fusing technologies similar experimental setups were used.

Radiant Fusing Breadboard (Fig. 6)

The samples (8) are transported by a linear guide (2) under a UV-lamp (3) and an optional IR pre-heater (7) with speed and power adjustable over a wide range. The breadboard is designed to absorb the radiation from the lamp during turn-on time and stand by, to avoid heating-up of the breadboard (4,5,6) and to shield operators from UV-light (1).

Flash Fusing Breadboard

The experimental flash fuser installed in a similar breadboard consists of a lamp housing (Fig. 7) carrying two 2” Xe-quartz bulb lamps (Rapp-Optoelectronics). Optionally Hg is added to boost the UV-portion of the spectrum. The inner diameter of the lamps is 4 mm. The reflector is designed so that two parallel lamps illuminate same area and can be used jointly or delayed. The power supplies of both lamps are equipped with variable capacitors up to 3260 µF at a maximum voltage of 450 V. An active cooling system was installed to allow continuous running of the breadboard.

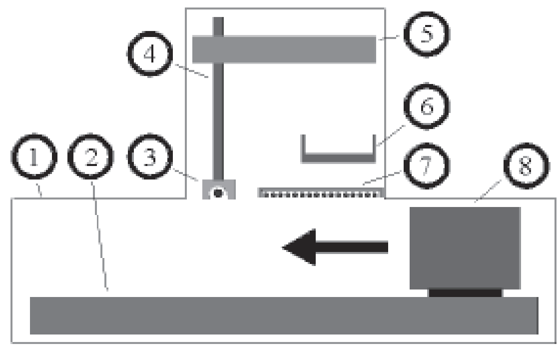

Figure 6. Experimental radiant fusing setups (Figures are explained in the text)

Enhancing UV-Fraction

Xe-flash lamps emit a broad wavelength band from UV to IR. Mercury (Hg) was added into lamps to enhance the UV portion.[14] Thus the UV-part of the spectrum could be enhanced from ca. 10% to 15%.

For continuous radiant fusing a commercially available Hg-vapor lamp with enhanced UV portion (UV-Technik Meyer GmbH UVH 1540/45 –O) was used[15] (Fig. 8).

For the flash lamp most of the intensity is still in the visible range, where the different colors absorb differently. For color independent fusing the visible part has to be cut off by filters.

Sharp Melting Toner

Toner for roller fusing has a certain inner cohesion that shows disadvantages when used for radiant fusing. For fusing with hot rollers heat and pressure is used. In a non-contact fusing process the toner has to flow without pressure. That requires a toner with low melt-viscosity. An additional requirement is no tacky behavior in the temperature range below 50°C to avoid problems in development and storage. Therefore a special Sharp Melting Toner was designed for this work.

Figure 9 shows the main differences compared to a roller fuser toner: The elastic modulus of toners measured with a Bolin rheometer is plotted against the temperature. Two toners from commercially available color printers with roller fusing (toner A and B) show a flat behavior whereas the Sharp Melting Toner specially designed for radiant fusing shows a sharp decrease of

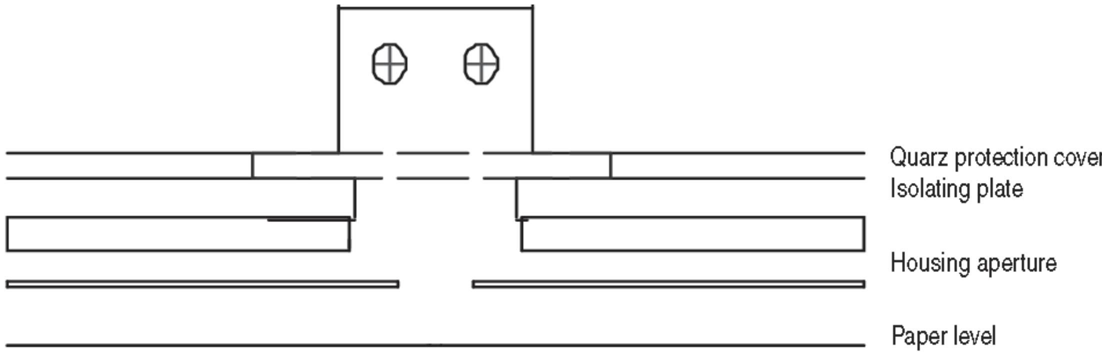

Figure 7. Experimental flash-fuser (sectional drawing of the lamp housing)

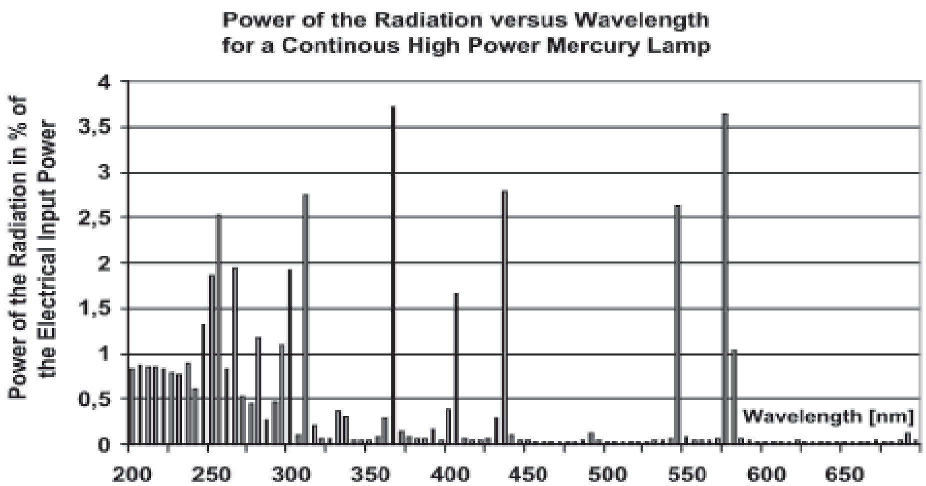

Figure 8. Radiation Power versus Wavelength for a Continuous High Power Mercury Lamp

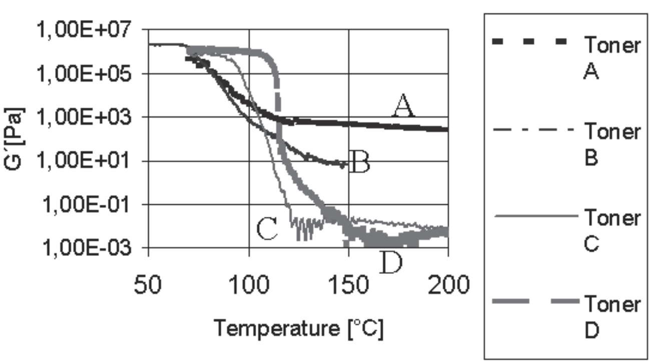

Figure 9. Elasticity of toners designed for roller fusing and for radiant fusing

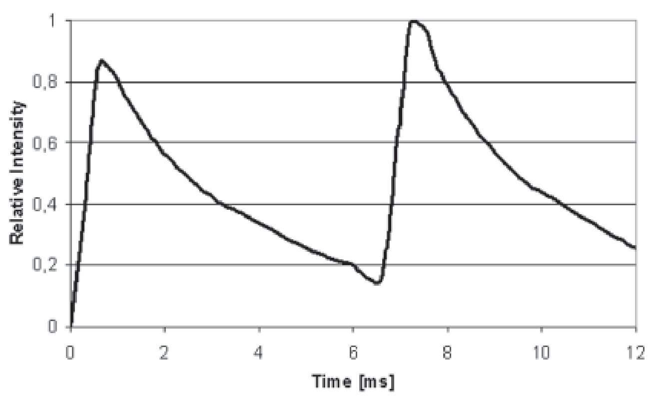

Figure 10. "10 ms-double pulse" made by combination of two 2.5 ms pulses from two flash lamps illuminating the same area

elasticity of orders of magnitude above the glass transition point.

Samples

Sharp Melting Toners of different colors were mixed with 30 μm hard ferrite carrier and this developer was inserted into a laboratory magnetic brush coater. The coater produced 20 mm × 100 mm sharp melting toner patches of 10%, 100% and 290% area coverage directly on the paper. For comparison purposes equivalent patches were produced using a commercial toner for roller fusing.

Flash Fusing of Sharp Melting Toner D and conventional roller fusing toner B were compared using flashes of 2.5 to 10ms pulse length.[16] The combination of available capacitance and voltage of the power supply allowed a maximum available flash energy, $E = (1/2)C \times U^2$ at a pulse length of ca. 2.5 ms. Shorter pulses could only be achieved by reducing the capacitance, which reduces the available flash energy density proportionally as well. These reduced energy densities were not sufficient for all tests. Thus 2.5 ms was chosen as a standard pulse length for this work. Single pulses longer than 2.5 ms

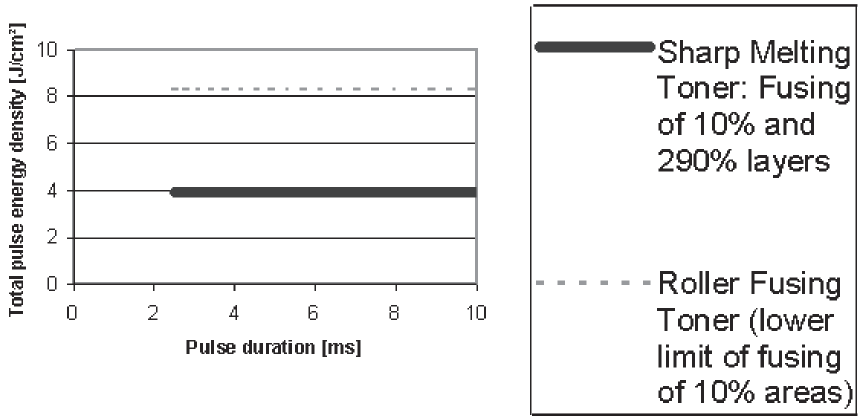

Figure 11. Flash fusing of 10% and 290% contone samples of sharp melting toner in comparison with hot roller fusing toner

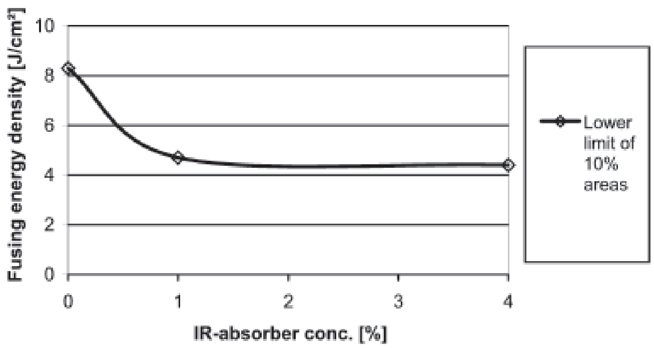

Figure 12. Flash Fusing of 10% contone samples with different concentrations of IR absorber added

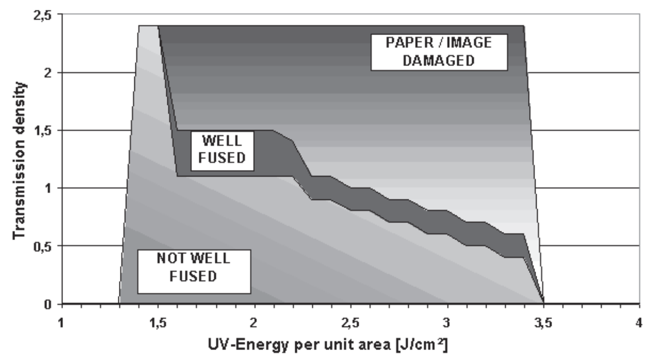

Figure 13. UV Radiant fusing using conventional toner optimized for roller fusing; glossy coated paper Magnostar 135 g/m²

are correlated with lower flash temperature and lead to reduction of the UV-portion of the light flash. To avoid reduction of the UV-portion by using single pulses >2.5 ms two pulses of 2.5 µm (one from each lamp) were combined without delay to produce a 2.5 µm pulse or with delay to produce longer pulses. Figure 10 shows a double pulse of ca. 10 ms length produced by a combination of two 2.5 ms pulses.

Figure 11 shows the fusing results of the cyan toners: The minimum fusing energy necessary to fuse 10% layers differs by a factor of two between both toners. Sharp Melting Toner shows a fusing window at this pulse energy. Conventional toner designed for roller fusing shows no fusing window due to unwanted effects (bubbles, color change) even on 290% patches.

Discoloring IR Absorbers

Sharp Melting Toner reduces the energy necessary for flash fusing but does not solve the problem of different absorption of the different colors. As discussed above IR absorbers can help to use the IR part of the Xe emission spectrum for fusing and to reduce color dependence. Different concentrations of an IR absorber were added to toner B. With the specific absorber used here, the color of the toner is darkened due to slight absorption in the visible range of 550 – 780 nm. Figure 12 shows the dependence of the lower limit of fusing of 10% layers of a conventional cyan roller fuser toner under flash fusing, on the concentration of the IR absorber added to the toner core formulation. Probably, there is already a strong effect for concentrations below 1%. Thus the flash fusing energy could be matched to that of black toner.

The darkening of the color was eliminated by the addition of a discoloring absorber to the toner formulation containing IR absorber.[17] The irradiation with visible light initiates photocopolymerization of the dye with a second component, shifting the absorption band from the near IR to the UV-range. Discoloring absorber (8%) was added to a toner containing 4% IR absorber. A 290% cyan patch discolors, when fused with 2 J/cm² flash light. The fused layer is slightly yellowish indicating a slight absorption in the shorter wavelengths of the visible range of the spectrum.

Fusing of Toner Containing Neutral Black Pigments

The use of neutral (non carbon) black pigments reduces the absorption differences between black and the three process colors. The carbon black may be exchanged for a mixture of the three process colors cyan, magenta and yellow. It has been reported that when the carbon black was fully exchanged for neutral black pigments, the black toner could be fused under similar conditions to the cyan toner.[18]

Radiant Fusing

Radiant fusing was investigated for conventional toner and Sharp Melting Toner on different paper types (Figs. 13 and 14). Conventional toner does not show a fusing window whereas sharp melting toner does. The spectrum of the lamp with a UV portion of >60% is suffi-

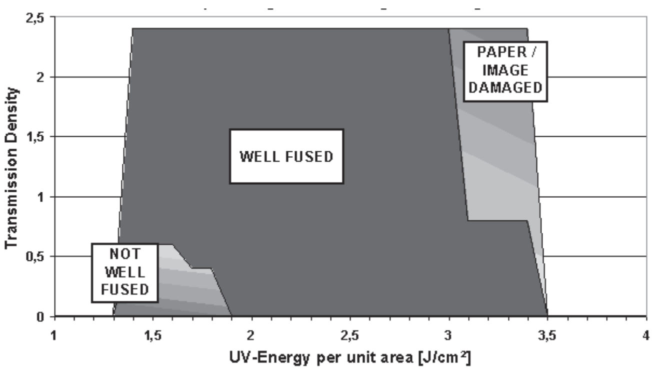

Figure 14. UV Radiant fusing using sharp melting toner; glossy coated paper Profigloss 135 g/m^2

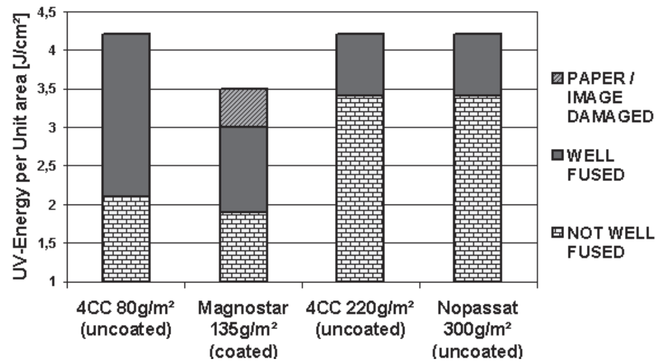

Figure 15. UV-radiant fusing; Fusing window of sharp melting toner on different papers

cient for fusing colors independently without additives like discoloring IR absorbers or neutral black pigments.

As mentioned before, the toner and the substrate in the interface area between toner and substrate has to be heated. For a low density toner layer the energy for fusing has to be higher than for a high density toner layer because of the relative low absorption of the paper even in the UV wavelength range. That means that the low density toner layer determines the fusing window (Fig. 15). This effect is even more severe for low density toner layers on heavy weight paper. To lower the energy needed for low density toner layers the absorption of the paper has to be increased, or in the areas with low density toner layers clear toner has to be added.

The fusing on coated and uncoated paper shows a fundamental difference for the high density toner layers. The uncoated paper shows no negative effects until a relative high energy per unit area of 4.2 J/cm^2 is reached. The high density toner layer on coated paper starts to form visible micro blisters in the toner layer at ca. 3 J/cm^2 and by further increasing of the energy the coated paper itself starts to blister.

Duplex Fusing

Depending on the lamp type, lamp geometry and the process speed the heating time in non-contact flash or radiant fusing is in the range of 1 ms – 400 ms. In two-pass duplex cut sheet printers[19] the paper passes the fusing station twice. Thus, the first image may be heated again above the glass transition temperature (Tg) during fusing of the second printed image. As a consequence the first printed image could be damaged during fusing of the second printed image by any contact paper transport devices.

Flash fusing using single or multiple pulses in the range of 1 ms has the potential to keep the backside temperatures below the glass transition temperature of the toner to avoid smearing of the toner on the paper transport means.

To prove this assumption we evaluated the time dependant backside temperature of the substrate after flash fusing with a fast pyrometer.

For radiant fusing the heating time is in the range of 100 ms – 400 ms causing the first printed image to be heated again above the glass transition temperature (Tg) during fusing of the second printed image. A possible solution is the use of a non-contact paper path device for the fuser and the cooler behind the fuser or the use of UV-curing toner.

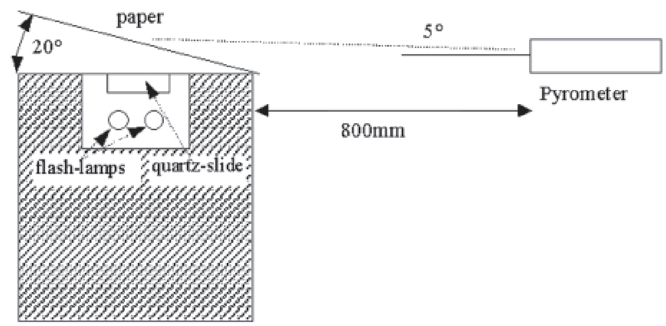

Figure 16. Experimental setups to measure paper backside temperature at flash fusing

Flash-Fusing

For the flash fusing experiments the flash-fusing breadboard described above was used.

Experimental Set-Up

The flash lamp housing was orientated with the flash going upward. A paper was held at an angle of 20° above the flash lamp without support to enable us to measure the backside temperature of the paper. A fast Pyrometer (sampling rate up to about 1 kHz) was installed to measure the surface temperature (of toner or paper) as a function of time (Fig. 16).

Substrates

The following paper types were used for this evaluation:

coated wood fiber containing paper, 65 g/m^2;
coated wood free paper, 130 g/m^2;
uncoated paper, 220 g/m^2.

The paper was printed as 100% patches of black toner either on one or on both sides to achieve maximum absorbance of the light flash. A Xe-Hg flash lamp was used resulting in a flash energy of 2.4 J/cm^2 in the middle of the fusing patch which was sufficient for fusing these samples.

Experiments and Results

The time dependence of backside paper temperature after flash fusing was measured and is plotted for different conditions in Fig. 17.

The measured temperature is a mixture of the paper temperature, the temperature of the toner (if the paper

TABLE III. Maximum Backside Temperatures for Different Papers

Paper	Maximum backside temperature
coated wood containing paper 65 g/m+	104°C after 35 ms
coated wood free paper 130 g/m+	75°C after 55 ms
uncoated paper 220 g/m+	52°C after 200 ms

TABLE IV. Backside Artifacts for Different Flash Conditions

Flash duration [ms]	Flash energy density threshold	Backside artifacts [J/cm²] (see text)
2.5	4.8	Glossy spots
10	4.2	Sticking of toner spots on Kapton belt
100	5.4	Glossy spots
1000	6	Glossy spots

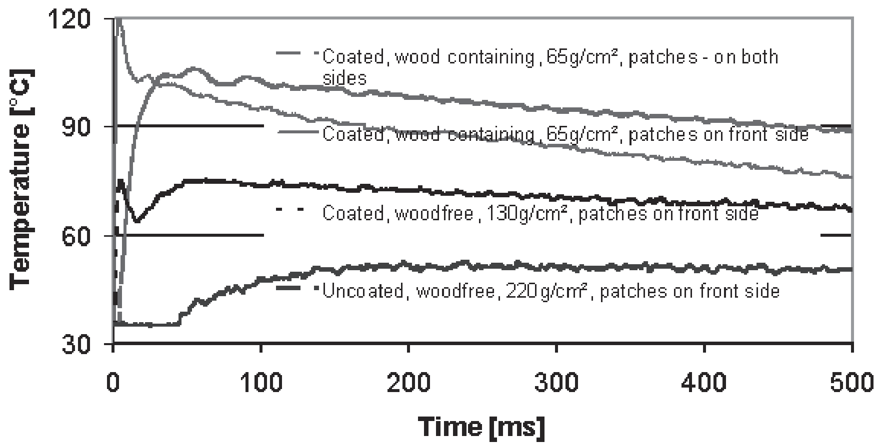

Figure 17. Time dependence of backside paper temperature after flash fusing for different conditions

is toned) and the infrared radiation transmitted through the paper. With a single side printed 65 g/cm² and 130 g/cm² paper, infrared radiation from the lamp transmitted through the paper is seen. Double sided printed 65 g/cm² and 130 g/cm² do not show this effect as the transmitted IR intensity gets lower as the paper and/or the toner layer are getting thicker. The temperature on the backside increases after a delay.

The backside temperatures of the papers at flash fusing after the initial peak are shown in Table III.

For thin paper without support backside temperatures in the critical temperature range are achieved. Backside temperatures of supported paper are expected to be lower as the support is working as a heat sink. To clarify this point, fusing tests on uncoated 80 g/cm² paper were performed. The toner used was a sharp melting dry ink with layer thickness of 290%, which is the maximum layer thickness of four-color prints when under color removal (UCR)[7] is used.

The sample paper was electrostatically attached to a Kapton® foil. The flash energy density was increased stepwise in 0.5 J/cm² steps until backside artifacts appeared. The pulsewidth of single pulses was 2.5 ms. Longer flash durations indicate double pulses of 2.5 ms each, separated by the indicated time. The energy threshold at which image artifacts start are listed in Table IV.

These results indicate that backside image artifacts of toners start well above the targeted flash energy density (of ca. 3 J/cm²).

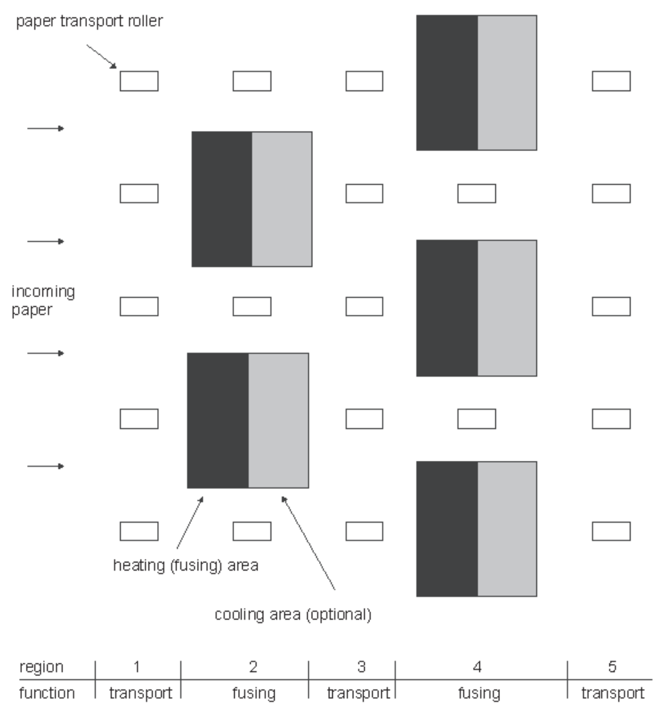

Figure 18. Schematic view of the staggered transport path with action areas of heaters and coolers

Radiant Fusing

We have evaluated the use of a non-contact paper path device for the fuser with the cooler behind the fuser[20] and alternatively the use of UV-curing toner.[21]

Non-Contact Staggered Paper Path

The transport device has several transport rollers to move the substrate in the area of the heater along the transport path. The transport path has at least two melting areas, which, viewed in the substrate transport direction, are located in succession and laterally offset to one another. The toner image is therefore not completely melted and fixed in one process, but at least a two-part melting process take place in which only one band of the toner image is melted at a time. This makes it possible to arrange the transport elements distributed around the melt areas of the heater. This means that no transport elements or other guide elements come into

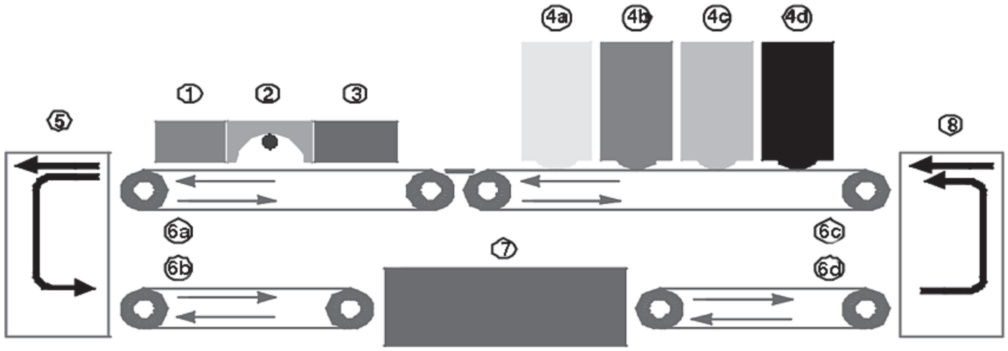

Figure 19. Breadboard for duplex color printing using UV-curing toner

contact with the top and bottom of the substrate in the melt areas of the heater and in the cooling areas.

When the toner image on the top of the substrate is melted there may be another toner image on the bottom of the substrate, which re-melts, under these conditions it cannot stick anywhere since it has no contact with the surface. When the first and/or second toner image comes into contact with the transport element or another surface, it has cooled down so far that there will be no adverse effect on the image quality or sticking of the substrate on this surface. Sticking of the toner images to a surface, for example to a transport element, is essentially precluded, since contact only occurs when the toner image is in the solid state again. The melt areas just contact each other or overlap one another slightly on the toner image to be fixed. This adjustment had to be optimized to avoid image artifacts due to remelting of the already fixed toner.

In the heater where the toner image is melted without contact, the toner image is exposed to radiation mainly in the UV-range. Figure 18 shows a schematic view of the transport path of the substrate (not shown) with the functional elements of the heaters and coolers. The fixing area of the fixing device in the substrate transport direction is divided into a total of five regions, three transport regions (1, 3, 5) and two heating/cooling regions (2 and 4), which each extend over the entire width of the substrate transport path. In a first fusing and cooling region (2) two stripes of the substrates are heated, fused and cooled down below the glass transition point. The substrate is then transported into a second fusing and cooling region (4), where three stripes of the substrates are heated, fused and cooled down. Finally five toner image stripes, which are the same width, are melted and fused, each of the melted toner image sections slightly overlapping the adjacent toner image section so that no unfixed toner image sections remain.

For transportation of the substrates in this case roller pairs are used. Above the rollers shown there is a second set of rollers.

Using this technology double sided non contact fusing technologies with long heating times where paper backside temperatures exceed the glass transition temperatures of the paper are possible.

UV-Curing Toner[21]

UV-curing of suitable toner[22] enhances the glass transition temperature by the curing process. Above that temperature the toner is transferred into a rubber structure so that no more image artifact occurs when the toner is heated a second time.

A first image is transferred onto a substrate sheet. Then, the toner is heated to its glass transition temperature or a temperature above it. In this process, the toner is fused until a certain gloss becomes set. Then the toned substrate is illuminated with ultraviolet radiation. Thus the original glass transition temperature shifts to a higher temperature as a result of the crosslinking of its polymer chains. In parallel, the viscosity of the toner increases so that the toner softens at a higher temperature when it is re-heated and obtains a rubber-like structure.

After the toner has then been fixed to the first side of the substrate, a second image is transferred to the other side of the substrate. In the second fusing step the toner on the second side will be fused and cured. The toner already fixed onto the first side of the substrate can no longer become liquid, but stays highly viscous when heated above its new glass point. Thus the toner applied and fixed onto the first side of the substrate does not smudge on its support, or experience a change in its gloss, on fixing of the toner on the other, second side of the substrate.

For our experiments we used a powdery dry toner that has a glass transition temperature, preferably in a range from 45°C to 75°C, and a glass transition point that shifts by ca. 10°C to 20°C, after it is heated for the first time above its original glass transition temperature and subsequent crosslinking of the toner, so that the lower value of its new glass transition temperature is in the range from 55°C to 65°C or higher. An experimental toner used in these experiments consists of the following components:

1. Uralac XP 3125 (polyester resin, DSM), with 79.05% portion of total weight of the toner;
2. Uralac ZW 3307 (crosslinking agent, DSM), 16.19% portion of total weight of the toner;
3. Irgacure 184 (photo initiator, Ciba Geïgy), 0.95% portion of total weight of the toner; and
4. Color pigment (3.81% portion of total weight of the toner).

Optionally, additives to control the melt flow, the surface quality, the toner charge, the powder flow, and if necessary, additional additives may also be added to the mix.

The raw materials of this toner are mixed together and molten-mixed in a heated two roller mill. The cooled-off extrudate is milled to a particle size of ≥3 mm and then brought into a fluid energy mill which pulverizes it further. Finally, the fine toner particles are classified to an average particle size of ca. 8 µm. The fusing of the toner for the purpose of fixing it onto its substrate is done at a surface temperature of ca. 70 – 120°C, at which the curing of the toner is also performed as a result of the crosslinking of the polymer chains when the fused toner is irradiated with ultraviolet light. By the crosslinking of the polymer chains, the glass transformation temperature of the toner increases by over 10°C, and its viscosity also increases.

A breadboard for non contact duplex fusing of toner layers is shown in Fig. 19 consisting of a image creating and transfer means (4a–d), melting station for softening the toner layer (3), curing means for crosslinking the toner (2), means for cooling the paper below T_g of the toner (5), and where the paper circulates back from the cooling equipment (1) to the (first) image creating and transfer station (4d) via a duplex loop. UV-enhanced radiant fusing – as we have used it in our above described radiant fusing experiments – can take over the role of heating and curing so that no separate equipment for heating is necessary.

If the heating and the curing means are kept separate the gloss can be influenced with certain limits. When the time and/or intensity is not sufficient to allow the toner to flow out from an even layer before entering the curing station, the surface topology of the toner is frozen in the curing station. By modifying the energy input in the melting step or the time between start of melting and start of curing the surface topology, and thus the gloss, can be modified.[23]

Comparison of Paper Path Requirements

Comparing flash and radiant fusing with respect to backside temperature and paper path requirements there are differences:

Backside Temperature. On flash fusing the backside temperature of supported paper does not exceed a critical threshold for backside image artifacts. For continuous radiant fusing however, the backside temperature exceeds this limit.

Paper Path. For flash fusing "simple" contact paper transport can be used. For radiant fusing a non contact paper path like our staggered paper path has to be used. A contact paper path requires other approaches like UV-curing toner.

Conclusions

We have evaluated the potential of the non-contact fusing methods, UV-Flash Fusing, and UV-Continuous Radiant Fusing, as fusing technologies for color toner images for production printing applications. We have found that there is a potential if a special newly developed sharp melting toner is used. For flash fusing the UV-portion of lamps has to be significantly enhanced or discoloring absorber and/or neutral black pigments have to be used.

We have analyzed paper path requirements for cut sheet printing with flash fusing as well as with radiant fusing. We have found that for flash fusing a "conventional" contact paper path can be used, whereas radiant fusing needs non-contact paper path designs like our proposed staggered paper path, or the use of UV-curing toner. Further work and progress is necessary before one of these technologies can be used for fusing in toner based color production printing, whereas UV-radiant fusing is especially useful for single pass duplex printing.

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