Durability of Ink Jet Transfer Prints based on Fusible Coatings

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Abstract

Fusible ink jet transfer coatings are used for special applications demanding high image permanence. Small format T-shirt transfers are already widely accepted while new applications in wide format printing are still in an early state. Excellent media and image durability can be achieved by fusing ink jet coatings comprising a high degree of polymeric organic pigments after printing by heat and pressure. Durability requirements for different applications and experimental results on the permanence of ink jet transfer prints will be discussed.

Introduction

The low stability of ink jet prints is still an issue for long term indoor and more generally for outdoor applications. Special applications as T-shirt printing even require very demanding durability properties. The main challenge for the widely used water based inks which are jetted by piezo or by bubble jet print heads is to render prints permanently waterfast and lightfast. Traditional ink jet media with porous waterfast coatings are able to be used short term in outdoor environments but for long term applications post printing processes as lamination, impregnation, edge sealing etc. are necessary. The recently developed ink jet transfer papers [(1)] based on fusible coatings have a different fixation process than the porous coatings used on many ink jet media. In these media dyes are fixed by cationic mordants while pigments are precipitated at the surface of the pores. Fusible coatings are able to enclose the ink ingredients into a polymeric hydrophobic matrix during the fusion step after printing [(2)]. Durability of the fused prints are mainly determined by the organic meltable polymer and the overall coating composition which has to encapsulate the colorants of the ink during the fusing step.

The objective of this study is to discuss the durability parameters for ink jet prints, the applications of fusible ink jet coatings and the durability of those prints. This will be related to the interaction between inks, coatings and postprocessing.

All materials used are commercially available. This should ensure that the results of this study are as near as possible to practical use.

Experimental

Commerially available transfer papers from Sihl were used. Product codes are 3873 ”IJS170 transfer easy melt” for wide format applications and 0744 ”IJS160 transfer paper soft feel” for small format transfers to fabrics. Transfers were done with a laminator (Seal Image 6000), heat press or an hand iron.

Results and Discussion

Ink jet prints can be exposed to different environmental impacts. The overall durability in the final application often depends on a combination of different deterioration processes. Thus, ink jet prints need:

Mechanical resistance against

- scratching
- rubbing
- folding
- stretching
- abrasion
- wet rub resistance

Water resistance regarding

- washing
- rain
- humidity

Light Resistance in

- UV light range
- Visible range
- Heat/Cold resistance

Resistance to Chemicals

- air pollutants like Ozone, NO_x
- washing powder/alkaline substances/detergents/oxidizing agents
- solvents

Ink jet transfer papers are made from a base paper, a release coating, an optional protective coating and the ink receptor coating. The last layer is porous and comprises a high content of organic pigments which can be molten in the fusing step after printing. During printing ink is taken up into the porous structure of the coating and pre fixed after drying. In a second step the mirror printed image is transferred by heat and pressure to a receiver medium by means of a heat press, a hot laminator or an iron. The polymeric pigments of the ink jet coating are molten and fused into a polymeric film encapsulating the colorants and developing adhesion to the receiver substrate. The release paper is removed leaving the inked ink jet layer and a protective layer on the receiver.

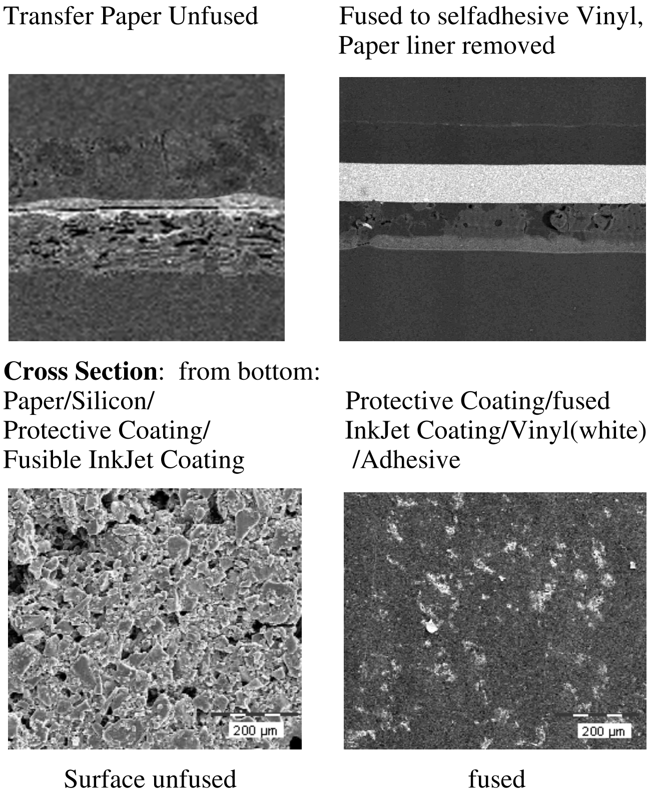

Figure 1. REM images of fused and unfused transfer media [3]

Mechanical Stability of Transferred Prints

Different kinds of mechanical impact are important for the application of ink jet transfers. In transfers to T-shirts mechanical stress is applied during wearing by streching, during washing in a laundry machine as well as during drying after washing. All these different stresses must be compensated by the ink jet layer transferred to the fabric. The print must resist repeated washing with washing powder, drying, reironing and streching. This can be achieved by an ink jet transfer layer which is flexible (not brittle) and which withstands water, chemicals (detergents, oxidation agents, enzymes) and heat. Therefore, the main component of such a material is a polymeric powder made of soft and flexible Polyamides. A protective layer favours the release of the print from the carrier paper and ensures stability of the print while the organic pigment is fixed to the fibres during the heat transfer process.

Flexibility of the transfer print is also important in outdoor banner applications. Here the print is transferred to one side or both sides of a banner material, typically comprising reinforced vinyl or PET fabric, and hung outside by grommets or other application means.

Scratch resistance is important in fleet graphics. Prints are transferred to selfadhesive vinyl and applied to a vehicle by heat assistance to guarantee adaption to curved surfaces and around corners. Abrasive particles in the wind as well as car washing are the main mechanical impacts. The intermediate coating which is transferred with the print protects the image as this film like layer is made from a resistant polymer. It contains UV-absorbing substances to improve light fastness of prints. Current results show that 1 year outdoor application in Californian and Middle Europe Environment did not change print quality within acceptable ranges in a fleet graphics application with weekly car washing. The expected lifetime of those prints is several years mainly restricted by the pigmented ink used.

Lamination is only recommended if scratch resistance has to be further improved. Common self-adhesive vinyls and lamination films for fleet graphics can be used.

The interface between the transfer layer and the receptor media is mostly the weakest joint in the laminate. The peel force depends strongly on the lamination conditions used. As the polymeric particles have to be molten and the resulting fluid polymer has to flow to build a homogeneous layer which encloses the ink and its ingredients and has to stick to the receptive media the following parameters for fusing and film forming are important:

- temperature of upper and lower laminator rollers
- preheating of both webs before contact in the nip (heat capacity of rollers)
- pressure in the nip
- dwell time in the nip

Higher temperature, higher pressure and longer dwell time improve adhesion (Fig.2). For most applications a minimum adhesion of about 200 N/m is sufficient. This can be achieved with most laminators using temperatures of 120 °C or more.

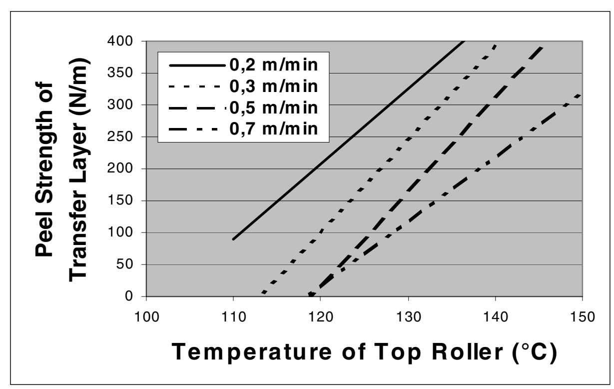

Figure 2. Peel strength of transfer layer from vinyl surface after transfer with Seal Image 6000 laminator to white self-adhesive vinyl (Fascal 4500 from Avery) and lamination with self-adhesive vinyl (DOL2000 from Avery); bottom roller temperature 115 °C

Water Resistance

Adhesion of the transferred coating after immersion of the print into water for 24 hours at room temperature was measured. Print Adhesion of the transferred image is nearly at the same level compared to unexposed prints (Fig. 3).

Humidity and rain are main environmental issues in outdoor application. With pigmented inks color shift is prevented by the nature of the fused polymeric layer. By melting the polymeric particles the colorants of the ink are totaly fixed in the resulting polymeric film. Thus, water or humidity are not able to change the image quality.

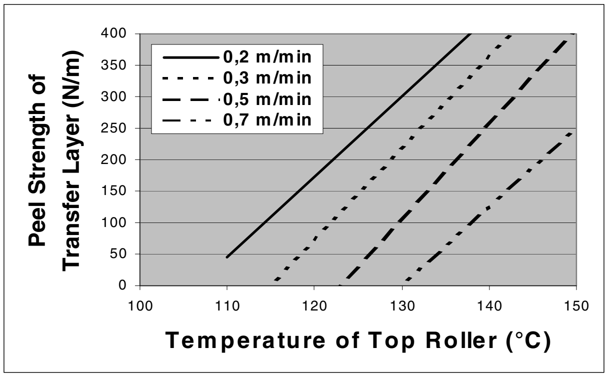

Figure 3. Peel strength of transfer layer from vinyl surface after 24 hours under water (lamination and materials as indicated in Fig. 2)

Light Resistance

The resistance of dyes in ink jet coatings is strongly dependent on the chemical environment given by the coating.[4] Fusible coatings are able to enhance light stability of dyes to a very high level (Fig. 4).

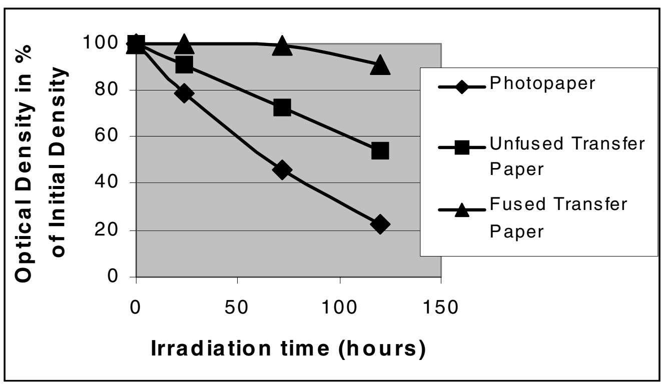

Figure 4. Fading of HP5000 Yellow 100% on Photopaper (Code 3837 of Sihl), Unfused Transfer Paper and Fused Transfer Paper 3873 (transfered to self-adhesive vinyl) in Xenotest Alpha Weatherometer (120W/m²; 65°C Black Panel Temp.; 30 % r.h.)

This strong increase in dye stability is observed with different inks and dyes. It is achieved by 2 factors: changing the coating from a porous structure to a film structure and protecting the ink from UV light by the UV-absorber in the protective coating. A main effect is proposed to be the exclusion of oxygen from air in the fused coating compared to the unfused porous coating by a strong hindrance for light induced oxidation of the dyes. As benchmark a photo paper with a swellable coating has been evaluated showing that the yellow dye itself is relatively instable.

Pigmented inks stability is generally high. There is nearly no change in color density in accelerated testing as well as in outdoor evaluation (Fig. 5). The initial decrease of density is due to a gloss change of the protective layer but has no influence on color reproduction or appearance of the print. To achieve long term stability the coating itself is made of lightstable components so that yellowing, cracking, adhesion failure etc. is excluded during the intended lifetime.

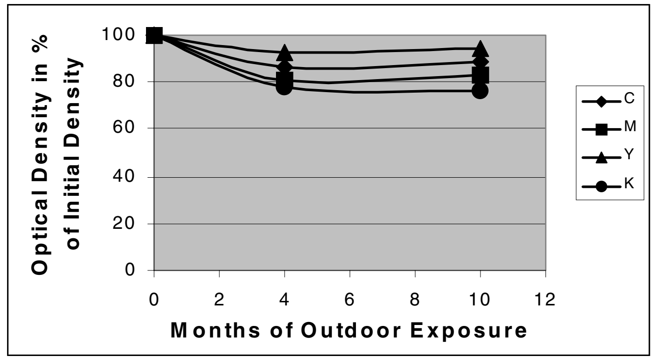

Figure 5. Optical Density of 100% Colors of HP5000 UV+ ink patches in outdoor exposure in Dueren/Germany. Print on 3873 transfered to self-adhesive vinyl (Fascal 4500 from Avery)

Print quality of unlaminated as well as laminated transfer prints made with HP´s UV+-ink have been proven to be nearly unchanged within 1 year of outdoor exposure in banner and display applications (self-adhesive vinyls). Vehicle graphics have been successfully applied in German and Californian climate including weekly car washing for 1 year.

Heat Resistance

For fabric transfers (T-shirts) highest temperature settings of the hand iron are used which is about 180°C to 220°C. Wide format transfers are made at 120°C up to 160°C. No changes were observed regarding dye stability or deterioration of the coating by this short term heat impact. Accelerated testing in Xenon arc lamp weatherometer at black panel temperatures of 65°C also did not change print quality.

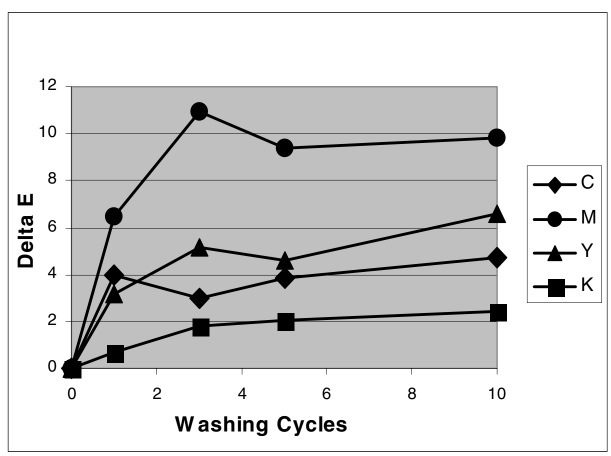

Figure 6. Color change with washing cycles of Epson Stylus Photo 870 transfer prints on T-shirts (100% colors); transfer paper code 0744

Resistance to Chemicals

In T-shirt transfer paper application washability is very important. Washing cycles with drying and reironing are not only applying strong mechanical impact on the print but also chemical and swelling attack to the fused layer. The fabric is porous and detergents, oxidants etc. can penetrate into the ink jet layer mainly from the fabric side as the front side is protected by the intermediate layer. Loss of color and brillance is dependent on ironing or heat transfer conditions. If not heated properly ink may bleed into the fabric, is washed into the rinse water or oxidized by the washing ingredients. All these effects result in reduced color brillance. A slight color shift in the first washing cycles is mainly due to a small loss of colorant which is not fully encapsulated probably close to the fibres of the fabric (Fig. 6). Colorants incorporated into the fused polymeric layer are protected from direct contact to external chemical attack as from detergents, enzymes, oxidation agents even at elevated temperatures of 30 °C to 40 °C.

Solvent resistance is not necessary in most applications but may be desired for new even more demanding applications on solvent resistant receptor surfaces. Resistance to most cleaning solvents is given (Table 1)

Table 1. Resistance of transfer prints to solvents (3873 printed with UV+ ink on HP3500CP tranfered to PET-fabric) by dipping into solvent for 5 minutes. Mechanical strength of the print surface was rated.

Solvent	Resistance
Ethanol	Excellent
Isopropanol	Excellent
Acetone	Not resistand
n-Hexane	Excellent
Toluene	Not resistant

Conclusions

Transfer prints based on fusible ink jet receptor layers have extraordinary durability for high demanding applications. The main benefits of ink jet transfers are that prints can be applied onto a wide variety of surfaces which cannot be printed directly and that prints show exceptional resistance to environmental impacts. Thus, the transfer process achieves excellent results in applications as on foam boards, scrim banners, T-shirts, fabrics as well as self-adhesive vinyls for signs, displays and vehicle graphics.

References

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Biography

Axel Niemöller is head of the Digital Imaging R&D department of Sihl in Dueren/Germany with strong focus on coated ink jet media. Sihl manufactures a full range of coated papers, films and specialities for ink jet printing mainly in wide format graphic arts, small format home and office applications, and CAD. Prior to his current position he worked for Sihl/Renker since 1987 as development manager responsible for laminated and self adhesive coated products as well as for reprographic products. Mr. Niemöller has a PhD in Physico-Chemistry with specialisation on polymer science.