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The Journal is fostering multidisciplinary research and scholarly discussion on scientific and technical issues in the field of graphic arts and media communication, thereby advancing scientific research, knowledge creation and industry development. Its aim is to be the leading international scientific periodical in the field, offering publishing opportunities and serving as a forum for knowledge exchange between all those scientist and researchers interested in contributing to or benefiting from research in the related fields.

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Contents

A word from the Editor

Nils Enlund
Editor-in-Chief

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Welcome to the first issue of the second volume of the Journal of Print and Media Technology Research! Our first year of publication is behind us and we can look back at a diverse and interesting selection of high quality scientific research papers. Diversity in journal contents is one of the objectives of the Editorial Board since this is a reflection of the breadth and the dynamics of the print and media technology field today.

The reactions to the journal from the readers have been very positive. They have welcomed the new platform for scientific publishing and interchange, they have found the published papers inspiring and useful, and they have appreciated the informative Topicalities section.

But instead of leaning back with a grin of satisfaction and continuing as we have started, we now intend to embark upon a journey of continuously improving and developing the journal. The editors will, step-by-step, introduce new features and sections in order to better serve the research and industrial community.

In this issue, a new section entitled Professional communication is introduced. In this section we will publish contributions that may not fully meet the strict criteria for a scientific paper but that are clearly of interest to the community of readers and contributors. The articles published in this section can range from preliminary study results to ideas for new research, from interesting observations to methodological ideas. We wish to impose no advance restrictions on the topic, as long as the Editorial Board finds it professionally interesting and worthy of publishing. You are therefore invited to contribute to the professional and scientific discussion and interchange by submitting short or not so short communications to the editors. Pure opinion and reflections on the state and future of science and the industry are welcomed to our future section on Opinions and reflections. Just keep those e-mails and letters coming!

The second new feature in this issue is a subsection on academic theses in the Bookshelf section. We believe that it is of interest to give exposure to the valuable work done in the form of academic theses at our universities. Supervisors of academic theses are therefore invited to submit short abstracts of relevant and high quality thesis publications along with information on where the full text can be obtained.

We also plan to intersperse the regular issues containing papers on varied topics with focused thematic issues. Hopefully, you will find these editorial strategies appropriate.

Most important is, however, that you submit your scientific and technical papers to the journal for peer review and that you encourage your colleagues to do the same. A continuous influx of good manuscripts will ensure that the quality and usefulness of the journal further improves.

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Flexographic printing of PEDOT:PSS on coated papers for printed functionality

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Abstract

Large area printed conductive surfaces are expected to have an impact on printed functionality ranging from electronics to photonics such as printed solar cells. We report here a study on formation of such conductive surfaces by flexographic printing using a PEDOT:PSS conductive ink on various coated papers. Printability of multilayer coated paper and TiO_2 nanoparticle coated paperboard generated by the liquid flame spray process are compared to plastic film typically used in printed functionality applications. The wettability of TiO_2 nanoparticle coating can be altered between superhydrophobic and superhydrophilic states by ultraviolet light. It is observed that superhydrophobicity of paperboard induced by TiO_2 nanoparticles results in poorer ink setting with the water-based PEDOT:PSS yielding lower conductivities. Therefore, we observe conductivity only after several successive prints. A solvent-based silver ink was used for comparison. It is believed that renewable natural fibre based substrates, such as coated paper meeting criteria for sustainable development will find more applications in the future.

Keywords: nanoparticle, printing, flexography, wettability, sustainable development

1. Introduction and background

Printed electronics and printed intelligence have been attracting growing interest since the beginning of the 21st century, with market value forecasts of up to 45 billion USD by 2022 (Das and Zervos, 2012). Conventionally, such applications have been produced on plastic films. However, paper based electronics (Tobjörk and Österbacka, 2011) has been studied recently and it has been shown that simple, all-printed transistors can be produced on multilayer coated paper (Bollström et al., 2009). Another example is a thin, lightweight, and foldable thermochromic display based on a regular copy paper in which thermochromic ink is utilized with patterned electrodes on the opposite side of the paper providing extremely low cost displays with price less than 0.10 USD per m^2 (Siegel et al., 2009). Such displays may find applications, for example, in data reporting on portable point-of-care devices. Natural fibre based substrates are rapidly finding new applications outside of the conventional graphic arts industry.

Paper has many advantages over the plastic films: it is made of renewable materials and it is inexpensive with tailorable surface properties. Paper can be 1 000 times less expensive than glass substrates and 100 times less

expensive than plastic films (Tobjörk and Österbacka, 2011). Cellulose, the major component of plant biomass, is the most abundant biopolymer on Earth with annual production up to 1.8×10^{12} tonnes (Eveleigh, 1987). However, compared to plastic films, paper is a porous, uneven, and rough network of fibres. Typically, paper surface is smoothened by a dispersion coating consisting of mineral pigments and organic binders. Recently, nanoscale coating techniques including layer-by-layer and liquid flame spray coating have been studied. These techniques allow for surface functionalization with significantly reduced coating amounts. Nanoscale control of surface properties is crucial for achieving good performance in electronics applications.

This study concentrates on printing large area conductive surfaces on various coated paper grades. An advantage of printing compared to coating methods is possibility of patterning (Tobjörk et al., 2008). Such conductive surfaces are needed, for example, in electrochromic displays and in solar cells. Photovoltaic (PV) devices on paper substrates were demonstrated by two groups in 2011. Barr et al. (2011) utilized an oxidative chemical vapor deposition (oCVD) for fabrication of PV cells on rough tissue paper. The key for the success of such an approach was perfect contour coating by oCVD, preventing formation of electrical shorts. However, the process is a slow batch process and such a process flow is not optimal as paper is in practice produced with line speeds typically above 1 000 m min^{-1}.

An alternative approach has been presented by Hübler et al. (2011), based on an all-printed process. Unfortunately, their approach does not allow a continuous process flow but rather has up to 12 hour gaps between different prints. The observed power conversion efficiency was 1.31 %. For cost-effective manufacturing of organic electronic devices, it would be beneficial to use an all-in-line printing process with possibilities for significant unit cost reduction of the devices (Berggren, Nilsson and Robinson, 2007).

In current PV applications, indium tin oxide (ITO) is typically used as a transparent conductive electrode. Unfortunately, there are two major drawbacks with ITO: first, it is an expensive and scarce material, and secondly, the brittle nature of the ITO films makes them unsuitable for flexible substrates. These limitations prevent the use of ITO in low-cost, large-scale PV applications. Conductive polymers such as poly(3,4ethylenedioxythiophene)/poly(styrenesulfonate) (PEDOT:PSS) may be suitable candidates as they can be both transparent and conductive. However, there is a strong correlation between conductivity and opacity, i.e., the film becomes more opaque as conductivity increases. This has been a bottleneck, but recent developments have eased the problem of achieving good transparency with high conductivity (Vosgueritchian, Lipomi and Bao, 2011).

In this paper we report on the effects of coating structure and surface wettability on formation of conductive surfaces. Tunable wettability of TiO_2 nanoparticle coated substrates has an effect on printability with water-based inks such as PEDOT:PSS as ink setting is poorer on superhydrophobic surfaces. This is also observable from measured optical densities of the printed layers.

2. Methods and materials

In our study we use a PEDOT:PSS conductive ink. PEDOT:PSS is the most common and affordable conductive polymer currently available on the market. It comes in 1 : 2.5 (pH 1.5 - 2.5), 1:6 (pH 4.0 - 7.0) or 1 : 20 (pH 7.0) ratio by weight with a solids content of 0.6 - 3.4 % dispersed in water. Viscosity can be varied from 4 to 350 mPas depending on the requirements of the application. In PV applications, PEDOT:PSS typically serves as a transparent conductive electrode or as a buffer layer in between the active layer and a metallic electrode. The conductivity of PEDOT:PSS can signifycantly be increased by addition of secondary dopants such as dimethyl sulfoxide, ethylene glycol, or glycerol.

As a comparison we use a solvent-based silver ink consisting of micrometer sized silver flakes. The printed silver patterns, grids, and electrodes require thermal sintering for conductivity. Flexographic silver ink is typically used for thick film electronics applications, where print layer thickness reproducibility and bulk silver conductivity are important.

We use two different natural fibre based substrates: a multilayer pigment coated grade and a nanoparticle coated paperboard in comparison with a traditional plastic film. The paperboard surface is functionalized by TiO_2 nanoparticles using a liquid flame spray (LFS) coating process. In the LFS process, a liquid precursor of titanium (IV) isopropoxide (TTIP) is fed into a high temperature and high velocity flame in which the metal salt evaporates and nucleates to form nanoparticles of the metal oxide. These nanoparticles can be collected on a paperboard surface in an on-line process flow and they cover the whole surface passing under the flame. For detailed description of the LFS process, see Mäkelä et al. (2011).

Caputo et al. (2008) have shown that ultraviolet (UV) illumination can be used to change the wettability of TiO_2 surfaces, and similar photocatalytic wettability conversion has been observed on TiO_2 nanoparticle coated paperboard surfaces from superhydrophobic (water contact angle (CA) over 150°) to superhydrophilic (water CA

less than 20°). Typical coating amounts on surface by the LFS are between 10 and 50 mg m^{-2} (Mäkelä et al., 2011) being several orders of magnitude smaller than in conventional dispersion coating concepts.

The three different printing substrates in our study are: a commercial poly(ethylene terephthalate) (PET) film (Mylar®A) as the reference plastic film, a multilayer coated paper, and a double pigment coated paperboard (200 g m^{-2}, Stora Enso, Skoghall, Sweden).

The multilayer coated paper contains a commercial finepaper (Lumipress 115, StoraEnso, FI) that is coated by a 10 g m^{-2} barrier layer consisting of platy kaolin (Barrisurf HX, Imerys Minerals Ltd, UK) blended with 50 pph ethylene acrylic latex (Aquaseal 2077, Paramelt B.V., NL). To adjust printability, a 5 g m^{-2} topcoating layer consisting of 70 pph fine platy kaolin (Barrisurf FX, Imerys Minerals Ltd. UK) and 30 pph fine blocky kaolin (Alphatex, Imerys Minerals Ltd., UK) blended with 6 pph SB latex (Basonal 2020.5, Basf, DE) was coated on top of the barrier layer. The paper was further calendered three times through a softnip at a line load of 120 kN m^{-1} and a temperature of 70 C°. The paperboard sample was coated by TiO_2 nanoparticles using a coating and lamination pilot line at the Tampere University of Technology (Tampere, Finland) with a 30 m min^{-1} web speed. TTIP was dissolved in isopropanol with a metal ion concentration of 11.9 mg ml^{-1} with a 29.5 ml min^{-1} feeding rate into the nozzle whose distance from the moving web was set to 15 cm. This results in a deposition mass of 12.7 mg m^{-2} with approximately 415 TiO_2 nanoparticles μm^{-2} (Stepien et al., 2011). The average diameter of the nanoparticles is between 40 and 80 nm.

Flexographic prints were made using a laboratory scale IGT GST 2 printability tester. The anilox cylinder had a cell angle of 45° with 40 lines cm^{-1} and volume of 20 ml m^{-2}. PEDOT/PSS (Clevios P HC V4) conductive polymer dispersed in water with viscosity of 100 - 350 mPas and a surface tension of 72 mN m^{-1} was tested at a print speed of 2 m s^{-1}. Solvent-based silver ink (Creative Materials 125-06 Extremely Conductive Ink) with a viscosity of 2 000 - 3 000 mPas and a surface tension of approximately 50 mN m^{-1} was tested at a print speed of 0.5 m s^{-1}. The pressure between the anilox cylinder and the printing plate as well as the pressure between the printing plate and the substrate was set to 50 N for PEDOT:PSS and 100 N for silver ink.

The contact angles of the inks were analyzed using a contact angle goniometer (KSV CAM 200) with a droplet volume of 10-12 µl and the UV-exposure of the TiO_2 coated surfaces was carried out using a Bluepoint 4 Ecocure source with an UVA filter for 30 minutes. The print densities were measured using a Techkon optical densitometer. Finally, a digital multimeter (Keithley, 2100) was used to characterize the conductivities between two hand-painted contacts of silver conductive paint (Electrolube).

3. Results

The contact angles (CAs) of water, PEDOT:PSS (solid content 1.0 - 1.4 %), and silver printing inks for flexography are summarized in Table 1. Water and silver ink contact angles were recorded at times at which the oscillations caused by kinetic energy from placing a droplet on surface had dissipated but before any observable absorption into the substrate occurred. Thus, for water and silver inks the CA values are taken after 1 s for each sample, whereas for PEDOT:PSS droplets the times are 1 s for multilayer, 10 s for paper-board, and 60 s for other samples. With TiO_2 nanoparticle coated samples we observe switching of superhydrophobic surface into superhydrophilic by UV light irradiation. Similar behavior is observed with water-based PEDOT:PSS ink but no effect on solvent-based silver ink is found. The paperboard sample denotes the double coated paperboard without the TiO_2 nanoparticles.

Table 1:
Measured apparent contact angles of water, PEDOT:PSS ink, and silver ink

	Plastic	Multilayer	LFS TiO_2	LFS TiO_2+UV	Paperboard
H_2O	75	50	153	7	74
PEDOT:PSS	74	62	160	26	69
Ag-ink	27	54	52	50	54

Optical print densities of PEDOT:PSS prints were measured before oven drying and are given in Table 2.

The values for print layers are calculated by subtracting the measured background value for the unprinted substrate by $D_{print} = D_{measured} - D_{unprinted}$. As expected, the print densities increase after each successive print. Furthermore, the smallest values are observed for superhydrophobic surface indicating a poor transfer of ink to the substrate.

Table 2: Measured addition of print densities of PEDOT:PSS after each successive print before curing in the oven

	Plastic	Multilayer	LFS TiO_2	LFS TiO_2+UV	Paperboard
1st print layer	0.02	0.03	0.01	0.07	0.01
2nd print layer	0.06	0.06	0.04	0.09	0.03
3rd print layer	0.08	0.09	0.06	0.13	0.09
4th print layer	0.09				

Table 3 summarizes the measured sheet resistance values of PEDOT:PSS flexographic prints after drying in an oven (1 h, 120 °C). Conductivity [S m^{-1} with S=1/Ω] is a reciprocal quantity to resistivity [Ωm], i.e., lower resistivity results in higher conductivity. It was observed that plastic films require more successive print layers (here 4 layers) to obtain lower resistance values due to poor wetting of smooth surface. The best performance was observed with a multilayer coated paper with controlled ink setting on the porous top layer. With TiO_2 nanoparticle coated samples we observe that surface wettability plays an important role when printing with water-based flexographic inks.

The sheet resistance values are higher when printing on superhydrophobic surface that is expected due to poorer wetting of the surface and formation of an uneven print layer. Hence, we can conclude that the superhydrophobicity survives even in the dynamic printing process and is lost only after several successive print layers.

Table 3: Observed sheet resistance (Ω/□) of different substrates with PEDOT:PSS successive prints

	Plastic	Multilayer	LFS TiO_2	LFS TiO_2+UV	Paperboard
1st print layer	$>10^8$	6.4×10^5	$>10^8$	1.2×10^6	3.6×10^6
2nd print layer	$>10^8$	2.0×10^5	5.3×10^6	2.9×10^5	2.7×10^5
3rd print layer	$>10^8$	4.0×10^4	3.3×10^5	1.0×10^5	8.0×10^4
4th print layer	6.2×10^5				

It is worth emphasizing that the substrates here are not optimized for printing conductive layers which explains the observed high sheet resistance (=low conductivity) values. For example, the LFS paperboard sample is a conventional paperboard used for packaging applications. With multilayer coating one can control ink setting resulting in lower sheet resistances. Moreover, successive prints yield a more even and homogeneous print layer with higher conductivities (Denneulin et al., 2008). The observed values are in agreement with the results shown by Barr et al. (2011) with oCVD coated thin PEDOT layers.

Figure 1: Flexographic PEDOT:PSS prints on different substrates (width of the printed area 7 mm)

Figure 1 displays the scanned images of the flexographic PEDOT:PSS prints. Poor ink setting both on plastic film as well as on superhydrophobic LFS TiO_2 substrate is observed which correlates well with the observed high sheet resistances. In multilayer coated structure the barrier layer below the thin and porous top coating layer prevents ink penetration deep into the structure resulting in the lowest sheet resistance values. Figure 2 shows a magnification of the printed layer structures. We observe a formation of branched clusters of polymer (dark areas), which are especially visible in the LFS paperboard reference sample. Similar behavior has been reported with spin-coated PEDOT:PSS thin films (Nardes, 2007). This results in anisotropy in conductivity values in machine and cross-machine direction. We characterized the paper surface roughness by the typical Parker Print Surf (PPS) device commonly used in the paper industry. The plastic film (0.25 µm) has the smallest roughness, as expected, whereas the calendered multilayer coated paper (0.43 µm) has a significantly lower surface roughness than paperboard (1.79 µm). These results are in agreement with the AFM

roughness analysis presented by Bollström et al. (2009) for plastic (root mean square (RMS) roughness 30 nm for 100 µm length scale) and multilayer coated paper (RMS 55 nm for 100 µm length scale). Similarly the paperboard (RMS 70 nm for 5 µm length scale) has the highest roughness in nanoscale (Stepien et al., 2011). The nanoparticle coating (PPS 1.71 µm) does not appear to significantly change the surface roughness of the paperboard at the length scale measured by PPS but the nanoparticles were observed to increase nanoscale roughness (RMS 94 nm for 5 µm length scale) (Stepien et al., 2011).

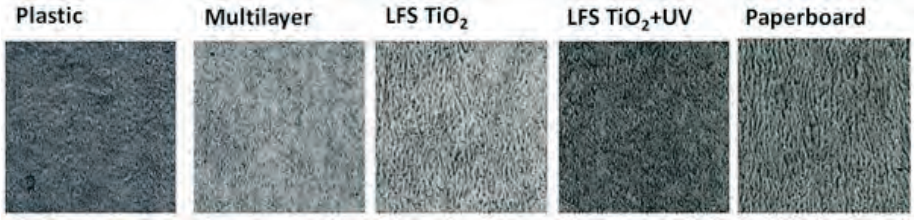

Figure 2: A larger magnification of the flexographic print layer (area 4×4 mm², 3 print layers)

The uneven ink setting on superhydrophobic TiO_2 LFS surface was also studied with an optical contact angle goniometer as shown in Figure 3. It is observed that with larger PEDOT:PSS droplets a neck is formed as the polymer concentrates on the droplet/substrate boundary. Initially the droplets behave like water droplets but as the polymer settles into the surface, the contact angle grows again with water minimizing the surface energy. The effect is rather slow for the large droplets. However, in flexography the size of the droplets is much smaller and hence, similar behavior may be observed in the print morphology.

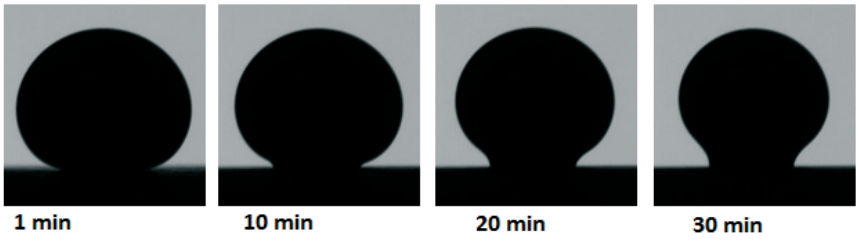

Figure 3: Time series of the PEDOT:PSS droplet on LFS surface

Finally, silver ink was used for comparison for printing conductive surfaces. All silver samples were sintered in an oven at 120 °C for 60 min. We observed a non-conducting layer with a single print. This is due to two factors: first, the amount of ink transferred from the anilox is too small in order to form a continuous layer on the surface. Secondly, the number of cells/cm in our anilox cylinder may be too small compared to the cell volume, i.e., individual cells are visible in the final print. Hence, no conductivity is observed as there is no connecting path between the individual silver flakes below the threshold value. Similar behavior was observed in an earlier study (Saarinen et al., 2011) that related the surface coverage values to the observed sheet resistances.

After the second and third successive prints we observed good conductivity with sheet resistance values less than 100 Ω/□ independent of the substrate being printed. This was expected as the solvent-based silver ink has similar wetting properties on all the used substrates as shown in Table 1.

4. Discussion

Flexographic printing has traditionally been employed in the packaging industry as a high throughput method for a wide range of flexible and non-flexible substrates. Thus, it can be used to scale up printed electronics from laboratory scale batch processes to mass printing volumes. Multilayer structures for printed electronics are achieved by several successive printing and/or coating steps in hybrid printers, which require orthogonal solvents, i.e., the solvent of each successive layer should not dissolve the previously printed layer. Current state-of-the art roll-to-roll demonstrators for printed electronics are typically manufactured by such hybrid printer lines utilizing, for example, die slot coater, gravure, inkjet and flexographic units. In this study we have shown that the ink setting properties play a crucial role for printed functionality. The formation of finger-like clusters in Figure 2 is related to the film splitting in the printing nip. Both surface roughness and surface wet-

tability of the substrate have an effect on the viscous fingering: the PEDOT:PSS ink splits unevenly in the printing nip due to local variation of adhesion and wettability. The phenomenon is especially visible with high roughness and low wettability surfaces such as TiO_2 coated LFS substrate. To test film splitting hypothesis a rod coating experiment of PEDOT:PSS on studied substrates was carried out. These rod coated samples did not show any finger formation as the coating method does not have film splitting. This supports the hypothesis that the film splitting in the printing nip is responsible for the viscous fingering.

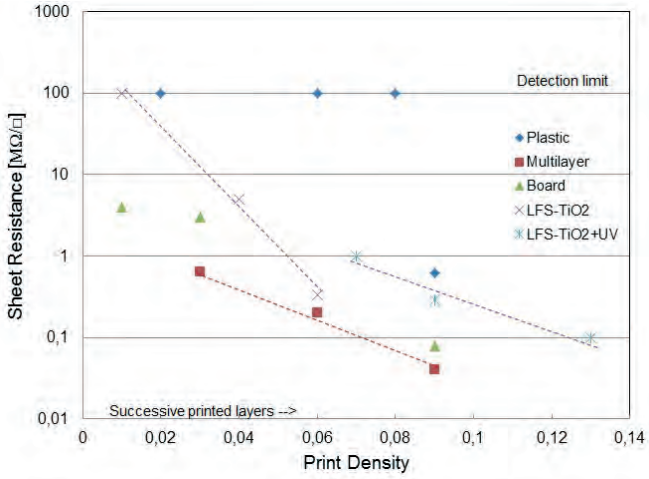

Figure 4: Sheet resistance in PEDOT:PSS in logarithmic scale as a function of print density for plastic, multilayer, and LFS paperboard (reference board, LFS-TiO_2, and LFS-TiO_2+UV treated)

Figure 4 shows the net sheet resistance of PEDOT:PSS layers in logarithmic scale as a function of print density for different print layers. We observe that the multilayer coated paper exhibits an almost linear trend in successive print layer resistance decrease on the logarithmic scale as a function of print density. This can be related to good ink setting properties of the top coating layer resulting in even print layers whereas the plastic film requires four successive prints before the sheet resistance values drop below the detection limit of our measurement system.

Figure 4 also clarifies the effect of wettability on the print density and sheet resistance for the LFS paperboard with TiO_2 nanoparticles. Ink transfer onto the superhydrophobic LFS TiO_2 surface is poor and thus, observed sheet resistance values are high with low print density values. On the other hand, after the UV-treatment the hydrophilic surface accepts the ink as observed from high print density values. The paper-board used for the LFS nanoparticle coatings is more porous than multilayer coated paper. Therefore, a larger ink transfer onto the LFS-TiO_2+UV treated sample is observed from print density values compared to the multilayer coated paper but the sheet resistance values do not differ dramatically between these samples. Hence, the ink that penetrates deep into the porous paperboard structure for the LFS-TiO_2+UV treated sample does not significantly contribute to the conductivity. This shows that controlled printability is crucial for printed functionality applications.

The optimal printing speed for the IGT printer with conductive inks was found to be different for PEDOT:PSS and for silver ink. PEDOT:PSS required faster printing speeds (> 1.0 m s^{-1}) for good reproducetion to minimize finger formation whereas for the higher viscosity silver ink lower printing speeds (< 1.0 m s^{-1}) were optimal. Independent of the ink formulation we observed conductivity after several successive prints in the flexography. For practical applications it would be beneficial to reduce the number of printing cycles: this is possible by optimizing the used anilox roll in the flexographic printing resulting in a homogeneous and conductive layer even with a single print. We plan to return to this issue in a future communication.

5. Conclusions

We have investigated the possibilities of forming large area conductive surfaces using a flexographic printing process with a laboratory scale test printer. Surface properties play a crucial role in the ink setting on the surface and in observed sheet resistance values. We have also shown that superhydrophobic surfaces result in higher sheet resistance values with water-based inks; to observe similar sheet resistance values as with hydrophilic surfaces several additional successive prints are required.

Comparing the observed sheet resistance values between paper substrates and commercial plastic film for PEDOT:PSS we can conclude that the porous paper surface provides a more uniform ink setting, and hence, improved conductivities. Further work is needed to optimize the coating structure and ink formulation to achieve high conductivities. As far as the authors know, this is the first study of flexographic PEDOT:PSS printing on LFS TiO_2 nanoparticle coated paperboard with controlled wettability by UV light. It is possible to control and tune the local wettability of such substrate using a mask during the UV exposure to either accept or reject water-based inks. Furthermore, we can retain hydrophobic and hydrophilic areas side-by-side without any need for additional layers on the surface. This may open up new possibilities for formation of conductive patterns on such TiO_2 nanoparticle coated substrates.

We believe that natural fibre based substrates will find many applications outside of the conventional graphic arts industry, promoting sustainable transformation from fossil fuel based plastic substrates to renewable natural fibre based platforms for printed electronics, photonics, and intelligence applications in the future.

A combination of different printing techniques may be used together in cost-effective manufacturing of multilayer structures such as organic PV in a roll-to-roll process flow.

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A multi colour separation system for graphic images

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Abstract

This paper reports on the development of a unique six colour separation system for the rendition of multi coloured images which has the elimination of practical printing issues at its focus. An algorithm is described which can be used for six colour separation of complex photographic images in order to maximise image gamut. Using a custom set of six colours a Yule-Nielsen modified Neugebauer equation is used to produce a colour model to predict colour mixing using 64 Neugebauer primaries. Over 60% of the model predictions were within a ΔE of 5. Some larger errors could be associated with the optical brighteners in the paper substrate. This model was considered sufficiently accurate for the basis of a colour separation model. To reduce computational effort at the separation stage a large pure lookup table was created to store the results of the colour model. This method is computationally heavy at the table creation stage, but fast for the user at the separation stage. The one-to-many mapping from XYZ to six colourants was dealt with by enabling a unique rule based system based on practical printing requirements and a smoothing function. The rule based system is based on practical printing issues which limits problems that could be experienced on press. The system was developed with maximum flexibility such that it can be adapted for an increased number of base colourants and alternate printing rules.

Keywords: colour separation, multi colour printing, Neugebauer

1. Introduction

The limitations of the four colour gamut are known with rich reds, violets, deep blues, bright greens being particularly difficult to achieve using a standard process set (Hitchcock, 2003). Numerous multi colour systems have been developed which allow a better rendition of saturated images and the use of process sets based on more than four colours is likely to increase in the future as it offers printers and ink makers a number of advantages. For the printer, the colour gamut and perceived quality of the print is increased and the number of Pantone and spot colours obtainable within a standard ink set is increased. This reduces the need for spot colours allowing the same colours to be kept in the press, eliminating costs associated with mixing and clean up times. For the ink maker, the reduced number of the spot colours which need to be held by the company and supplied to the printer is the primary advantage.

In order to widen the colour gamut, numerous commercial products have been launched, e.g. Hexachrome™ (Pantone, 2005) and Opaltone (Bernasconi, 1998). These system provide more or less a standard CMYK with the addition of other colours (green and orange for Hexachrome™, RGB for Opaltone) to produce the increased colour gamut. The aim of these systems is to enhance the colour gamut, eliminate the needs for spot colours and give better colour agreement between original and print (Viggiano and Hoagland, 1998). These have met with some limited commercial successes (Pantone ceased sales of Hexachrome in 2009) at the higher end of the market where the additional costs of extra print units and more plates/jobs can be accommodated.

The colour set examined within this study was supplied by a collaborating company (School of Colour Ltd) who has used the colour set for large gamut paintings in the fine arts industry, (Wilcox, 1993). The colour specifications were supplied by the collaborating company as they wished to explore the use of this colour set in the printing industry.

The benefits of a multi colour printing system must be balanced by the economic constraints of additional print units and plate materials. A further additional cost which must be met in multi colour halftone printing is the prepress time associated with colour separation.

Historically this has been achieved by skilled prepress operators who develop a sense of colour separations required to produce the best image. This subjective method can be slow, inconsistent and tends to be costly due to the time required by skilled labour. In order to reduce the financial burden associated with the prepress and improve consistency, this colour separation needs to be automated.

The investigations had three primary aims:

1. To investigate the merit of using a colour set developed as paints for the art reproduction in the printing industry.
2. To examine any printing issues in using such an ink set.
3. Finally, to develop an automatic system which could be used to provide consistent colour separation with a minimal intervention by the prepress operator and without excessive press fingerprinting using many test formes.

2. Summary of relevant literature

A number of methods have been developed for the separation of three channel images into multi colour separations. The key issues these have addressed are the colour mixing model, separation colourant selection, data storage and interpolation method and gamut mapping for out of gamut colours. These challenges are well summarised by Stollnitz et al. (1998).

The modified Neugebauer approach to colour model development has been used successfully by a number of authors. A common modification to the standard Neugebauer equations is to include the Yule-Nielsen correction for scattering (Stollnitz et al., 1998; Ostromoukhov, 1993; Pobboravsky and Pearson, 1972; Chen et al., 2003). The issue of gamut mapping between RGB and other colour gamuts has been examined on numerous occasions and is well reported in four colour printing applications. In the past, this issue has been ignored. It has been stated that the larger gamut of multi colour spaces does not require mapping, thus eliminating one of the most difficult challenges (Ostromoukhov, 1993). Methods which map a cylindrical mapping system to a circular mapping system have also been examined (Stollnitz et al., 1998).

One unique problem which arises in multi colour separation is the "one to many" mapping from XYZ to multi colour device space (Pobboravsky and Pearson, 1972; Chen et al., 2004). In three colour process printing, this issue does not arise since the number of colourants and the colour co-ordinates of any pixel are equal. With multi colour separation, there are a number of possible solutions to achieve a specified colour. The choice of solution is critical to the printability of the separation as artefacts and discontinuities can be created in the image. Separations containing discontinuities and artefacts impose extreme requirements on tone gain and register on the printer. A method which overcomes these issues by fixing certain colour components has been devised with success (Wang et al., 2006). The selection of colorants based colour constancy which reduced metameric effects has also been examined, (Chen et al., 2003).

One method which is increasingly being used in the commercial packaging industry for multi colour halftone printing is the use of ICC colour profiles. Commercial product packages offer the ability to produce test forms and generate profiles for multi colour separation. While this offers a commercial means of utilising multi colour halftone printing, it is a "black box" approach and it is likely to be even more problematic than four colour profiling (Sharma and Fleming, 2002).

3. Experiments

3.1 Colour set

1. In order to develop a separation system, a third party six colour set containing two yellows (an orange shade yellow and a green shade yellow), two reds (orange shade red and blue shade red) and two blues (green shade blue and red shade blue) was used, (Wilcox, 1993; Wilcox et al., 2005). For brevity, this particular colour set will be termed "W6" throughout this paper.
2. Inks matching the colourimetric properties set out in the colour system were formulated by a offset lithographic ink manufacturer. In all instances the pigments specified in the colour set could be incorporated into the offset lithographic inks. Pigment loadings were determined by the ink company such that the optical density was deemed to be correct at representative film thickness. Modifications to basic ink carrier in order to achieve stable formulations were not released by the ink supplier.

The experimental strategy was to initially appraise the visual performance of the colour set and to establish whether there were any practical issues in printing the materials. Having established the visual and practical implications of running the colour set, the next step was to

examine the colour space for the colour set through colourimetric measurement.

3.2 Examination of ink set visual performance and any practical issues during printing

Test images were printed which contained a number of standard images that allowed a visual assessment of the print quality. The images included a flesh tone, an image of food similar to that which would be used in the packaging industry and an image containing saturated colours. The test images for the W6 were separated using a skilled operator from the packaging prepress industry who used intuitive judgements to obtain the colour separations given the six base colours. In order to compare the performance of the colour set to more conventional colour sets, these test images were also printed using CMYK and Hexachrome. Separations for the CMYK and Hexachrome set were made using Adobe Photoshop and Hexwrench respectively. The screen angles chosen were set such that the shade for each pair of colours (e.g., green shade yellow and red shade yellow) were at the same angle. The angles used were 45 degrees for the blue, 75 degrees for the reds and 105 degrees for the yellows.

All experimental trials were carried out on an eight colour Speed Master offset lithographic press at Heidelberg UK. The printers found that the initial make ready time was approximately twice that of normal four colour jobs. This was partly associated with the additional plates and ink but a large portion could be attributed to the time associated with manipulating the ink keys to balance the need for set solid densities and visually correct image attributes. This is likely to reduce as press operators become more experienced with such a colour system. The main concern was the high ink coverage which was being printed in the shadow areas. This did not cause any set off problems on this occasion but printers felt that dark neutral regions with over 400 % ink lay down were excessive. The measured L*a*b* values at print density are tabulated in Table 1.

Table 1: Colour characteristics of the solid colours at print density (D_{50}^2)

	L*	a*	b*
Orange-Yellow	84.0	7.2	95.1
Orange-Red	60.4	63.9	30.0
Violet-blue	39.6	14.0	-71.7
Green-yellow	88.9	-8.1	72.0
Violet-red	56.2	71.3	-20.1
Green-blue	53.3	-33.4	-51.9

The intention of the relative visual comparisons was simply to yield a decision on whether there was any merit in developing the colour set and not to critically evaluate the absolute performance of each colour set. Visual assessment of the prints was carried out in a VeriVide CAC 150 colour assessment cabinet operating with a D65 illuminant with prints from each colour set being examined side by side against the neutral grey background of the cabinet. In total, 15 observers with printing science backgrounds were used and asked to give unprompted descriptions of the prints. All observers stated that the images printed with the W6 were significantly more vivid and saturated than those produced from CMYK. The most noticeable features found by the observers included brighter reds, deeper cleaner violets and smoother transitions through the mid-tones to shadow. All observers felt that the increased colour gamut produced by the six colour set enhanced the appeal of the image, particularly for the packaging type images of foodstuffs. It was difficult to come to any subjective value added perception to the image. Some observers, particularly those with a publication interest, suggested that practical constraints of registration and cost would require them to add black as one of the printing inks.

Having shown viability, the next aim was to examine a means by which an automatic colour separation model could be developed and then to test the accuracy of the separations.

3.3 Determination of colour gamut

The aim of this stage of the experimental development was to examine the colour gamut achievable, to assess the practicability of six colour halftone printing by offset lithography, to provide the necessary test data for the separation algorithm which was to be developed and to provide the test data against which a model could be measured.

Under the constraints of printable area, the available press time, the ease of data manipulation and the number of colour combinations required, a series of four test forms was produced which each contained 4096 patches laid out in a logical order, Figure 1.

Each test form was generated from custom postscript and consisted of all coverage combinations for each colour at 100 % and 0 % together with a pair of additional tonal values. The first test form contained all combinati-

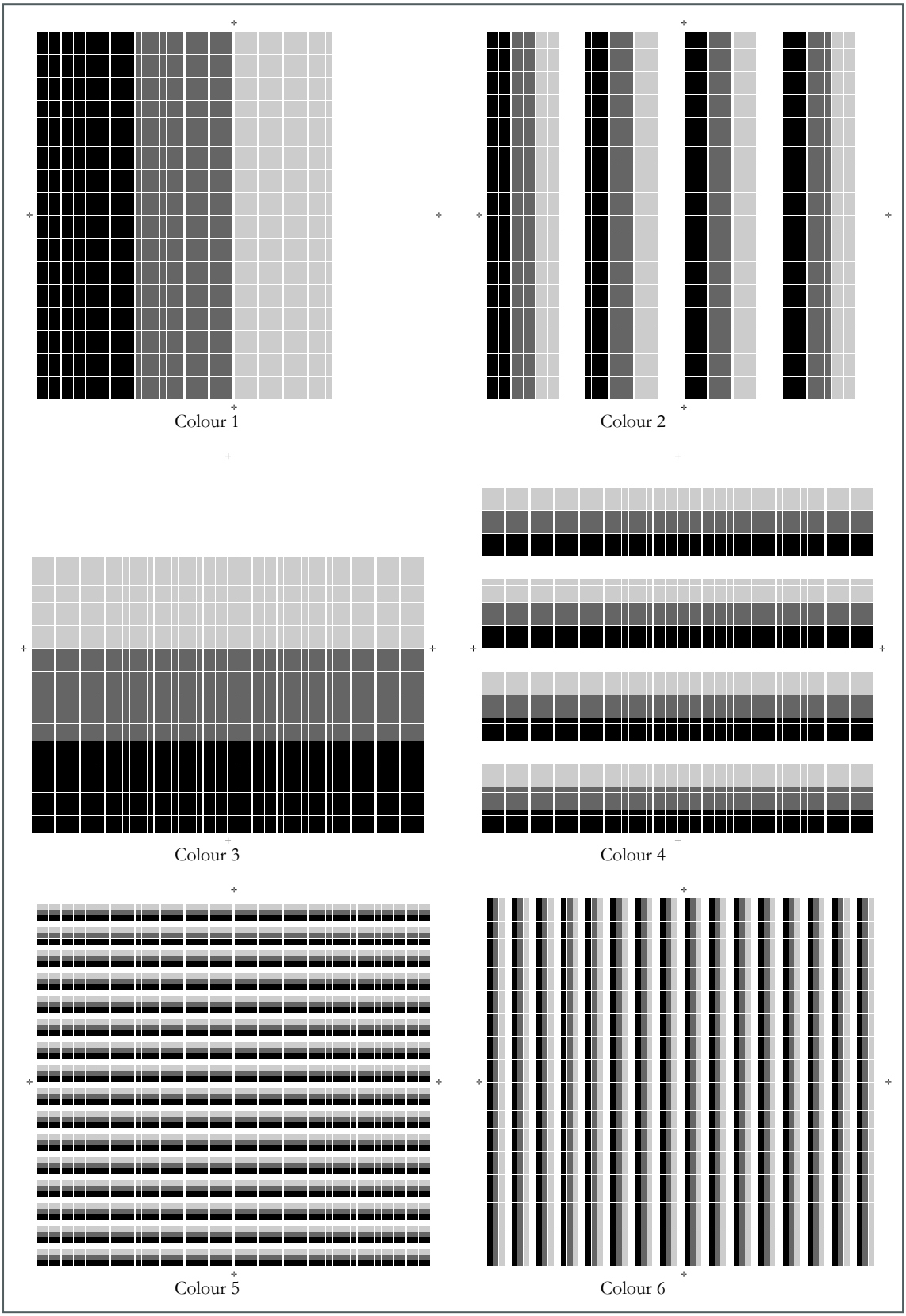


Figure 1: One of the four colour gamut and colour prediction model validation test form images. The image shown represents the all possible 60 %-20 % combinations of each colour

on of halftone patches 80 % and 50 %, the second 70 % and 30 %, the third 60 % and 20 % and finally the fourth 40 % and 10 %. The 100 % single colour and subsequent overlays in each test form allowed any variations between the test forms to be established.

With close control by the operators, the solid colour varied by less than ΔE_{ab} of 2 between each test form. In each case the measurements were compared to the colour gamut available in the Pantone colours for coated paper.

In each case the measurements were compared to the colour gamut available in the Pantone colours for coated paper. The comparison was made to the Pantone colours since ultimately a major advantage of the ink system would be an ability to reach a high proportion of the Pantone colours, thereby eliminating the need for spot colours. Examining the a*b* plane, Figure 2, shows that W6 colour gamut matches most of the Pantone colours, being only somewhat deficient in the green region.

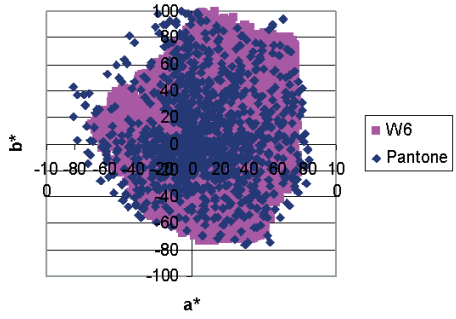


*Figure 2: A comparison between the W6 ink system colour gamut and the Pantone range of colours in the a*b* plane*

This small deficiency in the green can also be seen when one examines the view of the L*a* plane, Figure 3(a), where some of the Pantone light green colours are beyond the W6 colour gamut. Some of this may be associated with the limited number of test patches in the test forms and the tone gain on the press which would tend to darken colours. The colour gamut may be improved through increased testing in this region with lower percentage values and tone gain compensation. When the L*b* plane is examined, the wide colour gamut produced by the colour set is easily seen, Figure 3(b). Only some selected very dark blues are not covered by the colour gamut of the W6 ink set. Notwithstanding some deficiencies in the light green area of the colour space (some of which may be attributed to the lack of data in this region), the colour gamut produced by the ink colours was deemed to be appropriate for development of a separation algorithim.

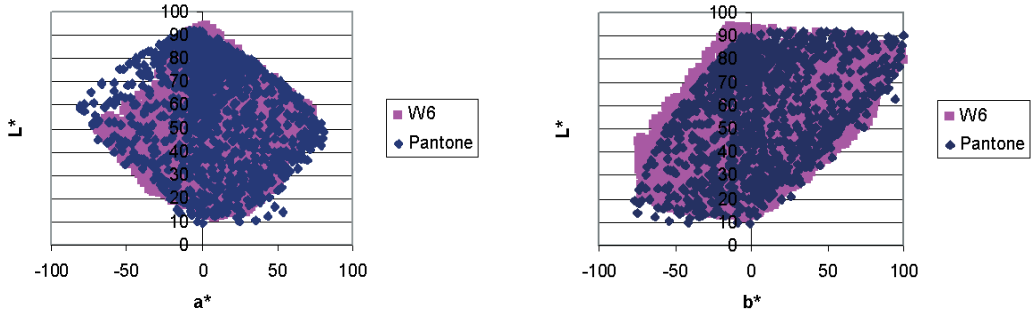


*Figure 3: A comparison between the W6 ink system colour gamut and the Pantone range of colours in the L*a* and L*b* planes*

3.4 Development of a colour prediction model

Having found that the colours selected and the ink set manufactured could be used as the basis of a colour set, the next experimental step was to examine how this colour set could produce separations automatically. The prediction of the XYZ colour within the algorithm is based on the Neugebauer equations which predict the colour based on the concentration of the Neugebauer primaries (the base colours and overprints). It was decided that the effect of trapping would be ignored, (Stollnitz et al., 1998). This was felt to be justified as it added additional complications (particularly with six colours) which could not be justified and required further assumptions which may be invalid.

For a six colour system there are 64 Neugebauer primary coefficients (64 single colours and overprints plus the substrate). The XYZ colour values can be calculated from equation 1 (Amidror and Hersch, 1999).

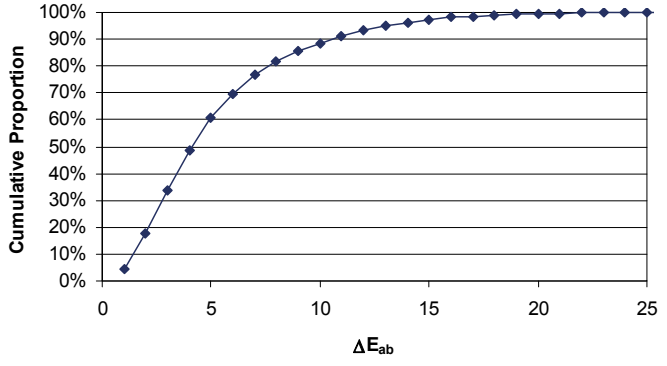
$$\begin{bmatrix} X_{tot} \\ Y_{tot} \\ Z_{tot} \end{bmatrix} = \sum_{1}^{64} a_i \begin{bmatrix} X_i^{\frac{1}{n}} \\ Y_i^{\frac{1}{n}} \\ Z_i^{\frac{1}{n}} \end{bmatrix}^n \quad [1]$$

In equation 1, the subscript tot represents the total colour, the subscript i is the ith Neugebauer primary, *a* represents the percentage area of the ith primary and n is the Yule-Nielsen factor. Given the XYZ values of the Neugebauer primaries, then for given percentage areas of each of the six colours the total colour can be calculated. Equation 1 assumes that the printed halftone tonal value for the ith colour is independent from the other colours. In practice, it is likely that the true printed tonal value may depend on the printed tonal value of other colours, particularly for colours printed later and areas of in higher mid-tones and shadows. The effect of the non-independence of the tonal values was assumed to be minimal in order to limit the number of test patches to 64.

In order to test the model for colour prediction, the data from the initial offset lithographic printing trial was used. This provided the necessary 64 Neugebauer primaries together with another 12384 unique patches which contained various combinations of printed percentages of the six colours. Thus, it was possible to compare the predicted colour against the measured colour. A parabolic dot gain curve was applied to the dot areas of each of the colours reaching a maximum at a 50 % tone. This maximum value varied between 10 % and 20 % depending on the colour. The Yule-Nielsen correction factor was calculated by measuring the tone strip using a densitometer and by image capture through a microscope. Image segmentation at a fixed grey value (mid-point between peaks at nominally 50 % coverage) through the tonal scale allowed the true physical percentage coverage to be calculated. The Yule-Nielsen factor was chosen at 1.2 such that it gave the minimum mean error between the calculation based on the Yule-Nielsen modified Murray-Davies equation and the physical measurements carried out using microscope image analysis of the halftones.

Figure 4(a) shows a cumulative distribution of ΔE_{ab} (between the predicted and measured colour) as a function of the percentage of patches. 60 % of the patches are within ΔE_{ab} of 5 while 90 % within ΔE_{ab} of 10. This represents reasonable agreement between measurement and prediction. When examined in terms of CIE 94 colour difference, around 80 % of the patches are within a ΔE_{94} of 5 while 95 % are within a $\Delta E_{94}$of 10.

(a) ΔE_{ab}



(b) ΔE_{94}

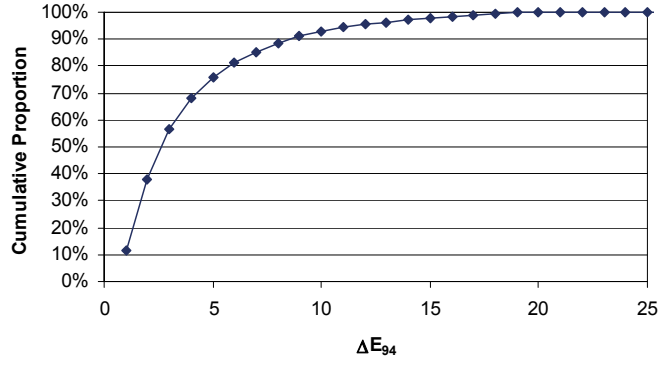


Figure 4: The cumulative number of points plotted against the colour difference between the predicted and measured colours for the 12384 measurement points for (a) ⊿E_{ab} and (b) ⊿E_{94}

The errors between the prediction and measured colours are deemed to be due to a number of factors. Firstly, the Demichel equations assume independence between the individual halftone screens. As the total ink percentage increases, then there will be interaction between the individual colours and the assumption becomes more invalid. Secondly, further analysis of the colours which were not well predicted (those where the ΔE_{ab} were larger than 10) showed that there was a pattern in these colours which was associated with the optical brighteners in the substrate whose colour was measured at L* = 94.2, a*= 3.5, b* = -13.53. The large values of ΔE_{ab} were concentrated in areas where no yellow was printed, Figure 5.

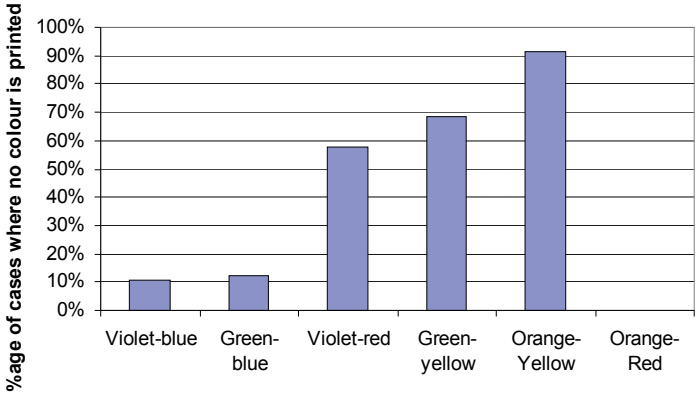


Figure 5: An analysis of the colour deviations greater than 10 between the predicted and measured colour

All predictions were accurate when the yellow was present as the yellow had the effect of filtering the strong blue nature of the paper brought about by optical brighteners.

Given that the model produced reasonable agreement between the predicted and measured values, it was decided that this could form the basis of a colour separation algorithm for six colours.

4. Implementing a colour separation model

4.1 Colour model separation assumptions

At the initial stages of model development, the gamut mapping was ignored. This principle has been used before (Ostromoukov, 1993) when examining the issue of gamut mapping. It was felt justifiable to ignore gamut mapping due to the large colour gamut of the process set. The implications of this are discussed later.

4.2 Separation methodology

In separating an image, the XYZ of the pixel is known and the percentage coefficients (a_i) must be calculated. The direct mathematical solution of these equations is extremely difficult since there are six unknowns (the percentages of each colourants) and three equations (one for X, Y and Z). This would require some predetermination of the solution and/or iterative techniques to find a solution. The equations are also highly non-linear and although mathematical techniques have been developed (Urban, 2007), their solution is not straightforward. Subsequently, an alternative strategy was devised. This involves looping through every possible combination of the seven ink colours from 1% to 100% in 1% steps (100^6 combinations) and calculating the XYZ and subsequently the L*a*b* coordinates of the predicted colour. Thus, a table representing the possible colour gamut is developed over time. A practical method for storing the data is to store one byte for each colour channel for each possible L*, a* and b* value with a byte representing each L*a*b* value. This creates a three dimensional table containing the six colourants required for 256^3 entries.

Given an RGB pixel value, it is possible to calculate L*a*b* and then directly point the algorithm to the relevant colourant combinations required to create this colour in the table. The algorithm is therefore a direct LUT (look-up table) and not a "look up, find near neighbours and interpolate" table. The advantage of this strategy is that it is quick at the separation stage since no LUT nearest point finding and interpolation is required during separation.

The disadvantage of this strategy is that it is computationally intense at the table creation stage, since all 100^6 combinations are calculated, and it requires the table of 2^{24} entries containing a byte for each of the six colourants to be stored in memory, approx. 100 Mb. This is memory, but not computationally, expensive at the separation stage. At the table creation stage this computation takes approximately four hours on a dual core Pentium PC.

There are two major issues relating to this strategy. One is the limited colour gamut of the six colour system compared to L*a*b* colour space, which results in null records being calculated for many L*a*b* colours. The other one is associated with the one-to-many mapping. In some instances, there were in excess of 10 000 combinations of the six colourants which would produce the necessary colour. By simply looping through all the possible combinations of the six colourants it is not possible to control which combination is chosen. Although the separations are colourimetrically correct, they tend to include discontinuities and bands in smooth transitions, as the choice of colourant is effectively dependent only on the order of the search. In order to overcome this limitation, a rule based system which aims to apply logic to the criteria was developed, coupled with an array smoothing function.

The rule based system can be prioritised for minimum ink use, preferential colours and dot size limits. Each factor is combined to create a "printing score" which reflects the ease with which the colour can be practically achieved on press.

Minimum ink use: The minimum ink use compares the amount of ink required to achieve a colour and selects the combination of colourants with the lowest total ink usage. Thus a colour combination requiring a total ink use of 230 % will be chosen in preference to one of 240 %. This rule ensures that colour combinations which are likely to be easier to dry through a reduction in total ink weight are selected.

Dot size limits: Incorporating the dot size limit ensures that the demanding process of extremes of printing low highlight and deep shadow are avoided. Separations which include either a halftone value less than 5% or greater than 95% are given a lower score. Thus if a colour can be obtained through a combination of midtones, it will score higher than one which requires deep shadows.

Preferred colours: The preferred colours are achieved by giving each colour a user weighting. This weighting would be based on user preference, pigment cost, light fastness and ink film thickness required to achieve the standard densities. For the initial study, five of the inks were weighted equally (a weighting of 1) with the violet-blue being ranked lower (a weighting of 0.7) as the cost of this pigment was somewhat higher. When comparing colour combinations, the combination chosen was the one with the highest ranking. For each ranking scheme chosen, the look up table will need to be recreated.

By examining the sum of the ranking, the combination which achieved the highest rank would then be chosen. This rule set is user defined and it is possible to accommodate other factors, other rules and weightings (e.g., to accommodate varying drying rates) into the printing score calculation. Before a colourant combination is stored in the array it is checked against the incumbent value using these rules and if it answers these rules more fully, it replaces the current value.

A flowchart of the table creation process is shown in Figure 6.

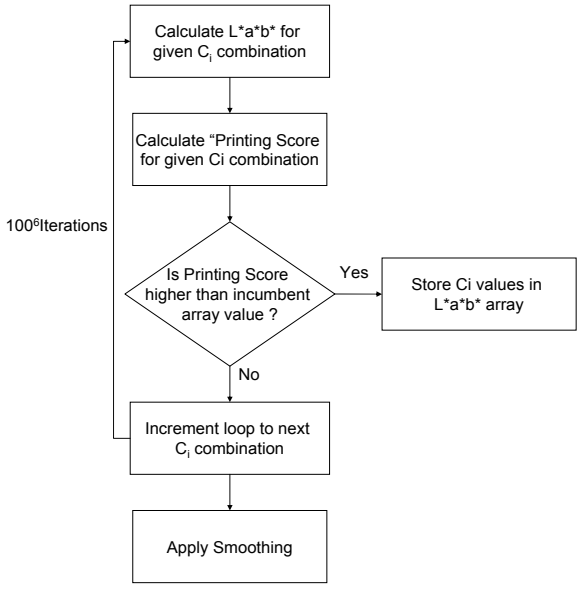


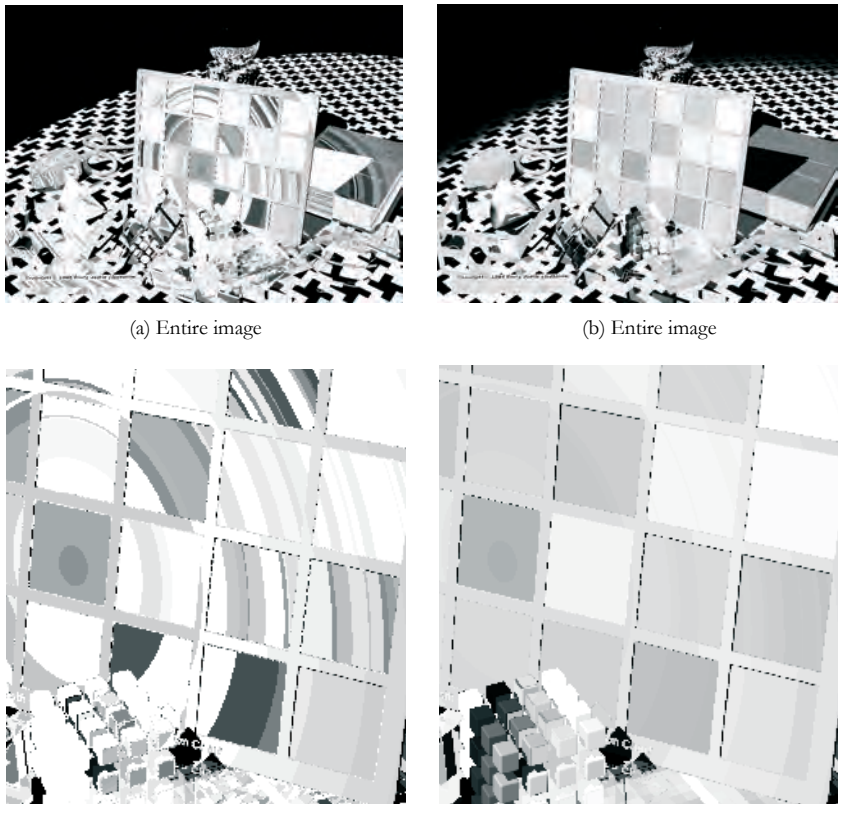
Figure 6: Strategy employed to examine the best colorant combination

Having filled the array with combinations of each colourant which produces each L*a*b* colour, a smoothing procedure is applied. The smoothing procedure minimizes any discontinuities in the separations which can lead to visible banding in the separations. Whilst this banding has no immediate effect on colour rendition, it

makes the separations very difficult to print in practice as there are sudden tonal jumps in each separation between adjacent areas. This smoothing effectively sacrifices some degree of optimal colour rendition in order to achieve separations which are easier to print.

The smoothing function minimises any individual values which are in the array but are significantly different from near neighbours. An algorithm was developed which examines each entry in the 24^3 array and compares the constituent colourants to its 8 near neighbours for each colourant. If the differences between the current entry and its near neighbours are above a threshold value, a smoothing function is applied to the entry. The smoothing function calculates a mean value from the near neighbours and places this mean value in place of the current entry. Banding is not eliminated if the threshold value is too high while too low a value results in excessive deviations in the reproduction in colour and loss of detail in the image. Through trial and error, we found that a threshold value of 3 % gives the correct balance.

Much of the testing of the separation was carried out using a test image which provides a challenging test of the system as it contains smooth blends, saturated colours, grey areas and fine detail (Lindbloom, 2009). Separations for the violet-blue with and without the rule based system and smoothing are shown in Figure 7. Although the modified separation is not completely free of discontinuities in tone, it is much more amenable to printing than the initial separation. The discontinuities are clearly evident in Figure 7(a) where sudden changes in tonal value are evident. Such artefacts are not present in the Figure 7(b). Some graduated changes in tone can be seen in the lower left corner patch of the magnified image in Figure 7(b) but these represent an increase of only a few percent tone.



(a) Entire image (b) Entire image

(a) Magnified centre of image (b) Magnified centre of image

Figure 7: Separations created (a) without and (b) with the rule based decisions and smoothing functions

In order to accommodate the printer's preference for a black ink within the set, a substitution mechanism was devised. The choice of which colour to substitute would depend on the image being printed. For example, if a particular image required a great deal of shadow and had little colour in the orange-yellow region, then it would be appropriate to sacrifice the yellow-orange ink to make way for the black. In order to limit the subjectivity of which colour to sacrifice, an automatic strategy is required which accommodates the black as a possible substitute colour for any of the primary colours used in the ink set.

In order to offer the possibility of black substitution for one of the colours, an additional six colour table was generated for black substitution for each of the colours. The

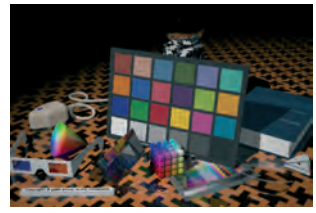
Neugebauer primary data for this was made by overprinting the 65 patches with a black overprint. This yields 130 patches with all combinations of six colourants.

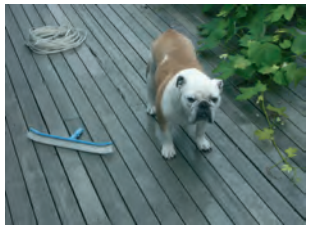
If all seven colour combination tables were to be kept in computer memory, then approximately 700 Mb would have to be allocated for table storage. To overcome this issue, seven single bit data tables were created representing each possible colour combination. Each table entry bit represents whether the RGB colour can be achieved using the chosen colour combination. Upon loading an image, the "in-gamut" RGB colours can be directly examined and a total of in-gamut and out-of-gamut colours created. By comparing the percentage of in-gamut colours for each colour combination, the optimal separation colours can be calculated. Typical examples of this are shown in Table 2 where the percentage of colours obtainable (irrespective of the area of colour) within each of the images (Figure 8) are shown for each colour combination.

In almost all instances, the six original colours are not the most appropriate (i.e. they do not give the largest percentage of coverage within the gamut). This is most noticeable in images with a higher degree of shadow and shows the difficulty in laying down a sufficiently dark colour using a high total ink coverage of the six original colorants. The analysis shows the usefulness of the technique in choosing the optimised ink colours for any image in terms of colour gamut. In the software implementation of the technique, the out-of-gamut section of images are shown visually.


Peppers


Romeo & Juliet


Delta E


Dog


Virgin Mary

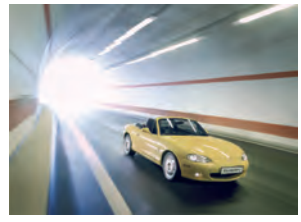

Sports car

Figure 8: Sample test images used to examine the optimum ink colourant solution

Table 2: Results of "in-gamut" for the images in Figure 8.
Each row represents the percentage "in-gamut" where black substitutes the noted colour

	Peppers	Romeo & Juliet	Delta E	Dog	Virgin Mary	Sports car
Original 6 colours	87	76	56	95	46	95
Violet-blue	94	85	63	99	97	97
Green-blue	75	82	60	92	98	96
Violet-red	77	81	62	99	98	97
Green-yellow	88	87	64	98	99	97
Orange-red	76	82	63	99	99	97
Orange-yellow	94	86	64	97	99	97

5. Assessment and separation analysis of complex printed images

In order to validate the automatic separation system developed, a further printing trial was carried out on the same combination of machine, ink and paper substrate using the same target ink densities as in the initial trial. The previously measured tone gain was applied to a series of photographic images during the separation process. The complex images were examined through a subjective assessment by the printers, based on running the

jobs, and by observers with experience of commercial printing, viewing the final prints. All commented on the increased colour gamut of the six colour print, the more realistic nature of the bright natural colours and the natural blends in vignette regions.

In order to provide a more objective analysis of the prints, printed samples were scanned on a EPSON 4490 scanner at 300 dpi and analyzed using proprietary software. All scanner software image enhancements were disabled and a template mounted on a scanner contained 16 solid reference patches of known measured colour. This calibration improves the accuracy of measured colour compared to built-in software profiles and limits any scanner drift or other variation. Only three patches are needed to calculate the unique XYZ-RGB calibration matrix, but 16 samples allows for 10 sets of three patches to produce an average calibration.

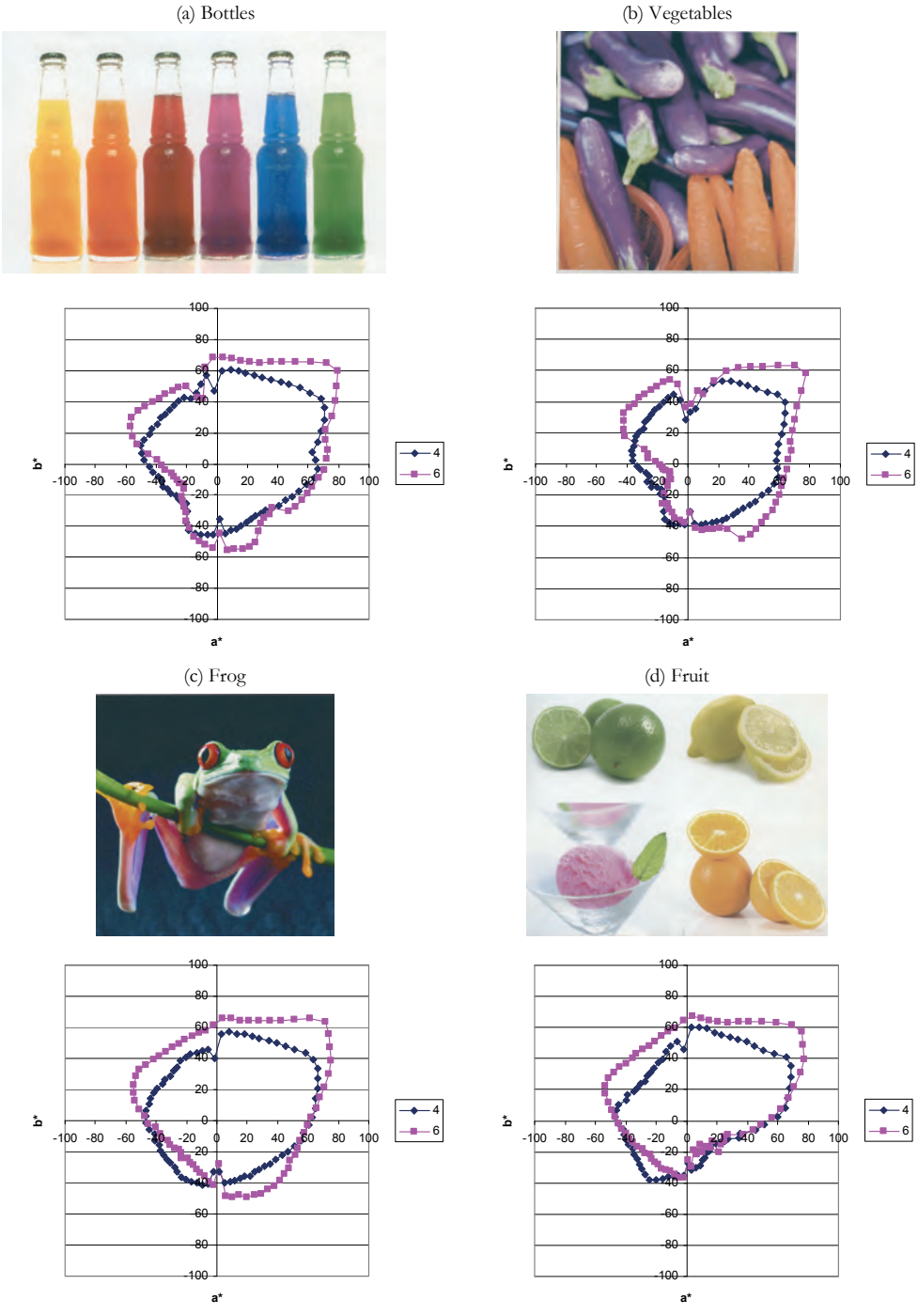


Figure 9: A comparison of colour gamut of four and six colour printing for a selection of saturated images

This limits colour bias if the reference samples are not selected optimally around the colour gamut. From the measured XYZ values it is possible to calculate the L*a*b* colour information of the printed images. No comparisons can be made between the printed colour and input data on a pixel by pixel basis due to the colour limitations of the scanner.

This method is in no way meant as an absolute measurement of the printed colour, but provides a relative measurement of the printed colour at the extremes of the gamut. The outer boundary of each image gamut is defined by the highest chroma value at each hue angle between 0 and 360 degrees.

In all instances the six colour print shows increased chroma, Figure 9. On average, this increase is most noticeable in the orange to violet sections of the gamut (hue angles of 300 to 60) with a smaller increase in saturation in the yellow-green (hue angles of 110 to 160). Interestingly, each image shows a region where the four colour image is more saturated in a green-cyan region of the colour gamut (hue angles of 170 to 250). Given that both systems employ a yellow and cyan to obtain a green, this may be related to the transparency of green-yellow ink in the six colour set which reduces its ability render saturated greens when printed on the cyan ink. No colourimetric tests were carried out on the ink to validate this hypothesis.

6. Discussion

The ink set used offers a number of distinct advantages over comparable ink systems used in commercial printing. There are, however, a number of technical and economic challenges which need to be addressed before the ink set is widely adopted. Instances of its use in the packaging industry are already available.

The basic economic challenge to the ink system is associated with the number of printing units required to print the job, the additional ink cost, the additional prepress costs and the time associated with developing a fingerprint for any press/ink/substrate combination. These may be significant issues in the four colour offset lithographic commercial printing sector where print is increasingly seen as a commodity and not a service. The use in the packaging market where multicolour presses are more common and the correct rendition of food colour is important offers significant commercial advantage.

The main technical challenge is associated with making the separation algorithm commercially robust. The algorithm developed operates well. It is robust and takes minimal computation at the separation stage, being a true LUT and not a "look-up, find nearest neighbour and interpolate" system. This approach is novel but is not very elegant and is only possible due to the computational power and storage capacity of modern desktop computers.

Although the system has been tested with the six colours described, the system has been designed to be "open" in that it has not been hardwired to operate with the here selected colourants. The increase in computational effort for additional colourants at the table creation stage would be significant, a factor of 50 or 100 dependent on the number of percentage steps considered. This would only occur once at the table creation stage. Separation time by the user would be unaffected. Instead of the full factorial approach used in the current algorithm during table creation, intelligent selection of the colourant combinations could reduce the superfluous computational effort considerably. With such a system, it is expected that a seven colour system may then have an increased run time of approximately twice that of the six colour system.

The inclusion of gamut mapping to compress the original's gamut into the available six colour gamut is needed to ensure that colour differences in the original close to the gamut edge are maintained in the print. Although observers were not visually aware of extreme gamut compression in high chroma colours, the sepa-rations clearly showed some high chroma regions where pixels were numerically different in the original L*a*b* but which were of equal colourant concentration in the separation. The limited sensitivity of the eye to small colour changes in high chroma regions is likely the key reason why these differences were not perceived by the observers (Fairchild, 2005).

The difficulty in rendering dark neutral colours without excessive total ink coverage using six colours is a fundamental issue which is likely to cause practical problems in implementing the six colour system. The addition of black reduces the total film thickness substantially but has an impact on the number of printing units required. Before the six colour system can be placed on the market, a valid economic model needs to be created which examines the balance of the financial penalty of the system with the potential increased revenue from new markets, value added printing and reduction in costs associated with spot colours. The economic argument is increasingly important in a world where print is seen as commodity. This requires more rigorous studies to be undertaken on financial added value and costs associated with spot colours to be more accurately modelled.

For scientific completeness and ease of data presentation, the workflow currently converts any RGB image

(from the most common RGB colour spaces) to XYZ and subsequently to L*a*b* and examines an L*a*b* LUT. In many instances, the XYZ to L*a*b* step can be removed and an RGB LUT created. This would remove a computational step in the data workflow and improve productivity. The RGB space chosen would need to have a colour gamut larger than the six colour gamut.

7. Conclusions

The system developed provides a robust way of converting an RGB image into six colour separations. The six colour system provides a wide colour gamut which can be used for chroma rich presentation of complex images. Utilising a modified Neugebauer model, there is sufficient agreement between the predicted colour and the measured colour to enable colour separation software to be based on the model. This model takes into account the practical printing issues associated with multi colour printing. The software created utilises a true LUT, dispensing with the need for interpolation. The software is computationally expensive during the production of the LUT but rapid during the separation process. It is likely that the system developed could be used for alternative colour systems and even be extended for additional colours.

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The effects of laser-engraving settings on etch depth of polymer clichés and pad printing quality

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Abstract

Laser has been used in many fields since its invention several decades ago. It can easily cut polymers. In this study, laser was applied in pad printing to engrave polymer clichés. It eliminated film and chemicals required in the conventional photographic method involving exposure with film positives followed by development. It also ensured direct image output and eliminated the myriad variables and time-consuming steps in the photographic method which affected consistent quality. A CO_2 laser cutter/engraver from Universal Laser Systems was used to engrave the image areas on polymer clichés. The laser system has a power of 150 watts and the laser beam has a spot diameter of 0.001 inch, which ensures fine detail reproduction. Image resolutions are determined by pulses per inch (ppi) in the *x*-axis and dots per inch (dpi) in the *y*-axis. The highest available resolution was used, which was 1 000 ppi by 1 000 dpi. Laser power and engraving speed determine the depth of the ink wells, so these two engraving parameters were varied to obtain optimum results. It was found that 100 % speed (70 inch/second) with 11 % power (17.5 watts) created an optimum etch depth. A line art as well as images with large open areas that were screened with different settings were laser-engraved on clichés and printed on a pad printer Model Sealcup 60 from Trans Tech. The engraved sidewalls appeared to be straight and pooling of ink did not occur in the printing process, thus producing high print quality of line art. Images with large open areas that were screened at a maximum angle of 45° with the doctoring direction and a high screen frequency of 200 lpi had the best print quality and highest print density. Differences between dot shapes were only observed when the screen frequency was low.

Keywords: laser engraving, polymer cliché, etch depth, pad printing, quality

1. Introduction and background

Laser is the acronym for light amplification by stimulated emission of radiation. After deducing the relationship between energy and frequency of radiation, Max Planck found in 1900 that light is a form of electro-magnetic radiation (Boringhieri, 1999). In 1917, Albert Einstein explained the theory of stimulated emission and theorized that electrons could be stimulated to emit light of a particular wavelength when absorbing and emitting light at the same time, which provided the basis of invention of laser. Based on the prediction of Einstein, Charles Hard Townes demonstrated the first laser which was microwave amplification by stimulated emission of radiation. In 1960, the first successful optical ruby laser was invented by Theodore Maiman, while Ali Javan developed the first gas laser (helium neon). The gas laser was the first continuous-light laser and the first to operate under the principle of converting electrical energy to a laser light output. In 1962, Robert Hall invented the semi-conductor laser as a revolutionary type of laser which is still used in many of the electronic appliances and communication systems. The carbon dioxide (CO_2) laser was invented by Patel Kumar at Bell Labs in 1964 (Kumar, 1964). It was the most powerful continuously operating laser of its time, and is now used worldwide as a cutting tool in surgery and industry. In 1965, Kasper and Pimentel (1965) invented the first chemical laser at University of California, Berkley.

Laser was a remarkable technical breakthrough, but in its early years it was something of a technology without a purpose. It has become widely used nowadays. On a daily basis, all computers, DVD and CD players use laser to decode the information stored on discs, and that information was put there by laser in the first place. In addition, almost

Note: Parts of this work have been presented at the TAGA Annual Technical Conference 2011.

all present non-inkjet printers and copy machines use laser to create documents. Besides our daily use, laser is used everywhere such as in engineering, medicine, nuclear energy science, and entertainment. In engineering, laser is applied in satellite communication and GPS, as well as fiber optic communication. In electrical engineering, laser is used for printed circuit boards. It is also used in distance measurement in civil engineering. In industry, laser is widely used for cutting, welding, and bending. Laser is also applied in medicine, such as ophthalmology, cancer and cosmetic laser surgery (Sakr, 2010). In nuclear energy science, laser is used for enrichment and fusion reactors. In entertainment, laser is used for light display to add stunning visual effects (Boringhieri, 1999).

Laser beams can easily cut polymers. Some researchers have carried out investigations of laser cutting on different polymeric materials. The results suggest that there are optimum values for different parameters to reach high process efficiency. Cutting speeds on polymers were found to be much higher than those on nonpolymer materials (Davim et al., 2008). It was also found in many cases that setup of high power in laser machines is not necessary for high efficiency. Baskoro et al. (2011) used low-power laser diode and CO_2 to cut polymer and gypsum materials and found that the depth of cut was determined by speed, power, thickness of layer and compressed air. The results showed that the increase of depth of cut was not linear because the sintered surface created in the cutting process could resist the laser beam to penetrate to the surface. Recently, an investigation carried out by Desai and Shaikh (2010) focused on micro-milling performance of thermoplastics with different parameters, such as laser power, cutting speed, laser beam absorptivity and latent heat of vaporization. Their study revealed that laser beam absorptivity, cutting power and cutting speed are the major influencing parameters on depth of cut. Depth of cut increased with decreasing cutting speed and increasing cutting power.

In this study, laser was used to engrave polymer clichés for pad printing. Pad printing is an indirect intaglio printing process based on recessed images. It uses an image carrier called *cliché*, which has image areas engraved on its surface (Kiddell and Swift, 2004). During the pad printing process, an ink-filled cup with a doctor blade ring swipes over the cliché filling the recessed areas with ink. A pad selected by shape and hardness is lowered and pressed onto the cliché to pick up the ink out of the recessed areas. The pad is then positioned above the substrate to be printed and lowered to transfer the ink onto the substrate surface and meanwhile the cliché is inked again by the ink cup. After ink is transferred, the pad is lifted and moved back to the cliché, and the printing process is repeated.

Polymer and steel are widely used materials for making clichés. Polymer clichés are typically produced in-house using a photographic method involving exposure with film positives followed by development. It begins with a positive image reproduced on a film. A polymer cliché is placed under the positive and then both are placed into a vacuum-sealed chamber and exposed for a specific amount of time. The positive image is then removed and a second positive film of a halftone screen is applied and the cliché is exposed for a second time. The positive film is removed and the cliché is washed to remove any excess emulsion or dust. The cliché is inspected carefully at this point to ensure that no random marks or dust are on the surface. Finally the cliché is baked to harden the remaining emulsion, leaving the image etched as a recessed area on the cliché (Swift and Kiddell, 2002). There are many steps in the process which affect consistent quality. The production of steel clichés is usually outsourced to professional etching houses because aggressive chemicals are used in the etching process (Adner, 2005). It is difficult to get straight-walled etching, because pooling of the chemicals causes uneven edges and rough bottoms.

Computer to plate (CTP) systems utilizing laser engraving to make pad clichés are available in the market today. They eliminate film and chemicals. They ensure direct image output and eliminate the myriad variables and time-consuming steps required in conventional methods (Adner, 2005; Peterson, 2007; Sharon, 2004). In this study, a laser cutter/engraver at Ball State University was used to make polymer clichés and their print quality was evaluated. This laser engraver has been used by students to study rapid prototyping and related technologies. Students and faculty use it to explore new applications of laser machining in other fields.

2. Experimental

A PLS6.150D laser cutter/engraver from Universal Laser Systems was used to engrave the image areas on a cliché. The laser system uses a CO_2 laser and has a power of 150 Watts. The high power density focusing optics (HDPFO) 2.0 inch lens made it possible to narrow the focus of the laser to a spot diameter of 0.001 inch, which ensures fine detail reproduction. Image resolutions are determined by pulses per inch in the lateral direction (*x*-axis) and dots per inch in the downward direction (*y*-axis). The maximum resolution of 1 000 pulses per inch (*x*-axis) by 1 000 dots per inch (*y*-axis) was used to ensure fine detail engraving.

Laser power and engraving speed determine the etch depth of the ink wells. The higher the power is and the slower the speed is, the deeper the etch will be. These two parameters were varied to obtain optimum engraving depth of 18-25 μm (Adner, 2005). Etch depth was determined by the difference of cliché thicknesses before and after laser engraving which were measured using a micrometer.

H2-Orange clichés from Trans Tech were used. They had a dimension of 5.5 x 2.75 inch with a 2.375 inch circular printing area in each half, which was determined by the ink cup size. They have a polymer layer for imaging with a steel back layer. They were attached to a magnetic plate during the laser engraving process to keep them flat throughout the process. They were then baked for 30 minutes at an oven temperature of 200 ºF to harden the printing surface.

A line art of Ball State University logo, shown in Figure 1, was first used for engraving. Two images of the line art with different dimensions, 0.75 x 0.625 inch and 1.5 x 1.25 inch, were engraved in the two printing areas of the same cliché.

Figure 1: The line art used for engraving

For pad printing, images with large open areas need to be screened (Kaverman, 2004). There are two reasons. First, most large open areas in images need to be screened to support the doctor blade or ring, preventing it from dipping down into the etch and pulling the ink out from below the level of the top surface of the cliché. This ensures a consistent ink thickness to pick up with the pad, instead of thick on the edges and thin in the middle. Second, the small hills in the screened images provide resistance to the flow of the ink when the pad compresses to pick up the image. In large open areas the pad can produce a wave action in the direction it is rolling during compression. The screen gives the ink something to hold on to in the bottom of the etch until it is picked up by the pad, so that a consistent ink thickness is achieved. In order to test images with large open areas, an image of 0.5 x 0.5 inch square was screened with different settings as shown in Table 1, and then engraved on clichés.

Table 1: Image Screen Settings

Dot Size (%)	Screen frequency (lpi)	Screen Angle (°)	Dot Shape
90	200 150 100	45 0	Square Diamond Round

A pad printer Model Sealcup 60 from Trans Tech was used for pad printing, as shown in Figure 2. It is a single color pad printer. A cone-shaped pad was used to print on a 60 # uncoated paper stock. Black Type G Ink from Trans Tech was mixed with a thinner to obtain desired viscosity to ensure good pick-up of ink by the pad from the cliché and good release of ink from the pad to the paper substrate. Relative reflection densities of printed samples to paper were measured using an X-Rite SpectroDensitometer 528.

Figure 2: The pad printer used for printing

3. Results and discussion

The power and speed settings of the laser engraver needed to be fine-tuned to achieve an optimum etch depth of 18-25 μm.

It was found that the maximum *x*-axis raster speed of 70 inch per second minimized processing time with favorable results, and therefore the etch depth was controlled using the power setting only.

Different power settings were used and the results are shown in Figure 3. It shows that laser power and etch depth have a very strong positive linear relationship, with a R2 value of 0.9785. Increasing power increased etch depth. It was found that 11 % power setting (17.5 W) resulted in an etch depth of 21.2 μm; therefore, it was selected for all the following cliché engraving.

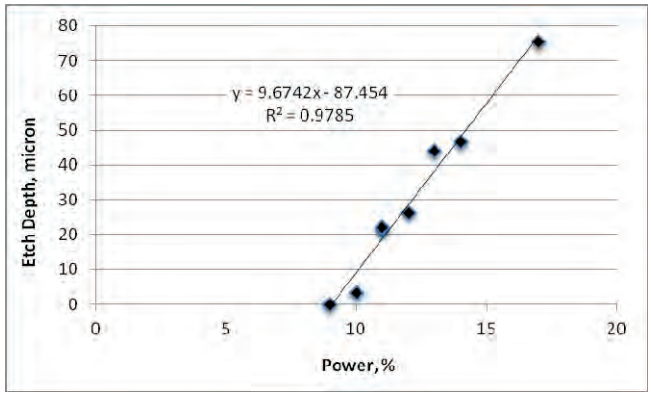


Figure 3: The relationship between laser power and etch depth

A laser engraved cliché is shown in Figure 4. Laser engraving created even edges and straight sidewalls, which are important for ensuring good print quality.

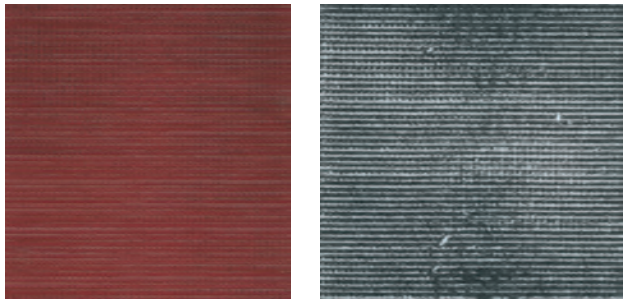
A printed line art using this cliché is shown in Figure 5. The overall print quality is good with uniform ink film thickness and optical density as well as sharp edges.

Figure 4: A laser-engraved cliché

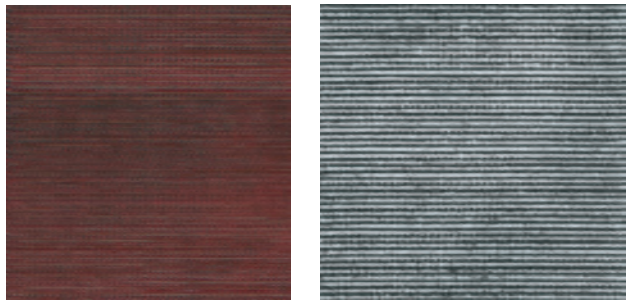
Figure 5: Pad-printed line art

As for screened images with large open areas, some of the engraved clichés and printed images are shown in Figures 6-8 for different screen settings. It was found that a cliché engraved with a screen angle of 0° printed a striped image, as shown in Figure 6.

The possible reason could be that the screen angle was parallel to the moving direction of the doctor ring so ink was pulled out from the ink wells during the inking process and there was not enough ink to cover the entire area.



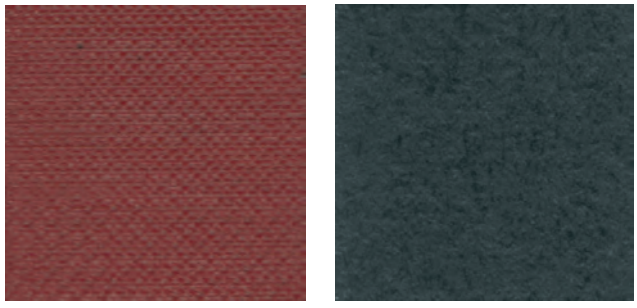
(Diamond dot shape, print density = 0.74)



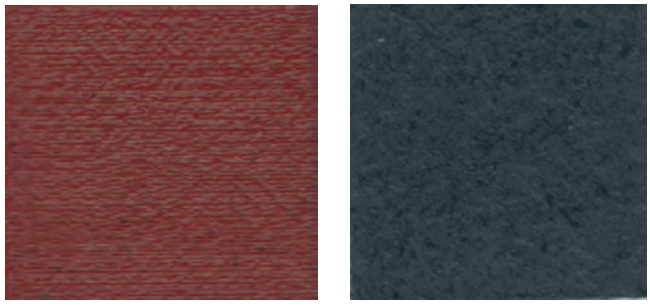
(Round dot shape, print density = 0.95)

Figure 6: Engraved clichés (left) and printed images (right) with screen settings of 150 lpi and 0° angle

This problem did not appear when the image was screened at a 45° angle, shown in Figures 7-8. The entire area was printed with consistent ink film thickness.



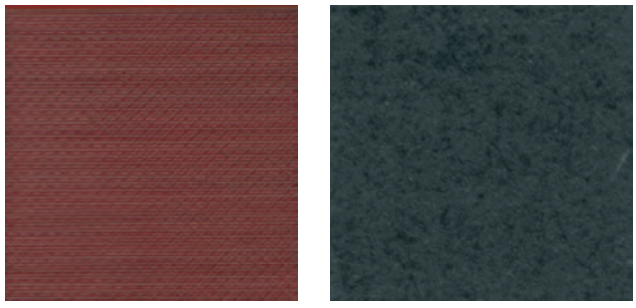
(Diamond dot shape, print density = 1.46)



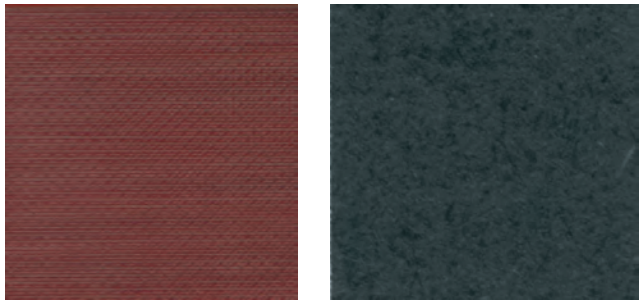
(Square dot shape, print density = 1.49)

Figure 7: Engraved clichés (left) and printed images (right) with screen settings of 100 lpi and 45° angle

Square dot shape resulted in a somewhat higher print density with a low screen frequency of 100 lpi (Figure 7) and there was little difference between these two with a high screen frequency of 200 lpi (Figure 8). By comparing Figures 7 and 8, it was found that a higher screen frequency resulted in a higher print density for both dot shapes. Higher density means more ink transferred from the engraved ink wells. The ink wells were larger with a lower screen frequency; therefore, more ink would be left inside the wells without being transferred to the pad. Smaller ink wells would allow more, although not all, ink to be picked up by the pad.



(Diamond dot shape, print density = 1.51)



(Square dot shape, print density = 1.51)

Figure 8: Engraved clichés (left) and printed images (right) with screen settings of 200 lpi and 45° angle

4. Conclusions

Laser engraving allows the output of a digital file directly to a cliché, eliminating the transfer of an image to film and thereafter to a cliché. Thus, considerable time is saved and the need for positive films and an exposure chamber is eliminated. In our experiments, the sidewalls appeared to be straight and pooling of ink did not occur in the pad printing process, which produced a high print quality of line arts.

Images with large open areas that were screened at a maximum angle of 45° with the doctoring direction and a high screen frequency of 200 lpi had the best print quality and highest print density. Differences between dot shapes were only observed when the screen frequency was low.

Consistency of etch depth over time is important and will be studied in the future.

Images that combine fine details and large open areas will also be used and large open areas will be screened before laser engraving.

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Minimizing the print quality limitations imposed by ISO screen angle choice when eliminating secondary moiré in monochrome halftone screen printing

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Abstract

Screen printing offers high ink deposition on a variety of substrates. This is a major advantage of this printing technology compared to offset, flexography and gravure. Due to developments in mesh manufacturing technology, we can now comfortably print halftone, with some losses in highlight and shadow areas, at a resolution of 100 lpi (lines per inch) and above. This has helped screen printing to improve the quality of monochrome continuous tone and full color graphic reproduction. The screen mesh parameters such as mesh count, thread diameter, and weaving method affect smoothness and uniformity of the reproduced halftone image. This may be addressed by using different combinations of dot shape and screen angle in the positive image used. ISO 12647:5 recommends screen angles for process color printing, but in the case of single color halftone printing the screen printer is required to use only one screen angle. This research contribution is aimed at identifying the optimum screen angle for monochrome halftone printing that results in minimum light interference, i.e., minimizing secondary moiré fringes as a function of mesh weave, using trials involving two mesh counts, four screen angles and two screen ruling frequencies.

Keywords: screen angle, screen ruling, dot area, mesh count, thread diameter

1. Introduction and background

Unlike other printing technologies, in screen printing, ink is forced through mesh openings onto the substrate. The transfer of ink from stencil to the substrate is governed by a number of factors that affect dimensional stability of the stretched mesh. In screen printing, the squeegee fills the mesh with ink and any excess ink is scraped off so that the stencil defines the image shape of the print. It is the theoretical ink volume defined by mesh geometry, however, which controls the thickness of the ink deposit. The structure of the screen mesh gives rise to a defect related to the formation of observed light interference bands, known as moiré. Primary moiré is image interference between two or more halftone patterns at different angles. This is common with all printing technologies using AM (amplitude modulation) screening. Halftone patterns interfere during printing because the respective angles create an undesirable wavy interference pattern. Secondary moiré occurs when halftone angles or line counts (rulings) interfere with the weave of the fabric. Tertiary moiré occurs when a halftone is printed onto a texture, such as textile, where the texture pattern interferes with the halftone dots.

Local moiré only occurs in certain tonal value areas of the image, whereas primary, secondary and tertiary moiré predominantly occur throughout the complete image (PDS Consulting, 2007). In case of secondary moiré, a large-diameter thread superimposes more halftone dots than a thin thread and, therefore, causes more moiré. Furthermore, for a same mesh count, large-diameter threads impede ink flow significantly more than the thinner threads. This regular restraint of ink flow is visible as moiré. Secondary moiré represents the greatest challenge to the screen printer. Factors such as the ratio between the fabric mesh count and the halftone screen ruling, mesh stretching, fabric color, halftone dot shape, halftone dot size, screen angle, stencil, and substrate cause and control moiré (Zoomer, 2011). Also, for a color which shows moiré, the effect is not equally visible throughout the tonal range - some tints show it strongly, others do not. The moiré can also depend on the shape of the dot (round, elliptical, geometric) but if it is minimized for one tint for one dot shape, it can form in another tint level for a different dot (Abbott, 2009b). In order to achieve satisfactory tonal reproduction along with minimum moiré fringe interference in screen printing, it is necessary that the printer ensures a minimum size of the highlight dot, which is defined as 1 opening + 1.5 threads, whereas minimum size of the shadow dot requires 2 opening + 1.5 threads (Balfour, 2004).

The structure of the screen material changes and mesh stability is lost under the conditions of printing. Stretched screen meshes may creep (relax) under tension. With low creep tensions the screen can remain stable and this optimal situation

may be used to maintain the effective mesh count (Abbott, 2009a). Under stress, a polymer screen, such as polyester, contains threads in which the individual polymer chains can gradually straighten out and slip over each other reducing tension in the stretched screen mesh, but at the knuckles of the mesh the fibers are locked against each other to a certain extent as a result of being bent during the formation of the knuckles (Abbott, 2009a). However, over time, with vibrations, stresses from the squeegee, and even lubrication by solvents or inks, the knuckles can eventually slip over each other resulting in creep. The weave of the mesh forms an orderly pattern which interferes with the screen angle of the half tone emulsion on positive film and increases it. After printing, this physical change leads to interference as an optical defect called secondary moiré (Ross, 2004). As per ISO 12647:5, screen angles for YMCK printing regions are defined together with dot shape with and without principal axis. According to the ISO standard, when reproducing a monochrome continuous tone original we can choose between multiple screen angles. Ranging through the screen angles as recommended by ISO 12647:5 in stencil making can ensure acceptable printability free from moiré interference (International Standards Office, 2001). Therefore, the effect of screen angle on print characteristics needs to be studied and in order to arrive at a screen angle giving optimal print characteristics with minimum tint loss.

2. Materials and parameters

In most of the half tone screen printing applications, two sets of screen angles are recommended by ISO 12647:5. The angles of the screen mesh are defined to be 0° and 90°, respectively, with respect to the frame having a screen ruling between 20 cm^{-2} and 40 cm^{-2}. For half tone dots without a principal axis, the nominal difference between the screen angles for cyan, magenta and black shall be 30° with the screen angle for yellow separated by 15° from each other color (International Standards Office, 2001). No color should align with mesh warp or weft, or the diagonal. In order to achieve this, each color should be rotated with respect to the mesh. These values refer to the films: right reading, emulsion up (International Standards Office, 2001). Screen angles for positives having dots without principal axis are shown in Table 1.

Table 1: Typical screen angles for half tone dots without a principal axis

Y	M	K	C
82.5°	67.5°	37.5°	7.5°

For half tone dots with a preferential axis, the nominal difference between the screen angles for cyan, magenta and black shall be 60°, with the screen angle for yellow separated by 150° from the colors. Again, these values refer to the films: right reading, emulsion up. The screen angles for positives with dots with principal axis are shown in Table 2.

Table 2: Typical screen angles for half tone dots with a principal axis

Y	M	K	C
82.5°	67.5°	127.5°	7.5°

The experimental set-up used in our study includes variable and constant parameters as stated in tables 3 and 4.

Table 3: Variable parameters

Parameter	Variable
Screen ruling (lines $inch^{-1}$)	70, 80
Screen angle (degree)	7.5, 37.5, 67.5, 97.5
Mesh (threads cm^{-1})	120, 165

Table 4: Constant Parameters

Parameter	Constant
Print / Return stroke speed (cm s^{-1})	10 / 10
Substrate	130 gsm Art Paper
Screen mesh tension (N cm^{-1})	20
Squeegee angle (degrees)	75
Squeegee hardness (Shore A)	75
Off contact (mm)	4.5
Squeegee pressure (kgf cm^{-2})	3.0
Printing ink	Sericol PVC
Half tone dot shape	Circular

The experimental model chosen covers a total of sixteen trials. The printing was carried out on a semiautomatic screen-printing machine. Fifty sheets were printed for each trial with strict control on keeping constant parameters. The test image combined a continuous tone wedge and continuous tone monochrome image. The gray scale helps facilitate the measurement of dot area of each tone gradation from each trial print using an electronic densitometer, whereas the image quality assessment is made visually. The test image as used in the trials is shown in Figure 1.

Figure 1: Continuous tone test image

The gray wedge is incorporated, in squeegee and cross direction, for analysis of variation in print characteristics resulting from placement of the image with respect to squeegee travel. The specifications of the selected screen mesh are mentioned in Table 5. It is clear from the information in Table 5 that the percentage of open area of the mesh decreases with an increase in thread diameter, changing the theoretical ink volume.

Table 5: Screen mesh: technical specifications

Mesh (threads cm^{-1})	Type of weave	Thread diameter (µm)	Mesh opening (µm)	Open area (%)	Mesh thickness (µm)	Theoretical ink volume ($cm^3 m^{-2}$)
120	Plain	34	51	36	51	18
165	Plain	27	33	30	40	12

3. Results

For every trial print the response dot area percentage was measured from the grey scale wedge and the dot area deviation was calculated. The observed dot area and the deviation (delta) are presented for screen meshes of 120 threads cm^{-1} and 165 threads cm^{-1} with screen frequencies of 70 lpi and 80 lpi in appendices A and B. Here, the results are shown graphically.

Figures 2, 3, 4 and 5 show the characteristics curves, i.e., the tonal curves of the prints at various mesh sizes and frequencies for the screen angles of 7.5°, 37.5°, 67.5°, 97.5°. In these graphs, the x- and y-axes represent theoretical dot area (%) and observed area on print (%) respectively.

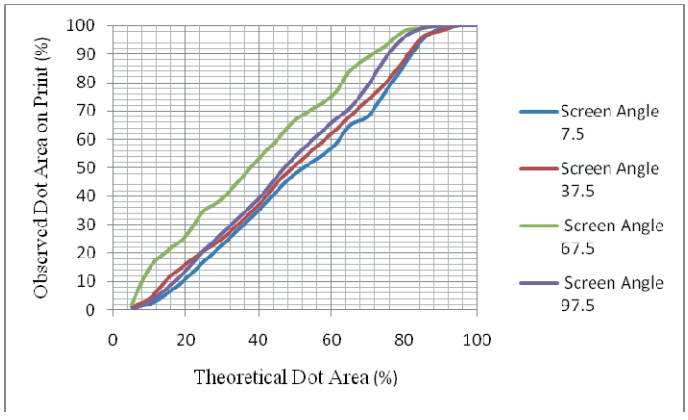

Figure 2:
Characteristics curve of 120 thread cm^{-1} mesh at 70 lpi

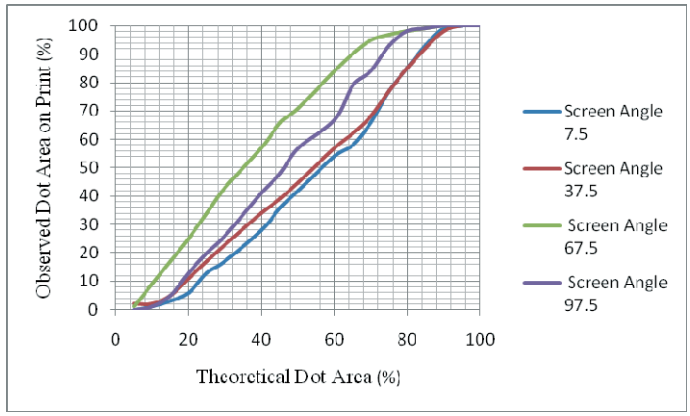

Figure 3:
Characteristics curve of 120 thread cm⁻¹ mesh at 80 lpi

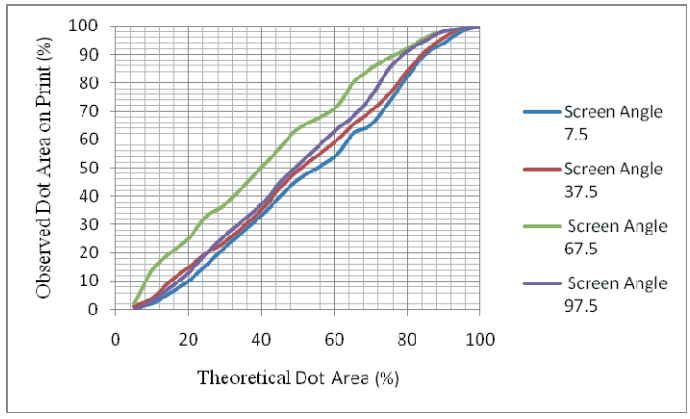

Figure 4:
Characteristics curve of 165 thread cm⁻¹ at 70 lpi

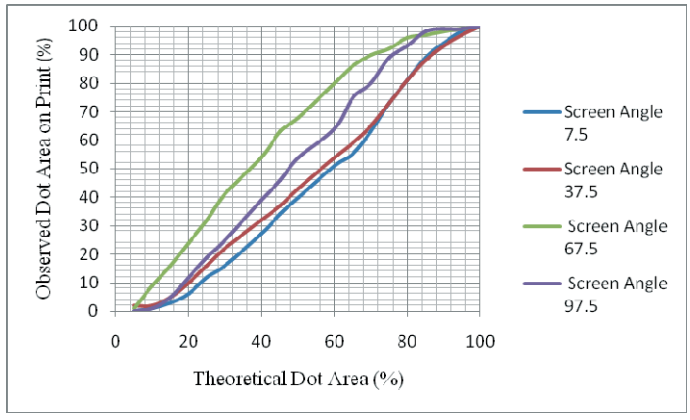

Figure 5:
Characteristics curve of 165 thread cm⁻¹ at 80 lpi

It may be observed from Figures 2 and 3, and Figure 4 and 5 that with same lpi (80 and 70) different tonal performances are experienced. In these trials with 70 and 80 lpi positives it can be seen that with 67.5° and 97.5° screen angles, a minimum reproduction loss in highlight and shadow areas is obtained. Particularly, in case of screen angle 67.5° irrespective of mesh count and screen ruling frequency, the dot loss is almost absent and the curves appear to exhibit standard characteristics. The characteristics curve is comparatively flat for screens taken with screen angles 7.5° and 37.5°, resulting in loss of tonal information in different tints. Similarly Figures 6, 7, 8 and 9 show plots of dot area deviation (delta) against theoretical dot area for prints made at the different mesh sizes and screen ruling frequencies for screen angles of 7.5°, 37.5°, 67.5°, 97.5° as defined in Table 3. In these graphs, the x- and y-axes represent theoretical dot area (%) and observed deviation (delta) (%), respectively.

The graphs shown in Figures 6, 7, 8 and 9 underline the aforementioned performance of screen angle 67.5°. From the dot area deviation plots it can be observed that the dot loss in highlight areas is at its minimum at a screen angle of 67.5° whereas the loss is significant at screen angles of 7.5°, 37.5°, and 67.5°. The loss at screen angles 7.5°, 37.5°, and 67.5° is significant throughout the theoretical dot areas and is evident by an observed deviation (delta) (%) in between 0% and -15%, but the reproduction at 67.5° is not showing any tonal loss. The dot gain curve, i.e., the deviation (delta) (%)

plot, at 67.5°, irrespective of mesh count and screen frequency, appears to exhibit normal characteristics and validates an improved print performance at 67.5°.

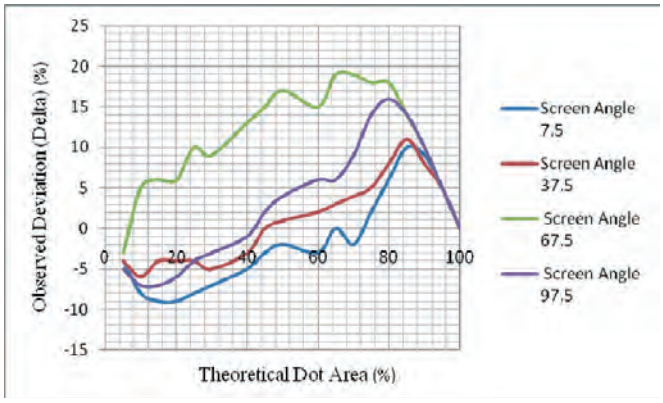

Figure 6:
Deviation (delta) plot of reproduced dot area for 120 thread cm⁻¹ mesh at 70 lpi

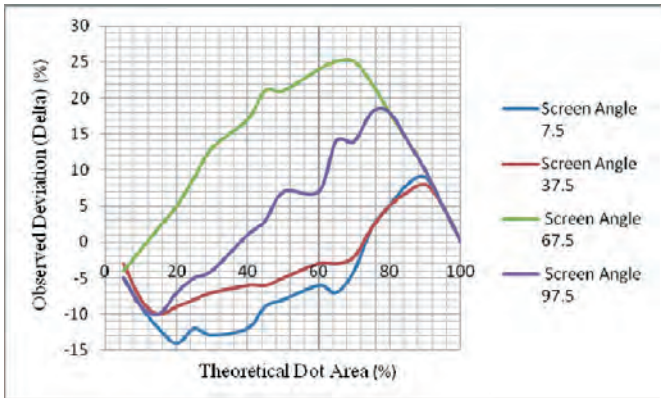

Figure 7:
Deviation (delta) plot of reproduced dot area for 120 thread cm⁻¹ mesh at 80 lpi

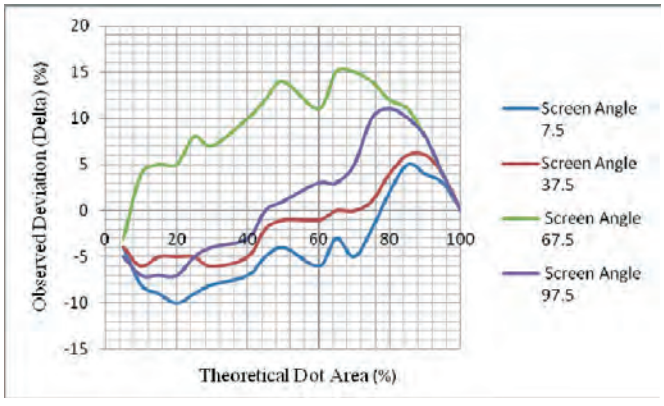

Figure 8:
Deviation (delta) plot of reproduced dot area for 165 thread cm⁻¹ mesh at 70 lpi

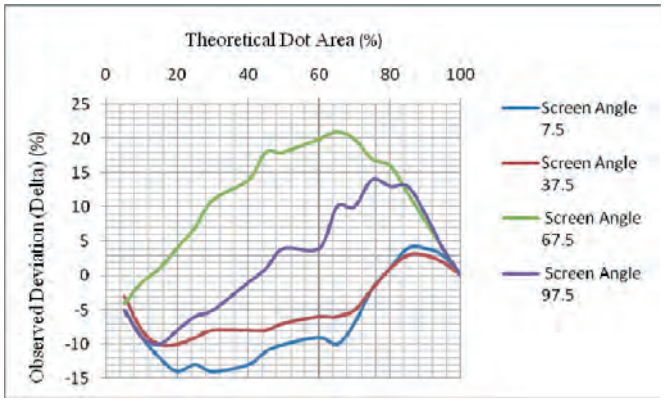

Figure 9:
Deviation (delta) plot of reproduced dot area for 165 thread cm⁻¹ mesh at 70 lpi

4. Conclusions

It can be concluded from these trials that in the case of monochrome halftone screen printing we are confronted with a situation in which only one screen angle has to be selected in order to achieve the best performance. In such a printing situation, color difference and printer-to-printer registration is less critical when compared with reproduction of a full color graphic original. Nonetheless, the tonal reproduction curve is important in deciding the continuity of the reproduction in addition to removing secondary moiré. A shift in the tonal reproduction curve results in loss of image details even if primary moiré is eliminated. Hence, selecting one optimal combination remains the best alternative for the screen printer. From these trials it can be established that the tonal reproduction is optimal at 67.5° as it follows the characteristics of facsimile reproduction, i.e., a straight line with a slope of 45° on the characteristics curve, and further refining of the screen angle at a given lpi can be achieved at 7.5° on either side of 67.5°. Thus, secondary moiré is at a minimum at 67.5°. The screen printer should not select the screen angle in haste - instead, in-house test runs are recommended.

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Appendix A

Observed dot area for 165/120 thread cm^{-1} mesh, and 70/80 lpi, as a function of screen angle

Dot area (%)	Mesh count 120 lpi: 70				Mesh count 120 lpi: 80				Mesh count 165 lpi: 70				Mesh count 165 lpi: 80			
	Screen angles				Screen angles				Screen angles				Screen angles			
	7.5	37.5	67.5	97.5	7.5	37.5	67.5	97.5	7.5	37.5	67.5	97.5	7.5	37.5	67.5	97.5
5	1	1	2	0	0	2	1	0	1	1	2	0	0	2	1	0
10	2	4	15	3	1	2	9	1	2	4	14	3	1	2	9	1
15	6	11	21	8	3	5	17	5	6	10	20	8	3	5	16	5
20	11	16	26	14	6	11	25	13	10	15	25	13	6	10	24	12
25	17	21	35	21	13	17	34	20	16	20	33	20	12	16	32	19
30	23	25	39	27	17	23	43	26	22	24	37	26	16	22	41	25
40	35	37	53	39	28	34	57	41	33	35	50	37	27	32	54	39
45	42	45	60	47	36	39	66	48	40	43	57	45	34	37	63	46
50	48	51	67	54	42	45	71	57	46	49	64	51	40	43	68	54
60	57	62	75	66	54	57	84	67	54	59	71	63	51	54	80	64
65	65	68	84	71	58	62	90	79	62	65	80	68	55	59	86	75
70	68	74	89	79	66	68	95	84	65	70	85	75	63	65	90	80
75	77	80	93	89	77	77	97	93	73	76	89	85	73	73	92	89
80	86	88	98	96	85	85	98	98	82	84	92	91	81	81	96	93
85	95	96	99	99	93	92	99	99	90	91	96	95	89	88	97	98
90	99	98	100	100	99	98	100	100	94	96	98	98	94	93	98	99
95	100	100	100	100	100	100	100	100	98	99	99	99	98	97	99	99
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Appendix B

Deviation (Delta) of printed dot area from theoretical dot area for 165/120 thread cm^{-1} mesh, and 70/80 lpi, as a function of screen angle

Dot area (%)	Mesh count 120 lpi: 70				Mesh count 120 lpi: 80				Mesh count 165 lpi: 70				Mesh count 165 lpi: 80			
	Screen angles				Screen angles				Screen angles				Screen angles			
	7.5	37.5	67.5	97.5	7.5	37.5	67.5	97.5	7.5	37.5	67.5	97.5	7.5	37.5	67.5	97.5
5	-4	-4	-3	-5	-5	-3	-4	-5	-4	-4	-3	-5	-5	-3	-4	-5
10	-8	-6	5	-7	-9	-8	-1	-9	-8	-6	4	-7	-9	-8	-1	-9
15	-9	-4	6	-7	-12	-10	2	-10	-9	-5	5	-7	-12	-10	1	-10
20	-9	-4	6	-6	-14	-9	5	-7	-10	-5	5	-7	-14	-10	4	-8
25	-8	-4	10	-4	-12	-8	9	-5	-9	-5	8	-5	-13	-9	7	-6
30	-7	-5	9	-3	-13	-7	13	-4	-8	-6	7	-4	-14	-8	11	-5
40	-5	-3	13	-1	-12	-6	17	1	-7	-5	10	-3	-13	-8	14	-1
45	-3	0	15	2	-9	-6	21	3	-5	-2	12	0	-11	-8	18	1
50	-2	1	17	4	-8	-5	21	7	-4	-1	14	1	-10	-7	18	4
60	-3	2	15	6	-6	-3	24	7	-6	-1	11	3	-9	-6	20	4
65	0	3	19	6	-7	-3	25	14	-3	0	15	3	-10	-6	21	10
70	-2	4	19	9	-4	-2	25	14	-5	0	15	5	-7	-5	20	10
75	2	5	18	14	2	2	22	18	-2	1	14	10	-2	-2	17	14
80	6	8	18	16	5	5	18	18	2	4	12	11	1	1	16	13
85	10	11	14	14	8	7	14	14	5	6	11	10	4	3	12	13
90	9	8	10	10	9	8	10	10	4	6	8	8	4	3	8	9
95	5	5	5	5	5	5	5	5	3	4	4	4	3	2	4	4
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Topicalities

Edited by Raša Urbas

Contents

News & more

New Videojet technology

One of the world-leading manufacturers of coding, printing and laser marking products, fluids, and accessories for the product identification industry has introduced two novelties. As experts in continuous ink jet, thermal ink jet, case coding, thermal transfer overprinting, and laser marking technologies they have made two new generations of inkjet printers.

Designed with new features to promote productivity and profitability, the 1550 and 1650 ink jet printers provide metrics to measure availability as well as the tools to measure and improve uptime and Overall Equipment Effectiveness (OEE). Simple to operate, both versions also include Code Assurance features to help reduce coding errors and ensure the right code is printed on the right products.

The new printers are designed for limited and simple interaction. Operators can access all common operations in five touches or less on a large, bright touchscreen interface. The 1550 and 1650 help provide improved control of job parameters and efficient, productive line management. In addition, the Videojet Smart Cartridge™ fluid system eliminates waste, mess and mistakes, and when it's time for planned maintenance, the modular core system is easily replaceable - getting customers right back to production quickly and efficiently.

The Videojet series 1550 and 1650 printers reduce unplanned downtime through features like the patented CleanFlow™ printhead and Dynamic Calibration™ ink flow system. Designed to resist ink build-up that can lead to a shutdown, both the printers possess an auto-cleaning function, meaning there are less frequent printhead cleanings and positive flow of filtered air for more reliable, clear and consistent codes, even at the end of long production runs. The unique printhead design and long-lasting core minimizes planned downtime due to long intervals - up to 14 000 hours - between planned routine maintenance cycles.

Provided OEE Availability metrics help measuring uptime. The Availability measure is also configurable to more closely reflect how customers operate production lines and measure Availability across their plant. Besides providing the Availability metric both printers present downtime information in a logical way to support efficient and effective problem solving. The printer enables drilling into Availability data to help discover technical and operator causes of downtime. Understanding root cause is critical to implement and achieve sustainable process improvements. The Videojet 1550 and 1650 possess Code Assurance features to foolproof and help prevent mistakes, keeping customer production lines productive and ensuring brand integrity.

With printer series 50 (1550, 1650) Videojet sets a new benchmark in the field of labeling and coding products and printed materials, such as packaging.

EncuPac project to promote UV offset printing

The Laboratory of Pulp and Paper Science and Graphic Arts (LGP2) of Grenoble INP-Pagora is taking part in the EncuPack project (Energy Curable Packaging) whose aim is to develop and promote the use of this technology (ink and drying) in offset printing. The project is supported by the European Union's EuroStars program which funds R&D projects taken on by innovative SMEs.

LGP2

Despite its advantages, especially for lower pollutant emissions into the atmosphere and the ability to print on non-porous substrates, including metal and plastic, UV offset technology has not found wide acceptance among printers as they are unfamiliar with this technology or claim to be put off by the printing problems associated with UV technology. Therefore the corporations Sinapse Print Simulators (France) and MetaPrint (Estonia) joined forces with the Laboratory LGP2 with the aim to develop a training simulator and a diagnostic troubleshooting help system.

In addition, several leading industrial companies already using UV technology (Felix Böttcher, IST-Metz, KBA Metal Print, Zeller & Gmelin in Germany, UPM-Kymmene in Finland) have joined EncuPack to bring their specialized expertise and to verify the realistic and applicable characteristics of the project results which will be available in 2014.

New colorFrame

The new colorFrame is a price attractive, ISO 3664 compliant portable viewing booth. The new elegant design is classic JUST blending smooth lines with ergonomic function.

Available in two sizes, the colorFrame can support ISO 3664 compliant viewing for sheets sizes up to 381 x 635 mm in a convenient portable size for use anywhere you have access to an electrical outlet.

Global Channel Partners 2013

PrintMediaPartners announced "Global Channel Partners 2013", a program specifically created to help print-media manufacturers to plan and implement a global development strategy for their products and services.

Based upon years of research and extensive practical experience, this unique program will prove indispensable to every manufacturer in the print-media industry, who wishes to and will increasingly need to go global with their products and services in the future.

Golden Pixel Award for Game around Printing

The Golden Pixel Award was announced for the first time in 2001 and is now one of the most prestigious prizes of the Austrian print and media industries. In 2012, almost 200 entries were recorded for 14 categories. Applications for the category "student productions" were invited worldwide in cooperation with the International Circle.

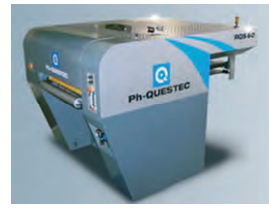
In the course of two semesters, nine students from the Stuttgart Media University (Hochschule der Medien, HdM) and its German-Chinese counterpart developed the game named "Press Ahead" from the first ideas up to the finished product. "Press ahead" is a game for players of almost any age. It can be played at two levels and hence is fun and learning for beginners and experts alike.

The question-and-answer game was published in five languages. It comprises 120 cards for the fields of prepress, press, finishing and packaging. The students created the questions and answers themselves, and they also organized the translations into four different languages.

The "Press Ahead" card game convinced the jury of the Golden Pixel Award and the students received the prize for the category "student productions" in November 2012. The next opportunity to take part in the international Golden Pixel Award for student productions is presumed in autumn 2013.

New rotary cross cutter

High-speed rotary cross cutters of new series are high-capacity cross cutters used for reel-fed offset printing machines. Apart from the novel paper web on air-transport system, the machines allow quality control of sheets at full production speed.



The series includes several cutters (RQS 50, RQS 60, RQS 65 and RQS V) which all have high efficiency and high production. Distinguished by ultra-accurate cut of ± 0.25 mm, simple automated handling and easy handling of any type of paper through WebSnap mechanism they present a new step ahead in the market.

The machines are capable of efficient energy savings up to 20 %. Heat-conducting aluminum gear unit reduces effects of abrasion roundabout 40-50 %. All cutter types produce less noise and offer quality control during operating by extracting single paper sheets.

Modern design and construction of RQS 50 and RQS 60 allow cutting of 600-1.000 mm wide paper webs, regularly coated and without perforation, in maximum speed rate of up to 50 000 pieces per hour. With a width of 400-600 mm, a loss of speed of about 20 % must be reckoned. The difference between both cutters is that RQS 60 is even more efficient then RQS 50 - it cuts single coated paper with ink and humidity evenly applied on a homogenous cover of silicon in paces of up to 60 000 cuts per hour.

RQS 65 represents a comfortable extension of both previously presented models. It possesses single servo drives which guarantee optimized precision in the production process, and minimization of waste, even at change of tempo. It is by default equipped with integrated register control which by optimized optical monitoring inspects every single color register mark.

The new RQS-V is one of the market's most well-engineered and technologically advanced Cross Cutters for the packaging industry. The machine has a highly customer-oriented operating concept and a very high degree of automation. It is ideal for high speed (365 m/min). A further special feature is the infinitely variable cut-off length of the paper during operation. Very flexible regarding paper weights (30 g/m^2). The RQS V is fitted with infinitely variable single-axis servo drives from AMK.

Permanent, transparent acrylic based adhesive

For label printing and label finishing a new adhesive was developed. Manufacturer, the Herma Company, claims to have enhanced production dependability and subsequent use of copier/laser labels.

The adhesive HermaperfectCut 62Dpc is said to prevent bleeding over the die-cut edges during label conversion. Even if they do not have a safety margin, labels produced with this adhesive can be processed smoothly by all copiers and printers.

Using Herma's multi-layer technology, a specially formulated second layer is applied at the same time as the adhesive to achieve good cohesion (in-

ner strength) without exposing the user to any compromises with regards to high initial tack and impressive final adhesion. The adhesive has been certified by the German institute ISEGA for direct contact with fatty foodstuffs.

The new 62Dpc adhesive supersedes the 62D adhesive that has previously been used for copier/laser applications. The use of the HermaperfectCut 62Dpc adhesive improving not only of the convertibility, but also of the functionality of the end-products can be achieved.

In a laser printer, the sheet of labels is usually given a hard time by deflection rollers. When a conventional standard adhesive is applied up to the edge of the sheet, minute traces can be transferred to the roller - especially upon exposure to temperatures of up to 200 °C that can arise in printers. Over time, such contamination impairs straight sheet feeding and the proper passage of the sheet through the printer. Due to that reason, it is essential to use an adhesive that does not escape at the die-cut edges but still offers users the good adhesive properties to which they are accustomed.

Acuity Advance Select

In an effort to meet the growing demand for expanding application and business needs, Fujifilm North America Corporation, Graphic Systems Division introduced four new models to its Acuity Advance Select.

The new Acuity Advance Select builds on all the advantages of the highly successful and popular Acuity Advance platform, with the same ultra-high print quality, but adds a number of new features that improve production efficiency.

The new Acuity Advance Select-4 (and Select-4 X2) and Select-6 (and Select-6 X2) represent the latest in a series of next-generation UV flatbed printers, and feature high quality, improved productivity, and greater versatility which allow their use in a wider range of applications.

The new models include four, six or eight independent ink channels in two different flatbed sizes (a standard 122 x 244 cm table or an X2 version with and 244 x 305 cm table), with an upgrade path on the 4 and 6 channel models to allow for application and business expansion.

In addition to the standard CMYK ink set, the Acuity Advance Select includes additional white and clear ink channels. These can be configured in a number of ways. The four-color Select-4 can be field upgraded to a six channel Select-6, and the six channel Select-6 can be upgraded to an eight channel Select-8.

The six color Select-6 model includes six independent ink channels with the first four configured for standard CMYK printing. Channels five and six can be configured with either clear + white or white + white. The Select-8 adds an extra channel of magenta and an extra channel of cyan along with new print modes to further boost productivity and versatility.

The six channel and eight channel Acuity Advance Select printers can configure clear ink and white ink in one of two ways depending on customer needs:

Standardized and automated workflow

Achieving higher efficiency and improved quality through standardized and automated workflows is now possible with the help of Color iQC Print and NetProfiler solutions by X-Rite. Both novelties enable the control of other color reproduction hardware (monitors, printers), thus ensuring the complete standardization of imaging processes.

Color iQC Print organizes information critical to efficient management of color data and greatly simplifies communication of the data across organizations. The application links seamlessly with the PantoneLIVE™ cloud-based color service that has a proven record improving color matches of labels and packaging across an array of printing technologies and substrates, which builds tighter and higher-value relationships between print companies and brand managers.

Color iQC Print allows any company in the workflow to designate jobs of measure data in the format it is accustomed to using and send data to next link in the supply chain with confidence that the information will be preserved exactly the way it was sent. Correct color information is not available only for actual production, but also for marketers, distributors, and potential packaging producers. All color information is archived so it can be used for reproduction.

NetProfiler 3.0 software verifies, optima-zes, and certifies handheld and press-sides spectrophotometers wherever they are used in the supply chain, thus ensuring that all stakeholders can use the same color standards and tolerances.

Solution extends the power of profiling to handled devices with embedded profiling capabilities, optimizing the performance of press-side spectrophotometers that all experience some data drift over time due to age and use. By this correctness of color management is ensured. With NetProfiler 3.0 we can precisely control the color information quickly and easily.

GREENGUARD certified products

The GREENGUARD Environmental Institute (GEI) is an industry independent, third party certification organization that qualifies products for low chemical emissions. Certified products can contribute to points in established green building programs, satisfy code or ordinance criteria or meet indoor air quality specific RFP requirements.

GREENGUARD certified products must meet stringent chemical emissions requirements, such as being screened for more than 10 000 volatile organic compounds (VOCs). Products have to undergo re-certification and quality monitoring tests on a regular basis to maintain this elite credential. Durst has been awarded GREENGUARD Certificates which cover "Indoor Air Quality" and "Children and Schools".

Rho Premium Rigid 30DM Inks and Rho Roll 30DM Inks, plus those used in the Omega 1, have passed the rigorous independent testing before being awarded the certification.

High resolution photopolymer plates

Printing of micro text and guilloche patterns requires the highest possible precision. With a resolution of up to 10 000 dpi nyloprint® plates are utilized for such extreme requirements. These stencil plates are used for inking-up the impression cylinder in intaglio printing presses. These plates have been developed after many years of experience in security printing and in close cooperation with customers.

In intaglio printing the gravure printing plate acts as the master form used in the galvanic processing of the actual printing plate. These plates make it possible to manufacture a complete form in one step, much quicker and easier than with previous processing methods. Many intermediate steps in the galvanic process are no longer required thus reducing the errors.

Highest precision and reproducible quality are the basic requirements for security printing which this new photopolymer stand for.

- *Clear + White*
  The clear and white ink channels allow printing on a range of non-white substrates and adding of a spot or flood coat "varnish" effect in a single operation all on one printer. This extends the application versatility of the Acuity Advance Select machine and improves the efficiency with which these types of added-value effects can be achieved.

- *White + White*
  Two white ink channels can improve the density of white in a single pass, which can be particularly useful for demanding backlit applications. These two channels can be used in whichever configuration best suits the application, with the ability to change from Clear + White to White + White (and vice versa) on demand.

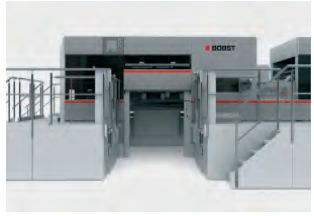
As with other Acuity Advance models, the Select has an optional roll media kit for printing onto any number of flexible materials. This simple-to-use option is incredibly versatile, allowing an operator to prepare rigid material on the flat bed while the roll media option is printing.

The printer also features additional vacuum zones, further reducing manual masking, together with new job handling capabilities for more complex jobs or those requiring multiple sets of prints - advancements which help to improve overall production efficiencies.

The Acuity Advance Select's print performance is optimized by Fujifilm's uniquely formulated Uvijet inks. These incorporate the company's proprietary "Micro-V" dispersion technology that consistently delivers wide adhesion, superb color vibrancy and excellent durability in every print.

The introduction of these new models to the series extends the versatility of Fujifilm's Acuity Advance Select range, building on one of the strongest line ups of mid-range high performance UV inkjet printers on the market, with a clear migration path for printers looking to upgrade in the future.

Hot foil stamper



Until now, only bolt-on foiling solutions have been available to finishers working in the size VI format. Now a new large-format foil stamping machine has been introduced for the 1 420 x 1 020 mm format. When margins are tight, getting extra products onto a sheet can dramatically change the economics of hot foil stamping.

The machine, developed by Leissing and BOBST is therefore suitable for packaging-folding carton, print finishing, label manufacture, tobacco applications and security applications. Main processed materials which can be used are paper (100 g/m^2), carton board (max 2 000 g/m^2), heavy solid board (max 2 mm) and semi-rigid plastics.

With a range of ingenious features, such as a walk-in foil section for ergonomic foil handling, together with process accuracy, this is the dedicated press that large format converters have been waiting for.

EXPERTFOIL 142 delivers the quality and combines it with a format and performance that means increased margins on a range of jobs, whether they are from existing markets or even from new ones.

Camera monitoring for quality control

An intelligent combination of imaging technology and the stroboscopic principle has set a new standard and alternative to modern methods of quality control.

The TubeScan system is based on a stroboscopic camera, which provides a high level of reliability and precision control even at maximum production speed printing labels. It provides consistent color representation labels comparable to Screen display regardless of any delays.

TubeScan provides two important functions with which much more process-safety is achieved. The function "digital strobe web viewing" always delivers a steady image and true color fidelity - regardless of the line speed. Thus, the operator retains in control of the entire production, even during the critical start and stop phases of the machine.

With the function "missing label detection" the system is not only counting accurately labels and missing labels per lane and in total, but detects also remains of label matrix across the entire web width.

The TubeScan is an achievement of Nyquist Technology GmbH & Co. KG group which is jointly owned by the two companies Eltromat and Nyquist Systems. With this solution they have filled in a much needed gap for the automatic production quality control of flexible packaging and labels. Specific requirements in the design were a high image refresh rate, automatic synchronization, as well as the high-quality image display also of reflective or metalized surfaces. Hereafter, a simple image processing functionnality for counting labels and the false label control is also important.

The concept of TubeScan was first introduced on Labelexpo Americas 2012 in Chichago, USA.

Color of the year 2013

The global authority on color and provider of professional color standards for the design Industries, announced PANTONE® 17-5641 Emerald, a lively, radiant, lush green, as the Color of the Year for 2013.

Previous Color of the Year for 2012, PANTONE 17-1463 Tangerine Tango, a spirited, reddish orange, provided the energy boost we needed to recharge and move forward. Emerald, a vivid, verdant green, enhances our sense of well-being further by inspiring insight, as well as promoting balance and harmony.

Green is the most abundant hue in nature - the human eye sees more green than any other color in the spectrum. As it has throughout history, multifaceted Emerald continues to sparkle and fascinate. Symbolically, Emerald brings a sense of clarity, renewal and rejuvenation, which is so important in today's complex world. This powerful and universally appealing tone translates easily to both fashion and home interiors.

PANTONE 17-5641 Emerald can also be cross-referenced to all other PANTONE Libraries including PANTONE PLUS for graphic design.

New Basic folder

One of the leading providers of papers has introduced a new catalogue Basic. This folder presents a multifunctional instrument for testing, comparison and selection. Quicker overview of the most important papers that have all the relevant information in a compact form can be made with it.

It presents papers for different fields of use like office paper, paper for digital printing of photo applications, natural papers, different special bulky materials and security papers.

The catalogue is suitable for all users in graphic industry as well as comercial/marketing agencies. Papers in this catalogue are presented in different grammages. Every sample is equipped with interactive QR code which enables the access to more detailed product information on Papyrus website. On this site all current certifications are in view as well as the calculation of the price index.

Developer waste reduction & water re-use system

With intention to reduce pre-press developer waste and water use for printers using plate production systems requiring chemistry, Fujifilm introduced the developer waste reduction & water re-use system.

Benefits of this new system are reduction of waste volume and costs of waste water treatment, the reduction of water consumption (distilled water can be re-used in the processor), and the reduction of CO_2 emissions generated by the transport and incineration of waste.

The XR-1200F system works by separating plate chemistry into concentrated waste, reducing it (by 70 to 90 %) and distilled water that can be reused either in the plate production process, or in other printing processes. System processing capacity is around 1.2 l/h.

The XR-1200F system is based on low pressure/low temperature distillation using a heat pump system that has been developed from technologies found in earlier Fujifilm's ZAC processors.

UV-LED flatbed ink jet printer

The Rho IP (Industrial Print) engine is a purpose built inkjet solution for Industrial screen and pad printing applications. It is a high speed inkjet engine which can be integrated into automated production lines and configured according to the application. This industrial production machine also provides screen and pad printers with the highest levels of flexibility which enables the profit from short runs, print on demand and just in time production, whilst being able to print directly onto the widest range of media.

It is ideally suited for the production of membrane switches, instrument panels, dashboards, cover plates (e.g. for washing machines) and small items typical of pad printing applications. The Rho IP engine offers the highest quality print, including finest text and solid lines and also perfect edge sharpness and registration. For printing on smaller items, templates can be mounted onto the table.

The modularity of the machine allows up to 5 ink channels (CMYK plus white) and there are 6 printheads per channel. The print engine can be equipped with up to 15 000 nozzles producing a printing speed of 8 seconds per table in single pass mode, or 20 seconds in per table in scanning 4 color mode including Variable Data Printing, if required. The innovative vacuum table uses mechanical pin registration and the vacuum is applied through microscopic pores in an aluminum plate.

Next generation of UV flatbed printers

A series of next-generation UV printers was recently introduced, that combines true flatbed printer design and an optional roll-to-roll capability. Two new models, the 480 GT and the 480 XT complete the Arizona® 400 series.

The printers are featuring exceptional quality, improved productivity and application versatility. Océ Arizona series uses imaging technology that delivers near-photographic image quality,with many options for upgrading. XT models offer the ability to print onto rigid media up 5 cm of thickness.

Laminator for finishing professionals

Combining over 100 years of knowledge and experience in engineering and design, the 65 Pro MD incorporates the newest technology and many unique features. This 65" wide laminator can run both hot and cold applications and is capable of running thermal film at two to three times the speed of other laminators on the market.

The new SEAL 65 Pro MD laminator offers a myriad of applications. It is a newly designed system, which is unique due to the new simpler management system - the "Easy Operator Interface - EOI" concept which offers maximum flexibility. The EOI concept is composed of touchscreen graphic interface which enables easy management of work temperature, speed and direction of lamination material. Rotating stand allows the user to control the system in all sides. Thus it offers bi-directional operation where thermal and cold lamination as well as mounting can be performed consecutively. By that fast change orders regardless of heated or cold lamination method of application is assured. Removable front and rear image roll simplify the change of rolls. Precision pneumatic rollers in seal 65 Pro MD ensure smooth performance while dual quartz infrared heated rollers increase thermal conductivity.

The system can process the materials of up to 50 mm thickness. Working width of the laminator is approximately 165 cm and the thermal encapsulation can be achieved at speeds of maximum 457 cm/min.

Seal 65 Pro MD also incorporates a variety of security, and finishing systems as well as systems for foil treatment. These systems are compatible and in an appropriate combination provide unlimited high-quality finishing applications.

Optimized folder-gluer

Expertfold is extremely flexible machine, which enables folding and gluing more than 3 000 different box styles, from small pharmaceutical cartons to large cereal boxes. The machine is not just a carton board gluer, because it is equally at home and efficient handling corrugated and synthetic materials.

Expertfold delivers the productivity, consistent accuracy and quality of product. It is suitable for packaging-folding carton and print finishing on materials like semi-rigid plastics and carton board.

It offers simple, fast and perfect alignment. To run consistently at high speed, every carton has to be accurately fed. The Accufeed ensures perfect alignment of every box as it enters the machine. The machine ensures accurate 180° prebreaking on all boxes at high speeds, regardless to the used material with smooth reopening. Folding is smooth no matter what material is used. The crease height expands from 2 to 15 mm and it reaches speed up to 10 000 bph.

Expertfold has oversized stainless steel glue wheel and it offers unique brass double scraper with micro-metric adjustment. Not all glue wheels are created equal, and the large wheel on folder-gluer has been specifically developed to ensure accurate glue delivery without glue splashing off, even at the highest speeds.

Bookshelf

UV Curing Technology:
Traditional UV Curing & UV LED Curing

Working for more than twenty-four years in the area of UV curing technology has enabled the author Bea Purcell to publish this practical guide for printers, printing industry sales, marketing, and technical professionals, non-printing industry professionals, students, and anyone interested in the relationship between the use of science and the printing industry.

The book offers the answers to questions like why some things fade when exposed to the sun, why used printing inks delaminate from the plastic and how UV LED cure UV inks. Beside mentioned chapters also describe the effect of ultraviolet energy on organic materials, the use of UV-curable inks and basics of UV LED.

UV Curing Technology: Traditional UV Curing & UV LED Curing is the book for anyone who is interested in the science behind ultraviolet-cured inks as used in the printing industry.

UV CURING TECHNOLOGY:
Traditional UV Curing & UV LED Curing
Author: Bea Purcell
Publisher: CreateSpace Independent Publishing Platform (2012)
ISBN 978-1477606193
84 pages
150 x 226 mm
Paperback

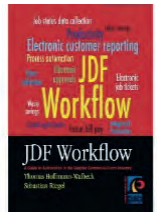
JDF Workflow:
A Guide to Automation in the Graphic Communications Industry

Thomas Hoffmann-Walbeck and Sebastian Riegel from the Stuttgart Media University (HdM) wrote an interesting book on Job Definition Format (JDF) and Job Messaging Format (JMF), based on the XML standard.

The book provides one of the most important recent innovations for the automation of print production. JDF Workflow demonstrates that it is more than just a data format by providing a comprehensive examination of the format, as well as the workflow that can be built with the help of JDF.

With the help of many examples from order management systems, prepress, printing, and finishing, typical graphic communications production processes and their implementation in the JDF model are presented. Some special concerns for package printing are also discussed. The book is ideal for apprentices in the graphic communications industry, students of printing and media technology, practitioners in print companies or manufacturers, as well as computer scientists.

JDF Workflow: A Guide to Automation in the Graphic Communications Industry
Authors: Thomas Hoffmann-Walbeck and Sebastian Riegel
Publisher: Printing Industries of America (2012)
ISBN 978-0883627181
230 pages
239 x170 mm
Paperback



Color Vision and Colorimetry: Theory and Applications

Author: Daniel Malacara

Publisher: SPIE Press,
2nd edition (2011)
ISBN 978-0819483973
188 pages
175 x 244 mm
Paperback

This second edition has been rewritten, updated, and enlarged, describing the basic principles of color vision and colorimetry.

It describes the history of color, along with the main methods used to measure color and their associated color systems, and the human eye and its color detectors are explained with some detail.

The book is distinguished by many colorful diagrams, tables for color matching functions and color transformation equations.

The book has been written with students in an introductory color course in mind, but those who have experience in the field will also benefit from the compendium of data within.

The Elements of Typographic Style: Version 4.0: 20th Anniversary Edition

Author: Robert Bringhurs

Publisher: Hartley and Marks Publishers,
4th edition (2013)
ISBN 978-0881792126
382 pages
234 x 137 x mm
Paperback

Renowned typographer, designer, critic and poet Robert Bringhurst, who has published more than thirty books, has brought clarity to the art of typography with this special style guide.

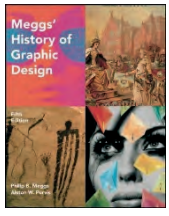
Combining the practical, theoretical, and historical aspects of the matter, this edition is completely updated, with a thorough revision and updating of the longest and most important chapter, "Prowling the Specimen Books" and many other small but important updates based on things that are continually changing in the field.

Meggs' History of Graphic Design

This Fifth Edition of Meggs' History of Graphic Design offers more detail and breadth of content than its heralded predecessors, revealing a saga of creative innovators, breakthrough technologies, and important developments responsible for paving the historic paths that define the graphic design experience. This last edition is an award-winning reference tool on graphic design recognized for publishing excellence by the Association of American Publishers. In addition to classic topics such, as the invention of writing and alphabets, the origins of printing and typography, and postmodern design, it presents new information on current trends and technologies sweeping the graphic design landscape - such as the web, multimedia, interactive design, and private presses, thus adding new layers of depth to an already rich resource.

With more than 1400 high-quality images, the book provides a wealth of visual markers for inspiration and emulation. This book presents an invaluable guide for professionals, students, and everyone who works with or loves the world of graphic design.

Available flashcard version offers a useful tool for studying graphic design history. It features 250 key images representing some of the most significant works in the field of graphic design and images pulled directly from every chapter in the bestselling graphic design text. It offers easy navigation (tap to flip cards and identify by book figure number, name of work, artist and year) and a browse tool, which provides browse cards by chapter, browse cards alphabetically or search by keyword.



Meggs' History of Graphic Design
Author: Philip B. Meggs, Alston W. Purvis
Publisher: John Wiley & Sons, Inc, 5th edition (2011)
ISBN 978-0470168738
624 pages
228 x 285 mm
Hardcover
Format: iPhone, iPad, & Web (format size 2.6 GB)

Coating for Biomedical Applications

The biomaterials sector is rapidly expanding and significant advances have been made recently in the technology of biomedical coatings and materials, which provide a means to improve the wear of joints, change the biological interaction between implant and host and combine the properties of various materials to improve device performance.

This book provides an extensive review of coating types and surface modifications for biomedical applications. The first part explores a range of coating types and their biomedical applications. Chapters look at hydrophilic, mineral and pyrolytic carbon coatings in and ex vivo orthopedic applications and finally at surface modification and preparation techniques. Part two presents case studies of orthopedic and ophthalmic coatings, and biomedical applications including vascular stents, cardiopulmonary by-pass equipment and ventricular assist devices.

Coating for Biomedical Applications
Author: Mark Driver
Publisher: Woodhead Publishing, 1st edition (2012)
ISBN 978-1845695682
376 pages
155 x 234 mm
Hardcover

Food Packaging: Principles and Practice

This work presents comprehensive and accessible discussion of food packaging principles and their applications. Integrating concepts from chemistry, microbiology, and engineering, it continues in the tradition of its bestselling predecessors and has been completely revised to include new, updated, and expanded content and provide a detailed overview of contemporary food packaging technologies.

The book covers the packaging requirements of all major food groups and it includes new chapters on food packaging closures and sealing systems, as well as optical, mechanical, and barrier properties of thermoplastic polymers. This third edition provides the latest information on new and active packaging technologies offering guidance on the design and analysis of shelf life experiments and the shelf life estimation of foods.

The author discusses the latest details on food contact materials including those of public interest such as BPA and phthalates in foods devoting extensive space to the discussion of edible, biobased and biodegradable food packaging materials.

An in-depth exploration of the field, Food Packaging: Principles and Practice includes all-new worked examples and reflects the latest research and future hot topics.

Comprehensively researched with more than 1 000 references and generously illustrated, this book will serve students and industry professionals, regardless of their level or background, as an outstanding learning and reference work for their professional preparation and practical application.

Food Packaging: Principles and Practices
Author: Gordon L. Robertson
Publisher: CRC Press (2012)
ISBN 978-1439862414
733 pages
178 x 254 mm
Hardcover

Advanced Packaging
(Structural Package Design)

Structural package design is a series of books, jam-packed with remarkable, structurally accurate, scalable packaging templates.

All designs are ready for immediate use and illustrated with 2-D and 3-D structural drawings and photographs. The CD contains the templates in various formats including EPS and PDF. Beside mentioned demo versions of Illustrator-Plug-Ins are included, providing professional package design possibilities.

This volume of Advanced Packaging contains 200 more complex designs.

Advanced Packaging (Structural Package Design)
Author: Pepin Press
Publisher: Pepin Press; Pap/Cdr Mu edition (2010)
ISBN 978-9057681448
431 pages
175 x 226 mm
Paperback

RFID Handbook:

Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communication

Author: Klaus Finkenzeller

RFID Handbook
Publisher: Wiley, 3rd edition (2010)
ISBN 978-0470695067
478 pages
170 x 249 mm
Hardcover

This new - third revised edition contains information on electronic product code (EPC) and the EPC global network, and explains near-field communication (NFC) in depth.

It includes revisions on chapters devoted to the physical principles of RFID systems and microprocessors, and supplies up-to-date details on relevant standards and regulations.

The book provides latest information on the use of RFID in ticketing and electronic passports, the security of RFID systems (explaining attacks on RFID systems and other security matters, such as transponder emulation and cloning, defense using cryptographic methods, and electronic article surveillance) and frequency ranges and radio licensing regulations.

The text explores schematic circuits of simple transponders and readers, and includes new material on active and passive transponders, ISO/IEC 18000 family, ISO/IEC 15691 and 15692. It also describes the technical limits of RFID systems.

Offering a complete overview of the large and varied world of RFID, it is useful for end-users of the technology as well as practitioners in auto ID and IT designers of RFID products.

Computer and electronics engineers in security system development, microchip designers, and materials handling specialists benefit from this book, as do automation, industrial and transport engineers. Clear and thorough explanations also make this an excellent introduction to the topic for graduate level students in electronics and industrial engineering design.

Bookshelf

Academic dissertations

Doctoral thesis - Summary

Author:
Rita Faddoul

Speciality field:
Fluid Mechanics, Energetics, Processes

Supervisor:
Anne Blayo

Co-supervisor:
Nadège Reverdy-Bruas

Defended:
May 2012 at PAGORA, Grenoble, France

Printing processes dedicated to the mass production of ceramic based electronic microdevices

The work demonstrates the printing processes potential for manufacturing ceramic based electronic devices. Several printing techniques were studied. Ceramic tapes surface properties were characterised: surface pore size, roughness and surface energy. These analyses allowed the selection of the inks raw materials adapted to the substrates and the printing processes. Water-based silver inks were formulated. Inks properties, rheology and surface tension were analysed and their effect on line properties was investigated. Printed substrates were afterwards sintered. Resistivity values close to that of bulk silver were reached (2 to 12 x 10^{-8} Ohm.m).

These work novelties are mainly the formulation of water-based environmentally friendly screen printing pastes and the flexography printing of silver inks onto ceramic substrates. This study offers new perspectives for the mass production of electronic components on flexible ceramic substrates.

Doctoral thesis - Summary

Author:
Imtiaz Ali

Speciality field:
Fluid Mechanics, Energetics, Processes

Supervisor:
Jean Francis Bloch

Co-supervisor:
Raphaël Passas

Defended:
September 2012 at PAGORA, Grenoble, France

Study of the mechanical behaviour of recycled fibres. Applications to papers and paperboards

By nowadays, the environmental policy is important: the deforestation or the stress on the wood market contribute to the increased interest to improve the recovered rate in papers. Particularly, high value papers constitute a specific target due to their high amount of virgin fibres. The aim of this work was to characterize the modifications of morphological and physical properties occurring during drying and rewetting cycles. To reach this aim, experimental techniques have been revisited or developed like the inverse size exclusion chromatography, the atomic force microscopy, the environmental scanning electron microscopy and the micro-tomography.

This experimental study showed that the main morphological changes occur during the first cycle. Furthermore, delamination and densification of cell wall fibres were highlighted. Evolutions of the mechanical behaviour of handsheets and their 3D structures were analysed in function of the proportion and the quality (number of cycles) of fibres. This work demonstrates the potential of valorisation of the recycled fibres in the paper area, especially for high value papers.

Doctoral thesis - Summary

Author:
Blaž Rat

Speciality field:
Typography, Graphic design, and Media visualisation

Supervisor:
Klementina Možina

Defended:
March 2012 at the Faculty of Natural Sciences and Engineering, Ljubljana, Slovenia

Typography digitization of Blaznik's printhouse and its applicability in various media

The aim of the research was to analyse the typeface used in the 19th century for a text in Slovenian, its digitisation and verifying its image options and applicability in various media. The thesis is based on the analysis of printed media - made by J. Blaznik (1800-1872), one of the most prominent printers in the Slovenian territory - preparation and recording of data, image analysis to obtain information on the typographic tonal density and typographic analysis. Based on the latter, a short-list was elaborated for the digitisation of the typeface which was selected according to the following criteria: most frequently used, most legible and the typeface demonstrating most authentically the Slovenian cultural heritage. The digitisation was performed with appropriate computer programs.

The digitised typeface called *Blaznic* was transferred onto various materials with different printing techniques (offset and digital printing) and into various mobile devices with different screen resolutions (mobile phone, e-reader, tablet). Quality measurements of the imaging and legibility were conducted. The legibility of the typeface intended for longer texts was checked with the "rate of work" method.

The research results demonstrate the wide use of the digitised typeface. It proved as good as or even better than the default typefaces. Its added value is in the width of stroke weight and in the high x-height, ensuring good legibility. Due to the design interventions into the height and form of serifs, stroke weight and stroke cuts at some upper- and lowercase letters, the typeface is very well depicted, stable and legible in smaller sizes. This classifies it into a suitable group for eco-design.

The Journal of Print and Media Technology Research will publish summaries of high quality academic thesis within the scope of the journal. Short summaries should be submitted to <journal@iarigai.org> by the thesis supervisor. Information on type and field of the thesis, author, supervisor, date and university of defense or presentation, as well as on how the full thesis can be obtained must be provided.

Events

CIE Symposium on Color Vision

Paris, France
12 to 19 April 2013

CIE is celebrating its one hundredth anniversary! A century during which the knowledge of lighting fundamentals has taken enormous leaps forward, bringing new applications of light supported by both technological advances and economic success. A century that began with the revolution of the electric light and efforts to bring both the electric light bulb and the power it required into common use ends with the need to reduce energy distribution and use, and brings a technology that promises to achieve this for lighting.

CIE's mission "to promote worldwide cooperation and exchange of information on matters associated with light and lighting" is as relevant today as it was one hundred years ago.

Between April 12 and 19, 2013 the CIE statutory bodies will meet, Divisions and Technical Committees will gather to find ways to light up the future, and an international conference with panel discussions, presented papers, a poster exhibition and participants from all continents will take place in Paris to exchange knowledge, enlarge networks and celebrate together. A PhD Workshop as well as a CIE Symposium on Color Vision to honor Yves Le Grand will complete CIE's centennial birthday celebrations.

Image & Print World Business Solution Congress

Barcelona, Spain
17 to 20 April 2013

Organized in collaboration with the Graphispack Association, graphispag.digital 2013 will present the latest in applications that open up new business opportunities to graphic companies and related sectors. New digital printing equipment, hybrid technologies, web-to-print, augmented reality, printed electronics and 3D printing will grab the attention of over 18 000 visitors expected to attend. The show will also feature new materials and substrates, as well as improvements in the finish and customization of printed products.

Given that the graphic communication, photography and imaging sectors share equipment, processes and materials, graphispag.digital will be held to coincide with Sonimagfoto & Multimedia. The events will co-host the international Image & Print World congress, where world experts will define the technology and trends that are transforming the graphic business model and product. Conferences and round table debates will offer knowledge and experience to help companies find a better position on a continually changing market and, thereby, respond to the needs of the clients. The sessions will combine technical contents with their application in business, to help increase competitiveness and improve companies' results. It will be a congress, in which experts will talk about business solutions for imaging and printing.

The London Book Fair

London, United Kingdom
15 to 17 April 2013

The London Book Fair encompasses the broad spectrum of the publishing industry and is the global market place and exhibition for rights negotiation and the sales and distribution of content across print, audio, TV, film and digital channels.

The London Book Fair 2013 is confirmed to take place at Earls Court and it will allow the visitors access to the exhibitors, show features and over 300+ Love Learning seminars and events.

Sign and Digital UK

Birmingham, United Kingdom
30 April to 2 May 2013

Sign & Digital UK is the largest and longest running (25 years) visual communications event in the United Kingdom.

Showcasing the latest in innovation and boasting the world's top suppliers, the exhibition provides the perfect platform for those looking to increase awareness and market share. Attracting manufacturers and suppliers from across the signage and print spectrum to demonstrate the latest in technology, services and advice, Sign & Digital UK is to be considered the visual communication industry's annual get together.

Organizers are looking for exhibitors to join the Green Trail at the 2013 show, which highlights sustainable or ethically sourced products for sign and display producers. Exhibitors featuring in the Green Trail will benefit from an extensive marketing campaign during the show.

Photo & Digital 2013

Istanbul, Turkey
11 to 14 April 2013

Photo and Digital 2013 is characterized as an international exposition for tapping global opportunities of photography, videography, digital imaging frame and album making industrial sector.

This biennial trade show will take place at the CNR Expo on nearly 7 000 sqm of exhibition area.

Reklama Polygraf

Prague, Czech Republic
14 to 16 May 2013

Annual - this year's 20th international trade fair Reklama Polygraf 2013 will be held from 14 to 16 May in Prague Letňany Exhibition Grounds, which has been for the first time moved from Holešovice to PVA Letňany, to a better equipped and more accessible premise.

This traditional trade fair offers magnificent opportunity for expert meeting of the people from advertising services and printing industry, as well as from marketing and media. It provides numerous novelties, workshops and accompanying program with the participation of leading experts for graphic arts, paper and packaging technology.

The event of dedicated information about presentation technology will showcase all types of sign-making, large format printing and outdoor advertising, adve articles, sales promotio tising services, prepres chines and services, materials, office appliances, printed and electronic media, devices and accessories in the photo and presentation technology.

Chinaplas®

Guangzhou, China
20 to 23 May 2013

Chinaplas® is the international exhibition on plastics and rubber industries. This year' event will pay high attention to new technology development and is committed to promoting sustainability in the industry. The show will unveil the future applications of plastics and rubber which are far beyond imagination.

The key topics at Image & Print World will be: Overview Global Printing Industry; Full Color Process Management; Multiple Media Printing; Social Media: News Business Opportunities; How to Innovate: Interactive Image and Printing. Web to Print; and Shoot and Create.

In addition to the Congress, graphispag.digital will host presentations and seminars promoted by sector organizations and companies. Another highlight will be Design Corner featuring conferences on the current situation of graphic design and the presentation of best practices, as well as a networking and exhibition area.

graphispag.digital

graphispag.digital will also be repeating the daily Youth Sessions - aimed at groups of students at graphic arts and design schools - that offer practical information on visiting the show, detecting trends and finding the main new products presented by exhibitors. The show will also host the "Marco de Oro Awards" that recognize the best screen-printing, pad-printing or digital printing work on any substrate using these techniques alone or in combination with other printing systems, carried out in Spain 2011 or 2012.

Grafitalia 2013

Milano, Italy
7 to 11 May 2013

This year's exhibition will be dedicated to converting and package printing technology, allowing market players to get an accurate picture of the industry without any waste of time.

Grafitalia 2013 is the exhibition which is for 35 years featuring the presence of a large number of companies displaying technology, applications and materials, offering visitors an exhaustive and up-to-date product overview. The brand name - Grafitalia - is strong, awaited with anticipation by technology suppliers and users who come together in a vast and knowledgeable community.

The event is promoted by the Italian Manufacturers Association of Machinery for the Graphic, Converting and Paper Industry (ACIMGA) and the Italian Printing and Paper Converting Industries Association (ASSOGRAFICI).

Printcom

Plovdiv, Bulgaria
15 to 18 May 2013

PrintCom is a successful trade exhibition in the field of printing communications. The event aims at showcasing the modern trends in the printing and publishing industries. The exhibition will cover different topics of printing related fields: paper, cardboard and products; printing materials; reproduction and copying equipment and supplies; desktop publishing systems (DTP); printing presses and machinery, bookbinding and finishing equipment; printing services and products; packaging; advertising agencies; services and information; etc. Organized by the Printing Union of Bulgaria and the Polygrafia trade magazine, Printcom will take place at the International Fairgrounds in Plovdiv.

Intergrafika & Modernpak 2013

Zagreb, Croatia
22 to 25 May 2013

The International Printing and Paper Industry Fair Intergrafika is the regional show of the latest world technology achievements in the printing industry as well as paper finishing and processing industry. This event is a biennial fair bringing together the leading world manufacturers of the machines, devices and the equipment for the printing, paper and cardboard industry, auxiliary materials and finished products.

Over the years, this specialized fair has shown that it has important prospects for this part of Europe and that it encourages development of the IT, publishing, printing and paper industry as well as the overall entrepreneurship in this branch of the economy.

Beside the exhibition part, Intergrafika will offer a rich program of professional and accompanying events to be attended by experts from the country and abroad and by exhibitors in order to exchange their knowledge and experience. The traditional presentation of awards to exhibitors for their successful participation will also take place.

Within the same term, another trade show - the Modernpak - International Packing Materials and Packing Technology Fair will be organized. The combination of these compatible economic branches will surely contribute to a quality event offering a high level of business efficiency to the satisfaction of all participants from the field of printing and packaging industries.

IE expo 2013

Shanghai, China
13 to 15 May 2013

This international trade fair for water, sewage, refuse, recycling, air pollution control and energy conservation has become in the latest years one of Asia's biggest meeting place for the sector.

Sustainable solutions for tackling the current and future problems in the sector will be showcased at this year's IE expo in Shanghai and will certainly draw the interest of the paper, printing and converting industries.

Graphitec 2013

Paris, France
11 to 14 June 2013

Graphitec Expo is the country's largest, longest running and one of the best trade shows for the graphic arts & printing industry. Each year it attracts the full spectrum from the design community, smaller quicker printers, and medium-sized facilities to the largest operations.

It is the exhibition for design, processing, transmission, printing and distribution of information. Graphictec is a meeting point for different professional and business figures, an occasion to update and to investigate topics ranging from research and new technology to marketing and the business outlook for the sector. For this reason, the event host seminars, debates, focus meetings and conventions.

LinuxTag

Berlin, Germany
22 to 25 May 2013

LinuxTag is the most important place for Linux and open source software in Europe. The 19th LinuxTag will take place on 22 to 25 May 2013 - for the seventh time at the Berlin Fairgrounds. It will present all the latest news and information for professional users, decision makers, developers, beginners and of course, the Linux community. The event is organized in partnership with Messe Berlin GmbH.

During four days visitors of the fair and the congress will be able to experience the open-source-trends. The main topics will include innovative Android projects and enterprise storage with a special perspective on the SSD drive as well as tools and methods of system management, such as monitoring and configuration management.

Many open source projects will present their free software. Special events such as the hacking contest, the Kernel-Kwestioning with many Linux developers, Key-Signing-Parties, LPI exams or numerous workshops will complete the program.

FESPA 2013

London, United Kingdom
25 to 29 June 2013

FESPA 2013 is the industry's landmark exhibition and the largest focused event for wide format print. 650 exhibitors together, will encompass the very latest equipment, technology and consumables for wide format digital print, narrow format digital print, screen and industrial printing, garment decoration and textile printing transforming the award winning ExCeL London Exhibition Centre into a hub for print innovation.

This event will offer a unique opportunity to all print professionals, brands and designers to engage with the print markets leading manufacturers and suppliers whilst exchanging ideas, updating on industry information and business solutions with more than 650 exhibitors and 10 free show features.

World Newspaper Congress
World Editors Forum
World Newspaper Advertising Forum

Bangkok, Thailand
2 to 5 June 2013

The annual summit meetings of the world's newspapers and news publishers have a new look in 2013, as the World Newspaper Congress and World Editors Forum will be joined by the World Newspaper Advertising Forum, making Bangkok the center of the publishing universe come June.

The 65th World Newspaper Congress, 20th World Editors Forum and 23rd Newspaper Advertising Forum, to be held concurrently from 2 to 5 June, are expected to draw more than 1 000 publishers, chief editors, CEOs, Advertising Directors and their guests to the vibrant city of Bangkok.

The three conference streams are designed to provide participants with strategic knowledge and ideas emerging from the rapid, constant change that characterizes the news media today, from technology to consumer habits to advertising formats and new reporting and storytelling techniques.

The World Newspaper Congress primarily deals with management and business issues facing news media and will examine emerging new business models and revenue streams.

The World Editors Forum provides newsroom personnel with an annual meeting place to examine innovations in journalism and newsrooms organization and to pick up new skills in data journalism, new storytelling tools and techniques and more.

The World Newspaper Advertising Forum is the annual venue for publishers and advertising executives to hear about successful strategies for increasing advertising revenues from both digital and print - and how to show advertisers the full value of your audience.

XIth Symposium on Graphic Arts

Pardubice, Czech Republic
17 to 18 June 2013

University of Pardubice, Department of Graphic Arts and Photophysics, will under auspices of IARIGAI and the Dean of the Faculty of Chemical Technology organize biannual international event - XIth Symposium on Graphic Arts.

This year's topic will cover different fields of graphic arts and printing – printed electronics and functional printing, image processing and analyses, printing quality, printing materials and quality control.

The best papers, presented at the symposium, will be published in the journal *Scientific Papers of the University of Pardubice, Series A*; which is a reviewed journal, annually published by the Faculty of Chemical Technology, University of Pardubice. IARIGAI will also award the author of the best paper.

Nanotexnology 2013

Thessaloniki, Greece
6 to 13 July 2013

Nanotexnology 2013 is the annual event which offers the opportunities in the emerging fields of Nanotechnologies & Organic Electronics. It includes a powerful community that brings together over 2 000 researchers, scientists, engineers, business and technical professionals to promote research and industrial collaborations and technology transfer by networking and matchmaking.

This year will under one name be combined several interesting events worth listening - symposium, conference, summers school, workshops, special sessions and a trade fair:

- 6th International Symposium on Flexible Organic Electronics,
- 10th International Conference on Nanosciences & Nanotechnologies,
- 7th International Summer Schools "N&N, OE & Nanomedicine",
- 3rd Nanotechnology Expo 2013.

40th International Research Conference of iarigai

Chemnitz, Germany
8 to 11 September 2013

The 40th anniversary of the International research conference of iarigai will be this year organized by the Department of Digital Printing and Imaging Technology of the Institute for Print and Media Technology of the Chemnitz University of Technology. This traditional annual event will take place in Chemnitz, Germany from 8 to 11 September. For the first time it will be this year combined with another event - traditional conference for junior scientists and PhD students - 5th Printing Future Days.

Both events will not be limited to traditional printing technologies and print media, but will include the new exciting fields of printed functionalities such as printed electronics and touch upon the convergence of different types of media.

According to the interesting and challenging title of this year's iarigai conference - "Digitalization of Print - Exchanging Ideas Across Generations" participants will be given an opportunity to present their research work, exchange the knowledge, discuss the challenges in the field with the experts from other research organizations and printing industry.

The combination of both conferences is the general concept and it inspires the whole event: In a combined keynote session leaders from industry and related scientific fields will present current key issues of the Print and Media Industry followed by a joint panel discussion. The poster session of the Printing Future Days will enable attendees of the iarigai conference to have a look on scientific results of the new generation of scientists. Furthermore, a versatile social program including the joint conference dinner gives additional opportunities for conversations across generations.

The organizers hope that the conference days in Chemnitz will help sharing the knowledge of researchers from various fields all over the world. They as well hope that the events will provide the means for further development of the printing industry.

PRINTING FUTURE DAYS 2013

Printing Future Days 2013

Chemnitz, Germany
10 to 12 September 2013

Printing Future Days provide an international platform for junior scientists and PhD students to gain first conference experiences. It has been, under the auspice of iarigai, organized since 2005 as a biannual event. This year it will be organized along with anniversary the 40th international research conference of iarigai.

Under a joint title "Digitalization of Print - Exchanging Ideas Across Generations" it will bring together young and senior scientists, representtatives of the industry and others for a successful exchange of knowledge and presentation of the latest research work.

Present topics of the Printing Future Days are in general related to the graphic arts but are also driven by the research of universities and institutes covering topics such as Digital Fabrication Technologies, Printed Functionalities and Printed Electronics. Special attention will be given to the topics of Color Image Printing, Packaging Printing, Applications and Functional Printing.

With a wish to support and encourage young people and universities, the Printing Future Days are free of participation fees for all students and PhD students. iarigai will traditionally award the author of the best presentation.

Nikola Perinka awarded as the best young author at Printing Future Days 2011

45th IC Conference

Toronto, Canada
2 to 6 June 2013

45TH ANNUAL CONFERENCE IC 2013 TORONTO

The 45th Conference of the International Circle of Educational Institutes for Graphic Arts, Technology and Management will be hosted by the School of Graphic Communications Management at Ryerson University.

The scope of the conference encompassses scientific and educational topics from the fields of Graphic Arts Technology, Management, and Communication in a broader sense.

High Security Printing Conference

Bogota, Colombia
8 to 10 July 2013

The 2nd Latin American High Security Printing Conference is the premier regional forum for secure document technologies and is the only event in Latin America and the Caribbean to address the needs, issues, challenges and opportunities for specifiers and producers of government documents in the region.

The Latin American High Security Printing Conference is the only event of its kind to cover the rapidly-emerging market in the region for government and high security documents.

CROSS SECURITY PRINTING CONFERENCES PART OF RECONNAISSANCE international

Topics of this year's conference will include various interesting opportunities to found out more about regional developments in document security, currency features and substrates, travel documentation technologies and features, anticounterfeiting, document verification and enforcement, printing, production, personalization and integration technologies as well as the information on new developments in e-ID cards and breeder documents and fiscal stamps, licenses and vehicle registration.

Call for papers

The Journal of Print and Media Technology Research is a peer-reviewed periodical, published quarterly by iarigai, the International Association of Research Organizations for the Information, Media and Graphic Arts Industries.

Authors are invited to prepare and submit complete, previously unpublished and original works, which are not under review in any other journals and/or conferences.

The journal will consider for publication papers on fundamental and applied aspects of at least, but not limited to, the following topics:

- Printing technology and related processes

  Conventional and special printing; Packaging, Fuel cells and other printed functionality; Printing on biomaterials; Textile and fabric printing; Printed decorations; Materials science; Process control

- Premedia technology and processes

  Color reproduction and color management; Image and reproduction quality; Image carriers (physical and virtual); Workflow and management

- Emerging media and future trends

  Media industry developments; Developing media communications value systems; Online and mobile media development; Cross-media publishing

- Social impacts

  Environmental issues and sustainability; Consumer perception and media use; Social trends and their impact on media

Submissions for the journal are accepted at any time. If meeting the general criteria and ethic standards of scientific publishing, they will be rapidly forwarded to peer-review by experts of high scientific competence, carefully evaluated, selected and edited. Once accepted and edited, the papers will be printed and published as soon as possible.

There is no entry or publishing fee for authors. Authors of contributions will be asked to sign a copyright transfer agreement, to determine the rights of authors and publishers.

Authors are asked to strictly follow the guidelines for preparation of a paper (see the abbreviated version on inside back cover of the journal). Complete guidelines can be downloaded from:

http://www.iarigai.org/publications/

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Submissions and queries should be directed to:

journal@iarigai.org or office@iarigai.org

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Authors are encouraged to submit complete, original and previously unpublished scientific or technical research works, which are not under review in any other journals and/or conferences. Significantly expanded and updated versions of conference presentations may also be considered for publication. In addition, the journal will publish reviews as well as opinions and reflections in a special section.

Submissions for the journal are accepted at any time. Papers will be considered for publishing if meeting the general criteria and ethic standards of the scientific publication. When preparing a manuscript for JPMRT, please strictly comply with the journal guidelines, as well as with the ethic aspects. The Editorial Board retains the right to reject without comment or explanation manuscripts that are not prepared in accordance with these guidelines and/or if the appropriate level required for scientific publishing cannot be attained.

A - General

The text should be cohesive, logically organized, and thus easy to follow by someone with common knowledge in the field . Do not include information that is not relevant to your research question(s) stated in the introduction.

Only contributions submitted in English will be considered for publication. If English is not your native language, please arrange for the text to be reviewed by a technical editor with skills in English and scientific communication. Maintain a consistent style with regard to spelling (either UK or US English, but never both), punctuation, nomenclature, symbols etc. Make sure that you are using proper English scientific terms.

Do not copy substantial parts of your previous publications and do not submit the same manuscript to more than one journal at a time. Clearly distinguish your original results and ideas from those of other authors and from your earlier publications - provide citations whenever relevant. For more details on ethics in scientific publication, please consult:

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B - Structure of the manuscript

Title: Should be concise and unambiguous, and must reflect the contents of the article. Information given in the title does not need to be repeated in the abstract (as they are always published jointly).

List of authors: i.e. all persons who contributed substantially to study planning, experimental work, data collection or interpretation of results and wrote or critically revised the manuscript and approved its final version. Enter full names (first and last), followed by the present address, as well as the e-mail addresses.

Separately enter complete details of the corresponding author - full mailing address, telephone and fax numbers, and e-mail. Editors will communicate only with the corresponding author.

The title of the paper and the list of authors should be entered on a separate cover page (numbered as 0). Neither the title nor the names of authors can be mentioned on the first or any other following page.

Abstract: Should not exceed 500 words. Briefly explain why you conducted the research (background), what question(s) you answer (objectives), how you performed the research (methods), what you found (results: major data attained, relationships), and your interpretation and main consequences of your findings (discussion, conclusions). The abstract must reflect the content of the article, including all the keywords, as for most readers it will be the major source of information about your research. Make sure that all the information given in the abstract also appears in the main body of the article.

Keywords: Include three to seven relevant scientific terms that are not mentioned in the title. Keep the keywords specific. Avoid more general and/or descriptive terms, unless your research has strong interdisciplinary significance.

Abstract and keywords should be entered on a separate page, numbered as page 1. Do not continue with the main body of the text, regardless of the possible empty space left on this page.

Introduction and background: Explain why it was necessary to carry out the research and the specific research question(s) you will answer. Start from more general issues and gradually focus on your research question(s). Describe relevant earlier research in the area and how your work is related to this.

Methods: Describe in detail how the research was carried out (e. g. study area, data collection, criteria, origin of analyzed material, sample size, number of measurements, equipment, data analysis, statistical methods and software used). All factors that could have affected the results need to be considered. Make sure that you comply with the ethical standards, with respect to the environmental protection, other authors and their published works, etc.

Results: Present the new results of your research (previously published data should not be included). All tables and figures must be mentioned in the main body of the article, in the order in which they appear. Do not fabricate or distort any data, and do not exclude any important data; similarly, do not manipulate images to make a false impression on readers.

Discussion: Answer your research questions (stated at the end of the introduction) and compare your new results with the published data, as objectively as possible. Discuss their limitations and highlight your main findings. At the end of Discussion or in a separate section, emphasize your major conclusions, specifically pointing out scientific contribution and the practical significance of your study.

Conclusions: The main conclusions emerging from the study should be briefly presented or listed, with the reference to the aims of the research and/or questions mentioned in the Introduction and elaborated in the Discussion.

Introduction, Methods, Results, Discussion and Conclusions - as the scientific content of the paper - represent the main body of the text. Start numbering of these sections with page 2 and continue without interruption until the end of Conclusions. Number the sections titles consecutively as 1, 2, 3 ..., while subsections should be hierarchically numbered as 2.1, 2.3, 3.4 etc. Use Arabic numerals only.

Note*: Some papers might require different structure of the scientific content. In such cases, however, it is necessary to clearly name and mark the appropriate sections.*

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Appendix: If an additional material is required for better understanding of the text, it can be presented in the form of one or more appendices. They should be identified as A, B, ... etc., instead of Arabic numerals.

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