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Effects of Different Solvents to Printability in Gravure Printing

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There are different solvents used in Gravure printing inks. Also there are different properties of solvents which affect the printing quality in different ways. In this study, four different gravure inks with four different solvents has been prepared. Prepared ink has been printed with IGT F1 Gravure and Flexo test machine on transparent low density polyethylene and opaque oriented polypropylene films. The used solvents amounts are not equal for same viscosity. This change also affects the printing quality. As a result, the fact that, which solvent constitutes the best print quality for gravure print on a low density polyethylene and oriented polypropylene has been understood.

Key Words: Gravure, Solvent, Gravure ink, Oriented polypropylene, Low density polyethylene, Print quality.

INTRODUCTION

The distinctive feature of Gravure printing technology is the fact that the image elements are engraved into the surface of the cylinder. The non-image areas are at a constant, original level. Prior to printing, the entire printing plate (non-printing and printing elements) is inked and flooded with ink. Ink is removed from the non-image (by a wiper or blade) before printing, so that ink remains only in the cells. The ink is transferred from the cells to the printing substrate by a high printing pressure and the adhesive forces between printing substrate and ink[1].

Rotogravure printing is used for the economical production of long print runs. Gravure printing forms are usually cylindrical. A special feature of industrial rotogravure printing is the fact that a whole cylinder (and no plate) is used per colour separation. This means that in a four-colour press four separate cylinders have to be changed for each new job. Consequently, a company that has a lot of repeat jobs is forced to store a large number of cylinders. Depending on the printing format, Gravure printing cylinders are generally rather heavy and require special conveying and handling gear systems.

Various Gravure printing techniques for reproducing the continuous tones of the original. It should be noted here that only variable-depth gravure printing and more particularly variable area/variable depth gravure are of any significance, due to their high quality. Pure variable-area (halftone) gravure is scarcely used nowadays.

Traditionally only variable-depth, gravure printing is also increasingly losing its importance since the printing plate production is based on complicated copying and etching processes which are almost impossible to standardize. It is for this reason that variable-area/variable-depth gravure printing processes, which are based on electronic/mechanical engraving (using a stylus) of the gravure cylinder, are becoming prevalent.

There are two familiar options for the structure of the gravure cylinder. The steel cylinder has an electroplated coating of base copper (typically about 2 mm thick) with an approximately 100 mm thick coating of engravable (cuttable) copper applied onto it. The steel cylinder has either the directly electroplated engraving copper or a so-called ballard skin on the base copper layer. This peeling layer is also applied by electroplating onto the base copper, over a separating layer and the print image is engraved into it.

In screening for gravure printing, the image is broken up into printing elements, the cells and then the non-printing elements, the cell walls. The cell walls serve to guide the blade when excess ink is being stripped. After the doctoring process, ink remains only in the cells. If ink were to remain on the cell walls, scumming would occur in the print and if there were localized blade defects, blade streaks[2] (Fig. 1)[3].

A gravure printing ink comprises a solvent, a colourant, a binder and additives. Wherein the solvent is water and organic solvents, the colourant is a water-soluble dye or a mixture of such dyes dissolved in the solvent while the binder is selected from different resins dispersed in the solvent that is above 7 pH degree (preferably at about pH 8-9 degree). The additives include a wax selected from the group consisting of polyolefin waxes, paraffin waxes and mixed polyolefin and paraffin waxes dispersed in the solvent[4,5]. A gravure printing ink is concentrated in order to prepare this printing ink comprising the components mentioned above in which the amount of solvent is reduced by about 1-20 % when it is compared with the amount of solvent in a gravure printing ink ready for use[6].

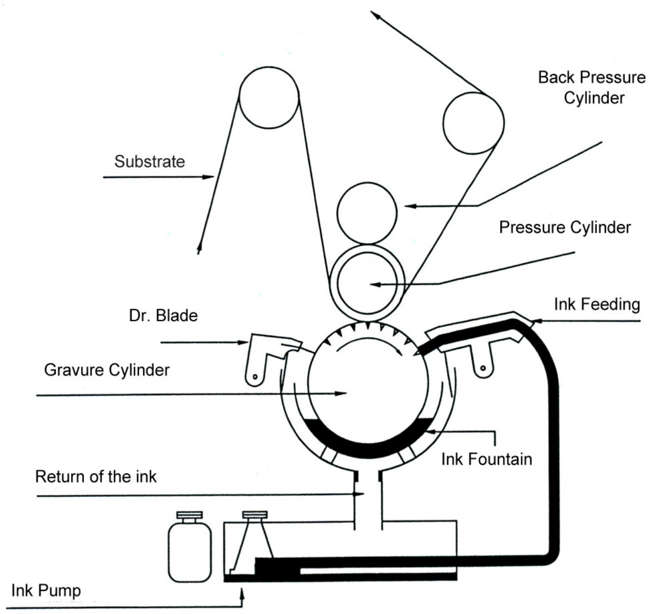

Fig. 1. Gravure printing system[3]

Polyethylene film-low density polyethylene: Polyethylene is a thermoplastic plastic that is produced by the polymerization of ethylene gas under the influence of high pressure and temperature. Polyethylene film that is produced by extrusion is relatively clear, transparent, odourless and tasteless, physiologically harmless, waterproof and resistant to water vapour, sealable, elastic, durable and extremely flexible, even at temperatures under 0 ºC. In chemical terms polyethylene is a saturated hydrocarbon. The properties can be produced by changing the molecular weight, density and degree of branching of the molecules (low, medium and higher density).

When it is extruded into film, polyethylene cannot be printed unless the surface is treated first. The printing ink would not bond to the film otherwise. The pre-treatment needed to make printing possible on the other hand impairs the sealability of the polyethylene surface and can reduce the tear strength and impact resistance of the film. Polyethylene film is normally prepared for printing by corona discharge treatment directly after extrusion.

This method involves discharging a high electrical voltage and under the indirect influence of ozone that is formed on the surface of the film. This treatment process is easy to control and economic and produces good results.

Medium and high-density polyethylene film is less elastic than low-density polyethylene film, but it is superior as far as oil and fat resistance and temperature stability are concerned. Medium and high-density polyethylene requires more intensive printing pre-treatment and is less strong than low-density polyethylene. Polyethylene that is printed is generally between 20 and 150 μ thick, while the thickness range is in between 10 and 250 μ.

Polyethylene is printed as blown film and cast film. Blown film is easy to process into carrier bags, plastic sacks and pouches by cutting it to the required length and sealing it at one end. When both the front and back of blown polyethylene film is supposed to be printed, both surfaces need to be pretreated.

Polyethylene film is used for a wide range of different applications, for example for packaging fresh vegetables, frozen food, bakery products and bread, where its extremely high level of resistance to water vapour, flexibility at low temperatures and in some cases-high gas permeability are very important and where transparency, long-term flexibility, strength and resistance make polyethylene a valuable and almost ideal packaging film. Its flexibility makes it possible for the housewife to feel the quality of the packaged goods through the film. Since polyethylene contains neither water nor plasticisers, the film cannot go brittle. Its functional efficiency, water vapour barrier and transparency are reasons why it is used on such a large scale in the packaging field.

Polyethylene film is difficult to print because of its relatively low strength, the fact that it softens at quite a low temperature and the low thickness it often has when it is printed. Registration is the main problem[7].

Biaxially oriented polypropylene films: These oriented polypropylene films are produced using a modified raw material of the kind from which-non-oriented cast films are made but the blown film or cast film is oriented and then heat set after the stenter or bubble process. Although oriented polypropylene films are typical plastic films, they have gradually managed to replace cellulose film. The films are produced in different forms for specific application areas: (a) Biaxially oriented, uncoated films with printing pre-treatment on one or both sides; (b) Biaxially oriented films made heat sealable on both sides by means of coextrusion, with polyolefin coating and with printing pre-treatment on one or both sides; (c) Biaxially oriented films coated on both sides with PVdC, PVC, polyacrylic etc. to be heat sealable.

Films (a) and (b) are processed by corona discharge treatment in such a way that a high enough surface tension level is produced to guarantee effective processing conditions for flexo printing.

Films (c) can normally be printed, laminated or glued without any printing pre-treatment, but the printing pretreatment equipment that is available on the flexo printing and laminating machines to some extent is turned on to improve ink/film bonding during processing operations.

The standard film thicknesses range between 15 and 50 μ. The films are pliable and flexible. The resistance of oriented polypropylene films to initial tearing is very high but its resistance to tear propagation is very low. There are the following reasons for the increase in the use of these oriented polypropylene films in recent years and for the good prospects they have in future: (1) The film is particularly economic due to its low specific weight of *ca.* 0.91; (2) The surface stability of the film is maintained even if there are moisture and temperature fluctuations and guarantees consistently attractive pack appearance; (3) In spite of the thermoplastic character of the film, similar outputs to cellulose films can be achieved by good orientation of the film, low thickness tolerance levels as well as good slip and flatness properties combined with appropriate modifications to the packaging machines; (4) Because of the excellent puncture resistance of the film, there is practically no danger of damage (carton corners, product with sharp edges *etc.*), even at low temperatures[7].

EXPERIMENTAL

Varnish, adhesive and wax were added to 50 g black ink paste of Seigwerk NC process colour series. Various solvents (Table-1.) were added on the mix to obtain several solutions each of which has a viscosity of 18. The properties of various solvents are given in Table-2[9]. Different amounts of solvents alter the pigment concentration in the unit volume. The concentration was supported by density measurements. All test prints were applied on transparant LPE and opaque oriented polypropylene with IGT F1. The gravure printing plate has original IGT F1 gravure plate (402:153:432)[8].

TABLE-1
PREPARED INKS CODES AND SOLVENTS

Ink code	Solvent
OBE 1	Ethyl alcohol
OBE 2	Ethyl acetate
OBE 3	Isopropyl alcohol
OBE 4	Ethoxy propanol

TABLE-2
PROPERTIES OF THE SOLVENTS [Ref. 9]

Solvent	Density at 4 ºC	Boiling point (ºC)	Evap. rate (Bu Ac = 10)	Flash point (ºC)
Ethanol	0.790	81.0	33.0	13.9
Ethyl acetate	0.900	77.0	62.0	-5.0
Ethoxy propanol	0.900	132.0	4.9	49.0
Isopropyl alcohol	0.785	82.3	29.0	11.7

Test prints were performed under room conditions. Viscosity measurements were done by using dyn4 cup. Density measurements were carried out by using X-rite spectro eye spectrophotometer. Spectrophotometer's measurement conditions are observer angle 2º, illumination D50 (5000 K), geometry 0/45. Polarize filter was used in density measurements. Visual print quality was observed with Olympus SZ61 Stereo Microscope by 50X magnification. Test print conditions are printing force 150 N/m and printing speed 0.20 m/s. 40 m low density polyethylene film and 40 m oriented polypropylene film were used in test prints.

For low density polyethylene: Fig. 2 shows print density of inks prepared with different solvents on to low density polyethylene and oriented polypropylene. Solvent's viscosities and proportion of different solvent in inks effect that ink viscosity. With less solvent, the ink that reaches the viscosity of 18 has higher density value than the ink that reaches the viscosity of 18 with more solvent. But except this ethyl acetate and ethoxy prophanol have high evoparation low temparature. These ink's densty values are lower than others.

For oriented polypropylene: When substrate is changed; due to the adhesion of the substrate; slight changes have occurred in the order above and in the viscosity changes of the ink solution with different solvents. The explanation made

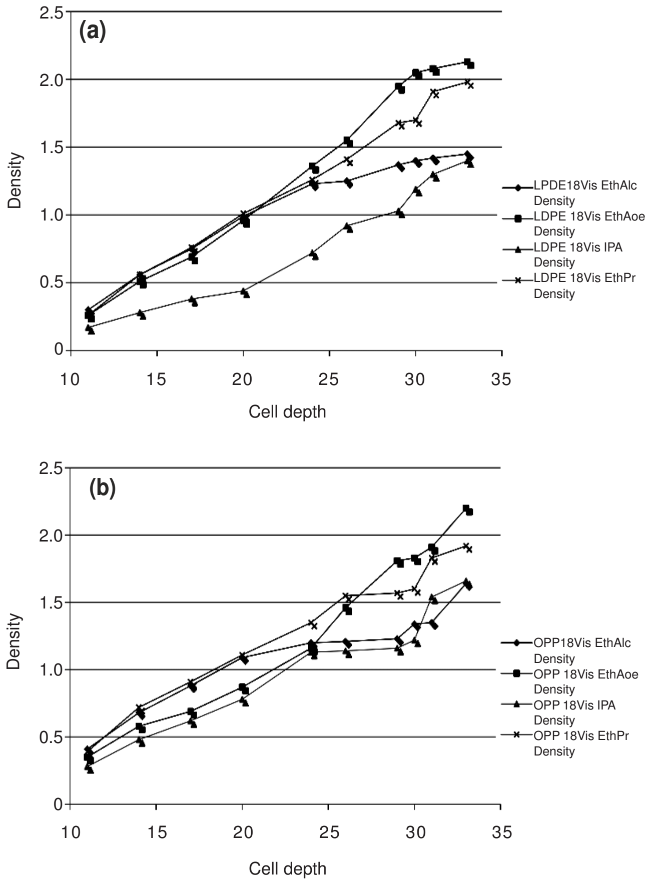

Fig. 2. Print density of inks prepared with different solvents; a) low density polyethylene; b) oriented polypropylene

for the low density polyethylene is also applicable to oriented polypropylene. But except ethyl alcohol's and isoprophyl alcohol 's print solid tone densities on to oriented polypropylene is higher than low density polyethylene. Because of this opaque surface of oriented polypropylene effects. Oriented polypropylene films have got higher surface tension than low density polyethylene's. We used same ink to print this substrates. The results of this low density polyethylene 's print quality better than oriented polypropylene's.

Test print cylinder plate's cell depts are between 0 µm and 30 µm. The solid tone density of ink are prepared with different solvents that are measured with spectrophotometer (Fig. 2). Ethyl acetate and ethoxy propanol based inks' solid tone densities are lower than isopropyl alcohol and ethyl alcohol. The inks which are prepared with ethyl acetate and ethoxy propanol have high drying velocity. But in practical this kind of inks dries fast on gravure printing process. Because of this ethyl alcohol, the combination with ethyl acetate generally used in Gravure printing inks.

The ethyl acetate's lowest boiling point solvent and it produced quick dry ink and the highest used solvent in gravure printing; ethyl alcohol's test prints' dot gain can be seen in Fig. 3.

Fig. 3. shows that, ethyl acetate based gravure ink's dot has not time to gain because of it's fast drying; on the other hand, ethyl alcohol based gravure ink's dot has a very long time to dry because of this it's dot gain value higher than ethyl acetate based ink's.

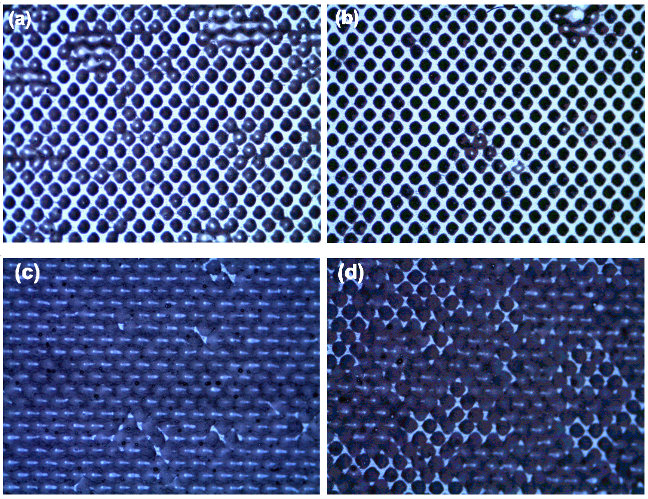

Fig. 3. 33 µm cell dept area test prints' microscopic photographs of a) Ethyl acetate based ink on LDPE b) Ethyl acetate based ink on OPP c) Ethyl alcohol based ink on LDPE d) Ethyl alcohol based ink on OPP.

RESULTS AND DISCUSSION

Solvent volume has inverse proportion with pigment concentration. Pigment concentration has diverse proportion with print density. When substrate is changed, slight changes occur in the order above due to the surface tension and opaquety of substrate and the changes in viscosity of the ink solution with different solvents. The explanation which is done for the low density polyethylene is also applicable to oriented polypropylene. Even though ethyl alcohol and ethyl acetate are not separate adequately, a mixture of these are good for printability. The Ink, which is prepared with high boiling point solvent, has high drying velocity.

Conclusion

Ethyl alcohol based ink's print dot gains better than other prepared inks'. But Ethyl alcohol based inks have a problem about drying. In industry it is not be preferred in gravure printing. Ethyl acetate based ink's prints dot shapes are better than other's. But ethyl acetate may be damages the cylinder cells. Therefore the ink which is prepared with % 10 ethyl acetate the high level ethyl acetate amount may not be used for industrial gravure printing processes. From this advantage and disadvantage hybrid inks may be used in gravure printing. As an example to this kind of hybrid ink is ethyl alcohol-ethyl acetate combination based ink that has optimum print quality results.

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