Development of Inkjet Supply for Offset Paper

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Abstract

Ink-jet printing is the fast-growing category for printing on various different materials. In production printing, the print speed is fast on coated paper. The use of ink-jet printing has been expected in this area, but now the use is limited to coated paper with ink absorbing capacity. Ink-jet supplies have been developed to print fine images on coated paper for offset printing where it is difficult for the paper to absorb ink-jet ink. Three types of supplies with different functions have been developed as follows.

1. Introduction

Since inkjet printing is able to deal with variable printing in which contents can be changed for each copy of printed matter, customers can offer value-added print service. In addition, in comparison with offset printing, inkjet printing is characterized by smaller numbers of loss of paper, less burden on environment regarding plate making, excellent environmental response, etc. Having such advantages, inkjet printers are in great demand and used for various purposes.

Ricoh launched GELSPRINTER printers using ink with both high viscosity and high permeability in February 2004. This printer can produce quality images free from inter-color bleed on plain paper and receives some good reputation in the business printer field.1) In addition, Ricoh focused on this merit from early on and have appealed and proposed a change from offset to digital, so-called "O to D change", to customers in the value-added commercial printing field. Based on technologies and knowledge cultivated in the business printer field, we have actively propelled the development of related technologies.

To let this "O to D change" happen, from a customer point of view, high performance and the image quality on a par with offset printing and compatibility with various media (kind and form) are demanded. These are large issues. For example, conventional coated paper for offset printing are mostly used in a roll form in continuous high speed printings. Since coated paper never or little absorbs aqueous inks, if the technologies controlling the viscoelasticity of ink droplets utilizing the advantages of high permeability developed for GELGET printers are applied thereto, the following drawbacks are involved: (1) Beading (merging of ink droplets of adjacent dots on paper), (2) Inter-color bleed at color interface, (3) Twining ascribable to insufficient drying and adhesion by ink between papers, and (4) Peeling-off of image caused thereby.

Usage of paper specialized to absorb an aqueous ink is one solution, but is not suitable because it diminishes customer values in terms of intended purposes and cost.

Therefore, we conceive developing three-layered supplies. The first layer is called "undercoat layer", which is to boost acceptability of an aqueous ink and improve resolutions of images by controlling viscoelasticity of landed ink droplets. With "undercoat layer", aqueous inks can be used regardless of media. The second layer is "ink". By compositional optimization of water-based components in ink, we have made an investigation to simultaneously achieve high speed printing by improvement on evaporation properties at drying and reliability of drop ejection from the print head (for reduction of viscosity change and nozzle clogging) by improvement on moisture-retaining properties at room temperature.

The third layer is "finishing" referred to as protector coating layer. This layer is provided to deal with uneveness of ink film formed below the layer and improve slidability by decreasing friction coefficient, thereby to suppress damage to an image ascribable to friction and impact.

Its details are described below.

2. Undercoat Liquid(UCL)

2.1 Pigment Agglomerating Polymer and Composition of Undercoat Liquid

To improve the adaptability of an aqueous ink on coated paper for offset printing, the first layer of the three layers mentioned above is to improve the acceptability of the aqueous ink by applying undercoat liquid to coated paper as preliminary treatment and reduce beading on the coated paper and suppress color bleed at color interface by controlling the viscoelasticity of landed ink. To fulfill the purposes, for example, the following methods are thinkable: (1) boosting the permeability of ink into media, (2) improving evaporation and diffusing speed, and (3) accelerating agglomeration of pigments in the ink by charge neutralization. Considering the impact on stability of ink and reliability of drop ejection from the print head, the method (3) of accelerating pigment agglomeration by charge neutralization was adopted. For this method, pigment agglomerating polymers are added to the undercoat liquid as the key material. Fig. 1 illustrates how the pigment agglomerates on paper after the ink lands thereon.

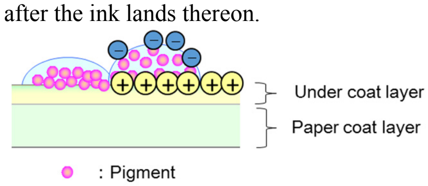
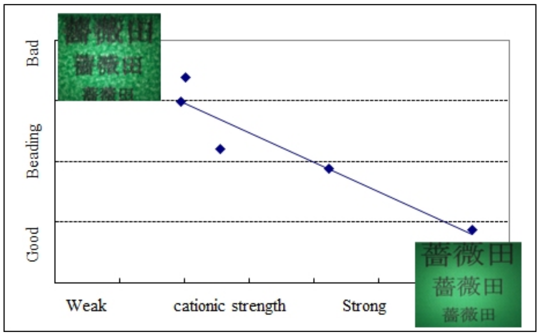


Fig.1 Scheme of pigment aggregation on coated paper.

2.2 Mechanism of Pigment Agglomeration and Image Quality on Coated Paper for Offset Printing

Pigment agglomeration utilizes charge neutralization. To be specific, agglomeration of pigment particles with negative charges on their surface in ink is accelerated by neutralization with the cationic charges present inside the pigment agglomerating polymer molecule contained in the undercoat liquid. By this neutralization, it is possible to obtain higher image qualities by suppressing merger of adjacent dots when the undercoat liquid is applied. The cation in the undercoat liquid is evenly applied to paper because it is a watersoluble resin. In addition, it does not damage the texture of paper. Moreover, the agglomeration property of cation polymers were investigated to accelerate agglomeration. Fig. 2 is a graph illustrating the correlation between cationic strength of the undercoat liquid and beading test results with related image. As seen in Fig. 2, it is obvious the cationic strength of the undercoat liquid has a correlation with the image quality.

Fig.2 Correlation between cationic strength and beading



As described above, by selecting pigment agglomerating polymers with high cationic strength, beading, which is a large issue having an adverse impact on the image quality on coated paper, is suppressed.

3. Quick Drying Ink (QDI)

3.1 Composition of Quick Drying Ink

Generally, aqueous pigment inks are composed of the following compositions. [2)]

- Pigment Dispersion Element
- Binder Resin
- Humectant
- Others

Permeating agent, pH regulator, preservatives and fungicides, etc.

Humectants are added to prevent clogging of nozzles. In general, glycols are mostly used as humectants, but an excessive amount thereof slows drying speed on paper while effective to prevent clogging. The kind of humectants should be selected bearing the following in mind.

1) High moisture-retaining property
2) No adverse impact on dispersability
3) Viscosity increase is suppressed at water evaporation [3)]

The quick drying ink was developed to secure image drying property on coated paper for offset printing paying attention to adverse impacts on dispersability ascribable to humectants selected and viscosity increase at water evaporation. The quick drying ink is required to have features of 1) image drying properties and 2) reliability of drop ejection from the print head. Fig. 3 is schemes illustrating image drying on plain paper and coated paper for offset printing. Image drying properties of plain paper for office use printers are mainly affected by permeation of ink compositions into paper. On the other hand, image drying properties of coated paper for offset printing is mainly affected by evaporation of ink compositions because ink absorption capability is weak.

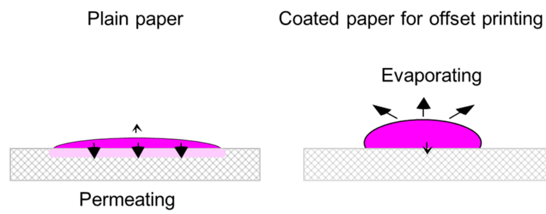


Fig.3 Scheme of ink drying process on paper.

For this quick drying ink, alcohols having high vapor pressure were selected as the ink humectant to dry the quick drying ink more quickly than conventional inks. For this reason, the ink was easily dried and the image drying properties were ameliorated when images were printed on coated paper for offset printing.
Furthermore, it is possible to prevent peeling-off of images caused by insufficient drying by providing a mechanism to dry printed images. Since the ink uses alcohols having high vapor pressure, evaporation of the ink is promoted by heating the printed image, resulting in improvement on drying properties.

3.2 Compatibility between Quick Drying and Reliability of Drop Ejection from the Print Head

In general, when a quick drying ink is used to ameliorate image drying properties, the ink easily dries inside heads, which leads to drop ejection trouble.

To prevent such drop ejection trouble, in particular clogging of nozzles, it is necessary to suppress viscosity increase caused by evaporation of the solvent components (water and organic solvents) in the ink at room temperature and agglomeration, sedimentation, or solidification of pigments and resins promoted by such viscosity increase. Therefore, in general, solvents having high boiling point are added to an aqueous pigment ink to keep moisture, thereby to prevent evaporation of the solvent components. In terms of the image drying property, such solvents having high boiling point are inhibiting factor. In addition, in the case of coated paper, compatibility between high speed printing and the image quality is a great issue.

In the present ink, improvement on drying property was investigated by selecting alcohols with high vapor pressure. Fig. 4 is a graph illustrating the drying speed of the inks. The drying speed of the ink is represented by the change in ink weight to the elapsed time when the ink is weighed and placed in a petri dish having an inner diameter of 33 mm and left still at high temperature.

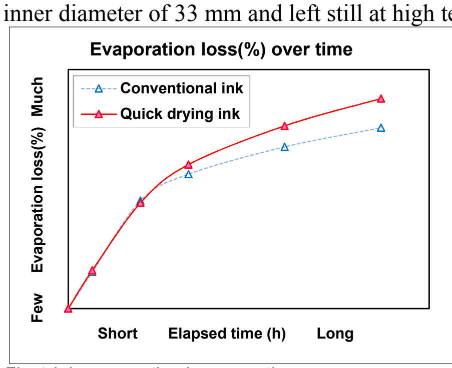


Fig.4 Ink evaporation loss over time.

The ink evaporates in a larger amount to the elapsed time than conventional ink, meaning that the ink has excellent drying property. Furthermore, the ink was investigated whether thickening and agglomeration can be controlled when the solvent evaporates to secure reliability of drop ejection from the print head by selecting alcohols having no adverse impact on the pigment dispersability. Fig. 5 is graphs illustrating the viscosity of the ink when the solvent evaporates in comparison with conventional ink.

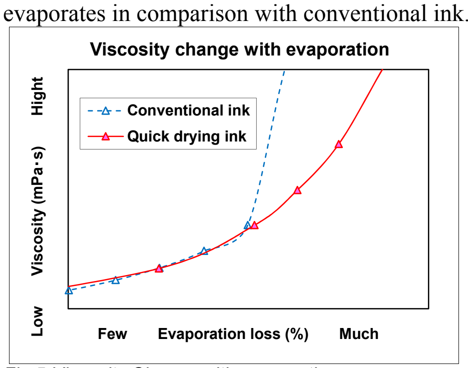


Fig.5 Viscosity Change with evaporation.

As seen in Fig. 5, while the viscosity of the conventional ink sharply rises, the viscosity of the quick drying ink rises gently. Accordingly, the viscosity increase is suppressed when the ink dries inside heads and drop ejection of the ink is restored at head maintenance, thereby to obtain good reliability of drop ejection.

4. Protector Coat Liquid (PCL)

4.1 Composition of Protector Coat Liquid

PCL was developed as a new supply to impart abrasion resistance to printed images. In the process in which the UCL and QDI described above are combined, formed images utilize pigment agglomeration and gelation so that attachability between particles in a dot is secured. However, the strength of attachment at the interface between the surface of coated paper to which the UCL is applied and the ink layer may deteriorate or become uneven, which increases the risk of peeling-off of the image from the medium due to the concentration of stress particularly in a process or state in which abrasion with a medium having a high friction coefficient occurs. Therefore, the following countermeasures are taken, (1) to form a uniform layer to secure the strength of ink film and (2) to reduce the surface friction coefficient of the surface of an image to increase slidability. For this reason, a third layer is required, that is, a protective layer by PCL. Formation of the third layer contributes to amelioration of gloss as a result of the uniformity of formed images. To form a uniform layer, it is necessary to fill gaps between dots with resin components to increase attachability therebetween. To fill such gaps, it is effective to use resin emulsion. The protective layer is formed immediately after the PCL lands on an image and the formed layer on ink has abrasion resistance and shock resistance. With regard to layer forming, it is necessary to select resins with a focus on the minimum film formation temperature (MFT). Moreover, addition of a lubricant is effective to reduce the surface energy after film forming. Abrasion resistance can be improved by using these two materials.
Fig. 6 is pictures illustrating the process of film forming of a resin.

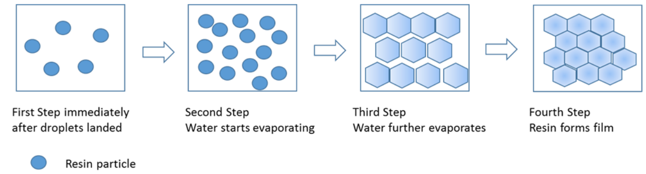


Fig.6 Film-forming process.

4.2 Mechanism of Improving Abrasion Resistance

The resin, which is the key material to improve abrasion resistance, needs to form a layer after it lands on an image. Mainly materials having an MFT lower than room temperature were investigated. Moreover, to decrease the surface energy of the film after film formation, a lubricant component was added to reduce the surface friction coefficient. Fig. 7 is pictures illustrating this concept.

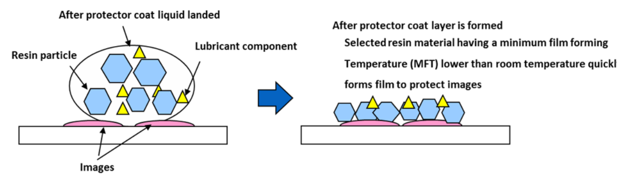


Fig.7 Concept for reduction of surface friction.

We focused our attention on two characteristics as liquid characteristics to impart abrasion resistance. (1) film formation after ink droplets land and (2) reduction of the surface energy of the film. The PCL was developed by the combination of them. The abrasion resistance of the film formed on an image was evaluated.
Abrasion resistance was evaluated according to smear fixing test. The abrasion conditions were refered to JIS LO849 (Test methods for color fastness to rubbing). 4) Fig. 8 and Fig. 9 are pictures illustrating the results of image fixability evaluation before and after the test and with or without PCL.

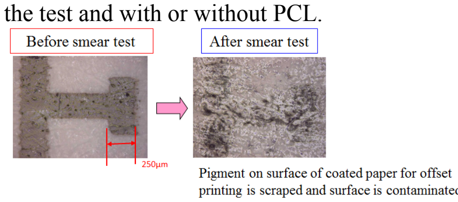


Fig.8 Smear Test result (No Protector coat applied).

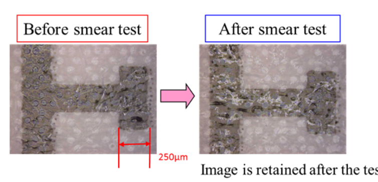


Fig.9 Smear Test result (Protector coat applied).

5. Outcome and Development in the Future

By providing three supplies of the undercoat liquid (UCL), the quick drying ink (QDI), and the protector coat liquid (PCL), images free from problems of beading and peeling-off of an image can be

formed on coated paper for offset printing on which an aqueous ink is never or little absorbed. That is, good images free from beading are formed by the UCL. Image drying properties and reliability of drop ejection are compatible by QDI. Abrasion resistance on coated paper for offset printing is improved by PCL.
From now on, we are going to satisfy the customer's need by improving print performance and increasing compatibility with various print media.

References

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[4] JIS LO849 Test methods for colour fastness to rubbing

Author Biography

Yuuki Yokohama received his M.E. in materials engineering from Tohoku University in Japan in 2005. He joined Ricoh Company Ltd. in 2005. Since then he has been engaged in development of inkjet materials.