INK TRANSFER MECHANISM IN OFFSET PRINTING PROCESS

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Abstract: This paper describes the mechanisms of an ink transfer in offset printing process. It is found that the ink layer on the dot resin of PS plate is a mountain shape. The mountain shaped ink layer on resin dot is transfered to gum blanket by printing pressure, and at that time, the dot gain takes place. The square dot changes to the circular one on the blanket and increases about 10 - 25% in dot size. If other printing condition is constant, the supply variation of a fountain solution on the dampening rollers slightly influence to the total ink layer thickness on dot resin of PS plate. Therefore, the ink dot size on printed paper little changes, but the ink layer thickness and its shape of printed dot on paper is changed by the variation of the fountain solution on the dampening rollers. The ink transfer mechanisms at the three positions in lithographic printing, that is, the ink transfer from inking roller to PS plate to blanket and blanket to paper are discussed by phenomenological model.

Introduction

It is well known that the halftone represents the approximate tonal distribution of a picture element, pixel, by varying the size, shape and thickness of a halftone dot. Changes in size, shape or thickness can affect tone reproduction, resolution, image sharpness and overal appearance. The size of a dot in a final lithographic halftone print is usually increased from that produced on the plate; this phenomenon is known as "dot gain". It is generally thought that the effect occurs principally as a consequence of the pressure between the plate and blanket and also between the blanket and substrate.

In order to provide optimum reproduction quality, it is necessary to identify and understand all important causes of changes in dot area, dot shape and dot thickness in

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lithographic offset printing. In particular, it is important to understand the ink transfer mechanism at the following three nips on running machine:

(1) Inking roller to the plate
(2) Plate to the blanket
(3) Blanket to the paper

With this in mind, a series of investigations was planed and carried out to understand the size, shape and thickness of a just inked dot on pre-sensitized plate (PS-plate), of a dot on blanket and of a dot on paper, and the effect of fountain solution supply to the ink transfer.

Experimental

The materials and machine used in this experiment are described below.

Dot image:	150 line/inch halftone 12 step wedge
Plate:	Fuji Film FDP Pre-sensitized plate
Ink:	Process color offset ink-magenta or cyan (Dainippon Ink Chemical Ind.)
Paper:	Art coated paper (90 Kg/m^2)
Machine:	Roland Ohenbacher M. offset machine
Blanket:	Gum blanket S-5300 (Kinyosha)
Fountain Solution:	Acid type
Speed:	6,000 impresions/hour

In order to obtain the samples which have inked dots on PS-plate, blanket and paper under running condition, respectively, the following procedures were carried out.

1) Inked dots on PS-Plate

When the printing by offset machine was continuously carried out and the prints having the constant image quality were obtained, the contact of all rollers on machine was momentarily separated just after ink-transfer from inking roller to PS-plate. We could obtain the PS-plate sample just after inking in printing.

2) Inked dots between plate and blanket

During the offset pinting under standard condition, the contact of all rollers of the machine was momentarily separated just after ink-transfer from PS-plate to blanket. We could obtain the blanket which ink was just transfered from PS -plate and the PS-plate which just gave ink to blanket.

3) Inked dots on paper

The printed papers just before which above mentioned oparations were performed were used as a sample for the dot observation. The dot images were observed by microscope and the microphotography of the images were taken of 150 magnifications.
The reflective illumination in dark field or bright field was used as the lighting system of an microscopic object.

Fig. 1 shows four positions of size measurement of a dot on microphotographic prints.

Inked dots at each ink transfer position

Photo. 1 shows inked dots on PS-plate, blanket and paper, respectively. Photo. 1 - a is the resist images on PS-plate. The thickness of the resist dots is about 2 um and its surface is uneven. Photo. 1 - b shows the inked dots on PS-plate just after ink transfer from inking roller. Table 1 is the dot size measured before and after inking on PS-plate. Then we find from Photo. 1 - b and Table 1 that ink is adhered only on a resist dot and no dot gain takes place on PS-plate under appropriate printing conditions. The ink shape on the resist dot is the mountain shape as shown in Photo. 1 - b and Photo. 2. A typical example of mountain shape ink layer is shown in Photo. 2 - b, which is the dot images inked by the proof printing machine.

Photo. 1 - d shows ink dots on blanket just after ink-transfer from PS-plate to blanket, and Photo. 1 - c shows its residual ink dots on PS-plate just after which gives ink to blanket. The ink dot on blanket takes place dot gain, that is, the dot shape changes from square to larger circular dot in some degree.

Photo. 1 - e shows ink dots on paper. The dot size of printed papers is slightly smaller than that of blanket.

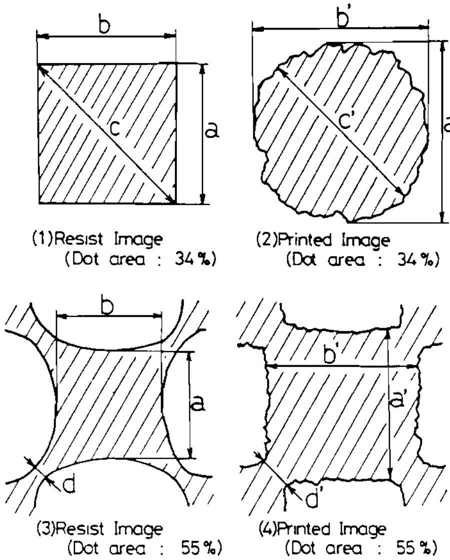


FIG. I MEASURED POSITION OF DOT SIZE (a, a'; LENGTH, b, b'; WIDTH, c, c'; DIAGONAL, d, d';CHAINED WIDTH)

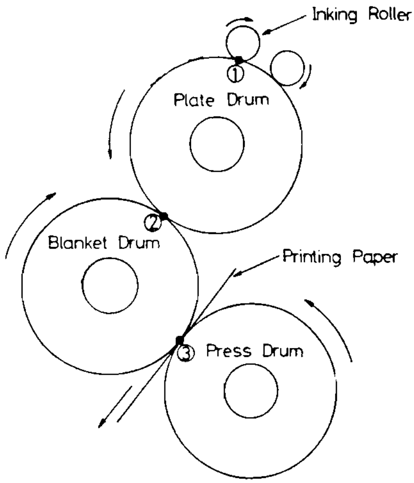
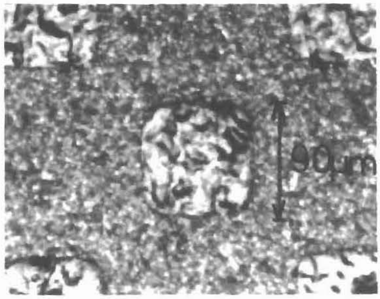
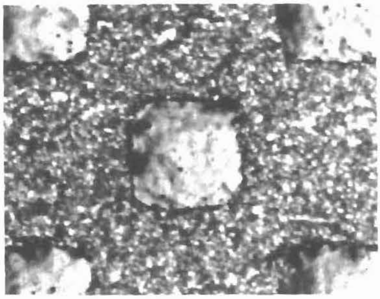


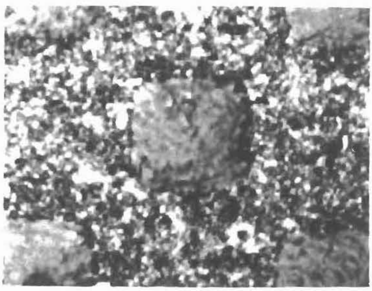
FIG. 2 INK TRANSFER OCCURING AT THREE POINT (1, 2, 3) IN OFFSET PRINTING PROCESS ON MACHINE

(a) resist images on
PS plate

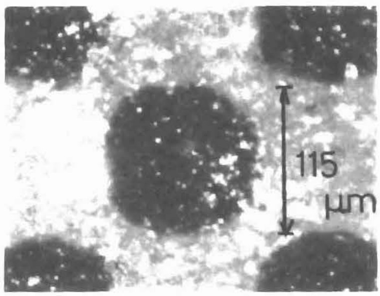


(b) inked dots on
PS plate



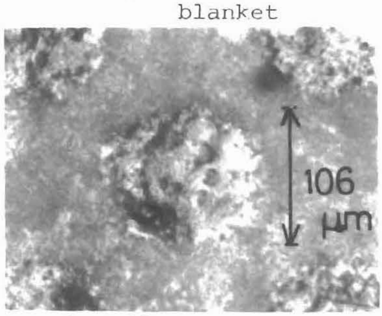


(c) residual ink on
resist images

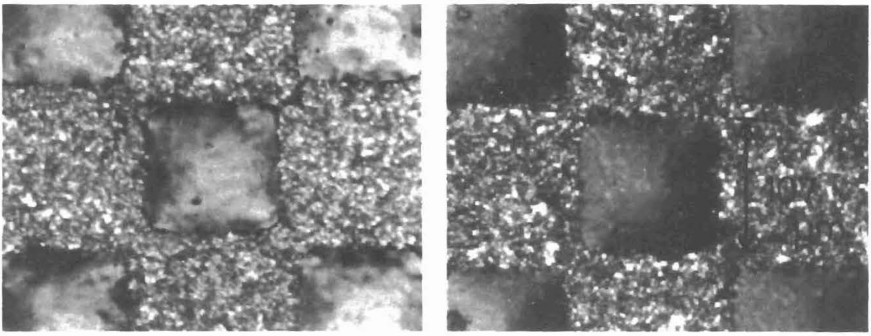


(d) inked dots on
blanket

(e) inked dots on
paper



Phot. 1 Changes of dot shapes in offset printing process



(a) (b)

Phot. 2 (a) Inking dot images on PS plate by offset printing
(b) Inking dot images on PS plate by Proof offset printing

dot (%)	a		b		c or d	
	inkless	ink on	inkless	ink on	inkless	ink on
4	24.08	24.50	24.40	24.88	22.36	22.74
8	37.40	37.45	36.59	37.77	35.26	35.47
14	53.39	54.57	54.89	55.43	55.37	55.48
24	74.37	75.65	76.13	76.77	83.73	84.85
34	86.56	87.53	87.42	87.79	105.72	106.20
45	99.30	99.35	99.24	99.67	127.92	129.10
55	110.21	110.26	111.60	111.82	10.81	10.97
66	122.03	123.16	124.44	124.98	34.13	34.78
76	134.07	134.87	132.52	134.02	54.73	54.84
86	156.22	157.50	158.95	160.55	84.48	84.64
92	171.25	172.54	174.30	175.69	99.62	100.58
96	184.48	184.58	184.41	184.79	117.54	117.91

TABLE. I AVERAGE VALUES OF DOT SIZE OF RESIST IMAGES (um)

This phenomenon have been observed in every dot percent having some difference in the magnitude of size decrease.

It have been concluded from Photo. 1 that the dot gain talks place mainly on blanket by nip pressure.

Ink transfer from inking roller to PS-plate

As shown in Photo. 2, ink layers on resist dots are a mountain shape. The cross sectional model of the ink layer on resist dot is shown in Fig. 3. From this shape, phenomenological model of ink transfer process from inking roller to PS-plate have been proposed as shown in Fig. 4. The mountain shape of the ink layer on resist dot remarkably appears in isolated dots less than 55% dot size, although this mountain shape phenomenon occurs at every dot percent. It is very important that the ink layer on resist dot as shown in Fig. 4-6 contains fine particles of fountain liquid inside the layer.

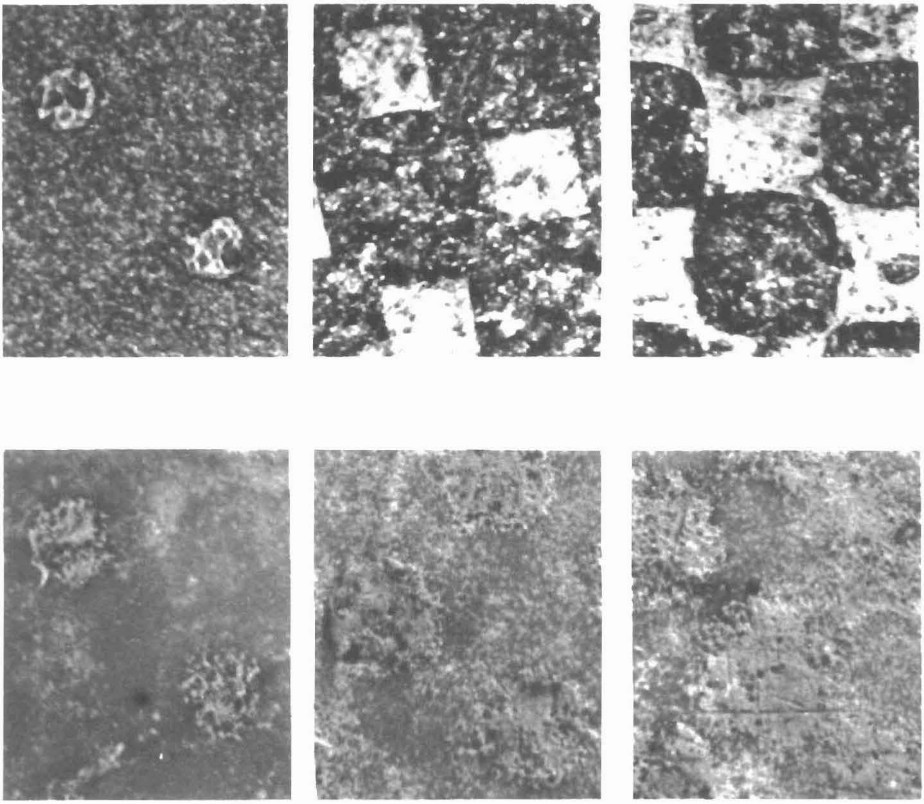
Ink transfer from PS-plate to blanket

The mountain shape ink layer on resist dots was pressed between PS-plate and blanket, and at that time was spread out the form of concentric circle as shown in Fig.5. As a result, a square dot changed to larger circular one and a pincusion dot changed to larger square one as shown in Photo.3.

Photo.4 is the microphotography of the same dots on blanket taken under bright or dark field illumination. The dark spots inside ink dot in Photo.4-a or the blight spots inside ink dot Photo.4-b are spherical holes without ink or with thinner ink. It is thought that the fountain solution may be responsible for the hole formation of ink layer as mentioned at later section.

From these phenomena, phenomenological model of ink transfer process from PS-plate to blanket have been proposed as shown in Fig.6. In the figure, Fig.6-(1) to (4) are the pressing process and Fig.6-(5) to (8) are the separating process.

Fig.6-(8) shows the residual ink layer after giving ink to blanket on resist dot. The residual ink layer shall be held the constant shape and thickness under the steady conditions of the printing sequence. At first, the fountain solution was supplied on residual ink layer and grained Al surface of PS-plate, and then ink was supplied on wetted residual ink layer. Therefore, as shown in



a) circular dot   b) squar dot   c) pincushion dot

Phot. 3 Difference of dot shape between resist images on PS plate and ink images on paper

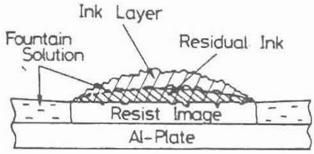
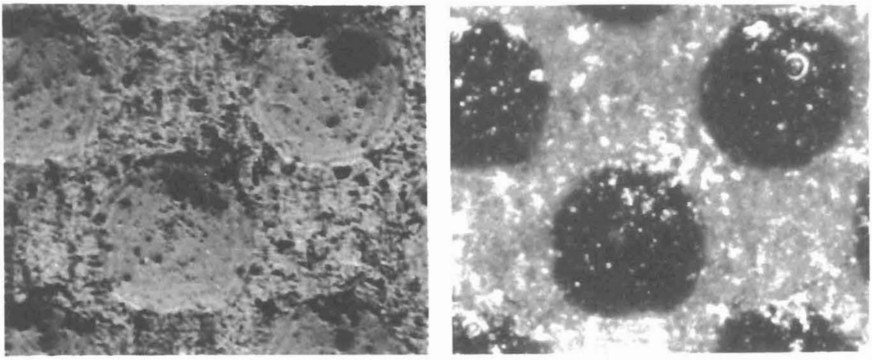


FIG. 3 PHENOMENOLOGICAL MODEL OF THE INK LAYER ON A RESIST IMAGE



(a) (b)

Phot. 4 Transfered ink images on blanket
(a) Under the bright field illumination
(b) Under the dark field illumination

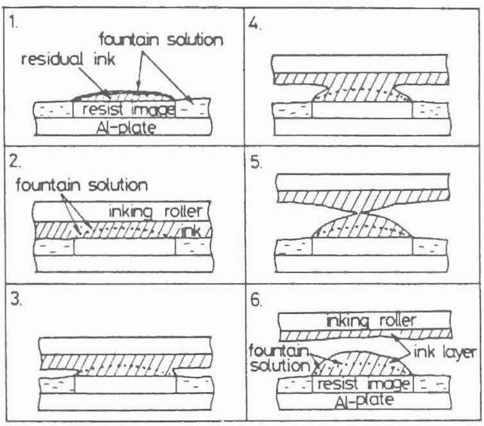
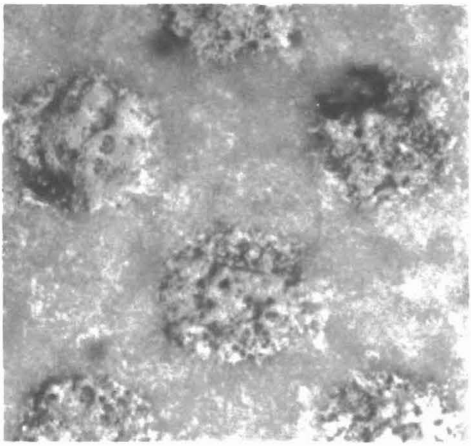
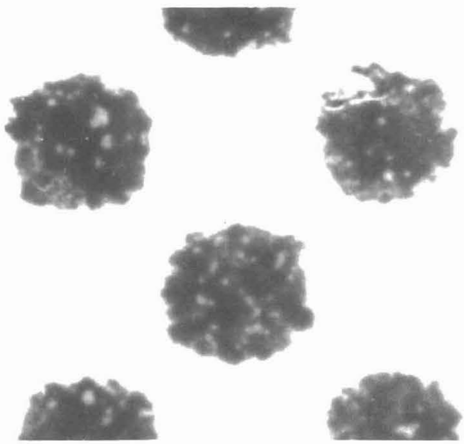


FIG. 4 PHENOMENOLOGICAL MODEL OF INK TRANSFER MECHANISM FROM INKING ROLLER TO PS PLATE



(a) Bright field



(b) Dark field

Phot. 5 Transfered ink images on paper

Fig.4 and Fig.6-1, the ink layer being available for transfer is upper layer from the interface which contains fine liquid particles inside ink layer on resist dot.

It is important to obtain the print materials having stable and good quality that the shape and thickness of the upper layer of inked resist may be held always constant in printing sequence.

Ink transfer from blanket to paper

As shown in Photo. 1, it is seen that no dot gain takes place in ink transfer from blanket to paper under optimum printing conditions. The surrounding of ink dot on paper is seen an indented dot, compared with the dot on blanket. This phenomenon is possibly caused by the unevenness of paper surface. The model to illustrate the ink transfer from blanket to paper is shown in Fig.7. The free surface of ink dot on paper, which is ink interface of blanket side, is unevenness. The deep or shallow holes of spherical mode may be caused by small particles of fountain solution presenting inside ink layer.

Effect of fountain solution

Supplying the fountain solution was changed in three levels, that is, 50% as optimum level, 30% as decreased level and 90% as increased level.
The microphotographic dot images of the obtained paper samples are shown in Photo.6. Fig.8 shows dot gain under different printing conditions.

It can be understood from Photo.6 and Fig.8 that there is no significant change in dot size with dampening level, but the shape and thickness of the inked dot are evidently affected.
Fig.9 shows the model to illustrate the influence of fountain solution supply to ink layer thickness and its shape on PS-plate. It is suggested that the physical meaning of ink/water balance is to be held constant at the thickness of the upper ink layer of a dot as shown in fig.9.

Effect of inking level

Inking supply was changed in three levels, that is, zero as optimum level, +20 as increased level and -20 as decreased level under optimum level of fountain solution

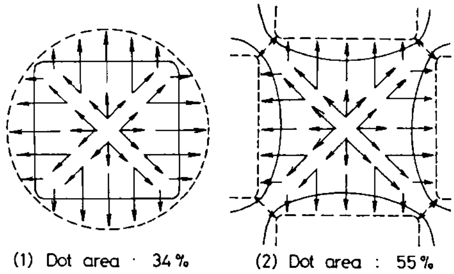


FIG. 5 MOVEMENT OF THE INK ON BLANKET BY PRINTING PRESSURE

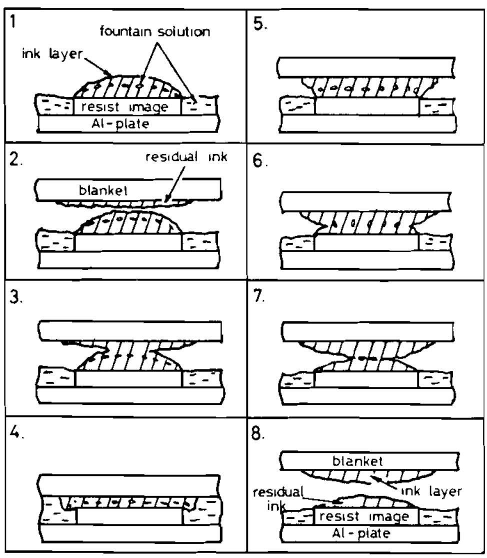


FIG. 6 PHENOMENOLOGICAL MODEL OF INK TRANSFER MECHANISM FROM PS PLATE TO BLANKET

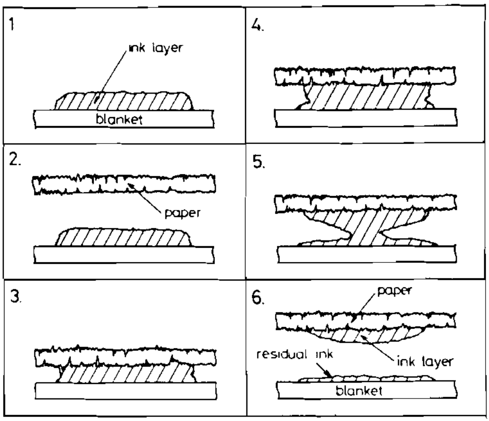


FIG. 7 PHENOMENOLOGICAL MODEL OF INK TRANSFER MECHANISM FROM BLANKET TO PAPER

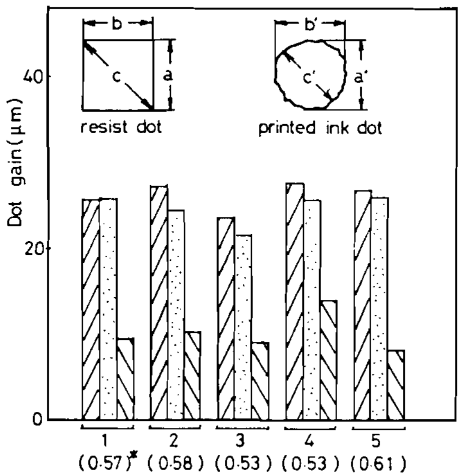
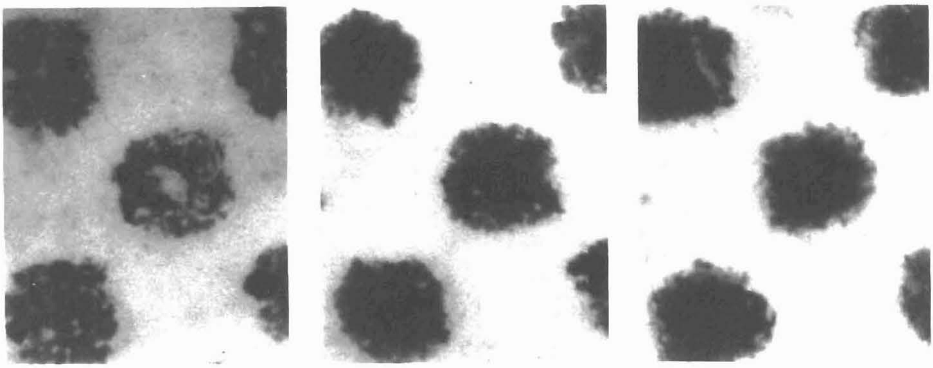


FIG. 8 DOT GAIN UNDER DIFFERENT PRINTING CONDITIONS
DOT GAIN (A, B, C) ARE DEFINED AS:

A=a'-a B=b'-b C=c'-c

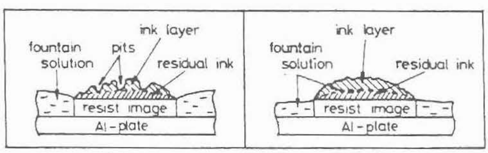
PRINTING CONDITIONS
1; NORMAL CONDITION
(INK SUPPLY ±0%, FOUNTAIN SOLUTION 50%)
2; INK SUPPLY UP (+20%)
3; INK SUPPLY DOWN (-20%)
4; FOUNTAIN SOLUTION UP (90%)
5; FOUNTAIN SOLUTION DOWN (30%)

* DIFFUSE REFLECTION DENSITY



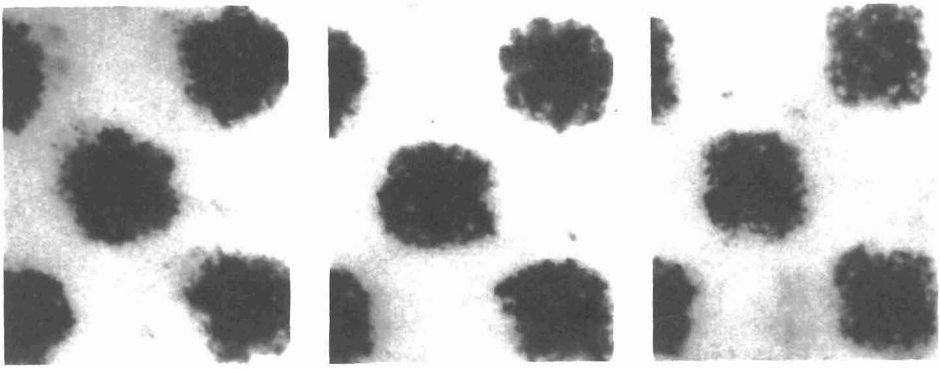
(a) (b) (c)

Phot. 6 Influence of fountain solution to inked dots on paper
(a) Fountain Solution Up (90%)
(b) Normal Condition (50%)
(c) Fountain Solution Down (30%)



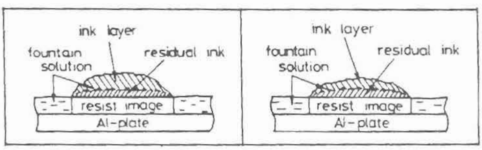
(a) (b)

FIG. 9 PHENOMENOLOGICAL MODEL OF THE INFLUENCE OF FOUNTAIN SOLUTION TO INK LAYER THICKNESS ON PS PLATE
(a) INCREASING OF THE AMOUNT OF FOUNTAIN SOLUTION
(b) DECREASING OF THE AMOUNT OF FOUNTAIN SOLUTION



(a) (b) (c)

Phot. 7 Difference of inked dots on paper in the case of the changing ink supply
(a) Ink Supply Up (+20%)
(b) Normal Condition (± 0%)
(c) Ink Supply Down (-20%)



(a) (b)

FIG.10 PHENOMENOLOGICAL MODEL OF THE INDLUENCE OF INK SUPPLY TO INK LAYER THICKNESS ON PS PLATE
(a) INCREASING OF THE AMOUNT OF INK SUPPLY
(b) DECREASING OF THE AMOUNT OF INK SUPPLY

supply.

The microphotographic dot images of the obtained paper samples are shown in Photo. 7. It may be seen that more or less quantity of ink supply is capable of affecting both size and thickness of inked dots on paper. Fig. 10 is the model to illustrate the influence of different inking level to ink layer thickness on SP-plate.

Conclusions

In this paper, we have mentioned the importance of observing microscopically one dot under printing sequence. Supplying level of fountain solution does not significantly affect dot size but can increase the number and size of white spots in inked dot and decrease the ink layer thicness as the supply becomes excessive. Ink transfer mechanisms in lithographic printing process have been proposed.

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