Variation of Gravure Printing Characteristic Curves

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Abstract: Gravure characteristic curve reflects the process of dot transmission. In order to explore the influence of the various factors on the printing characteristic of gravure, the printing samples were made on a gravure press with different ink cell shapes, ink viscosity, paper types and reducer component. Curves of printing characteristic were drawn and analyzed. The results showed that these factors all had certain influence on the printing characteristics such as contrast, dot gain, and tone jump on the pressworks.

Keywords: gravure; printing characteristic curve; ink cell shape; ink viscosity; reducer

1. Introduction

In China the proportion of gravure in packaging printing improves steadily due to its features like ink layer thickness, bright and uniform color, rich and distinct layers, strong feeling of stereo [1]. However books and relevant researches on gravure are limited. At the same time, since the ink of gravure transmits directly from the ink cells to the surfaces of the printing stocks, it is different from offset in the process of ink transmission and layer reappearance etc. Thus the study on gravure is imperative [2]. Liquid ink is adopted for gravure. Factors like viscosity of ink, ratio of reducer, ink cell shape and the choice of paper have great influence on the quality of prints. Herein, printing characteristic curves were established as a result of experiments. The influence of various factors on printing characteristics was discussed. The law of dot transmission of gravure was explored.

2. Influence of Ink Cell Shape on Characteristic Curve of Gravure

2.1. Ink Cell Shape

Gravure ink cells, formed by electro-graving, were determined by the shape of engraving needle, frequency of electro-graving and cylinder rotational speed. There are three kinds of shapes of ink cells including square, diamond and rhomboid shown in Fig. 1. Square-shaped

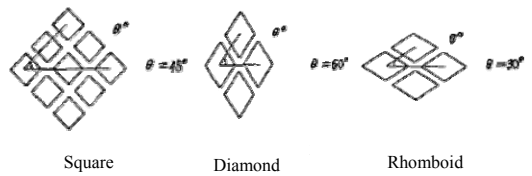

Figure 1. Ink cell shapes.

ink cell is also called standard ink cell with an angle of 45°. It is No. 3 or 4 ink cell. Diamond-shaped ink cell is No. 2 ink cell with an angle of 60°. Rhomboid-shaped ink cell is also called compression-type ink cell with an angle of 30°. It is No. 0 ink cell. In the actual engraving, the angle of ink cells can vary between 30° to 60°. The four types of ink cell were shown in Fig. 2.

2.2. Printing Characteristic Curve of Gravure

Using HELL electro-graving machine, total ten-level gradient color batches were engraved with different angles on gravure cylinder with transverse diagonal length of ink cell from 62 to 212 μm in order to draw printing characteristic curves. At the same time, bar chart was also engraved showing continuous shifts with transverse diagonal length from 0 to 212 μm in order to observe the tone jump during dot transmission. The specimen pages were printed on gravure press using coated paper with grammage of 120 g/m^2 and ink with viscosity of 35s. The densities of every color batch on the above gravure pages of No. 0 compression ink cell were tested using X-Rite spectrodensitometer. The corresponding printing characteristic curve was shown in Fig. 3. It could be seen that for printing characteristic curve of gravure, there were three specific zones including zone of beginning tone, zone of tone jump and zone of density saturation. In the zone of beginning tone, the densities of presswork were close to those of paper

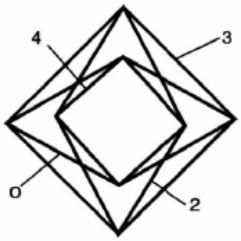

Figure 2. Four types of ink cell.

and the reappearance of tone was not ideal. It was because the ink cell was too small which affected the sufficient transfer of ink. With the increase of transverse diagonal length, the densities of presswork also increased. After entering the zone of tone jump, densities increased sharply and the phenomenon of tone jump appeared. Be

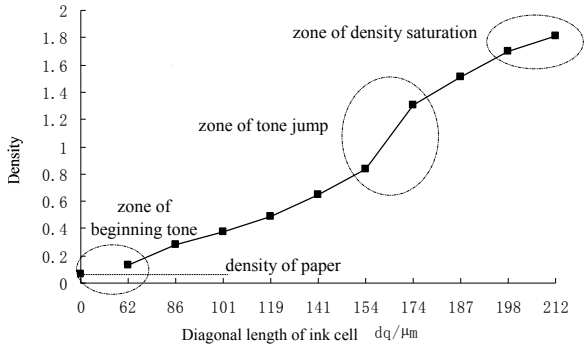

Figure 3. Printing characteristic curve of gravure.

cause of the pressure of printing, ink spreaded at wall. When ink cell expanded to a certain level, the dots on presswork contacted each other at the fringe leading to the above phenomenon. With the continuous increase of transverse diagonal length, the increase of densities of presswork slowed down leading to zone of saturation.

2.3. Influence of Ink Cell Shape on Characteristic Curve of Gravure

The printing results with different ink cell shapes were shown in Fig. 4, where the printing characteristic curves of samples printed using No. 0, 2, 3 and 4 ink cells were drawn respectively. No. 4 ink cell is square-shaped thin ink cell. Its curve had the smallest slope among the four curves. In the zone of beginning tone, it had relatively bigger density. It meant that ink transferred quite well, which was probably due to larger number of dots in thin ink cells. There was no obvious tone jump. It was different from the situation of mutual contact of dots for ink cells with other shapes. It was beneficial for the detailed reappearance of middle tone of images. In the zone of density saturation, the extent of increase of density

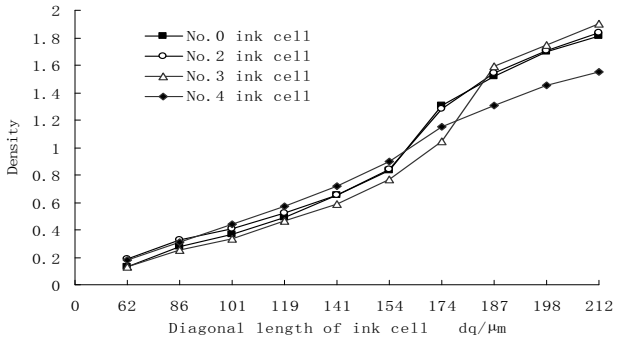

Figure 4. Printing results for different types of ink cells.

Table 1. Ink with different viscosity

No.	Viscosity	Ratio of Tusche to reducer
INK1	28s	2:3
INK2	35s	2:3
INK3	60s	2:3

obviously decreased and maximum density was the smallest among four curves. It might because thin ink cell was shallow in shaded area and the transfer of ink was not prominent, which caused the decrease of contrast value of presswork. Thus No. 4 ink cell was not suitable for printing light color like yellow, or even magenta and cyan. However it was commonly used for black.

No. 3 ink cell is square-shaped thick ink cell. Its curve had a low density in the zone of beginning tone and the transfer of ink was poor. However the density increased in zone of tone jump and the transfer of ink was better. It was probably because there were fewer dots in the tinted area of thick ink cells while dots were darker with more ink in shaded area. Thus the contrast value of the whole presswork increased. Therefore No. 3 was usually used for yellow to compensate for the inadequate contrast for yellow while printing. It could be seen in Fig. 4 that the tone jump of No. 3 ink cell curve lagged, which was unlike the appearance of tone jump at 50% area of square-shaped dots of offset printing. No. 3 ink cell had the biggest range of tone jump, which had certain influence on the reappearance of image layer.

Rhomboid-shaped No. 0 ink cell and extension No. 2 ink cell were all diamond-shaped ink cells, whose curves almost overlapped. In the zone of beginning tone, densities of No. 2 were bigger than those of No. 0 indicating the transfer of ink of No. 2 in tinted area was better. For the entire curve there was a distinct tone jump, which had certain influence on image layer and was different from two tone jumps for chain-shaped dots of offset.

3. Influence of Ink Viscosity on Characteristic Curve of Gravure

Using No. 0 ink cell with 63 l/cm, coated paper with grammage of 118 g/m^2 and ink with different viscosities shown in table 1, experimental specimen pages were obtained on gravure press. Ink was obtained by mixing Tusche (TR10-900014-1.710) and reducer (TR15-000029-7.1710) with the ratio of 2:3. Afterwards dimethylbenzene was used as diluent to adjust the viscosity

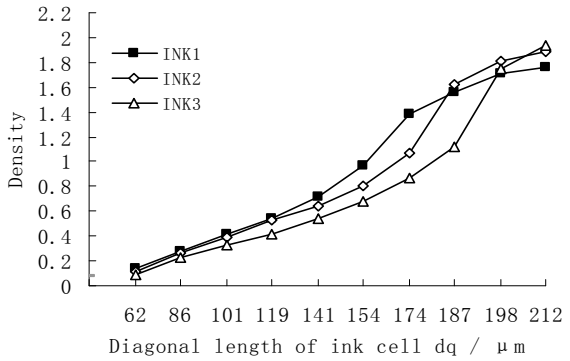

Figure 5. Influence of viscosity of ink on characteristic curves of gravure.

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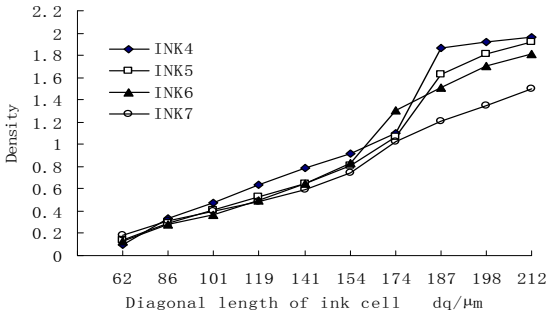

Figure 6. Influence of reducer on characteristic curves of gravure.

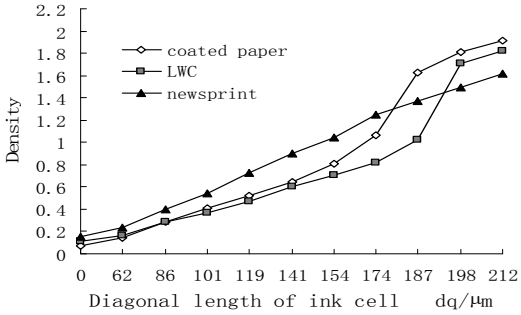

Figure 7. Influence of paper types on characteristic curves of gravure

of ink. Viscosity was determined using Zahn cup with the diameter of pore as 3 mm. The printing results were shown in Fig. 5.

Compared to curve INK2 which was selected as reference, the minimum density of curve INK1 was bigger. Tone jump was ahead of time and the extent of jump was smaller. In the zone of saturation, the slope of curve decreased distinctly and the maximum density was smaller. For curve INK3, minimum density was smaller, tone jump lagged, the extent of jump was bigger, maximum density was slightly bigger. The addition of diluent made the viscosity of ink decrease which was beneficial for the transfer of ink and the ink was more likely to spread at the wall. As a result, the density increased in zone of beginning tone and the tone jump was brought forward. Therefore the position of tone jump of gravure in the printing characteristic curve was not like that of offset printing, and the latter depended completely on the shapes of dots. However the gravure depended not only on the shapes of dots but also on the spread factor of ink at wall, which was affected by the ink viscosity and the absorption condition by paper. Understanding the change of position of tone jump of gravure in printing characteristic curve could provide important guidance for the loyal reappearance of printing tone and color.

4. Influence of Reducer on Characteristic Curve of Gravure

The parameters of ink were shown in table 2. The printing results on coated paper with grammage of 118 g/m^2 were shown in Fig. 6 using different ratios of ink and reducer. For INK4, the tone jump during printing

Table 2. Characteristic of ink with different mixture ratio

No.	Ratio of Tusche to reducer	Viscocity	ink cell Shape
INK4	1:0	35s	No. 0
INK5	2:3	35s	No. 0
INK6	1:2	35s	No. 0
INK7	1:4	35s	No. 0

was the most obvious and also it had the maximum density in the zone of saturation. With the increase of the proportion of reducer, the extent of tone jump decreased slowly, the slope of the curve decreased, the contrast of presswork reduced and the color in shaded area became pale.

5. Influence of Paper Type on Characteristic Curve of Gravure

Using INK 4 and No. 0 ink cell, experiments were performed on coated paper (118 g/m^2), light weight coated paper (LWC) (85 g/m^2) and newsprint (80 g/m^2) with the results shown in Fig. 7. It could be seen that the choice of paper had significant influence on the reappearance of image layer of gravure. For coated paper, there was relatively bigger tone jump. The contrast of presswork was the biggest. For LWC, the contrast was relatively big, reappearance of middle tone area was good but there was big tone jump in shaded area. With the increase of density, the change of printing density of newsprint presswork was most gentle. The phenomenon of tone jump almost disappeared and the contrast of presswork was minimum, which was due to the good absorption property of ink by newsprint.

6. Conclusion

There are three specific zones including zone of beginning tone, zone of tone jump and zone of density saturation in printing characteristic curve of gravure. The difference of ink cell shape will change the range of dot tone jump and the contrast of presswork. The printing characteristic of curve of No. 4 ink cell was relatively smooth and the contrast of presswork was minimum with no obvious tone jump. The printing characteristic curve of No. 3 ink cell had the maximum range of tone jump and the contrast of presswork was also maximum. The decrease of ink viscosity led to the decrease of contrast of presswork, increase of minimum density, advance of tone jump, decrease of the extent of tone jump and the decrease of maximum density. The increase of reducer proportion caused the extent of tone jump decrease slowly,

the slope of characteristic curve decrease, the contrast decrease and the color in shaded area become pale. The change of paper type had big influence on the reappearance of image layer of gravure. There was bigger tone jump in middle tone for coated paper and the contrast was the biggest. For LWC, the contrast was big and the reappearance in middle tone was better. However there was big tone jump in shaded area. For newsprint, the contrast was the smallest and the tone jump was not distinct. Factors like shape of ink cell, type of paper, ink viscosity and the proportion of reducer had great influence on the printing characteristic of gravure and reappearance of image layer. The deep investigation of the printing characteristic curve under different conditions can provide guidance for the loyal reappearance of printing tone and color.

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