INFLUENCE OF INK CHARACTERISTICS AND OPERATING CONDITIONS ON ROTOGRAVURE DOT SHAPE AND COLORIMETRIC READINGS

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1. INTRODUCTION [1,2,3,4,5,6,7]

The rotogravure decoration technique has occupied quite an important place in the modern ceramic tile industry. Basically the technique consists in applying a series of ink dots over the tile surface. Together the dots form a pattern that can't be seen as isolated points by the naked eye. The principle is very similar to the pixels in a computer monitor. In practice, however, depending on the ink characteristics and operating conditions, the dots are not always circular and may be only partially filled with ink. These deviations from the theoretical shape may or may not affect significantly the hue of the decorated tile. Several studies have studied this decoration technique, however none has actually studied the influence of the ink characteristics and operating conditions on the shape of the dots and how this variable, the shape of the dots, affects the colorimetric readings. So the objective of the present work was to be an initial study in this direction. The studied variables were the viscosity of the ink, the speed of the line, and the temperature of the support. The evaluation was done for different pigments and vehicles in industrial conditions. The characterization of the shape of the dots was done in a digital optical microscope and the colorimetric evaluation was done by a spectrophotometer. The results have shown that the shape of the dots, for the same operating conditions, is different for different inks and that, for the same ink, the line speed affect the shape of the dots. From a colorimetric point of view, variations of the shape of the dots within a certain range do not significantly influences the colorimetric readings. The most important achievements of the present study were the visualization of the dots produced by standard rotogravure cylinders and the practical identification of the limits for the dots characteristics to avoid hue variation. This new approach to the problem may prove useful in future works related to the rotogravure decoration technique.

2. MATERIALS AND METHODS

The inks used were prepared in an industrial laboratory (20wt% pigment, 39wt% flux, 40wt% vehicle and 1wt% bentonite), with a 0.01g precision balance. A mechanical stirrer was used to mix and homogenize the inks, the viscosities being adjusted to 20 seconds in a 4mm Ford cup viscosimeter. Ink applications were done in a Rotocolor® equipment, in synchronous mode, over the unfired surfaces of glazed tiles (white glossy glaze) collected directly from the production line. The band used for all samples was a greyscale with apertures varying from 1% to 100% (1% increments in the 1-10% range and 5% increments from 10 to 100%), recorded at 04/45°. The studied variables were analysed one at a time at two distinct values; the variables were: production line speed (15m/min and 53m/min), tile temperature (34°C and 70°C) and ink viscosity in a 4mm Ford cup (16s and 20s). The printing dots obtained were analyzed in an Olympus MIC-D optical digital microscope, and colorimetric readings were conducted in a Minolta 2600d spectrophotometer with a D65 10° illuminant.

3. RESULTS AND DISCUSSION

Analyses were conducted with four inks with different pigments: a blue, an orange, a green and a black. Results from the blue pigment experiment are presented separately for each variable.

3.1. PRODUCTION LINE SPEED

Figure 1 exemplifies the results obtained with blue pigment at 65% greyscale, showing the printed dots, and Figure 2 shows corresponding colorimetric curves. Results have shown that the speed of production line is a process variable that exerts influence on the shape of printing dots, showing more defined/stable dots when the production line speed is higher, with a direct influence on the sharpness of the design transferred to the tile. It can also be observed a displacement in colorimetric curves, with an increase in luminosity (L) and changes in tonality that generates a colorimetric variation ($\Delta E=8.39$), perceptible by naked eye. A similar behaviour was noticed on experiments conducted with others inks, with exception to the ink with green pigment, which did not presented changes in dot behaviour.

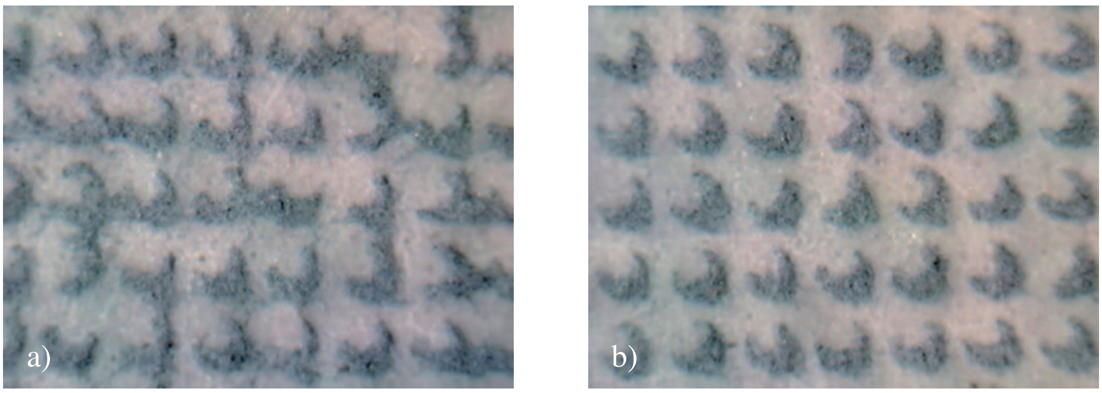

Figure 1. Digital images of blue pigment dots for 65% greyscale with different production line speeds, a) 15m/min. and b) 53m/min.

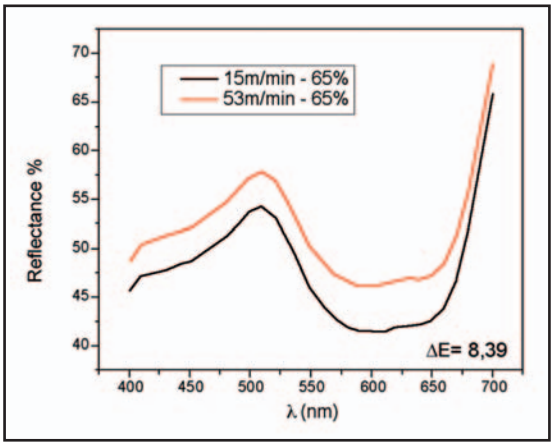

Figure 2. Spectral reflectance of glazed tiles from Figure 1.

3.2. TILE TEMPERATURE

Figure 3 shows the printed dots of blue pigment at 65% greyscale, and Figure 4 presents the corresponding colorimetric curves, tile temperature influence being noticeable. The results obtained do not show, in a general manner, a great influence of tile temperature on dot stability besides a slightly higher stability of dots at low temperature; a similar behaviour was noticed to orange pigment. Colorimetric analysis suggests that the shape of dots do not alter obtained colours, but an influence on luminosity (L) is noticed, in a minor extent (ΔE=1,54).

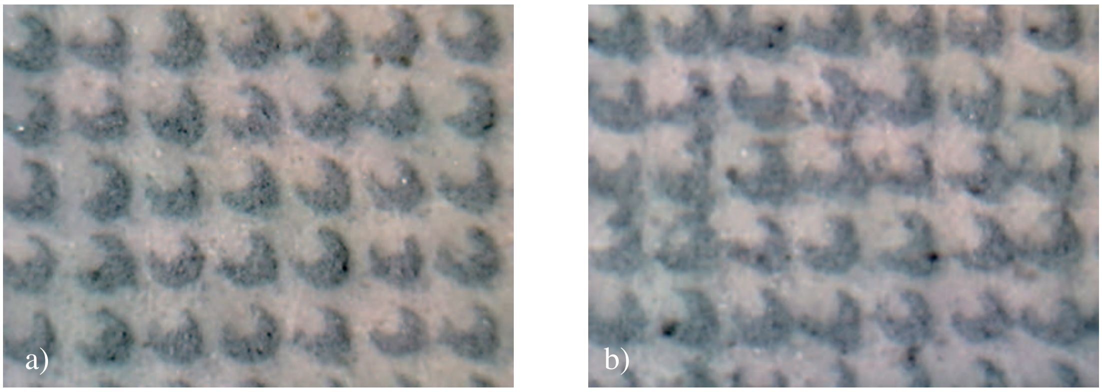

Figure 3. Digital images of blue pigment dots for 65% greyscale with different tile's temperatures, a) 34°C and b) 70°C.

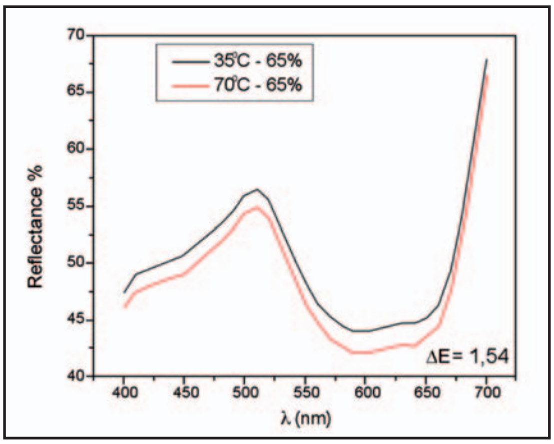

Figure 4. Spectral reflectance of glazed tiles from Figure 3.

3.3. INK VISCOSITY

The printed dots at 80% greyscale of blue pigment ink and the colorimetric curves are presented at Figures 5 and 6, respectively. The viscosity of the inks, as can be observed in the figures, was the variable that had more influence on the shape of printed dots, that seems to be more stable when the viscosity of the inks are higher. The results obtained from evaluated samples with 16s ink viscosity showed that individual dots coalesce into a spot even with the initial greyscale apertures, affecting the sharpness of the design to be applied on tile's surface; similar results were obtained with others inks. Colorimetric analysis suggests that the shape of dots does not exert influence on tile's surface tonality, but a significant influence in L coordinate is observed, resulting in a large colorimetric variation (ΔE=12,54), easily distinguished by the naked eye.

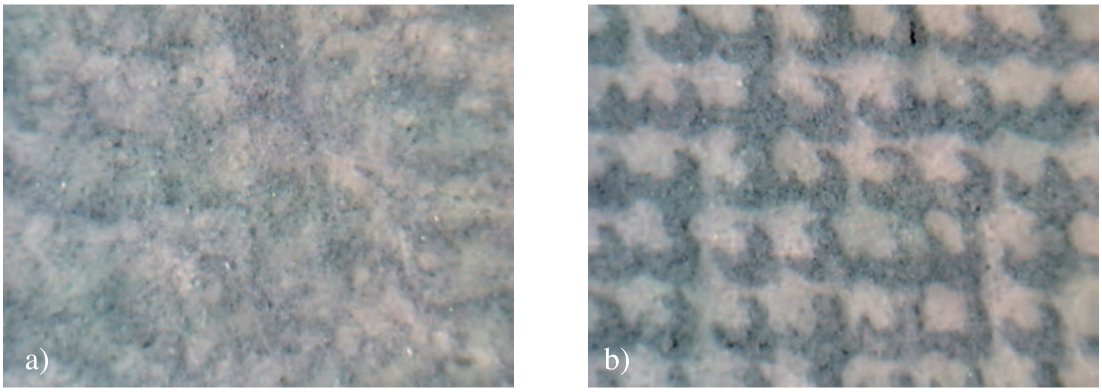

Figure 5. Digital images of blue pigment dots for 80% greyscale with different ink viscosities, a) 16sec and b) 20sec.

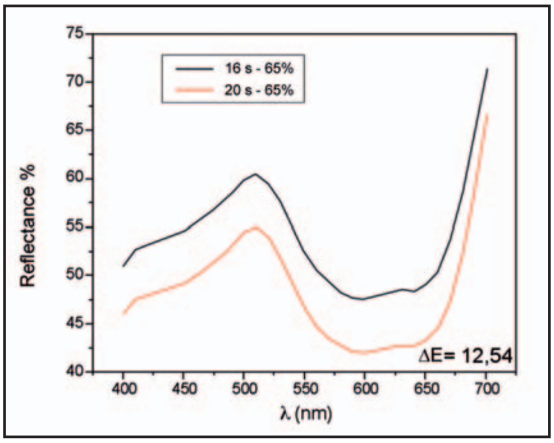

Figure 6. Spectral reflectance of glazed tiles from Figure 5.

4. CONCLUSIONS

The analysis of experimental results shows that the viscosity of the inks and the speed of production line are highly related to the phenomena of lack of stability of printed dots, impairing the appearance of final design transferred to the tile. Changes in tonality were not easily noticeable, but luminosity seemed to be more sensitive to this lack of stability. It could also be concluded that the temperature of the tiles had little influence on dot's shape and chromatic characteristics of decorated tiles.

5. ACKNOWLEDGEMENTS

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