EFFECT OF SCREEN-PRINTING VARIABLES ON SHADES IN TILES

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Colour differences (shades) arise in the manufacture of ceramic floor and wall tiles. Such variations are not always due to a variation in glaze colour but rather are a consequence of unsuitable tile processing specifically in the screen-printing operation.

Current ceramic tile production is typically and extensively decorated by screen-printing. The use of printing screens is the most common method for the application of the decoration. Printing pastes based on organic vehicles of different nature are widely used in transferring the decorating glaze to the body.

Variations arise in colour even with screen-printing glazes and pastes that undergo correct controls from a colour-variation point of view.

It has become necessary to determine the effect of printing screen preparation conditions and screen use, screen-printing pastes, the dynamic behaviour of the vehicles employed, and the screen-printing operation on shades in order to attempt to solve a problem affecting final quality, logistics, production management, and ultimately costs.

In the present study, the process variables were defined, studied and correlated relating to:

- Printing screen preparation
- Conditions of the materials used in screen-printing pastes:
  - Vehicles and nature
  - Screen-printing base and conditions
  - Colour and conditions
  - Screen-printing ink preparation (different preparation methods).
- Screen-printing operation and associated variables (machinery and operation) which can affect colour variability in ceramic tile production.

The variables were studied from two points of view: effect of each, while keeping the others steady, and the relative effect of each, i.e., weighting the ordinal effect of each. To do this the study was divided into two parts:

1st.– Study of all the variables individually, taking into consideration the most significant ones.

2nd.– Study of the most significant variables on applying experiment design to identify the priority of each and their possible interactions.

The data are industrial results obtained under standard working conditions for floor and wall tiles.

A "sericheq" system was designed, which allowed the screen-printing operation variables to be independently and numerically controlled, in order to study the variables in the experiment design, with a view to adequately keeping them independent when this was necessary, without losing sight of the fact that industrial process data were involved

This system was also used to verify the continuity or stability of the screens.

Industrial facilities were used throughout for:

1.– Ink preparation:
   - Colloidal mill
   - Screen and stirrer

2.– Inks (vehicles and glazes)

3.– The vehicles used had an ethylene glycol-diethylene glycol, monopropylene glycol base

4.– Screens. Fabric quality "estal mono"

5.– Printing heads

6.– Screen-printing line

7.– Kiln

To control colour (calculation of ΔE) a Minolta CR-10 colorimeter was used. For the ink employed, a visual colour difference (shade) was found when $\Delta E > 0.5$.

For fabric tension control a SST-Newtontester was used.

Ink particle-size distribution was controlled with a Coulter LS Particle Analyser.

A "sericheq" laboratory system was designed and built to run the trials for squeegee pressure, off-contact and printing rate. The system was fitted with precision elements for controlling these variables.

CONCLUSIONS

In the present study, and as most innovative aspects with regard to studies reported

in the literature, which they complement, are to be highlighted the introduction of fabric tension as a variability factor in the appearance of shades, ink release or open area (with regard to mesh count and thickness). The various influencing factors were made independent by designing specific equipment, the statistical variations were assessed in working conditions, and the variables were controlled in different ranges. Certainty intervals were determined. The foregoing was all carried out with different vehicles and preparation methods to include these factors as correcting elements or simple additional variables (under study).

The following conclusions could be drawn from the results of the study:

1.– Shades:

1.1.– For a single production batch:

- The most significant variables in the appearance of shades in screen-printing were:
    - Screen off-contact from the tile.
    - Variation in the quantity of released solids:
        - Screen clogging:
            - Unsuitable ink particle size/ open area ratio
            - Drying, because of agglomerates (unsuitable wetting), of the ink
    - Variation in rheology between ink batches
    - Variation in squeegee pressure
- Factors of little or no importance:
    - Variation in screen tension
    - Printing rate

1.2. - Between different production batches:

- The most significant variables in the appearance of shades in screen-printing were:
    - Ink solids content
    - Fabric tension
    - Once production had started, the same as under point 1.

2..– The use of the "sericheq" system can help define screen-printing variables, standardising them for the different products to be made.

3.– The production of screen-printed products using ever finer open areas requires previously defining a series of parameters relative to the ink (vehicles and glaze), screen open area, and operating variables.

4.– Systematic control of the screen-printing variables is required (off-contact and squeegee pressure).