EFFECT OF MATERIALS AND PROCESSING VARIABLES ON THE PRESENCE OF SHADES IN CERAMIC TILES DECORATED BY ROTOGRAVURE

J. M. Campos(*), P. Corma(**), J. López(***), F. Lucas(****),

S. Pasquetto(*****), V. Moreno(******)

(*)Cerámicas Diago,(**)QPT, (***)Keros, (****)Fritta, (*****)System, (******)Rocersa

ABSTRACT

Variations in colour (shades) occur in ceramic floor and wall tile manufacture. These variations are not always due to a defect in the variation of glaze composition colour, but are often the result of inadequate processing in ceramic tile manufacture, specifically during the decorating operation.

In current ceramic tile production, roller decoration, specifically the rotocolor (*) system by the firm System, is becoming increasing widespread.

Variations also occur in colour using glaze compositions and decorating pastes, which had been properly controlled from a colour variation point of view. It thus becomes necessary to establish the influence on colour variation of the quality and production of the decorating rollers and their use, of decorating pastes, the dynamic behaviour of the vehicles used and the screen printing operation, as well as the characteristics of the body to be decorated, to be able to address a problem that affects final quality, logistics, production management and, ultimately, Costs.

The present work defines, studies and correlates the process variables of:

- *Decorating roller preparation. Characteristic of the cavity.*
- *Decorating paste component condition:*
  - *Vehicles and their nature*
  - *Screen printing base and additives*
- *Decorating operation and associated variables.*
  - *Characteristic of the body to be decorated and their variation*
  - *Decorating equipment variables (machine and rollers) and their variation*

The results obtained under standard working conditions are presented, both for ceramic floor and wall tiles.

The difference with regard to other previous works, mentioned in the references, which this study supplements, lies in incorporating the new decorating system, which requires reconsidering the variables mentioned in those studies.

The objectives of the present work are:

- To define the variables and working conditions that minimise colour variability in roller decoration.

(*) The term rotocolor is used throughout the work, since it has become a generic term, and not just a trademark.

INTRODUCTION

Rotocolor decoration is the most widely used new method for transferring designs to ceramic floor and wall tile surfaces.

flat screen printing	rotocolor	others
65%	25%	10%

Table 1. Use of the various decorating techniques

Bearing in mind current tile production, about 400,000 square meters are decorated daily by rotocolor application. This provides some inkling of the importance of the technique, particularly considering that the method has been operating for about 4 years.

- ***First a list was made of the defects to be considered within the objectives of the work:***

  - Shades
  - Badly painted sides (no painting)
  - Blurring (badly painted)
  - Badly painted bevelling
  - Difference in intensity on the tile between entry and exit
  - Badly painted hollows
  - Difficulty of working with dark colours

Rotocolor decoration basically consists of depositing a paste (ink) on the item to be decorated. This is done by a roller containing a series of incisions that are filled with ink by means of a rotating system fitted with a doctor blade, which transfers the ink to the tile on contact. The design will depend on the form and distribution of the incisions in the roller.

Overlapping or successive roller applications with their corresponding colours produce the design.

It follows from the above that design fidelity, the fidelity in the repetition of the openings of the incisions in the rollers, will be decisive in the faithful repetition of the colour or tone. In previous works, other influential variables were studied such as firing

and glaze typology (see references). Another issue, of the greatest importance, is the constancy of the roller and machine elements in service . Two factors are thus associated with the roller/tone:

- Constancy in making the same roller when it is ordered on successive occasions
- Constancy in roller working conditions and ancillary elements during in service

The factors to be considered are:

- Geometric forms of the incisions
- Constancy in the filling of the incisions

Rotocolor application involves making inks with a greater colour yield, producing greater sensitivity with regard to tone. Similarly, ink rheology needs to be reviewed in view of type of application and proportioning (ink tanks in closed circuits).

The inks used in the tile industry are mostly concentrated suspensions of solids, with a variable composition involving base frit or glaze, pigment and vehicle.

The Frit (Base or Glaze), as well as the Pigment (Colour, which in the case of roller applications can make up 70 and 80% of the ink composition), are usually milled to adapt their particle size to the mesh aperture of printing screens, and are adequate for the rotocolor operation.

On the other hand, it is necessary to guarantee an appropriate degree of frit and pigment dispersion in the vehicle. This dispersion varies, depending on the method used for mixing and/or milling. To control the degree of dispersion, image analysis can be used.

The vehicles typically found *in flat screen printing* are based on *polyethyleneglycols* of low molecular weight:

- Advantages: Plasticisers and Lubricants
- Disadvantages: Low binding power

The binder addition tries to compensate the previously mentioned disadvantage and allow successive applications without deterioration of the previous coatings (first screen prints). These fixatives are based on: *Polyvinyl acetate and/or polyvinyl alcohol, etc.* This technique brings with it:

- Disadvantage: Sticking, as a result of the drying rate.

During the actual decorating operation, ink behaviour is determined by its rheology. Ideal behaviour would be:

- High viscosity at rest: This impedes dripping and improves definition
- Low viscosity in motion: This improves passage and heightens definition

In the case of rotocolor decoration, the selection of the vehicle will depend on **type of production**: Twice fire or Single fire.

And on the **type of incision** of the roller:

- Standard incision (e.g. 04/45°)
- High definition incision
- Profile incisions (mask or hexagonal)

Required characteristics will be:

- Suspending power
- Wetting power
- Self-fixing power
- Rheology
- Stability in production
- Low surface tension for good wetting

EXPERIMENTAL

Industrial facilities were used throughout:

1.- Ink preparation:

- Colloidal mill
- Sieve and stirrer

2.- Inks (Vehicles plus glazes and additives)

- Ink with a light colour: L=90 where L is the chromatic co-ordinate associated with whiteness (light/dark)
- Ink with an intermediate colour: L = 85
- Ink with a dark colour: L = 75

3.- The vehicles used were:

- Vehicle 1: Base glycols and synthetic resins
- Vehicle 2: Base diethyleneglycol / propyleneglycol

4.- Rotocolor rollers. HD (High definition) quality and quality 0.4/45°

5.- Group of rotocolor decorating cylinders

6.- Glazing line

7.- Kiln

- A Minolta CR-10 colorimeter was used for colour control (calculation of dE). For the inks used, a visual shade was detected when dE>0.5.
- For viscosity measurement, the following were used:
  - Ford cup viscometer
  - Brookfield viscometer and rheometer
- A balance was used, accurate to three decimal points, for measuring deposited ink weight in grams.

RESULTS AND DISCUSSION

POSSIBLE IMPACTING VARIABLES

To determine the possible variables to be studied, a brainstorming sessions was held amongst the members of the team, which is summarised below:

Variable	First level	Second level
Materials and Process Variables	Nature of the body	White or red body
	Spray dried powder particle size	
	Spray dried powder moisture content	
	Tile thickness	
	Number of pieces in the die	Way of loading the cavities
	Tile temperature	
	Shape of the bevel	Possible glaze accumulation
	Moistening	Way of applying the water
	Engobe	Plasticity
		Rheology
		Quantity applied
		Way of applying it
		Particle size
	Glaze	Plasticity
		Rheology
		Quantity applied
		Way of applying it
		Particle size
		Ratio frit / raw materials
		Quantity of colour in the composition
		Glazed tile surface dust
		Green deformation of the glazed tile
		Glaze stretching and absence of irregularities
		Glaze accumulation on the sides (bevel and surface T.)
		Surface moisture of the glaze layer
		Surface porosity of the glaze layer
		Tile temperature
Ink	Micronised material	Particle size
		Specific weight
		Ratio frit / raw materials
		Suspending agent. Additives
	Vehicle	Base typology
		Water content
		Binder content
	Colours	Wettability
		Yield (charge % in the composition)
	End ink	Preparation method
		Component % (micronised material, colour, vehicles, etc)
		Sedimentation
		Surface tension
		Application temperature
		Temperature variations
		Flowability, viscosity, rheology
		Evaporation
		Time of previous rest
Machine and Roller Variables	Roller	Arising surface pressure
		Variation in off-distance

		Dot shape and distribution in the elastomer:
		- Size 0.4:
		  - Shape and size
		  - Edge wear
		- High resolution:
		  - Size 0.1 and random dots
		  - Shape and size
		- Mesh:
		  - Various sizes
		  - Scale of greys

		Type of elastomer (hard, T1, soft)
		Dot surface wear owing to time of use and empty friction
	Blade	Empty work
		Angle
		Deformations (knocks, temperature, etc.)
		Service wear
		Pressure
		Material of which it is made
	Original	Scale of greys (dot density)
	Trough	Trough level and variations
	Feed	Dot feed
		Multiple dot feed

Table 2.

AFFINITY DIAGRAM

Based on the above groups of possible factors, the following Affinity Diagram can be made:

- Variable: Applied glaze suction rate by the body:

- Associated variables:
    - Green tile porosity.Compaction
        - Powder particle size
        - Powder moisture content
        - Cavity charge
    - Tile thickness
    - Quantity of applied water
    - Engobe particle size
    - Engobe Plasticity
    - Engobe Rheology
    - Engobe Quantity (quantity of water, density)
    - Glaze Plasticity
    - Glaze Rheology
    - Glaze Quantity (quantity of water, density)
    - Ratio frit/raw materials

- Variable: Water evaporation rate

- Associated variables:
    - Tile temperature
    - Quantity of applied water
    - Quantity of water in the engobe
    - Engobe quantity
    - Layer porosity
        - Engobe particle size
        - Engobe rheology
        - Glaze particle size
        - Glaze rheology
        - Ratio frit/raw materials
    - Quantity of water in the glaze
    - Glaze quantity
    - Engobe plasticity
    - Glaze plasticity

- Variable: Glazed surface texture

- Associated variables
    - Surface dust
    - Surface moisture content
    - Glaze stretching
    - Glaze accumulation of the edge
    - Bevel shape

- Variable: Ink

- Associated variables:
    - Behaviour during preparation and time in the machine:
        - Wettability
            - Particle size of the micronised material
            - Nature of the micronised material
                - Ratio frit/materials
                - Suspending agent
            - Nature of the vehicle
                - Base typology
                - Water
                - Binder
            - Nature of the colour
            - Preparation method
            - Time of previous rest
        - Sedimentation
            - Specific weight of the micronised material
            - Micronised material particle size
            - Nature of the vehicle
            - Relation between micronised material, colour and vehicle composition
            - Evaporation
            - Time of previous rest
        - Rheology
            - lowability, viscosity
            - Evaporación
            - Time of previous rest
    - Behaviour on the decorated tile
        - Yield (charge %)
        - Yield (relation to the glaze)
        - Surface tension

In all, the hierarchy of relations will involve:

- Body and / or layer suction rate
- Variable: Water evaporation rate
- Variable: Glazed surface texture
- Variable: Ink
- Variable: Roller pressure on the tile
    - Variations across tiles or in the same tile
- Variable: Cavity filling pressure
    - Variations across tiles or in the same tile
- Variable: Dot shape, size and distribution in the elastomer
- The above Affinity Diagram has enabled:
    - Relating variables to each other
    - Ranking them:
        - First step. Measurable variable
        - Second step. Variables relating to and affecting the first variable
        - Third step. Variable: Determining element (cause)
- The variables to be studied can be summarised as follows:
    - Body suction
    - Water evaporation
    - Surface texture: Glaze additives
    - Ink conditions (vehicle and additives)
    - Ink settling
    - Ink rheology
    - Roller pressure
    - Cavity filling pressure
    - Dot shape, size and distribution
    - Original (for design)

STARTING DATA
VARIABILITY OF MATERIALS AND PROCESS VARIABLES

First the variability was calculated under standard working conditions of certain variables:

Press:

- Moisture content
- Bulk density

Glazing facility:

- Temperature of the tile to be decorated
- Ink temperature on the roller
- Ink density

- Ink viscosity
- Ink weight
- Suction of the surface to be decorated

First Conclusions

The variation found, during the normal production process in the materials and process variables is very low, both for those concerning the presses as for those relative to glazing and ink values.

This leads to considering variations in colour or the appearance of decorating difficulties in terms of:

- Accidents or

- Other variables not considered in this collection.

The only variable that presents greater variability is that of the temperature of the piece to be decorated. To this are to be added the variations occurring throughout the process, owing to line stoppages, pieces in the compensator, etc.

Variability in Presses:

Bulk density was taken as the variable associated with the previous Affinity Diagram.

Measurement of Dap in a corner, at the side and in the centre, and the average value, present a minimum variability around 2,13/2,14. In fact the oscillation travels between minimum and maximum values 2,12/2,14.

It can be stated that the variation of Dap is not significant. This was held during the experiments. On the other hand, with the current presses, dies and plates, it is common to find swings like those mentioned.

The influence of the variability of Dap is discarded in the appearance of shades, since this variability is typical and can practically not be bettered, while the appearance of problems is irregular.

Variability of Density, Viscosity and Engobe and Glaze weight

Just as in the case of Dap, in the engobe and glaze slip variables, the variability is minimal, in accordance with stability of these slips and usual controls the lines.

The range found for the engobe and glaze densities is 1 g/cc, and is practically negligible.

The range found for the engobe and glaze viscosities is 2/3 seconds, which is not significant, even for the case of engobe with total values of 50 seconds. For the glaze, it is around 145 seconds.

For the case of deposited weight, the Range is 2 grams for the engobe, with absolute values of 33 grams. For the glaze it reached 9 grams at values of 70 grams average

deposited weight. *These swings can also be considered standard oscillations in the running operation and unrelated to the appearance of shades.*

Variability of ink density, viscosity and deposited weight

The existing ink control produces few variations of these variabilities. The following values were found in standard working conditions.

The Range of ink density is 3 g/cc at absolute values of 157.

The Range of ink viscosity is 4 seconds at absolute values of 34 seconds.

The Range of deposited weight is zero.

In this case it can also be stated that these oscillations are quite acceptable.

The above is valid for a working range in which ink reloading has not taken place, stable working conditions, etc. It can be concluded that interventions can affect ink viscosity considerably, while stable production with inks in appropriate conditions is not affected to the same extent. It is the external intervention that introduces variability.

Variability of tile temperature

Tile temperature exhibits larger variability values. The values range from 53° to 61° for standard working conditions. In the case of stoppages or of pieces in the compensator, cold pieces at 35° and even very hot pieces in the vertical dryer (75°) can be found.

In view of these swings and their irregularity, *tile temperature was taken as a variable to be considered in the study.*

Variability of ink temperature

Ink temperature, during the work does not present important fluctuations. It varies from about 33° when tiles are not travelling through, up to 38° with continuous tile flow. The time required for the ink to go from 38° to 33° is about 8 minutes with no tile flow.

EXPERIMENT FOCUS

First: Temperature of the tile to be decorated

Keeping in mind the greater variability in the temperature of the surface to be decorated, experiments were carried out at different temperatures, keeping the rest of the variables (ink and roller variables) constant.

Second: Moisture of the surface to be decorated

Experiments were carried out only varying the moisture of the surface to be decorated and holding the rest of the variables.

The experiments were carried out in two ways:

- Moistening the body more
- Drying the glazed surface

Third: Vehicle

Experiments were carried out only varying the nature of the ink vehicle and holding the rest of the variables.

Fourth: Ink base

Experiments were carried out only varying the nature of the ink base and holding the rest of the variables.

Fifth: Ink base additives

Experiments were carried out only varying the nature of the ink base additives and holding the rest of the variables.

Sixth: Glaze base additives

Experiments were carried out introducing various additives to the base glaze. The nature and proportion of these additives were varied.

Seventh: Shape and dimensions of the roller cavity

Experiments were carried out only varying the shape and dimensions of the roller cavity and holding the rest of the variables.

- Roller with HD (High definition) incision
- Roller with 0.4 incision

Eighth: Wear of the loading blade

Experiments were carried out only varying loading blade wear and holding the rest of the variables.

Experiments were carried out taking time of the blade in contact with the working roller as a variable.

A specially prepared cylinder was used for the tests, with the following characteristics:

- Flat design, the whole surface with incisions. Regular surface
- Half roller with incision: 0.4/45°
- Half roller with incision: HD

Decoration was on paper and the quantity deposited in each test was measured.

TESTS

Temperature of the tiles to be decorated

Glazed tiles were taken at different temperatures and decorated. The variation in colour was measured.

TILE TEMPERATURE	dE
55	0
65	0.3
70	0.5

Table 3. Models with value L= 75.

In view of the results, it can be stated that under standard working variations, no change in colour is observed, but *at oscillations exceeding 30° shades can appear (cold or hot tiles after downtimes and dryer start-ups).*

Moisture content of the tile to be decorated

Glazed tiles were taken with different moisture contents:

- After dipping several times in water:

DIPS IN WATER	dE
1	0
2	0.2
4	0.3

Table 4. Model with value L=75 and tile temperature of 55° C at the decoration entrance.

No significant variation is found as a result of exposing a tile to a greater or lesser quantity of water in its first application.

-Tiles left to rest for different times after glazing.

Minutes' rest	dE
0.5	0
1	0.7
3	0.9
6	1.9

Table 5. Model with value L=75 and tile temperature of 55° C at the decoration entrance.

These values vary as a function of the nature of the glazed tile surface, as will be seen below. However, the tendency is always the same, i.e., variation of dE and rising values of L with time, that is, lighter with time (drier tile) and darker when wetter.

In this case, a variation in colour is observed with tile time of rest, especially in the case of dark models. This is associated with tile surface moisture. With a wet surface,

transfer takes place better than with a dry one, which can even can cause problems owing to surface dust.

Glaze reject

Glazed tiles were taken with the same glaze but at three different mill rejects:

GLAZE REJECT	dE
1.8 %	0
3.6 %	0.2
7.1%	0.4

Table 6. Model made with a transparent glaze and value of L=75.

Glaze reject is not a factor to be considered in the appearance of shades.

Roller cavity shape

- Two roller qualities were taken: HD and 0.4

Deposited weight was verified by the paper test

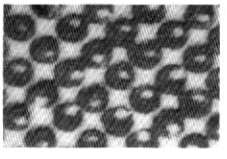
Applications were conducted at various pressures (modify height)

Height (mm)	0.4/45° Roller	HD Roller
8.0	-	-
7.5	0.76	0.61
7.0	0.83	0.71
6.5	0.84	0.74
6.0	0.86	0.78
5.5	0.86	0.75

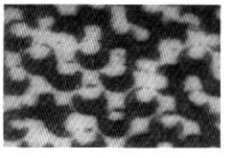
Table 7.

A tendency is observed to deposit a larger quantity as pressure increases (smaller distance) Fig. 1. It can similarly be observed that a larger quantity is deposited by the 0.4/45° quality than by the HD roller Fig 2. Dot definition is greater by 0.4/45°.

roller height

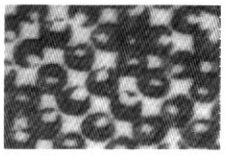


roller height – 1.5 mm

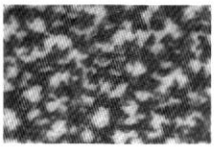


roller height + 1.5

Fig. 1: (0.4 roller) NORMAL.



0.4 incision



HD incision

Fig. 2: constant height.

Blade wear

Tiles decorated with a roller were taken, with different blade use times in service.

Blade use time	Light model L=90	Dark model L=75
hours	dE	dE
1 hour	0	0
5 hours	0.6	1.1
10 hours	1.0	1.8
20 hours	1.2	1.9

Table 8.

The change is more noticeable in the dark models. This change occurs relatively quickly, in about 3/5 hours, and then stabilises.

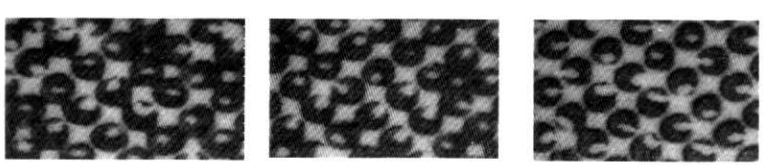
Blade wear	Light model L=90	Dark model L=75
mm	dE	dE
2 mm	0	0
1 mm	0.6	1.3
0 mm	1.2	2.1

Table 9.

Therefore, the main wear in the doctor blade occurs after around 3/5 hours (depending on the type of design, ink, etc.), and then stabilises.

Vehicle type

Two vehicles were taken: No. 1, No. 2



Vehicle 1 (23 sec.) *Vehicle 2 (22 sec.)* *Vehicle 1 (33 sec.)*

Fig 3. Height, incision, blade constants.

Three base types were tested.

Three different additives were taken:

- Additive 1: Organic/inorganic compound
- Additive 2: Micronised clay
- Additive 3: Bentonite

A bigger colour release is observed when additive 1 is used compared to 2. Definition improves with viscosity but the release is smaller (Fig. 3).

The use of roller 0.4/45° is observed to smooth the differences in applied weight as a consequence of the additive and vehicle variations.

Type of glaze additive used

The following were added to the glaze:

- Binder TO (low viscosity)
- Binder B (high viscosity)
- Plasticiser

The following conclusions can be drawn:

- With longer tile drying or rest time, the value of L (chromatic co-ordinates) rises and the colour therefore becomes lighter.
- Shades appear with rest (time between the glaze application and the decorating application)
- This is valid for every Glaze, both the standard glaze and those to which binders or plasticisers were added.
- For the case of the Binder TO addition:
    - Smaller increase in parameter L
    - Greater stability of dE with drying time
    - Very slight increase in viscosity
- For the case of the Binder B addition:
    - The variations in viscosity are considerable and they prevent achieving binder concentrations that improve colour stability.
- For the case of the plasticiser addition:
    - Smaller increase in parameter L
    - The value of dE is smoothed
    - Its effect is smaller than the one due to the binder addition

A test was also performed moistening the piece (before the decorating application) with an aqueous solution of Binder C, which yielded the best colour stability.

Therefore, despite stoppages, a slightly moist surface with moisture constancy, will be a fundamental colour stability factor.

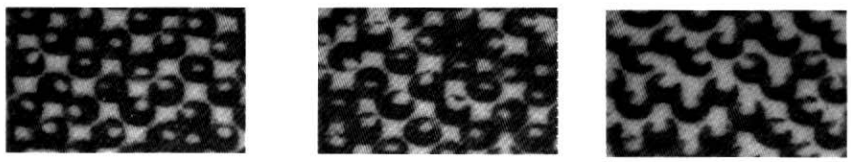
Blade position

Tiles were produced altering the blade position, on the model of value L=90 and on the model of L=75.

Blade position	Light model L=90	Dark model L=75
value	dE	dE
0	0	0
-5	0.6	1.1
-10	1.0	1.7

Table 10.

Owing to machine design, the position of the blade is a factor of the greatest importance in the quantity of deposited ink. It is especially significant for the dark models since swings of 2 and 3 points cause shades to appear.



-7 0 +7

Fig. 4 Blade angle.

Quantity of deposited ink

The quantity of deposited ink was measured on the same dark model with value L=75, by varying the position of the blade.

Ink quantity	Dark model L=75
g	dE
4	0
4.7	1.6
5.7	3.5

Table 11.

As is logical, with a larger quantity of ink, caused by blade adjustment, the variation in colour is evident. At this point it is important to note that standard production oscillations do not cause these variations in deposited quantity (except for accidents or unforeseen handling).

CONCLUSIONS

The results of the present study enable drawing the following conclusions:

Variations in colour:

• *In the same production lot:*

Of the studied variables, the most influential in the appearance of shades during the decorating operation are:

- Variation in the quantity of deposited solid:
  - Variation of blade working angle. Blade wear. Pressure on the blade (rotocolor S2 model)
  - Variations in degree of tile surface dryness
  - Variations in ink density and viscosity. Ink decantation. Degradation of the ink by length of use
- Glaze transfer problems to the first roller and ink transfer problems between the first and second roller
- There can be differences in the same lot caused by different ink additions, when carried out with an almost empty trough

Factors of little or no importance:

- Variation in ink temperature owing to use
- Typical variations in glaze rejection

• *For different production lots*

To the above, it would be necessary to add the variations of materials in lots produced at different times:

- Variation of application conditions across lots
- Variation of ink rheological conditions across lots
- Variation of glaze rheological conditions across lots
- Variation of blade conditions (wear and angle)

The variables mentioned are closely related to materials handling and control in the plant. They could be said to be related to the human factor.

On the other hand it is necessary to start with previously studied materials, whose behaviour is known, though the decisive factor will be good management and control of these materials and associated variables.

The variables highlighted are related, fundamentally to working variable constancy, associated with control and the human factor. It is therefore necessary:

- To use materials that lead to stable slips with regard to rheology
- To establish a control system to hold these variables
- To establish an alarm system in the case of deviation of these variables, to enable correcting them

• *As recommendations of a general type the following deserve to be noted:*

-Inks:

- Use vehicles that provide maximum antisettleability
- Use vehicles that keep maximum constancy in viscosity
- Use vehicles with low surface tension
- Use vehicles with good wetting capacity
- Use vehicles with minimum evaporation
- Use inks that impede transfer between rollers

- Ink base:

- Avoid particle sizes exceeding 0.045 mm, since they increases blade wear and can even produce clogging. The dimensions of the cylinder incisions (hole diameter) are:
  - 0.4 Quality: 300 microns
  - HD Quality: 100 microns
- Use bases that require (for the same particle size) the smallest quantity of vehicle.

- Glazes:
  - Use additives that allow maintaining a certain degree of moisture in the tile surface. The pieces should reach the decoration with a certain degree of moisture. This affords a series of advantages:
    - More regular ink deposition
    - Greater regularity in ink absorption
    - The ink passing through does not dry and facilitates covering
  - Avoid dusty surfaces to the greatest possible extent:
    - They cause greater wear
    - They cause contamination in the ink and variations in rheology
  - Avoid applications on hollows or surface roughness.
- Blade:
  - Control wear, especially straight after replacement:
    - Wear is greater with incision 0.4
    - Wear is greater with larger ink rejects
    - Wear is greater with a higher colouring oxide content
    - Glaze surface dust accelerates wear
    - Wear increases with blade angle
  - Maintain pressure, once set as a result of colour adjustment or other operations.
  - Use a double blade to keep greater constancy in charging and cleaning.
- Roller:
    - Maintenance and cleaning
    - Control of wear

• *The following are recommended as controls of a general type:*

- Before decorating:
  - Tile temperature
  - Glaze composition (especially the constancy of the binder or the clay it contains)

  Glaze application:
    - Density
    - Viscosity
    - Weight
  - Distance, drying time between the last application and decoration
  - Glaze surface

- During decorating:
  - Ink composition
  - Type and constancy of the vehicle used
  - Weight, density and viscosity of the applied ink
  - Speed of the belt
  - Blade angle
  - State of the blade
  - Type of blade quality

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