PROPOSAL FOR IMPROVING THE DEVELOPMENT STAGE IN ROTOGRAVURE DECORATION PROCESSES

M.D. Llanes, V. Moreno, M. Amorós, S. Benages; M, Carmona;

R. Carrasco, M.A. Esbrí, J. Rambla, L. Traver

I+D+I Laboratory , Roig Cerámica S.A.

ABSTRACT

The present work has attempted to understand and identify the variables that characterise a computer graphic document, as well as its transfer to ceramic design to optimise and control the development of tile decoration by the rotogravure technique. The reason for undertaking the study has been the great variety of results obtained with the same graphic document and different engraving characteristics, glazes, inks, etc., owing to not having any suitable laboratory method for reproducing it, and using the traditional flat screen method during development.

1. BACKGROUND

In the last few years, a new printing technology called rotogravure decoration has been incorporated in the ceramic sector. This technology is based on the use of a silicone roller, on whose surface a series of incisions are made by means of a laser system, which together define the design to be transferred to the ceramic piece. The diameter, depth, as well as the separation of these cavities, are determined by the laser engraving program. This printing machine is a technology transferred from the graphic arts sector. However, there are big differences in the use of this technology in the two sectors:

GRAPHIC ARTS	CERAMIC TILE SCREEN PRINTS
Very high resolution	Low resolution
Inks: solutions	Inks: suspensions

Table 1 : Differences between the graphic arts and ceramic tile sectors.

On adapting this technology to the ceramic floor and wall tile sector, various problems have appeared that considerably affect industrial control of the products manufactured with this decorating technique:

- Adaptation of ink physico-chemical characteristics
- In-depth knowledge of process variables
- Adaptation of the design to achieve the desired result

This last point has to date received little attention, due to the numerous production problems caused by ink formulations and their rheological conditions. In the current state of technology, in which ink physico-chemical characteristics have been improved, though not optimised, it seems appropriate to try and improve the design definition process.

DEFINITION OF THE DEVELOPMENT PROCESS:

The graphic images that are transferred to the printing cylinders can be acquired, elaborated and saved by computer systems. Image acquisition can be carried out by a colour scanner, followed by manipulation involving superimposition, corrections of colour, dots, gradations and by means of any graphic treatment system. The great problem, which we are seeking to minimise, resides in the difficulty of knowing exactly when the document presents optimum variables to proceed with roller engravure, since the design effect that one can see in paper prints or on the screen, are only related to the aesthetic end effect of the ceramic tile. After the adjustments, the graphic information can be digitised and saved.

Laser engraving forms small cavities that are filled with ink, which is transferred to the tile. Several types of engravings exist, depending on the type of print sought. The transfer of the design to the surface of the cylinder, i.e., the laser engraving, is carried out by data acquisition of the saved digitised image. The fact that the engraving is a digital and non-manual system enables fast engravure, with great precision and quality, as well as being reproducible over time. It also allows using a wide range of graphic possibilities, which means that the design can print the smallest details, in contrast to a printing screen, which requires adapting the document, since very fine gradations are used. The final result will be highly influenced aesthetically by how digital image detail contrasting has been performed, i.e., by how it has been digitally "defined".

2. OBJECT AND SCOPE OF THIS STUDY

The objective of the present project is to optimise the designs to be engraved by laser on the roller to decorate ceramic tiles by the rotogravure technique.

It is sought to obtain a greater understanding of graphic document-to-tile transfer, taking into account the other working conditions, to enable optimising the development process with a smaller number of tests and a greater fidelity in the result of the development.

Thus, the variables of the computer graphic document will be related to each other. These are:

✓ Design curve.

✓ Definition of the engraving on the printing element.

✓ Nature of the printing element.

✓ Nature of the engobe and glaze, whose coefficient of expansion, shrinkage-expansion curves, and surface chromatic co-ordinates will be studied.

✓ Required, preset aesthetic characteristics, for which a set of models with very different aesthetic qualities have been selected.

With all this information it will be attempted to:

✓ Adapt the most convenient type of engraving to each design, as well as to the nature of the silicone..

✓ Modify the graphic document with greater certainty that the result will be close to the one sought, in terms of the desired ceramic product, starting from the selected design.

3. TECHNICAL CONCEPTS

The rollers used in rotogravure printing can be classified by the nature of the silicone (supersoft or hard), and by the degree of engraving definition.

The following table sets out the advantages and disadvantages of the different types of silicone:

	ADVANTAGES	DISADVANTAGES
SUPERSOFT	Better fit to the tile.	Fast wear of the silicone and deformation of the cavities
HARD	Greater durability and no deformation of the cavities.	Worse fit to the tile.

Table 2: Differences between the two types of studied silicone.

The degree of definition of an image is determined by the number of dots (or pixels) per unit surface used to represent the image. The incision step of an image is the distance between one pixel centre and the immediately following one.

There are two main groups as far as incision resolution is concerned (see Table 3):

- Standard incisions, with constant incision steps similar to the resolution. The grey scale is created by varying the dimensions of the holes or cavities.

- High definition incisions, with constant cavity size of 100 μm. In this type of incision, the grey scale is created by varying dot density per unit surface.

	CAVITY SIZE (μm)		DISTANCE BETWEEN CAVITIES (μm)	
0.4	VARIABLE	1%: 170 100%: 310	CONSTANT 400	
0.3	VARIABLE	1%: 150 100%: 270	CONSTANT 300	
TR	VARIABLE	1%: 150-160 100%: 270	CONSTANT 238	
HD	CONSTANT 100		VARIABLE	1%: 1000 100%: approx. together

Table 3: Definition of the different types of laser engraving.

4. - EXPERIMENTAL PROCEDURE AND ANALYSIS OF RESULTS

4.1. - DESIGN CHARACTERISATION

4.1.1.- Design selection

The selection of designs to be studied was based on the experience of three years' work with this type of decoration system. The variables used in selection were:

A) Aesthetic appearance of the design, in form and amount of painted surface.

- Vein designs.
- Background designs.

B) Engraving program of the silicone roller.

- 0.4
- 0.3
- TR
- HD

C) Nature of the silicone used.

- Hard
- Supersoft

All the selected designs have been used in production lines for a minimum time (50,000 m^2) to be able to know their real problems, a priori, and thus interpret the results with a smaller margin of error.

The following set of designs was chosen with all these variables:

Design no.	Design type	Engraving	Silicone	Problems in production
1	Veins	0.4	T1	No problems
2	Background	TR	T1	No problems
3	Veins	0.4	T1	No problems
4	Veins	HD	T1	No problems
5	Background	HD	T1	No problems
6	Veins	HD	Supersoft	Slight difficulty in holding the colour
7	Background	HD	T1	Difficulty in holding the colour
8	Background	HD	Supersoft	Very problematic

Table 4: Definition of the designs studied..

Throughout the present work, the term "*standard way of working*" will be used to refer to production conditions in which all the parameters are close to an optimum, in which the arising variations within the normal work margins do not affect final product quality, i.e., working with no problems.

4.1.2.- Design characterisation

To characterise the designs, a horizontal line was traced (in each and every channel making up the design) in an area considered representative of the design, viewed on a computer screen, measuring the dot intensity of each centimetre, with ± 0.1 cm to avoid point alterations.

4.1.3.- Data plots and curve analysis

The dot intensity values found were plotted on a system of Cartesian co-ordinates, as a function of the distance in centimetres along the transverse line traced previously. The relationship of the resulting curves was analysed (together with the inks used) with the previously encountered problem, to thus relate the problems to the variables being studied.

Table nomenclature in this section is as follows:

✓ D: Definition of the design of each channel

- Background: Channel in which the design percentage covering the tile surface is approximately more than 70%.
- Vein: Channel in which the design percentage covering the tile surface is less than 30%.

✓ I: Ink colouring intensity, measured as units of colouring oxide per hundred units of transparent base frit.

✓ N: redominant nature of the colouring oxides used.

The resulting graphs are shown below for each selected design channel, as well as the square of the characteristics of the variables entering into the characterisation of the models.

MODEL 1: MADE UP OF ONE CHANNEL

This design gave rise to no problems in production in all the manufactured metres, since as Figure 1 and Table 5 show, its graphic design involves only one low intensity vein, with a reduced concentration of ink of an intense colour, engraved on a hard silicone roller with a non-demanding engraving definition. This all means that in this design, even with a low concentration ink, all the other parameters are optimum, and within what we have defined as the *"standard way of working"*, as a result of the experience accumulated over three years, which is just a definition for a *"way of working without problems"*.

CHANNEL No.	D	I	N
1	Vein	2	Spinel

Table 5: Model 1 characteristics.

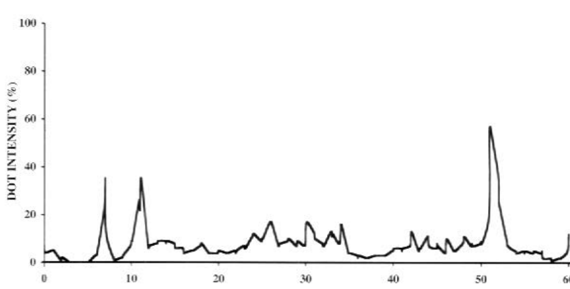

Figure 1: Design 1. First channel. Vein. 0.4 engraving.

MODEL 2: MADE UP OF THREE CHANNELS

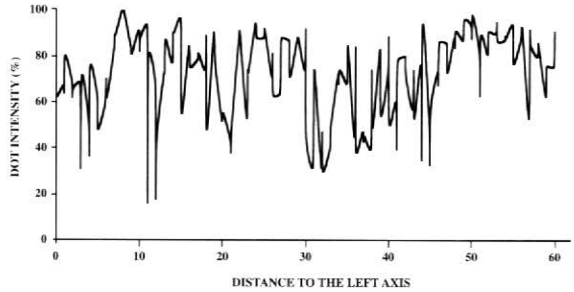

Fig.2: Design 2. First channel. Background. TR engraving.

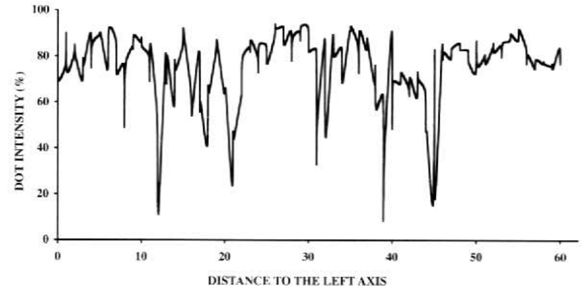

Fig. 3: Design 2. Second channel. Background. TR engraving.

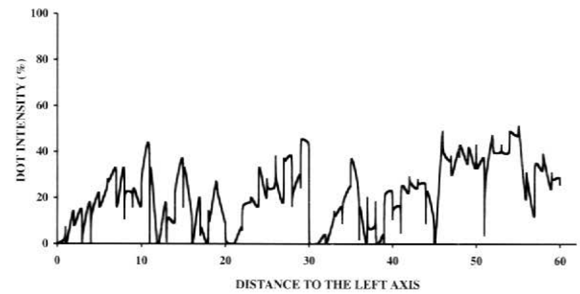

Fig. 4: Design 2. Third channel. Vein. TR engraving.

CHANNEL No.	D	I	N
1	Background	20	Zircons
2	Background	40	Spinel
3	Vein	80	Spinel

Table 6: Model 2 characteristics.

This design gave rise to no problems in design production. This can be explained taking into account the combination of the intensity in the background channels, and the dot pattern program engraving on hard silicone, together with some inks with medium concentrations. This combination allows perfect ink release, and thus enables decorating most ceramic tile. These types of backgrounds are within the optimum range of the *"standard way of working"*.

MODEL 3: MADE UP OF THREE CHANNELS

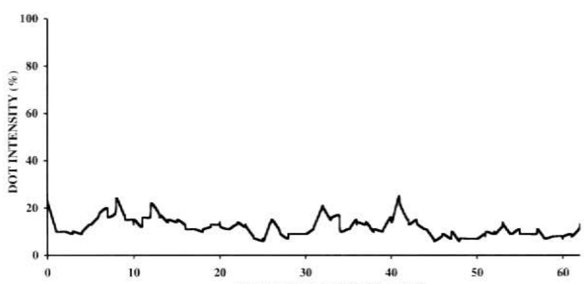

Fig. 5: Design 3. First channel. Vein. 0.4 engraving.

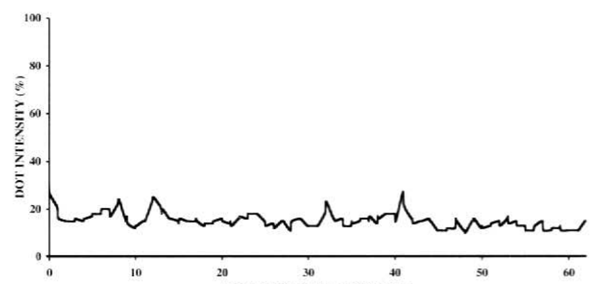

Fig. 6: Design 3. Second channel. Vein. 0.4 engraving.

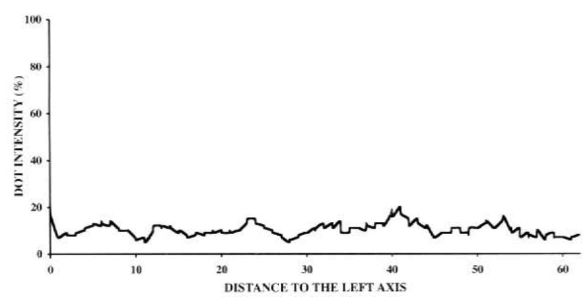

Fig. 7: Design 3. Third channel. Vein. 0.4 engraving.

CHANNEL No.	D	I	N
1	Vein	15	Zircons
2	Vein	5	Zircons
3	Vein	2	Spinel

Table 7: Model 3 characteristics.

This design gave rise to no problems in production in all the manufactured metres, since, as can be observed in Figures 5, 6 and 7, dot intensity exhibits low values and the colour percentages used in the inks are small (see Table 7). Moreover, the engraving program was 0.4 and the silicone was hard. In this case, it can be concluded that in this design no variable is in a very demanding situation. This set of conditions also lies within the previously defined *"standard way of working"*.

MODEL 4: MADE UP OF TWO CHANNELS

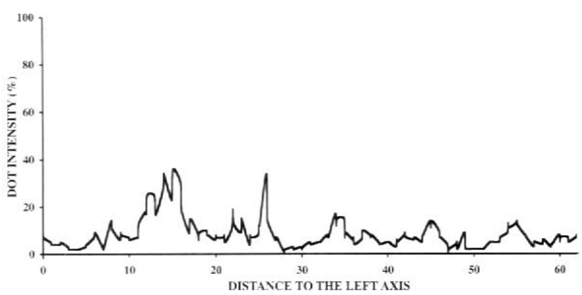

Fig. 8: Design 4. First channel. Vein. HD engraving.

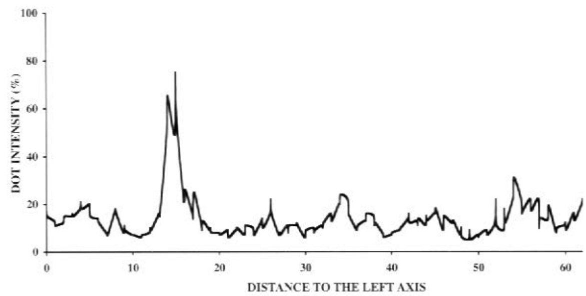

Fig. 9: Design 4. Second channel. Vein. HD engraving.

CHANNEL No.	D	I	N
1	Background	10	Spinel
2	Vein	20	Spinel

Table 8: Model 4 characteristics.

This design gave rise to no problems in production in all the manufactured metres. The explanation is related to the wide area of low dot intensities in the design, together with a more than acceptable ink intensity and engraving on hard silicone. This set of variables minimises the possible risk of using a high definition program, which is very appropriate for the vein channels owing to the optical and aesthetic sensation that they produce.

MODEL 5: MADE UP OF THREE CHANNELS

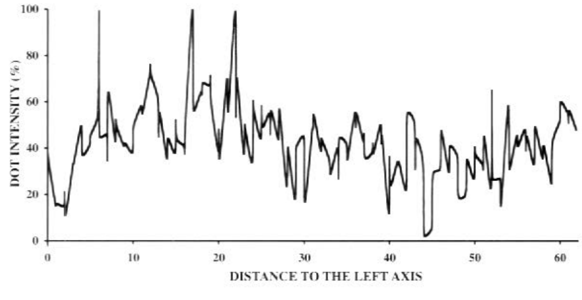

Fig. 10: Design 5. First channel. Background. HD engraving.

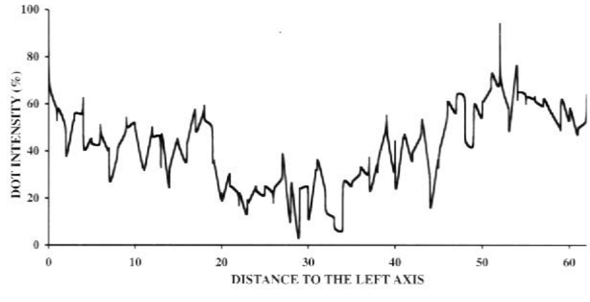

Fig. 11: Design 5. Second channel. Background. HD engraving.

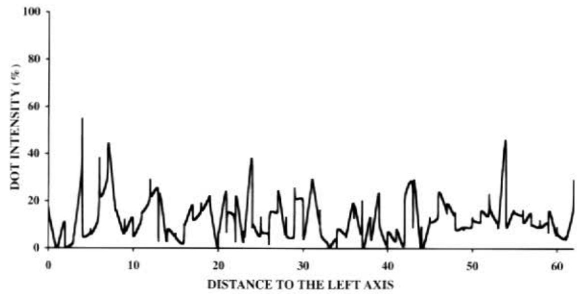

Fig. 12: Design 5. Third channel. Vein. HD engraving.

CHANNEL No.	D	I	N
1	Background	200	Zircons
2	Background	150	Spinel
3	Vein	40	Spinel

Table 9: Model 5 characteristics.

This design gave rise to no problems in production in all the manufactured metres. This is because, as Figures 10 and 11 show, dot intensity presents medium values in the first two channels (background), although the colour concentration is very high and lies outside the ranges that could be considered standard (Table 9). The vein (Figure 12) is inside standard working conditions, in the "*form of the design*" and in colour concentration. All this, together with a design engraved on hard silicone, even with a high-definition engraving, enables its working variables to be considered standard, though not all are in the optimum band.

MODEL 6: MADE UP OF TWO CHANNELS

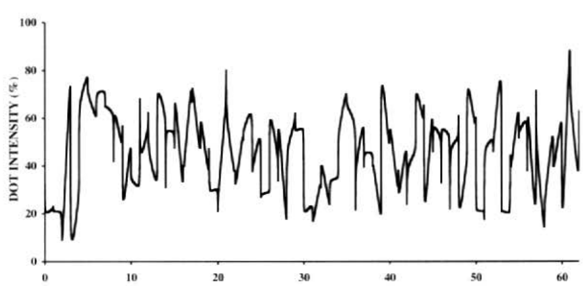

Fig. 13: Design 6. First channel. Background. HD engraving.

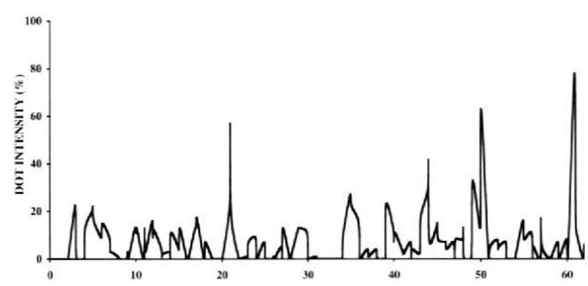

Fig. 14: Design 6. Second channel. Vein. HD engraving.

CHANNEL No.	D	I	N
1	Background	1	Spinel
2	Vein	2	Spinel

Table 10: Model 6 characteristics.

Observation of Figures 13, 14 and of Table 10 would lead to expect this design not to pose any type of problems, since the dot intensity values keep to medium-low values, and the colour percentage is very small. However, this design caused slight difficulties, during the different productions, in keeping a constant colour. This is related with the nature of the silicone, since having medium values in the graph and such a weak ink concentration, a situation of high sensitivity to deformation and wear of the cavity in production arises, and also to the adjustment and regulation of machine working conditions, which have important repercussions on the quantity of colour deposited on the piece, and therefore on the final optical effect.

MODELO 7: MADE UP OF THREE CHANNELS.

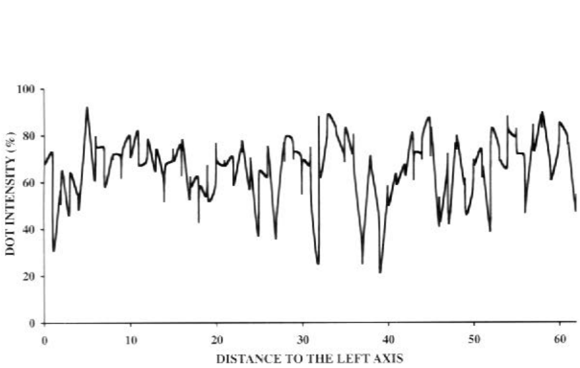

Fig. 15: Design 7. First channel. Background. HD engraving.

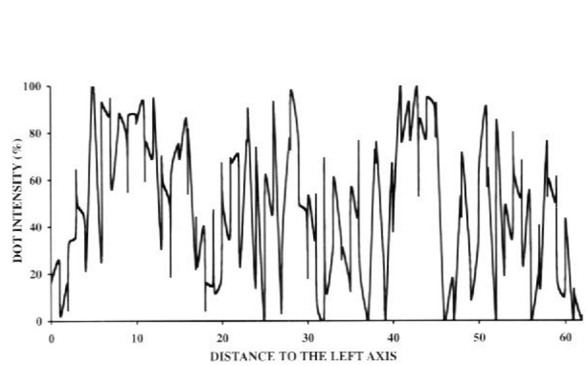

Fig. 16: Design 7. Second channel. Background. HD engraving.

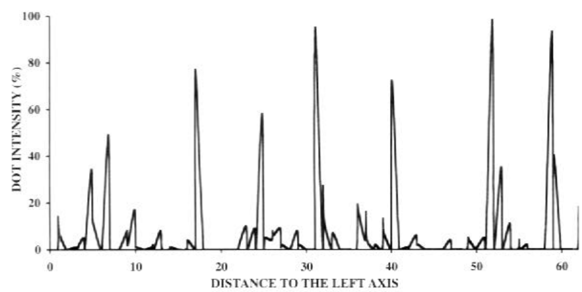

Fig. 17: Design 7. Third channel. Vein. HD engraving.

CHANNEL No.	D	I	N
1	Background	70	50% Zircons 50% Spinel
2	Background	70	Zircons
3	Vein	70	Spinel

Table 11: Model 7 characteristics.

This design has presented a high degree of difficulty in its industrialisation. Many lots have been made in which variables such as ink colour concentration, density and viscosity, as well as machine regulation conditions have had to be modified every time. With this model, at no time have working conditions been reproducible, although in each lot it has been possible to standardise and manufacture the model. However conditions never stabilised adequately in production to be good enough to serve for a following production lot. It has been necessary to re-establish working conditions, in order to hold the product within the aesthetics of the model. All this has meant downtimes, shades, and uncertainty, etc.

The reason for the problem lies in the situation of the four variables analysed in this work. The first and second channel, which form the background of the design, have maximum demand regarding dot intensity, and the inks already exhibit high concentrations. Together with this great demand for intensity with regard to the background, there is high-definition engraving, which by its characteristics (very small cavity size, with very little ink deposition), is not the most appropriate when the whole tile surface needs to be covered.

As a result of the above, the only solution in these cases would be to act upon on the design engraving, making the corresponding adjustments so that the final aesthetics of the product will not vary compared to the standard model.

MODELO 8: MADE UP OF FOUR CHANNELS.

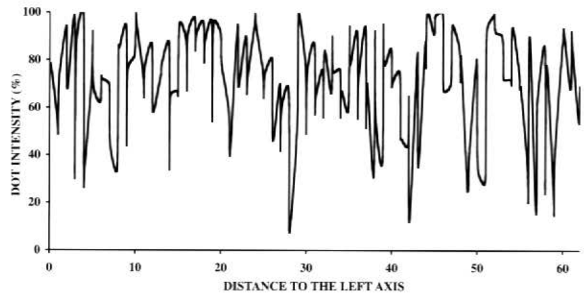

Fig. 18: Design 8. First channel. Background. HD engraving.

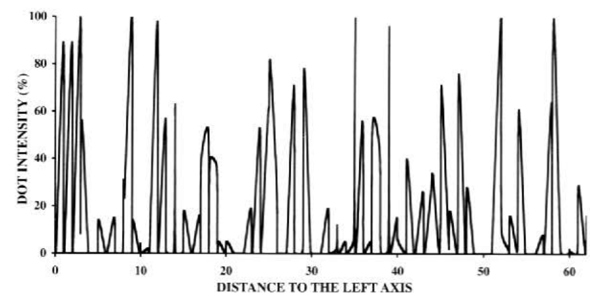

Fig. 19: Design 8. Second channel. Vein. HD engraving.

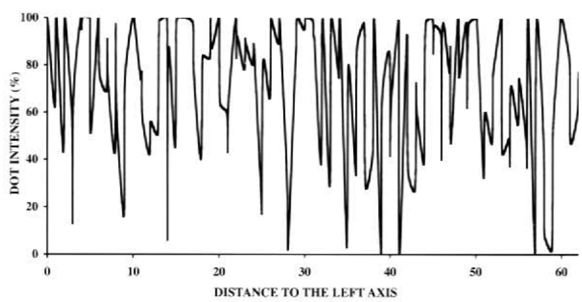

Fig. 20: Design 8. Third channel. Background. HD engraving.

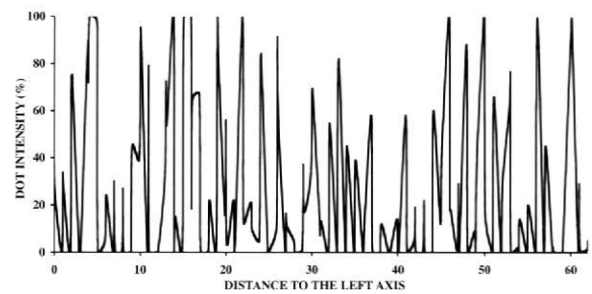

Fig. 21: Design 8. Fourth channel. Vein. HD engraving.

In this design there were a great number of problems during the various productions, which can be explained by the fact that most of the variables are in extremely demanding situations. In the first place, when analysing the dot intensity plots of the background channels, they are observed to present extremely high values; added to this there is high colour intensity (mainly in channel number 3) and high-definition engraving on supersoft silicone.

CHANNEL No.	D	I	N
1	Background	10	Zircons
2	Vein	20	Zircons
3	Background	100	Spinel
4	Vein	40	Spinel

Table 12:Model 8 characteristics.

The great problem has been related to the striving to produce backgrounds almost totally covered with high colour intensity using a high-definition engraving (i.e., with small size cavities) on a weaker silicone with regard to wear, and more sensitive to the ease of release owing to dot deformation.

The following synoptic table presents a general summary of all the analyses of the variables studied in the eight designs, to enable comparing the problematic with the non-problematic combinations, based on experience.

Design No.	Design Type	Engraving	Silicone	Difficulty
1	Veins	0.4	Hard	None
2	Background	TR	Hard	None
3	Veins	0.4	Hard	None
4	Veins	HD	Hard	None
5	Background	HD	Hard	None
6	Veins	HD	Supersoft	Certain difficulty Clear ink + Supersoft silicone
7	Background	HD	Hard	Medium difficulty Background channel + HD engraving
8	Background	HD	Supersoft	High difficulty Background channel + HD engraving + Supersoft silicone + high ink intensity

Chart 1:Summary of the results obtained from the plots.

4.2. – TRIALS WITH TEST ROLLERS

After extensive analysis of the designs and their characteristics, test rollers were designed to establish the correspondence between the graphic design observed on the screen and the gradations actually engraved on the roller, since the laser program used is a variable that decisively affects the aesthetic part of the design, as had been noticed in the work made by flat screens, which it was later attempted to reproduce in laser-engraved rollers.

The designed test roller consists of uniform dot patterns with different dot densities, between 5% and 100%, differentiating between 0.4 and 0.3 engraving. On the other hand, a flat test screen was designed to enable comparing the difference in the evolution of the gradations in both technologies. Thus, with the same patterns as in the rotogravure test document, a photolitho was filmed at 20 dots/cm, with which a 68 # screen was made, and another photolitho at 24 dots/cm to make a 90 # screen.

The first thing one notices is the great disparity between the theoretical document observed on screen and the results on the ceramic tile, by screen printing with a flat screen and by rotogravure roller, mainly with regard to the progression of the gradations. The theoretical gradations on the screen are logical; intensity increases in each square as dot pattern density rises. However, in the other two cases this does not occur, as Figures 22, 23 and 24 show.

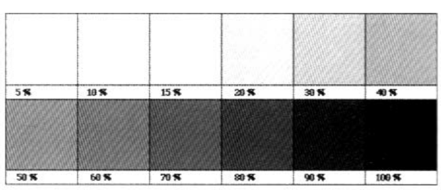

Figure 22: Theoretical document.

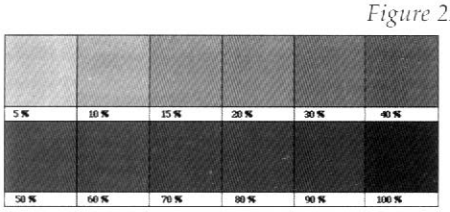

Figure 23: 0.4 rotogravure.

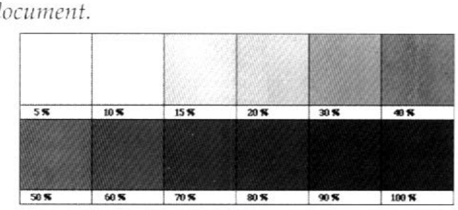

Figure 24: 68 # flat screen.

It can be observed that between the theoretical document and the flat screen, there is a certain difference, which is however minimal. On the other hand, in the 0.4 rotogravure resolution sequence, i.e. 25 pixel/cm, there is an important leap in intensity between 90% and 100%. The other jumps from ten to ten are gradual but not logical. From 5%-30% the colour variations are minimal, with very smooth steps. The same occurs from 40-70% and 70-90%; there are practically three plateaux, but there is not a gradual increase as should be found. At 0.3 resolution, i.e. 33 pixel/cm, there is also this important leap between 90% and 100%, but it is much smoother. Therefore, as definition increases on engraving the document, the practical results approach theoretical conditions more closely, but at the same time it becomes more difficult to work in production.

To be able to visualise these observations graphically, the pieces obtained were scanned, then measuring the whiteness index (L) of each of the dot pattern percentages on the computer. (Figures 25 and 26). The three most noteworthy points of these discrepancies can be divided into three areas: from 0-30% the gradations are very similar, in rotogravure and in the flat screen. From 30-80%, the difference is quite considerable, since while the flat screen curve progressively descends, in rotogravure the curve appears almost parallel to the abscissa axis. From 80-100%, there is a great divergence in the behaviour of both curves, since the flat screen follows the same type of descent, while in rotogravure it presents a sharp drop, with a very steep jump in the 90-100% range, departing excessively from the theoretical evolution.

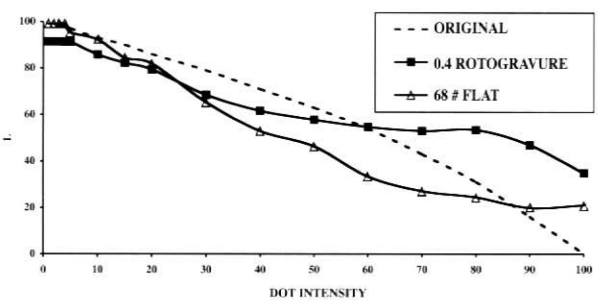

Fig. 25: Comparison of black and matt ink colorimetries. 0.4 rotogravure print – 68 # flat screen.

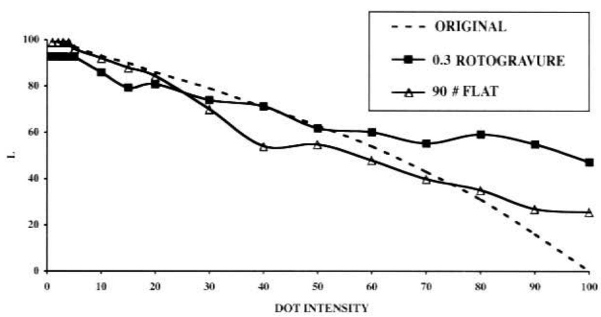

Fig. 26: Comparison of black and matt ink colorimetries. 0.3 rotogravure print – 90 # flat screen.

In view of the previous variations between the flat screen and rotogravure, it was considered convenient to also analyse the gradations between 1% and 5%, since in all the rotogravure engravings the phenomenon known as dot gain appears, i.e., coverage of the whole tile background. Test screens and roller were therefore prepared with uniform dot intensity patterns of 1%, 2%, 3%, 4% and 5%.

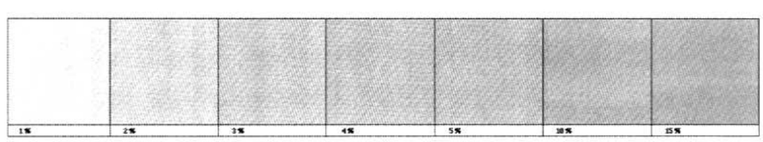

Fig. 27: 0.4 rotogravure.

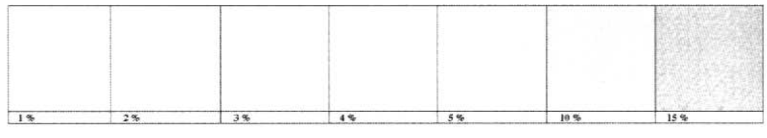

Figura 28: 68# flat.

As the previous figures show, in this dot intensity range there is a great difference between both technologies, which is largely responsible for the lack of agreement on an aesthetic level between products made with flat screens and those produced with rotogravure rollers, based on the same computer design document As the pieces decorated by the test roller in Figure 27 show, intensity is practically constant from 1%-10%, really dirtying the background just as with the 10% pattern, so that the background is practically covered. In contrast, in the flat test screen, the 1%-3% gradations are not observed; between 4%-5% background colouring commences lightly, and it is from 10% on when the pattern already has considerable colour consistency.

4.3. - GLAZE CHARACTERISATION

Throughout the experience of these three years' work with rotogravure decoration, the importance has been noticed of appropriately selecting the glaze on which the design is to be applied, with all its fixed characteristics, since in certain circumstances undesired technical and aesthetic defects can arise. For the reasons set out above, three base glazes were chosen and characterised, which are used in most floor and wall tile production, and whose nature differs considerably (TABLE 13).

	TRANSPARENT	Zr WHITE	Zn MATT
T shrinkage start (°C)	860	890	830
T shrinkage end (°C)	1020	1030	1110
Softening (°C)	1050	1070	1140
Sphere (°C)	1110	1110	1180
Semisphere (°C)	1220	1240	1220
Melting (°C)	1240	1260	1240
$\alpha_{50\text{-}300}$ (°C^{-1})*10^{7}	63	62	60
$\tau_{50\text{-}300}$ (°C^{-1})*10^{7}	189	186	180
$\alpha_{300\text{-}500}$ (°C^{-1})*10^{7}	66	65	69
$\tau_{300\text{-}500}$ (°C^{-1})*10^{7}	198	194	207
T transformation (°C)	661	636	608
T softening (°C)	845	826	1010
L*	91.0	94.4	92.5
a*	-1.26	-0.56	-0.52
b*	2.88	0.21	0.93

Table 13: Definition of the different glazes tested.

To be able to relate the influence of the glaze to the group of variables in point 4.1, the test roller previously defined with 0.4 resolution was used with three standard inks (black, leather colour, and light grey). This roller was placed in the printing machine and tried on the three reference glazes, to see which dot densities were lost and which were not, in terms of the physico-chemical characteristics of the glazes, type of engraving and inks.

The following chart summarises the defect-free dot intensity ranges with the different inks on the three glazes chosen and characterised for this study, where TN is a black ink (high colour percentage), TC is a leather-coloured ink (medium colour percentage) and TG is a grey ink (low colour percentage). By concentration and nature of the colour, the most refractory ink was TN, and the most fluxing one was TG.

Engraving	TRANSPARENT			MATT			WHITE		
0.4	TG	TC	TN	TG	TC	TN	TG	TC	TN
	1- 100%	1- 70%	1- 60%	1- 90%	1- 80%	1- 70%	1- 80%	1- 50%	1- 20%
0.3	TG	TC	TN	TG	TC	TN	TG	TC	TN
	1- 100%	1- 90%	1- 70%	1- 100%	1- 90%	1- 80%	1- 90%	1- 60%	1- 30%

Chart 2: Relation of glaze variables with the non-problematic dot intensity area.

It can be inferred from the foregoing, that if the glaze is selected prior to use, it is necessary to keep in mind the dot intensities in the design to be used in the development; however, if a certain design has been chosen first, it is necessary to use the most appropriate glaze to avoid technically incorrect areas (segregation, matting, etc.), since developments can be approached from both standpoints.

The colorimetries found for each dot pattern according to the glaze on which the decoration was applied, keeping the ink constant, were then compared. The black ink was chosen to perform this comparison.

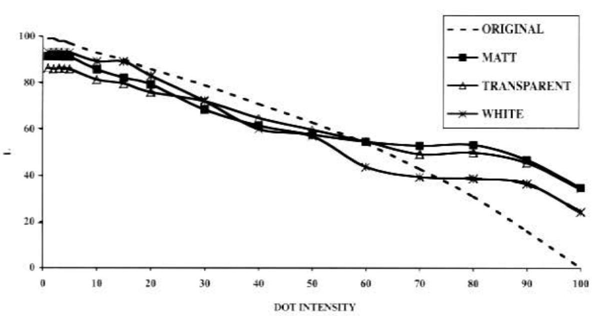

Fig. 29: Comparison of black ink colorimetries on different glazes. Rotogravure roller. 0.4 definition.

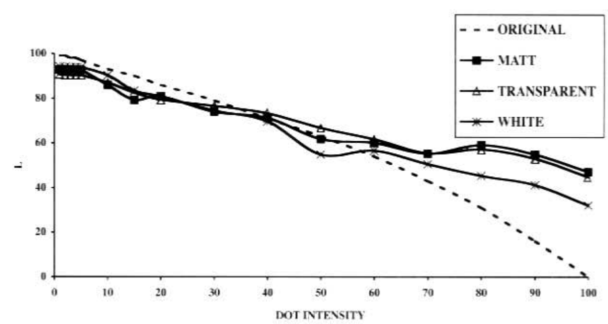

Fig. 30: Comparison of black ink colorimetries on different glazes. Rotogravure roller. 0.3 definition.

It can be observed in Figure 29, that at low dot intensities (up to 20%), the value of L behaves as expected, i.e., the values of the zirconium white and matt glaze lie close together, while the transparent glaze produces lower L values, since the colour is integrated better in the glassy structure of the glaze (it melts). For high dot intensities (over 60%), the opposite happens, i.e., the matt and transparent glazes present similar values and the white glaze produces darker colours, (lower values of L); this is because in the transparent and in the matt glaze, the colour integrates in the base glaze and diminishes its yield; however, this does not happen in the white glaze since segregation occurs, so that what is really measured is colour dots that have not been able to melt in the base glaze. The same effect can be observed in Figure 30, though more smoothed. The transparent-matt curves separate from the white glaze curve at higher dot intensities (approximately 80%). This is because on being smaller dots, this effect is slowed.

5. CONCLUSIONS.

- ✓ There is a great difference between the dot intensity curves that define the vein and background channels; these differences set the framework for choosing the engraving variables and nature of the silicone.

- ✓ Prior to the development of a model with this technology, it is necessary to carefully analyse the aesthetic contribution of each channel, because on most occasions their number can be reduced compared with the flat screens. This can be done after establishing the influence of all the variables considered in this work.

- ✓ There are many more combinations of these variables, which have not been selected in this work owing to lack of time for their presentation, but they have in fact been studied and reflect and confirm the general observations made.

- ✓ The features commented show that on processing the aesthetic effect of the design in one way (flat screen) or another (rotogravure) in the decorating process, the result will be different if all the foregoing characteristics are not considered during development. However, in view of these points, the initially sought theoretical result can be improved and the previously selected aesthetic qualities achieved.

- ✓ The whole study has shown that as work solutions are enhanced, the graphic arts theory is more closely approached. However, we are narrowing the working margins in standard production systems at the moment, so that it is necessary to adopt a committed approach in rotogravure development. It is necessary to try and keep aesthetic losses to a minimum without making it necessary to work outside reasonable production constraints, since this can only lead to non-uniform productions, as a result of not being able to hold the printing variables. It has been proven that with good adaptation of the variables, it is possible to work within the variables of rotogravure technology without any problems.

- ✓ It is recommended to use intense colours in ink formulation in rotogravure (where the coat is thin) which yield a similar colour to the colours that are pastel by structure, since they allow an important reduction in colour percentage, producing a similar tone by a smaller ink deposition with this printing system on the tile. This would enable entering more readily into standard working conditions.

This whole study has been based on practical experience and on methodical data collection over three years, which leaves the door ajar for comment. At no time has it been sought to establish a way of acting, but it has been simply sought to transmit the conclusions of experience. It has been attempted to create a system of work, to make the selection of the variables in developments with this technology in ceramic decoration more methodical.

6. REFERENCES

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