RELATION BETWEEN TILE CURVATURE AND ENGOBE LAYER CHARACTERISTICS

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INTRODUCTION

Amongst the engobe layer functions, the role of the engobe in fitting has received little attention in the literature. The glaze-body fit has been studied, and the effect of glaze and body incompatibility on tile curvature is well established. Little mention is made however of the intermediate engobe layer, which precisely by lying between the body and the glaze affects fit characteristics. The study thus attempted to identify the engobe layer characteristics that play a critical role in the arising curvature. Determining these characteristics and how they act enables controlling ceramic tile curvature more efficiently.

PROCEDURE AND DISCUSSION OF RESULTS

The work was basically divided into two stages. In the first stage, two engobes with different characteristics were used, which are employed in making floor tile with the same body and the same glaze. The aim was also to determine how a simple change of engobe could alter tile curvature. In the second stage, it was attempted to identify the engobe layer characteristics that are capable of altering the glaze-body fit and hence determining floor tile curvature.

To conduct the studies, tests were performed at a floor tile manufacturing facility. The ceramic floor tiles were sized (20x30) cm, classified by draft standard ISO 13.006 as BIIb. The standard body (consisting of two clays) and glaze used in production were employed in the tests. Two engobes with different characteristics were used - one with a high thermal expansion (AET) and the other with a low thermal expansion (BET).

Fifteen tiles were taken from the industrial production line. A 30 g (50 mg/cm^2) AET engobe layer and a 26 g (43 mg/cm^2) layer of airbrushed industrial glaze were applied to five of these tiles. The same quantities of engobe and glaze were applied to five other tiles, using engobe BET instead of AET. The remaining tiles (N) were fired without any coating to determine the tile curvature produced by the kiln.

These 15 items were fired in the company kiln (one after another in the centre row), with a 35-min cycle and peak firing temperature of 1120°C. Samples were taken of the body and the engobe and glaze suspensions. The fired tiles were characterised with regard to centre curvature with a dimensional analysis system.

Table I presents the results of the centre curvature determination run on the tiles fired in the industrial kiln. The tiles without any coating (N) exhibited a slight convex curvature. However, adding the engobes and glaze changed the curvature. The convex curvature became more pronounced in the tiles coated with engobe AET, whereas in the tiles fired with engobe BET, the curvature became concave. These results indicate that a sight change in engobe characteristics, using the same body and glaze, can change the nature of the curvature and its intensity.

As different engobes produce different curvatures, the engobes were characterised to establish how their properties differed. Linear shrinkage and the coefficient of thermal expansion were therefore determined of the body, engobes and glaze as set out in Table II. The engobes can be observed to exhibit differences in refractoriness as well as in their coefficients of thermal expansion. Engobe AET has a lower shrinkage than the body, while BET has the greatest linear shrinkage of the analysed elements.

Tile reference	Centre curvature (%)
N	-0.03 ± 0.05
AET	-0.12 ± 0.04
BET	0.07 ± 0.03

Table 1. *Centre curvature measurements of the fired tiles.*

Elements	α 100 - 500 (°C^{-1})	Linear shrinkage (%)
Body	102 x 10^{-7}	5.30
Engobe AET	93.0 x 10^{-7}	4.77
Engobe BET	65.0 x 10^{-7}	5.57
Glaze	85 x.0 10^{-7}	n/d

Table 2. *Characterisation of the elements making up the tile.*

The foregoing procedures were repeated at a porous wall tile (BIII) manufacturer, using the same industrial body and glaze. However, three engobes were formulated with similar thermal expansions but with different refractoriness. Table III gives their linear shrinkage and coefficient of linear thermal expansion data.

Engobes / Characteristics	Engobe I	Engobe II	Engobe III
Linear shrinkage (%)	3.70	1.86	0.64
Coeff. of Thermal Exp.: α 60–325°C (°C^{-1})	88.7×10^{-7}	90.6×10^{-7}	86.8×10^{-7}

Table 3. *Characteristics of the studied engobes.*

It can be observed that the engobes exhibited very similar coefficients of thermal expansion, though their refractoriness differed considerably. The curvature of the tiles made with these engobes (Table IV) changed noticeably according to the engobe used. As the engobe coefficients of thermal expansion can be considered identical, simple control of thermal expansion is not sufficient to ensure tile planarity. The results indicate that the control of engobe refractoriness, which can be performed by determining linear shrinkage, is of great importance for ensuring glaze-engobe-body fit and avoiding tile curvature.

Specimens	Centre curvature		
	30 g	40 g	50 g
Engobe I	0.18 / 0.14	0.11 / 0.05	0.09 / 0.03
Engobe II	0.19 / 0.15	0.18 / 0.11	0.13 / 0.08
Engobe III	0.26 / 0.22	0.28 / 0.22	0.28 / 0.24
Body	0.01 / -0.03		

Table 4. *Centre curvature of tiles produced with different engobe layers.*

CONCLUSIONS

Engobe characteristics considerably affect tile curvature, so that simple control of the body and glaze coefficients of thermal expansion is not enough to control tile flatness.

The thickness of the applied engobe layer considerably affects tile curvature and can be used in controlling tile curvature. This alternative is not always feasible from an economic point of view, so that the most suitable option would be to formulate engobes with more appropriate characteristics to avoid the appearance of curvatures of great intensity.

The results show that refractoriness and linear thermal expansion are the two engobe characteristics to be taken into account in order to ensure good fit and control tile curvature.