STUDY OF THE MECHANICAL PROPERTIES OF CERAMIC TILES OF THE PORCELAIN STONEWARE TYPE SUBJECTED TO FAST FIRING

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ABSTRACT

In the ceramic industry, energy (thermal and electric) is a key component of the process. The production of porcelain stoneware tile with shorter cycles than those used currently represents a great challenge for technicians, in order to assure the required dimensional stability, porosity, water absorption, linear thermal shrinkage and mechanical strength of the product.

Preliminary studies have shown that it is possible to obtain a porcelain tile body composition with appropriate characteristics, using a firing cycle that takes a total of 2 minutes.

1. INTRODUCTION

The main objective of this study is the application of the fast firing concept of porcelain tile, in order to determine its technical limitations and to evaluate the mechanical properties of this type of composition, assessing the possibility of industrial use of very fast and therefore cheaper firing cycles.

2. CHARACTERISATION TECHNIQUES

2.1. CHEMICAL CHARACTERISATION OF THE BODY COMPOSITION

Element	% by weight	Element	% by weight
SiO_2	66.24	NaO	2.39
Al_2O_3	17.45	K_2O	1.52
Fe_2O_3	0.47	TiO_2	0.08
CaO	0.85	Li_2O	0.27
MgO	0.45	P_2O_5	0.07
MnO	0.04	SrO	< 0.1
ZrO_2 + HfO_2	6.22	Pérdida por calcinación	3.94

Table 1. Chemical composition of the body.

2.2. PREPARATION AND FIRING OF THE TEST PIECES

The test pieces were formed at a pressure of 400 kgf/cm^2. The pieces were then placed in a kiln at a temperature of 200°C and 650°C for 24 hours. The test pieces were subsequently subjected to a temperature of 1200°C in a tube kiln with residence times of 1s, 3s, 6s, 10s, 15s, and 20s, with different times for placing and withdrawing the test pieces of 5s, 10s, and 20s. The variation was greatest with a 10-minute residence and 20s for placing and withdrawing the test pieces.

3. PRELIMINARY RESULTS

3.1. PHYSICAL PROPERTIES OF THE COMPOSITIONS – ULTRA-FAST CYCLES

Drying at 200°C Tmax = 1200°C, 20s	Firing shrinkage (%)	Water absorption (%)	Modulus of rupture (MPa)	Bulk density (g/cm^3)	Pyroplasticity index (cm^{-1})
Residence:10 min	8.67	0.11	68.67	2.41	234.99
Residence:15 min	8.65	0.03	69.63	2.42	344.27

Drying at 650°C Tmax = 1200°C, 20s	Firing shrinkage (%)	Water absorption (%)	Modulus of rupture (MPa)	Bulk density (g/cm^3)	Pyroplasticity index (cm^{-1})
Residence:10 min	8.81	0.07	73.79	2.42	274.90
Residence:15 min	8.62	0.03	**66.82**	**2.41**	347.63

3.2. PROPERTIES UNDER NORMAL PRODUCTION CONDITIONS IN A MUFFLE KILN

Drying temperature 120°C, 4h	Firing shrinkage (%)	Water absorption (%)	Modulus of rupture (MPa)	Bulk density (g/cm^3)	Pyroplasticity index (cm^{-1})
Tmax = 1200°C Residence = 10 min Heating rate =15°C/min	9.139	0.051	67.0915	2.459	333.158

4. CONCLUSIONS

The results show that the best condition was immobilisation at 650°C, with a residence time in the kiln of 15 minutes.

These conditions guaranteed the same results as a body composition under normal conditions.

Therefore, a technical porcelain stoneware type of product was obtained by drying at 650°C for 24h, followed by sintering at 1200°C with a 15-minute residence in the kiln.

This enabled very significant energy savings to be obtained. The challenge now consists of achieving these conditions in industrial kilns.

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