USE OF GLASS FROM THE RECYCLING OF LAMPS AND FLUORESCENT TUBES AS FLUX IN CERAMIC MEDIUM COMPOSITIONS

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1. ABSTRACT

Waste Electrical and Electronic Equipment, WEEE, generate different waste, one of which is glass from lamps and fluorescent tubes. The use of other glasses in ceramic products has been widely researched, with the main advantage of reducing firing temperatures of ceramic products due to their melting characteristics. However, there is no evidence of the use of glass from lamps and fluorescent tubes in ceramic tiles. For this reason, the viability of using this type of glass has been studied in low porosity ceramic tile compositions, namely red glazed tile stoneware and glazed tile porcelain stoneware, with the aim of reducing optimum firing temperatures.

Two percentages of glass, 5 and 10%, have been tested in the two types of compositions (proportionally reducing the rest of the formula). The results show a considerable melting effect of the glass in the two types of compositions. In the case of porcelain stoneware, the melting effect of glass is higher due to higher firing temperatures. Although in principle, 10% enables greater reduction of the firing temperature of each product, in the case of red glazed tile stoneware composition, it also excessively increases the piroplasticity index (tendency to bend during firing). Furthermore, in the two types of compositions the firing interval is excessively reduced when 10% glass is used. Therefore, the optimum percentage of glass would be close to 5% for the two types of compositions if the objective is to reduce the maximum firing temperature.

2. INTRODUCTION

Waste Electrical and Electronic Equipment, WEEE, generate different waste, one of which is glass from lamps and fluorescent tubes. The use of other glasses in ceramic products has been widely researched [1][2][3], with the main advantage of reducing firing temperatures of ceramic products due to their melting characteristics. However, there is no evidence of the use of glass from lamps and fluorescent tubes in ceramic tiles.

For this reason, the viability of using this type of glass (whose chemical composition is shown in Table 1) has been studied in low porosity ceramic tile compositions, namely red glazed tile stoneware and glazed tile porcelain stoneware, with the aim of reducing optimum firing temperatures, thus reducing energy consumption as well as CO_2 emissions.

Oxide	Glass from lamps and fluorescent tubes (% by weight)
SiO_2	72.1
Al_2O_3	2.02
Fe_2O_3	0.12
K_2O	4.34
MgO	1.79
Na_2O	2.55
BaO	14.0
B_2O_3	1.17
PbO	0.50
Loss of ignition	0.37

Table 1. *Chemical composition of the glass used in the study (% by weight).*

3. INTRODUCTION OF GLASS INTO CERAMIC MEDIUM COMPOSITIONS

Two percentages of glass, 5 and 10%, have been tested in the two types of compositions, red glazed tile stoneware and glazed tile porcelain stoneware (proportionally reducing the rest of the formula). The compositions have been prepared by wet milling and have been characterized by determining their residue at 63 µm while evaluating their behaviour during shaping and firing as well as the tendency to deform due to pyroplasticity [4].

The gresification diagrams, figures 1 and 2, show a considerable melting effect of the glass both for red stoneware compositions with lower firing temperatures, as well as for porcelain stoneware with higher temperatures. In the case of porcelain stoneware, the melting effect of glass is higher due to higher firing temperatures. On the other hand, in the case of red stoneware, the glass causes very pronounced swelling; greater with an increased percentage of glass. Conversely, for porcelain stoneware compositions, in spite of gresifying at higher temperatures, swelling is much lower. The reason for this difference in behaviour must be the different particle sizes of the glass in the two series of compositions. In fact, in the red stoneware compositions, the degree of milling was lower (sieve residue of 63 µm of 5-6%), therefore, the glass particles must be larger compared to those present in the porcelain stoneware compositions (sieve residue of 63 µm of 1-2%). The smaller particle size of the glass in the porcelain stoneware compositions should favour more homogeneous mixing with the rest of the components while attenuating the tendency to swelling (as a consequence of its high melting point).

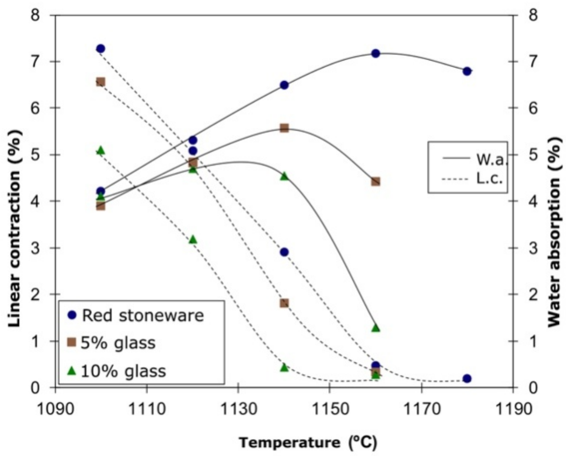

Figure 1. *Gresification diagrams of red stoneware compositions.*

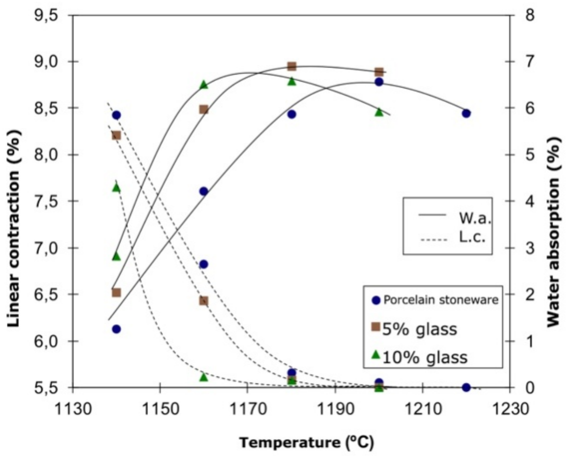

Figure 2. *Gresification diagrams of porcelain stoneware compositions.*

Based on the gresification diagrams, optimal firing temperatures and properties of pieces at these temperatures have been calculated (tables 2 and 3). As a consequence of the notable swelling produced by the glass in the red stoneware compositions, the bulk density and linear contraction corresponding to water absorption of 3%, decrease as glass content increases. On the other hand, although in principle, the percentage of 10% enables greater reduction of firing temperature for each product, in the case of red glazed tile stoneware compositions, it also excessively increases the pyroplasticity index (possibly due to the aforementioned effect of larger particle sizes).

Furthermore, in the two types of compositions the firing interval is excessively reduced when 10% glass is used. Therefore, the optimum percentage of glass would be close to 5% for the two types of compositions if the objective is to reduce the maximum firing temperature. In the case of porcelain stoneware compositions, it is possible that this percentage could be increased if glass is introduced as substitution for feldspar, designing specific formulas for this purpose. This would reduce dependence on imported raw materials for this type of composition.

Composition	Stoneware	5% glass	10% glass
Temperature (ºC)	1139	1133	1121
Linear contraction (%)	6.5	5.5	4.7
Loss of ignition (%)	5.58	5.37	5.05
Apparent density (g/cm^3)	2.370	2.262	2.227
Pyroplasticity index ($cm^{-1}x10^5$)	3.8	4.3	5.0

Table 2. *Properties of red stoneware compositions at the temperature required to achieve water absorption of 3%.*

Composition	Porcelain Stoneware	5% glass	10% glass
Temperature (ºC)	1198	1183	1168
Linear contraction (%)	8.8	9.0	8.9
Loss of ignition (%)	3.88	3.74	3.70
Apparent density (g/cm^3)	2.410	2.407	2.405
Pyroplasticity index ($cm^{-1}x10^5$)	4.7	5.0	4.9

Table 3.*Maximum densification properties of porcelain stoneware compositions.*

4. AKNOWLEDGMENTS

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