USE OF SPODUMENE AS A FLUX IN PORCELAIN TILE COMPOSITIONS

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1. INTRODUCTION

Spodumene is a lithium aluminosilicate with the formula $Li_2O{\cdot}Al_2O_3{\cdot}4SiO_2$, which has a pyroxene structure. It has a melting temperature of 1420 °C, density of 3.2 g/cm^3 and Mohs hardness of 6.5 to 7. The world's largest spodumene production comes from the Sons of Gwalia LTD mine at Greenbushes (Australia). The starting mineral contains 4 % Li_2O and is processed to yield various grades. The purest grade has a Li_2O content of up to 7.5 %.

Despite its own high refractoriness, spodumene has traditionally been used as a flux in various ceramic products (glass, frits, vitreous china sanitary ware etc.), owing to the formation of eutectic points with the rest of the composition's constituents.

The present work addressed the feasibility of using this raw material as an auxiliary flux in porcelain tile compositions.

2 MATERIALS AND EXPERIMENTAL DEVELOPMENT

The study was conducted with a porcelain tile composition formulated using a white-firing kaolinitic-illitic clay, sodium feldspar and feldspathic sand. These raw materials, at their respective proportions in the composition, are the standard industrial constituents used in porcelain tile manufacture. A commercial sample of spodumene referenced "Universal Grade Spodumene", containing 6.0 % Li_2O, was also used.

The present work involved determining how adding spodumene affected pressing behaviour (bulk density) and firing behaviour (peak temperature and firing range), as well as certain end product properties (whiteness and stain resistance). Finally, the possibility was studied on a laboratory scale of reducing the firing cycle in spodumene-containing compositions.

Table 1 details the compositions that were prepared. The compositional changes made involved the progressive substitution of up to 8 % of sodium feldspar by spodumene.

	SP0	SP2	SP4	SP8
Clay	40	40	40	40
Sodium feldspar	45	43	41	37
Feldspathic sand	15	15	15	15
Universal Grade Spodumene	0	2	4	8

Table 1. *Prepared compositions (% by weight).*

3. RESULTS AND DISCUSSION

It was found that replacing sodium feldspar by spodumene did not alter the behaviour of the composition in the pre-firing stages (similar compaction and dry mechanical strength values were obtained), as neither particle-size distribution nor colloidal particle content varied significantly. However, adding spodumene substantially modified tile firing temperature, as Figure 1 shows. It can be observed that the progressive substitution of sodium feldspar by spodumene shifted the density-temperature curves to lower temperatures, indicating a rise in the vitrification rate. The rise increased as larger amounts of spodumene were added. In the tested composition range, this effect produced a drop of 5 °C in tile firing temperature with each 2 % spodumene addition.

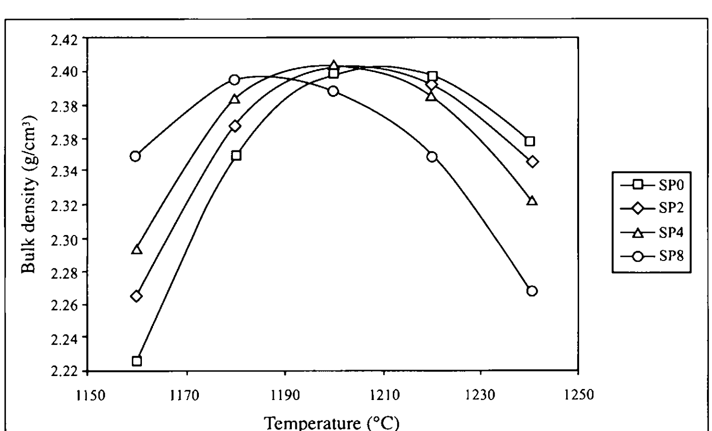

Figure 1. *Evolution of bulk density with firing temperature.*

An important aspect to be noted is that the rise in fusibility did not entail any significant variations in tile properties at working temperature, such as size, porosity, whiteness or stain resistance. The usual narrowing in the firing range (temperature range during which the product holds its characteristics) found with other vigorous fluxes was not detected either.

The additional fusibility provided by spodumene can be used to lower tile firing temperature or shorten tile residence time at high temperature (>1100 °C). With a view to approximately establishing by how much the firing cycle might be reduced by adding spodumene, firings were performed in the laboratory with different residence times (tp) at peak firing temperature with compositions SP0 and SP4. The heating and cooling rates were not modified in this series of experiments.

After running these tests, it was found that in the tested range of residence times (tp), the required state of maximum densification could always be attained (2.40 g/cm^3), though this logically entailed raising peak firing temperature (Tmax).

Figure 2 plots the pairs of values peak temperature (Tmax)-residence time (tp) at which tile porosity remained invariable. It can be observed that composition SP0 with a 6-min dwell attained maximum densification at 1210 °C. Taking this point as a reference, if composition SP4 is used and peak firing temperature is not modified, the residence time required to achieve maximum densification will drop to 4 min, i.e., the time the tile is held at peak firing temperature is reduced by 33 %. These calculations, performed just by modifying tile residence time at peak temperature in a laboratory kiln, will need to be appropriately transferred to an industrial kiln.

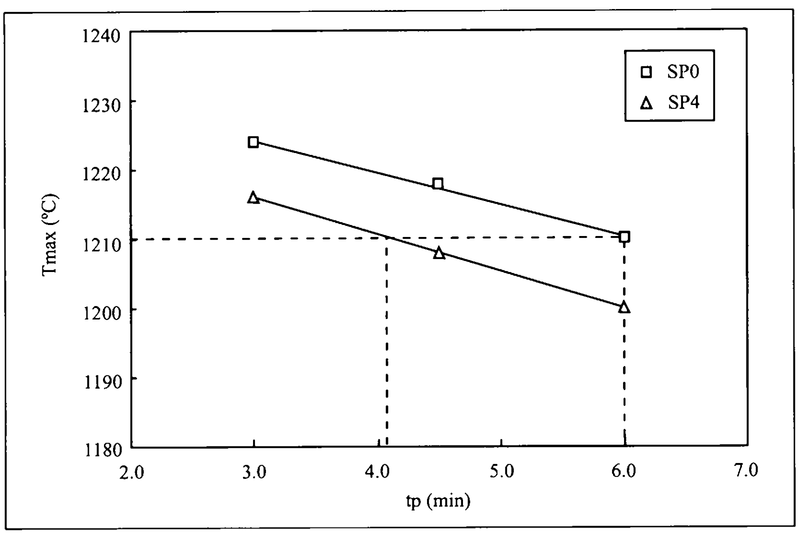

Figure 2. *Firing conditions (residence time and peak temperature) yielding maximum densification.*

4. CONCLUSIONS

- Substituting sodium feldspar by spodumene in porcelain tile compositions lowered tile firing temperature without changing tile characteristics (size, porosity, etc.).
- Reducing firing temperature did not narrow the porcelain tile firing range, which represents a technical advantage compared to other vigorous fluxes.
- The fluxing effect of spodumene can enable lowering porcelain tile firing temperature and/or reducing current firing cycles.