DEVELOPMENT OF HIGH QUALITY CERAMIC PRODUCTS USING GRANITE

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Introduction

Red clay based products are received much attention in the recent past due to higher availability of raw materials, lower vitrification nature of red clay and capability of incorporating waste materials of other industries into the red clay body composition.

The existing clay minerals in red clay such as illite and montmorillonite and impurity minerals facilitate to vitrify the red clay product at lower temperatures. However, the usage of elevated content of clay in the body composition of the red clay product results in severe defects of the final product such as dimensional variation, warpage and blotting (Riley, 1951). The increase of the quartz content of the body composition is the well known practice to overcome these defects. However, the addition of quartz can increase the maturing temperature and decrease the strength and other mechanical properties of the final product. Consequently, the firing cost increases and the quality of the final product decreases. Therefore, it is clear that the replacement of certain amount of clay with good fluxing raw material is necessary to obtain a high quality product by reducing the vitrification temperature.

The main objective of the present study was to use commonly available granite as a fluxing material of red clay products without using high purity feldspar unnecessarily. The efforts were also made to compare the fluxing potential of granite with respect to high purity potash feldspar.

Materials and Methods

Red clay, granite, feldspar and quartz were collected from locally available deposits. The particle size distribution of red cay was determined using laser particle size analyzer. Mineralogical composition of raw materials was identified using XRD analysis. Chemical composition of raw materials and products were measured using Atomic Absorption Spectroscopy (AAS). Different body mixtures were prepared by changing the ratio of granite/feldspar as indicated in Table1.

Rectangular specimens 70 mm × 2.5 mm × 3 mm, obtained by uniaxial pressing at 20 MPa were dried at 110 °C for 24 h and fired at 1000, 1050 and 1100 °C with 20 min soaking period.

Table 1. The mixing proportions of raw materials

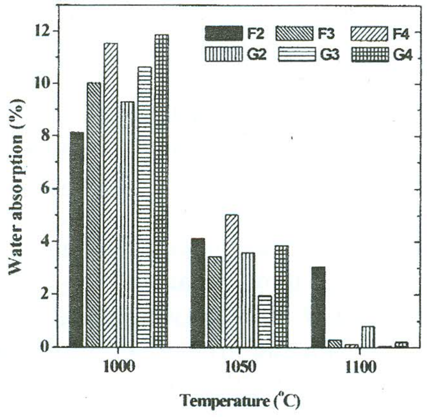
Compositions	Quartz (wt. %)	Clay-silt (wt. %)	Granite/Feldspar (wt. %)
G2/F2	10	70	20
G3/F3	10	60	30
G4/F4	10	50	40

G2, G3 and G4 for granite compositions and F2, F3 and F4 for feldspar

Bulk density, water absorption, three point flexural strength and fired linear shrinkage of five test specimens were measured and the average was taken for the analysis. Linear shrinkage was measured using Mitutoyo caliper. Bulk density of the fired samples was determined through the Archimedes' method with water immersion. Water absorption was determined according to the test method of ISO-standard 10545-3. Three point flexural rupture strength was determined by universal testing machine using a cross head speed of 0.5 mm/min. Microstructures of fired samples were analyzed using Scanning Electron Microscope (SEM).

Results

XRD results showed that microcline and anorthite were identified as main mineral phases and biotite and quartz were identified as minor constitutes of granite. Feldspars are mainly microcline. Chemical data showed that granite contains a lower amount of main fluxing (Na_2O and K_2O) oxides than feldspar. However, it contains a significantly higher amount of auxiliary fluxing oxides (CaO, MgO and Fe_2O_3) than feldspar.



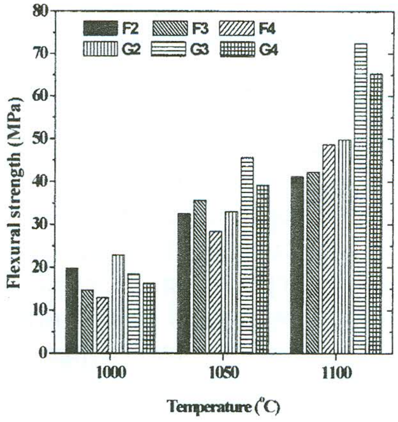


Figure 1. The variation of water absorption (left) and flexural strength (right) of fired samples containing feldspar (indicated by F2, F3 and F4) and granite (indicated by G2, G3 and G4)

Figure1 shows that water absorption decreases and flexural strength increases in all samples with increasing the temperature. In addition, water absorption of samples 3 and 4 of both feldspar and granite have achieved below 1 % after firing at 1100 °C. However, flexural strength of samples having formulation G3 and G4 of granite shows relatively higher value than that of feldspar both fired at 1050 and 1100 °C. Further, the maximum strength and the lowest water absorption were measured on composition with 30 wt. % of granite (G3, see Table 1). The results observed in bulk density and linear shrinkage (not presented) was closely correlated with the results of water absorption. In addition, SEM images of fracture surfaces of samples fired at 1100 °C showed that the smooth glassy phase with closed pores was observed on feldspar samples while the most of quartz and feldspar particles have dissolved in glass phase. However, there were some undissolved particles embedded in glass phase on granite samples fired at 1100 °C and closed pores were not observed.

Discussion

Samples with granite is characterized the good vitrification at 1100 °C (see water absorption results of Figure 1) since it has higher amount of auxiliary fluxing oxides, even though it has the lower amount of main fluxing oxides. On the other hand, the higher flexural strength of the granatic samples may be due to the presence of higher amount of Ca and Mg ions in its glass phase since the glass phase rich in Ca and Mg ions results in a high strength material (Volf, 1990). Furthermore, Ca and Mg ions result in a high viscous liquid phase that would result into embed the new forming crystals and remaining crystals. As a result, closed pores were not observed within the granatic samples. However, alkali rich feldspar samples form the glass phase with low viscosity that would result in formation of closed pores within the feldspathic samples (Wilson, 1995). The closed pores present in feldspathic samples would also result in decreasing the strength of the samples.

Conclusions

High quality ceramic products with less than 1 % of water absorption and flexural strength of 72 MPa can be fabricated by using red clay, quartz and granite at 1100 °C. The fluxing effect of granite is comparable with high purity feldspar. In addition, granite is responsible for a higher strength product than the product with feldspar.

References

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