

CALCIUM CARBONATE DECOMPOSITION IN POROUS WALL TILE BODIES DURING FIRING. INFLUENCE OF TEMPERATURE

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1. INTRODUCTION

The compositions used in wall tile manufacture contain calcite as a raw material, since this mineral contributes the necessary calcium oxide during firing to form the crystalline phases that give these tiles their characteristic properties (high dimensional stability, low hydratability, high porosity, etc.).

This mineral breaks down during firing releasing carbon dioxide, which can give rise to point defects in the glaze surface if CaCO_3 particle size is not sufficiently small and the firing cycle is not appropriately designed.

In this work the influence was studied of firing temperature on the decomposition rate of the calcium carbonate particles present in wall tile bodies.

2. EXPERIMENTAL

The study was performed using a mixture of raw materials with a composition and particle size similar to the ones used in industry to form wall tile bodies. Cylindrical test specimens, 7 mm thick with a diameter of 40 mm, were made by uniaxial pressing from this mixture under pressing conditions similar to industrial conditions.

Firing experiments were conducted with the test specimens under isothermal conditions in air atmosphere in a tubular laboratory kiln. The carbonate particle breakdown reaction was monitored by measuring specimen weight loss during heat treatment. As the calcium carbonate decomposition reaction overlaps that of clayey mineral dehydroxylation, two series of experiments were carried out to obtain the weight loss curves exclusively due to carbonate particle breakdown. In one of these series, test specimens were formed from the mixture containing calcium carbonate, whereas in the other the same mixture was used without calcium carbonate. The difference between the curves of weight loss versus time of each pair of experiments yielded the curve of the weight loss solely due to carbonate particle decomposition.

Finally, the degree of conversion of the calcium carbonate decomposition reaction was calculated by the following equation:

$$X = \frac{\Delta M}{\Delta M_{\infty}}$$

where ΔM is mass loss at a given moment and ΔM_{∞} is mass loss at infinite time.

3. PROPOSED MODEL

To develop the model it was assumed that carbonate particle decomposition in the body develops according to the unreacted core model, assuming that the slowest step is the chemical decomposition reaction. It is furthermore assumed that the calcite particles are uniformly spread inside the body and that breakdown takes place from the outside of the piece inwards, according to the unreacted core model, schematically illustrated in Figure 1.

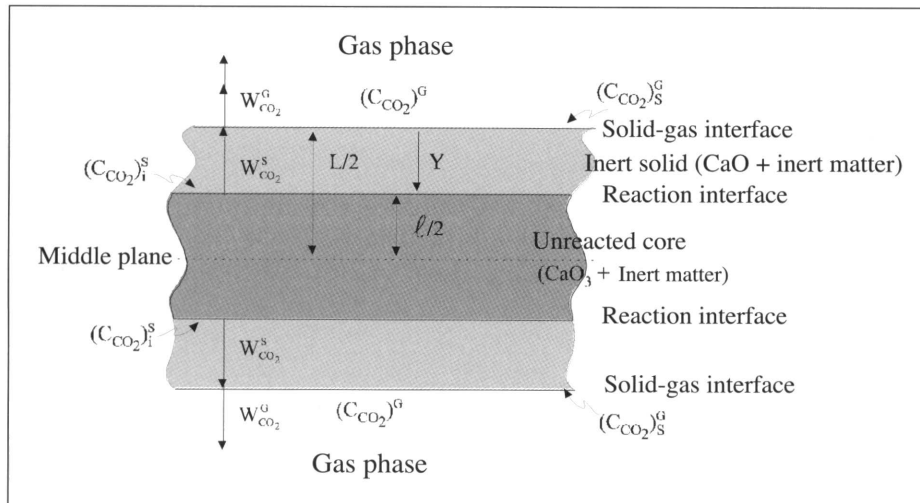


Figure 1. Schematic illustration of the reaction model considered.

4. RESULTS

Figure 2 shows the values of the degree of conversion versus specimen residence time in the kiln for the various isothermal heat treatments conducted. It can be observed that as heat-treatment temperature rose, the calcium carbonate particle decomposition rate increased, considerably reducing the time needed for total decomposition.

The figure also presents the results obtained, given in solid lines, on applying the proposed kinetic model. It can be observed that the model fits the experimental points quite well. The mathematical equation obtained relates the degree of conversion of the calcium carbonate contained in the body with time and temperature, allowing the time required for full calcium carbonate breakdown during the firing process to be predicted. The effectiveness of the model remains to be tested on modifying the body's porous structure through which the CO_2 released from the decomposing CaCO_3 particles is transferred by diffusion.

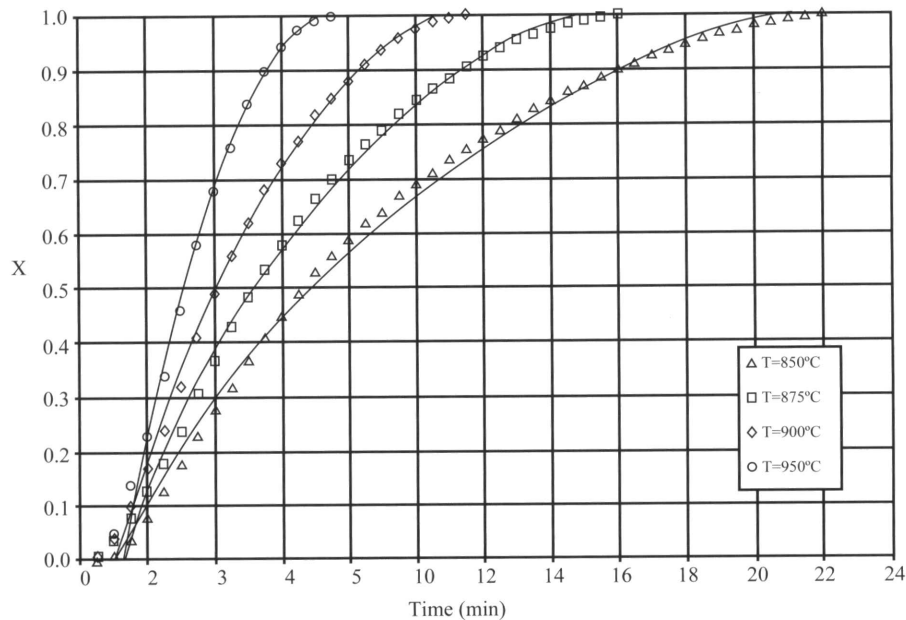


Figure 2. Evolution of degree of conversion with time.