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In situ evaluation of physical properties of colloidal silica-bonded refractory ceramics

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Refractory ceramics are divided into two categories, molded and unmolded (monolithic) structures. While the former has a defined shape as bricks, monolithic ones can be converted to any desired shape, such as concrete or mortar. These refractories are designed from coarse (aggregates) and fine (matrix) grains with fillers, binders, additives, and water. These materials are capable of withstanding severe conditions in service and are used as coating in steel industry furnaces and various other base industries, resisting temperature gradients, thermal shocks and chemical attacks that over time lead to corrosion. Alumina refractory alloys bonded with calcium aluminate cement (CAC) resist well to these conditions, thanks to their excellent strength, toughness and resistance to thermal shock. However, at high temperature, calcium-rich phases deteriorate the refractory properties. To improve the quality of these products, the use of colloidal silica (CS) stands out as an alternative to CAC as a binder system for the development of alumina-based refractory concretes due to its high permeability, ensuring the reduction of explosion risks during the drying stage of the compositions. In this work, the objective was to evaluate the physical properties during the drying stages and in different heat treatments to understand the microstructural evolution, besides the mechanical performance. From the results obtained, it was found that the refractory matrices bonded with colloidal silica presented lower total mixing time when compared to those bonded with CAC and low susceptibility to curing conditions (time and temperature). Results that are justified by the consolidation mechanisms presented by colloidal silica, because in addition to not involving the formation of hydrated phases, produce highly permeable and porous structures. Important and desirable characteristics because it contributes to the reduction of total processing time, facilitating the drying of parts. The analysis assesses whether the highly porous structure formed after the consolidation of colloidal silica indicates that the material in the green stage also has mechanical properties favorable to use and remains at approximately constant levels during initial heating before the sintering. Dilatometry tests and in situ monitoring of mechanical properties (modulus of elasticity, heat resistance) during different thermal treatments were performed. Physical and mechanical properties evolved due to dehydration phenomena (ambient temperature at 800°C), liquid phase sintering from 800°C to 1300°C, and microcrack formation during cooling.