X-Ray diffraction study of high temperature reaction products in the barium oxide-silica-alumina-ferric oxide system

by

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The ever-increasing environmental pollution and the fast depletion of fossil fuels have contributed to the need to find suitable ways to reduce the energy consumption in the manufacture of Portland cement. Substantial savings in this regard in the manufacturing process can be achieved if more belite and less alite are necessary to produce a cement of good quality. To allow for more belite and less alite in the cement, the reactivity of the belite phase has to be increased. The addition of small quantities of barium to the raw mix is said to increase the reactivity of the belite phase. This study was initiated to obtain a better understanding of the reaction products that can be expected in systems containing combinations of barium oxide, silica, alumina and ferric oxide under similar reaction conditions as used in the manufacture of normal Portland cement.

After careful consideration, binary, ternary and quaternary samples were prepared containing different proportions of barium carbonate, silica, alumina and ferric oxide. In the case of the quaternary samples, the silica modulus and alumina modulus were kept constant at 2.3 and 1.5, respectively, while the "barium oxide saturation factor" was chosen to be 86, 90, 94, 98 or 102 %. The quaternary samples were burnt in air under varying conditions of heating time and temperature to simulate the clinkering process in the manufacture of Portland cement.

The crystalline phases that formed under various conditions in the samples were determined by means of XRD analysis. XRD analysis proved to be a useful tool to determine the effects of heating temperature, heating time and mix composition on the formation of some of the phases. Some of the contradictory statements found in the literature were discussed as well as the trends observed in the ratio of dibarium silicate to barium carbonate in the samples. The hydration and carbonation of barium oxide were also discussed with the aid of the diffractograms.

SAMEVATTING

X-straaldiffraksiestudie van die hoë-temperatuurreaksieprodukte in die bariumoksied-silika-aluminiumoksied-ysteroksiedsisteem

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Die toenemende omgewingsbesoedeling en uitputting van brandstowwe dra by tot die behoefte om maniere te vind om die energieverbruik tydens die vervaardiging van Portlandsement te verminder. Aansienlike besparings in hierdie verband kan teweeggebring word indien meer dikalsiumsilikaat en minder trikalsiumsilikaat benodig sou word om 'n sement van goeie gehalte te vervaardig. Om vir 'n groter hoeveelheid dikalsiumsilikaat voorsiening te maak, is dit nodig om die reaktiwiteit van hierdie fase te verhoog. Daar is aanduidings dat die byvoeging van klein hoeveelhede barium tot die grondstofmengsel van die sement die reaktiwiteit van die dikalsiumsilikaatfase verhoog. Hierdie studie het ontstaan uit die behoefte om 'n beter begrip te verkry van die reaksieprodukte wat verwag kan word in sisteme wat bariumoksied, silika, aluminiumoksied en ysteroksied bevat, onder reaksietoestande soortgelyk aan wat gebruik word tydens die vervaardiging van gewone Portlandsement.

Na deeglike oorweging, is twee-, drie- en vierledige monsters met verskillende hoeveelhede van bariumkarbonaat, silika, aluminiumoksied en yster(III)oksied voorberei. In die geval van die vierledige monsters was die silikamodulus en die aluminiumoksiedmodulus konstant gehou op 2.3 en 1.5, onderskeidelik, terwyl die bariumversadigingsfaktor 86, 90, 94, 98 of 102 % was. Die vierledige monsters is verhit

onder wisselende toestande van verhittingstemperatuur en –tydsduur om die klinkeringsproses tydens die vervaardiging van Portlandsement na te boots.

Die kristallyne fases wat onder verskillende omstandighede in die monsters gevorm het is by wyse van X-straaldiffraksie-analise bepaal. X-straaldiffraksie-analise was nuttig om die invloed van verhittingstemperatuur, -tyd en monstersamestelling op die vorming van sommige van die fases te bepaal. Sommige van die teenstrydige stellings wat in die literatuur voorkom is bepreek, asook die verhouding van dibariumsilikaat tot bariumkarbonaat in die monsters. Die hidrasie en karbonasie van bariumoksied is ook bespreek met behulp van die diffraktogramme.