The removal of phosphorous impurities and subsequent use of phosphogypsum in Portland Cement

by

Elizabet Margaretha van der Merwe

submitted in partial fulfilment of the requirements for the degree

Philosophiae Doctor

Chemistry

in the Faculty of Natural and Agricultural Sciences

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Supervisor: Professor C A Strydom

Abstract

Phosphogypsum is a by-product in the production of wet phosphoric acid, and most of the phosphogypsum produced in the world remains unutilized at present. The impurities included in phosphogypsum seriously restrict its industrial use as a set retarder in the cement industry. The aim of this study was to investigate different methods to remove the phosphorous impurities contained in South African phosphogypsum. The application of treated phosphogypsum samples to replace natural gypsum as a set retarder in Portland cement was subsequently studied.

It was indicated that sieving could be applied to reduce the amount of phosphorous impurities in some phosphogypsum particle size fractions. However, the amount of phosphorous impurities contained in the particle size fractions with fewer impurities was still above requirements, and were therefore unacceptable for use in Portland cement.

A method involving thermal treatment followed by washing with water and milk of lime proved not to remove the phosphorous impurities contained in the phosphogypsum crystal lattice, but was successful in removing some of the water-soluble impurities. Some improvement was shown in the performance of cement containing these treated phosphogypsum samples when compared to cement containing untreated phosphogypsum. However, this improvement proved to be unsatisfactory for the replacement of natural gypsum by these phosphogypsum samples in Portland cement.

The application of a method comprising the combination of thermal and sulphuric acid treatment proved to be successful in removing most of the harmful phosphorous impurities from the phosphogypsum crystal lattice. Subsequently, South African phosphogypsum treated by this suitable method could successfully replace natural gypsum in Portland cement.

This study attempts to readdress the worldwide problem of phosphogypsum waste utilization, and shows that its application as a set retarder in Portland cement is possible after exposure to an effective purification method.

Samevatting

Fosfogips is 'n neweproduk in die vervaardiging van nat fosforsuur. Die oorgrote meerderheid fosfogips wat tans in die wêreld geproduseer word, word nie benut nie. Die onsuiwerhede in fosfogips beperk die industriële gebruik daarvan as 'n set reguleerder in die sement industrie. Die doel van die studie was om verskillende metodes te ondersoek om die fosfor onsuiwerhede uit Suid-Afrikaanse fosfogips te verwyder. Die toepassing van behandelde fosfogips om natuurlike gips as 'n set reguleerder in Portland sement te vervang, is daarna bestudeer.

Daar is aangetoon dat sifting gebruik kan word om die hoeveelheid fosfor onsuiwerhede in sommige partikelgrootte fraksies te verminder. Die hoeveelheid fosfor onsuiwerhede in die fraksies wat minder onsuiwerhede bevat het was egter steeds hoog, en was onaanvaarbaar vir gebruik in Portland sement.

'n Metode wat termiese behandeling gevolg deur wassing met water en kalkwater insluit, kon nie die fosfor onsuiwerhede uit die fosfogips kristalstruktuur verwyder nie, maar was suksesvol in die verwydering van sommige van die water-oplosbare onsuiwerhede. 'n Verbetering in die werkverrigting van sement wat die behandelde fosfogips bevat is getoon in vergelyking met sement wat onbehandelde fosfogips bevat. Hierdie verbetering is egter nie bevredigend vir die vervanging van natuurlike gips deur hierdie fosfogips monsters in Portland sement nie.

Die toepassing van 'n metode bestaande uit die kombinasie van 'n termiese en swaelsuur behandelingsmetode was suksesvol in die verwydering van meeste van die ongewensde fosfor onsuiwerhede uit die fosfogips kristalstruktuur. Suid Afrikaanse fosfogips wat met hierdie geskikte metode behandel is, kon natuurlike gips suksesvol in Portland sement vervang.

Hierdie studie poog om weer die wêreld-wye probleem van fosfogips afvalbenutting aan te spreek, en toon dat die aanwending van fosfogips as 'n set reguleerder in Portland sement moontlik is na blootstelling aan 'n effektiewe suiweringsmetode.

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