AN ABSTRACT OF A THESIS

KINETICS AND MICROANALYSIS OF THE REACTION BETWEEN FLY ASH AND CALCIUM HYDROXIDE

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Master of Science in Chemical Engineering

The objective of this thesis was to determine kinetic and microstructural information for the reaction between a class F fly ash and calcium hydroxide. This system was chosen because the pozzolanic reaction (the reaction of $Ca(OH)_2$ with SiO_2 and Al_2O_3) of fly ash could be investigated without the problems associated with cement phases, which make quantification of pozzolanic reactions difficult.

Electron microscopy, x-ray microanalysis, and synchrotron x-ray diffraction were used to investigate the fly ash microstructure and crystallography. The results show that there are a variety of particle types in the system. Crystalline phases, including quartz, mullite, Fe_2O_3, $Ca(OH)_2$, $CaSO_4$, and Fe_2O_3-MgO, were found in irregularly-shaped particles. The glass phase was found in spherical particles, which were sometimes in the form of cenospheres or plerospheres. Chemical microanalysis suggests two glass phases with nominal composition AS_3 and A_2S_3, which contain varying amounts of calcium and iron.

Several microanalytical techniques including scanning electron microscopy, x-ray microanalysis, Auger spectroscopy, and synchrotron x-ray diffraction were used to identify and characterize the reaction products between the fly ash and $Ca(OH)_2$. The results show that the major reaction products include calcium silicate hydrate, with a Ca/Si ratio of 1.4, and katoite ($(CaO)_3(Al_2O_3)(SiO_2)(H_2O)_4$). The investigation of early age samples shows the formation of hydration product on the surface of $Ca(OH)_2$ suggesting that the $Ca(OH)_2$ surface is an *active* site for precipitation.

Kinetic data for this system were obtained using thermal analysis and synchrotron x-ray diffraction. The reaction was modeled with a variety of methods, including the Avrami, Knudsen, and Jander equations. A two-surface model presented by Biernacki was also investigated. The results show that the dimensionless activation energy, E_a/R, ranges from 5700 to 8400 depending on the initial amount of fly ash in the sample.

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CERTIFICATE OF APPROVAL OF THESIS

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