New hydrothermal methods for the transformation of iron oxides in bauxite residue into magnetite

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Extended Abstract

Bauxite residue is a waste stream of the alumina industry and has left a legacy of 2.7 billion tonnes. This work presents two novel ways to approach the possibility of transforming hematite (Fe_2O_3) and/or goethite (FeOOH) into magnetite (Fe_3O_4) in bauxite residue. This magnetite could be magnetically separated from the rest of the bauxite residue. Unlike high temperature processes that necessitate drying and reduction, typically by a carbon-bearing source at temperatures exceeding 700 °C, the processes herein take place in a slurry state and at a relatively low temperature. The motivation is to introduce this step before filter pressing the red mud, in an existing Bayer cycle.

The first process was based on the process of refluxing under an inert environment and the addition of ferrous salt. Initial experiments were performed on pure hematite and goethite. A solution of 0.05 mole Fe_2O_3, 50 ml of 2 M NaOH and 250 ml demineralized water was flushed with nitrogen gas to remove all oxygen. Subsequently, 0.05 mole of ferrous salt was added to the solution and heated to 100 °C for 1.30 hours, still under nitrogen. The solid was filtered and dried at 60 °C in air. The XRD results indicated a maximal transformation yield of 72 % and 75 % for goethite and hematite, respectively. It was suggested that this transformation yield could be further increased through agitation. Additionally, it was determined that the driving force and the rate of the reaction could be increased by increase in temperature from 25 °C to 100 °C. The transformation yield for hematite increased from 18 % to 68 %. Furthermore, the ratio of ferrous salt to hematite plays a significant role on the transformation yield. It was concluded that an excessive amount of ferrous ions in the solution have a negative effect on the transformation. However, the effect of an excess of ferrous hydroxide on the transformation was not research and needs to be further investigated.

Similar experiments were performed on bauxite residue. XRD results indicated the presence of hematite and goethite in the bauxite residue. It was concluded that the ferrous hydroxide did not react with the hematite and goethite present. The influence of time (i.e., 1.30, 3.00, 4.30, and 6.00 hours) had no influence on the

transformation to magnetite. In order for the transformation to occur, a possible adsorption of the ferrous ion onto the iron (hydr)oxide is needed. The transformation was assumed to be hindered due to the presence of other minerals (e.g., silica). Therefore, further investigation is needed to obtain an understanding of the influence of other minerals in bauxite residue on the transformation of hematite and goethite into magnetite.

The second process consisted of introducing metallic aluminum as a hydrogen gas agent in a gravity pressure vessel (GPV). These tests were performed at Innovation Concepts B.V., Gorinchem, Netherlands. A mixture of 150 g of bauxite residue and 800 ml of H_2O was put in the GPV, with an input pressure of 20 bar nitrogen gas. The pressure varied between 50 and 100 bar, the temperature varied between 200 and 250 °C, and the addition of metallic aluminum varied from 3 to 10 g. The duration of the experiment lasted for three hours. The solid was filtered and dried at 60 °C in air. The XRD results of these experiments indicated no formation of magnetite. It was concluded that the role of the partial pressure of water vapor over the partial pressure of hydrogen gas needed to be further investigated.

Key words: bauxite residue, magnetite, ferrous iron, iron oxides, metallic aluminum

Cement, Concrete, Ceramics and Novel Applications