Investigating the grinding characteristics of vanadium-titanium iron ore tailings for sustainable utilization in cementitious material preparation

ABSTRACT

The study of the cementitious material activity of industrial solid wastes is a key issue in the comprehensive utilization of its green building materials. In this study, mechanical activation was used to prepare cementitious materials from vanadium-titanium iron ore tailings (VTIOT) as the main raw materials, and the effects of grinding time, the key parameter, on the grinding characteristics of VTIOT, the mechanical properties of the VTIOT cementitious material, and the hydration mechanism were investigated by means of surface area analysis, particle size analysis, X-ray diffraction (XRD), scanning electron microscopy (SEM), alkali leaching, mechanical testing, hydration heat analysis, and thermogravimetric analysis (TGA). The results show that: the grinding time and specific surface area of VTIOT exhibit a linear correlation. Prolonging the grinding time, the fractal dimension of the particles gradually increases. The activity of Si4+ and Al3+ elements increases rapidly, reaching a Si4+ and Al3+ content of 96 mg·L− 1 at 90 min of grinding. With a VTIOT mixing amount of 30 %, a mortar paste ratio of 1:3, and a water cement ratio of 0.5, the 50 min ground VTIOT mortar demonstrates 7 d and 28 d compressive strengths of 29 MPa and 38.7 MPa, corresponding to the highest values of the activity index, measured at 71.4 % and 75.2 %, respectively. Under standard curing conditions, the hydration products of cementitious materials at 7 d are ettringite (AFt), calcium silicate hydrate (C-S-H), alumina, ferric oxide, mon sulfate (AFm), calcium hydroxide (Ca(OH)2), and calcium silica (CS). In the hydration process of 7 d, the exothermic peak and exothermic amount of the 50 min VTIOT cementitious materials are greater than those observed for other grinding times, but lower than those of pure reference cement.