Manufacturing of FeSiB high-temperature phase change material by silicothermic reduction

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ABSTRACT

Fe-26Si-9B(wt.%) is identified as a potential high-temperature phase change material (PCM) due to its significant properties, such as its high latent heat of fusion and low volume change. For the successful utilization of this alloy into thermal energy storage systems, the development of a cost-effective production method is essential. Presently, Fe-26Si-9B alloy can be produced by mixing FeSi alloys with either pure boron (B) element or FeB alloys. However, the use of pure B is financially prohibitive, and the carbothermic reduction of FeB alloy results in high greenhouse gas emissions and high energy consumption. In this regard, our study proposes a silicothermic reduction method for the production of Fe-26Si-9B by using FeSi alloys and B_2O_3-based oxides. Accordingly, the influence of various parameters on the production was investigated: operating temperature, holding time, B_2O_3 concentration in charging oxides, and slag/metal ratio. Based on the experimental results, the optimal parameters for producing FeSiB alloys with over 8wt.% B were determined. The mixture of FeSi alloys and oxides enriched with 50-65wt.% B_2O_3 should be subjected to temperatures ranging from 1550-1650°C, maintain a slag/metal ratio exceeding 1, and ensure a holding duration beyond 1 h. Moreover, the energy consumption of this process was estimated to be ~1.6 MWh/tonne and the mass loss is observed to be in the range of 0.5-6.9%. Therefore, silicothermic reduction offers a potential, environmental method for producing the FeSiB alloys.