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Effect of Particle Size and Relative Density on Powdery Fe_3O_4 Microwave Heating

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ABSTRACT

In recent years, microwave energy is expected to be a heat source of high temperature process aiming for CO_2 reduction and energy conservation owing to the possibility of volumetric heating. In order to examine the applicability of microwave heating to ironmaking, it is important to investigate the microwave heating of raw materials of ironmaking such as Fe_3O_4. In this study, the effect of particle size and relative density on microwave absorptivity of powdery Fe_3O_4 was elucidated by the heating curves. Powdery Fe_3O_4 samples having different particle sizes and relative densities and bulk Fe_3O_4 samples were heated at the positions of the H (magnetic) and E (electric) field maxima in a 2.45 GHz single-mode microwave cavity. Sample temperatures abruptly increase and become constant after a while. At a constant temperature, the energy balance is attained, i.e., the rate of microwave energy absorption is equal to the rate of thermal energy dissipation. Assuming that the thermal energy dissipation rate due to convection and radiation heat fluxes is only a function of the sample temperature, the microwave absorptivity could be evaluated by the temperature at the steady state. It has been found that the microwave absorptivity of Fe_3O_4 powder decreases with an increase in relative density. On the other hand, the microwave absorptivity hardly depends on the particle size, which may be due to its quite a large penetration depth of Fe_3O_4 compared to metal.

KEYWORDS: Fe_3O_4, powder, ironmaking, microwave absorptivity, particle size, relative density

INTRODUCTION

Currently, CO_2 emission reduction and energy conservation are urgent tasks for the prevention of global warming. Since large fraction of CO_2 emission is attributed to the blast furnace-type ironmaking in Japan in spite of the fact that Japanese blast furnace technology has been already advanced, new ironmaking process should be invented based on innovative theories and mechanisms. So far, ca. 500 kg of coke is consumed to produce one ton of pig iron. Of this total, percentage of coke consumption for the iron ore reduction and carburization is ca. 45%, and the residual 55% is used to heat the raw materials and cause the reduction reaction which is an endothermic reaction. If heat source for the latter can be supplied by electric energy produced by electric sources such as nuclear power, wind power and solar power, CO_2 emission could be dramatically reduced. We have focused on the microwave heating as a new heating source for iron making [Nagata et al., 2008; Ishizaki et al., 2006; Ishizaki and Nagata, 2007; Ishizaki et al., 2007].

Ishizaki et al. [2006] have produced pig iron from a carbon composite pellet (ca. 8 g) composed of the mixture of magnetite ore (Romeral) and coal (Robe River) powders by means