Minerals Engineering 24 (2011) 963–966

Contents lists available at ScienceDirect

Minerals Engineering

journal homepage: www.elsevier.com/locate/mineng

Technical Note

In situ observation of quartz particles entrained into magnetite coagulates in a uniform magnetic field

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ARTICLE INFO

Article history:
Received 17 November 2010
Accepted 27 March 2011
Available online 22 April 2011

Keywords:
Magnetic separation
Iron ores
Fine particle processing

ABSTRACT

The entrainment of fine quartz particles into magnetite coagulates in a uniform magnetic field was studied through in situ observation using a video microscope. It is shown that the mechanisms for this entrainment are attributed to the magnetic coagulation of locked quartz–magnetite particles with free magnetite particles, the entrainment of free quartz particles into magnetite pearl chains, and wrapping of magnetite circular chains round free and locked quartz particles.

1. Introduction

Magnetic coagulation is termed for the aggregation of magnetic particles in an external magnetic field due to magnetic attraction between the particles (Garcia-Martinez et al., 2004). It happens to ferromagnetic particles in a low-intensity magnetic field (Gokon et al., 2002; Stolarski et al., 2007) and to paramagnetic particles in a high-intensity magnetic field (Tsouris and Scott, 1995). For instance, magnetite particles in a magnetic drum separator aggregate in the form of chains. In magnetic screen process, finely ground magnetite particles aggregate in a uniform magnetic field and then are separated from individual gangue mineral particles by screening (Feng et al., 2006).

Magnetic drum separator is widely used in industry for magnetite concentration (Svoboda, 1987; Rayner and Napier-Munn, 2000). It upgrades magnetite concentrate till 67–68% Fe. However, SiO_2 grade in the concentrate is still high (3–7%), which causes a high energy consumption in smelting. It has been accepted that the silica contamination is attributed to the entrainment of the silicate mineral particles into magnetite coagulates. However, it has not been proved by any direct evidence yet. In this work, an attempt was made to investigate the mechanisms by which fine quartz particles are entrained into magnetite coagulates in an external magnetic field through in situ observation using a video microscope, in order to improve magnetic drum and magnetic coagulation processes for the deep elimination of silicate minerals from magnetite concentrates.

2. Experimental

2.1. Materials

The magnetite concentrate sample was collected from the Peña Colorada concentrate plant in Colima state, Mexico. Only the size fraction of −25 + 20 μm was used in this work. The sample assayed 67.5% Fe and 2.7% SiO_2, respectively. The water used in this work was distilled first, and then passed through a resin bed and a filter.

2.2. Methods

Two Helmholtz coils were used in this study for the generation of a uniform magnetic field (Trout, 1988), in which field intensity was controlled by adjusting excitation current. The magnetic coagulation of magnetite particles in water was realized in the magnetic field, while it was observed in situ by using a digital video microscope. First, 0.5 g magnetite sample and 10 ml water was mixed in a acrylic cell. Next, the sealed cell was moved to the Helmholtz coil rings. After that, the exciting voltage in the coils started and then increased gradually to make the magnetic field intensity from 0 to 0.01 T (Tesla). The rate of the intensity increase was 0.001 T/min. The movement of particles in the cell was recorded by the digital video camera throughout the intensity increase. Some pictures from the video were selected and reported in this work.

3. Results and discussions

The sequence of photographs of a locked quartz–magnetite particle entrained into a magnetite chain in the uniform magnetic field

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doi:10.1016/j.mineng.2011.03.022

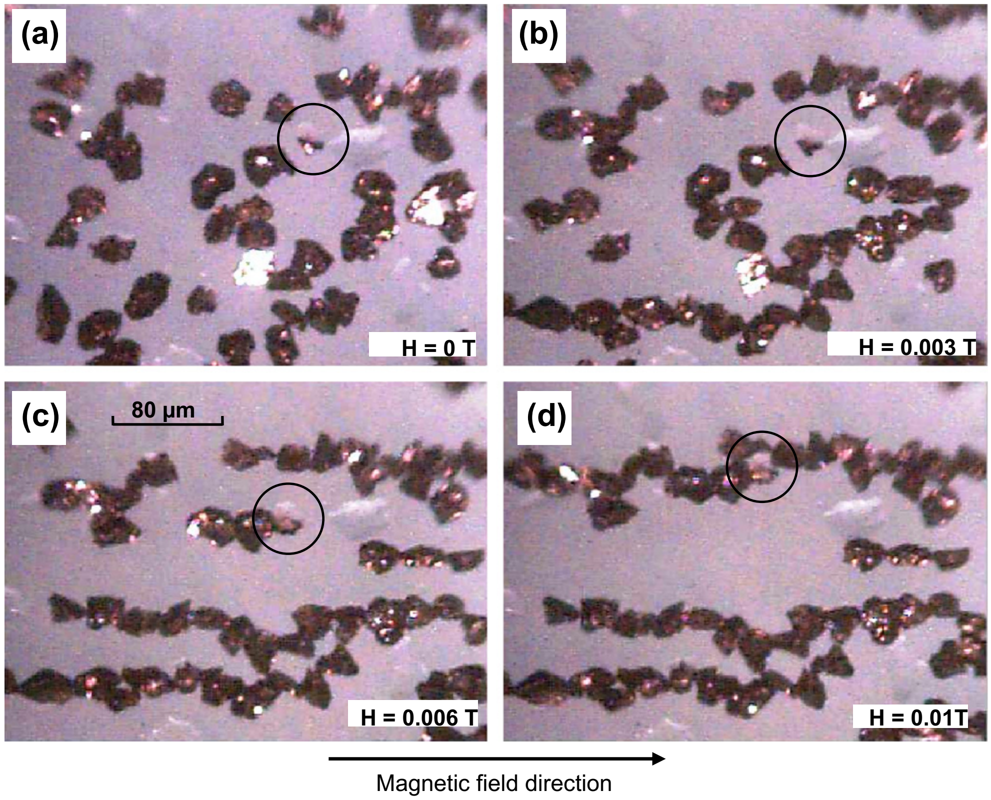

Fig. 1. Sequence of photographs of a locked quartz–magnetite particle entrained into a magnetite coagulate in a uniform magnetic field with gradual increase of magnetic field intensity. (a) $H = 0$ T; (b) $H = 0.003$ T; (c) $H = 0.006$ T; (d) $H = 0.01$ T.

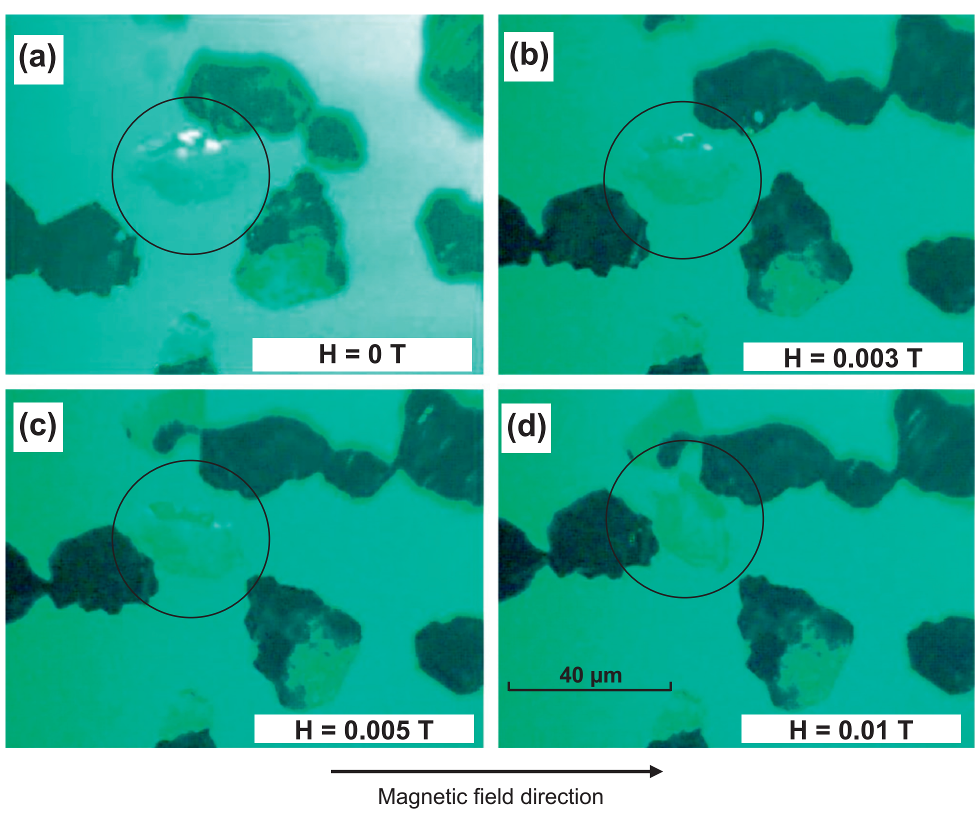

Fig. 2. Sequence of photographs of a free quartz particle entrained into a magnetite coagulate in a uniform magnetic field with gradual increase of magnetic field intensity. (a) $H = 0$ T; (b) $H = 0.003$ T; (c) $H = 0.005$ T; (d) $H = 0.01$ T.