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Electrostatic beneficiation of diatomaceous earth

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ABSTRACT

In many parts of the world, important reserves of Microscopic Biogenous Sediments or Pelagic Sediments occur which primarily consist of settled siliceous or calcareous microorganisms. Such sediments typically have zones, in which an intimate association of siliceous remains of diatoms and $CaCO_3$ is experienced. The purity of diatomite crude ores is very important for producing the filter grade finished products by means of the conventional flux calcination procedures. Calcination of DE materials with high calcium carbonate is not economically or environmentally friendly. The prime objective of this study was to evaluate the advanced STET tribo-electrostatic separator for the beneficiation of DE having relatively high quantities of $CaCO_3$ to produce a suitable calciner feed for the production of filter grade finished products.

In the best operating conditions, the STET technology showed the ability to reduce the calcium carbonate content of a natural-grade DE product from 19.5% to 10.9% which is an acceptable quantity of $CaCO_3$ for calciner feeds. Limitations of the DE recovery process using this technology was primarily due to superficial heterogeneity of some DE particles. The validation process of the beneficiated DE confirmed that the STET technology has the potential for upgrading natural-grade DE products having relatively high quantities of $CaCO_3$ to produce a suitable calciner feed for the production of filter grade finished products with the exception of the brewery industry.

1. Introduction

Diatoms are single-celled organisms with siliceous exoskeletons (frustules). They exhibit great differences in shapes and sizes. They are mostly found in the photic zone of oceans and seas and nearly every freshwater habitat. They are very important for our planet.

When diatoms die, their siliceous exoskeletons settle to the bottom of the water bodies and form a soft, very fine grained sedimentary rock called diatomite (Wallace et al., 2006). Diatomite deposits occur globally and may be of either marine or continental-lacustrine (fresh water) origin. Diatomite deposits are mined as an important industrial mineral because of the unique physical and chemical properties of diatomite such as inertness, abrasiveness, insulating properties, high purity and light weight (Womersley, 1991; Hurd, 1983).

Economical diatomite deposits are usually mined by surface mining methods. Conventionally, the diatomite crude ores can be treated by disagglomeration, drying, degritting, sizing and classification to produce natural grade diatomaceous earth "DE" products. They are most suited for secondary uses as fillers, functional mineral additives and speciality applications such as flattening of paints and coatings. These DE products are usually unattractive for commercial filtration applications.

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The beneficiated DE can be calcined with or without addition of a flux such as carbonate (soda ash) in conventional rotary kilns to produce DE of filter grade quality (*Calcination of Diatomaceous Earth*, 1961; *Treatment of Diatomaceous Earth*, 1954; Olmsted, 1982; Ediz et al., 2010). The purity of diatomite crude ores is very important for producing the filter grade finished products by means of the conventional flux calcination procedures.

The purity of a diatomite is mainly controlled by clastic and volcanogenic input during deposition and/or post-deposition (Inglethorpe, 1993). Calcium carbonate is one the main chemical compounds of Microscopic Biogenous Sediments. Therefore, in many parts of the world an intimate association of siliceous exoskeletons of diatoms and calcium carbonate is found.

Calcination of DE materials with high calcium carbonate is not economically and environmentally friendly. The decomposition of $CaCO_3$ is associated with a large amount of energy absorption, as calcination of $CaCO_3$ is a highly endothermic reaction. Also, calcination of these materials is not an environmentally friendly approach due to increasing greenhouse gas emissions. In the rotary kiln, CO_2 can be produced in a large quantity from both the heat source and the calcination reaction of $CaCO_3$ (Moffat and Walmsley, 2005).

Therefore, the prime object of this study has been to provide a process for the mineral beneficiation of diatomite crude ores and/or upgrading natural-grade DE products having relatively high quantities

Table 1
Particle size distribution of the DE sample compared with a DE calciner feed from the same DE processing plant.

	D10	D50	D90	Mean	Unit
The sample	2.4	11.2	23.1	12.4	μm
Calciner feed	2.7	10.9	21.0	11.6	μm

of $CaCO_3$ to produce an improved calciner feed for the production of filter grade finished products.

Conventionally, froth flotation is a widely used wet process to separate industrial minerals (Industries, N.R.C.C.o.T.f.t.M., 2002). The reverse anionic flotation of $CaCO_3$ can be applied for upgrading DE with high $CaCO_3$ content using sodium salt of oleic and tall oil fatty acids as collectors (Nyamekye, 2003; Filippova et al., 2015; Fooks, 2010; Rezai, 2005). Enrichment can be done on the upgraded DE by acid treatment (Zhang et al., 2013; Wang et al., 2013; Şan and İmaretli, 2011; Şan et al., 2009; Kokunešoski et al., 2016; Alyosef et al., 2014; Li et al., 2014; Tsai et al., 2006; Hamdi et al., 1998), high-speed shear (Zhang et al., 2013), ultrasound (Zhang et al., 2013), and the like. However, in wet processing of a ton of ores, generally several tons of fresh water is needed (Inoue, 2009). Dry processing is more favourable in some geographical regions, due to the limited availability of water supply (Inoue, 2009). Particle size distribution is one of the most important process variables which can affect the separation of minerals. DE particles are very fine and tribo-electrostatic separation methods would be suitable for separating particles < 1 mm, although there is no literature on electrostatic beneficiation of DE having relatively high quantities of $CaCO_3$.

In this study an advanced tribo-electrostatic counter current belt-type separator was applied for electrostatic beneficiation of DE.

2. Materials and methods

2.1. Sample

The diatomaceous earth (DE) was obtained from IMERYS Filtration & Performance Additives Division, which is one of the world biggest producers of DE products. The DE had been dried (moisture content = 5%), milled, classified and was uncalcined (a low-grade natural-grade product) so contained 19.5% $CaCO_3$.

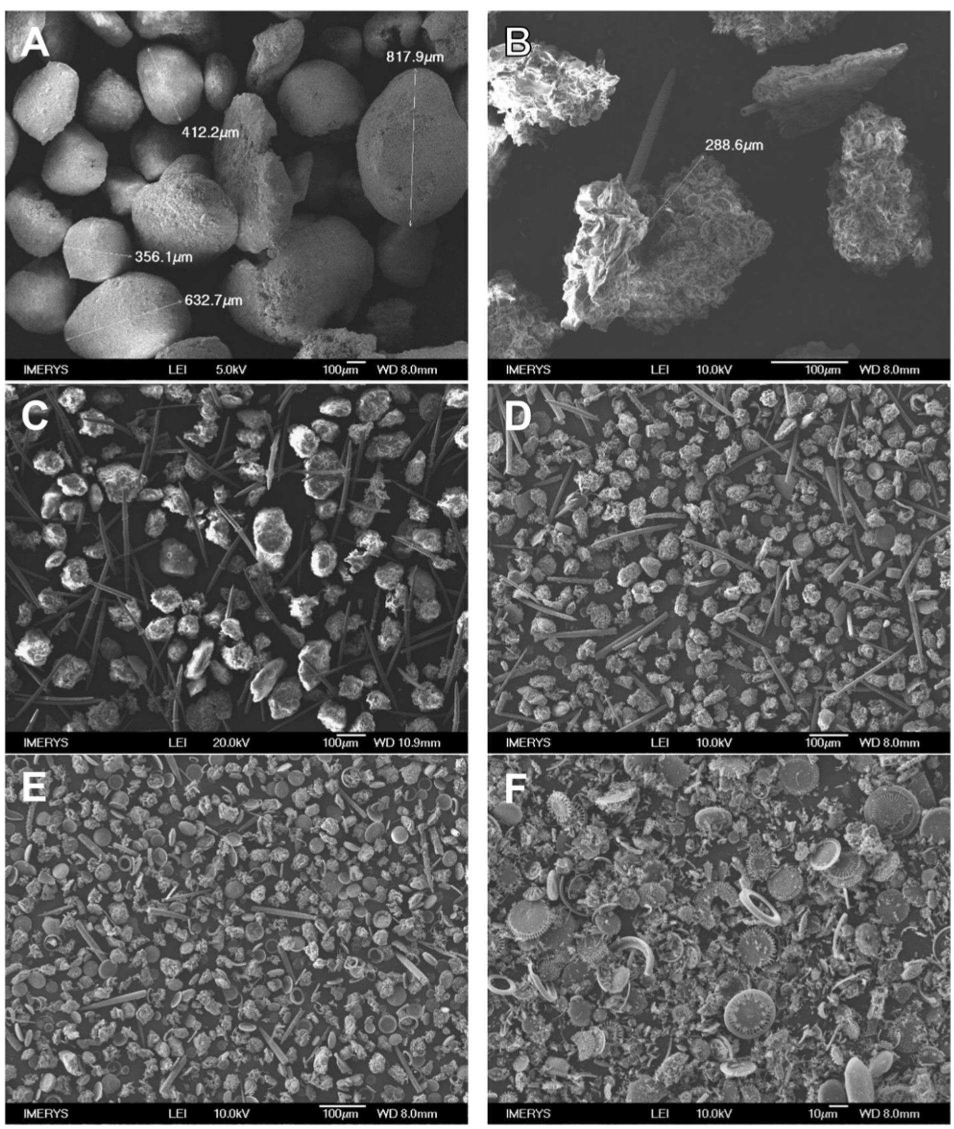

Fig. 1. Images of particles in the different size fractions captured with JEOL 6700F Field Emission SEM. Size fraction of >212 μm (image A); <212 μm >106 μm (image B); <106 μm >53 μm (image C); <53 μm >38 μm (image D); <38 μm >25 μm (image E), and <25 μm (image F).