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Review

Industrial mineral powder production in China

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Abstract

The recent annual output of major industrial mineral powders in the mainland of China has been more than 100 million t, accompanied by active development of such supporting technology as comminution, classification, separation/purification, and surface modification. In particular, the present paper reviews technologies for preparing ultra-fine particles involving dry and wet processing, modification and composition, calcination of kaolin clay, and processing of spherical/acerous industrial minerals.

Keywords: Industrial minerals; Powder; Processing

Contents

1. Recent production

According to China Non-Metallic Minerals industry Association and China Building Material Industrial Association, the total output of industrial minerals in the mainland of China was 103.9 million t in 2005, about 7% more than that in the previous year. Since 2004, the domestic demand for refractory materials has been increasing due to the rapid growth of steel and building industries. For instance, the production of magnesite increased by 30% from 2002 to 2003 (Wang, 2006), and that of ground calcium carbonate (GCC) increased by 9.5% from 2004 to 2005 (due to the increased demand for paper-making and the plastic industries) (Li, Yan, & Lei, 2006; Song, 2005; Tang & He, 2006).

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The growth of gypsum (excluding chemical gypsum) was from 29.5 million t in 2004 to 32.0 million t in 2005, at the rate of 8%, with the corresponding price increased by 10–20% (Zhu, Zhang, & Zhang, 2006). During that same period, the annual production of barite, mica, wollastonite, and asbestos all increased due to both export and domestic demands (Tang & He, 2006; Wang, 2005; Zhang, 2006; Zheng, 2005, 2006). However, kaolin clay production hardly increased due to the diminishing high-quality resources (Li et al., 2006; Tang, Cai, & Zhang, 2006; Wu & Wang, 2005). The annual production of lime for 2004 and 2005 was respectively 142.0 and 150.0 million t corresponding to the annual growth rate of 4.6 and 5.0% (China Lime Association, 2005; Zheng, 2006). The main use of lime in China is in the production of precipitated calcium carbonate, calcium carbide and caustic soda, as well as in the field of building, steel and non-ferrous metallurgy and sundry branches of chemical engineering (China Building Glass and Industrial Glass Association, 2005; China Fluorite Professional Association, 2006; China Non-Metallic Minerals Industry Association, 2005; Dai, 2006; Miao, 2005; Shen, 2005; Zhang, 2006; Zhang & Zhao, 2005; Zheng & Zu, 2006).

2. State of the art processing technology

2.1. Comminution and classification

In the mainland of China, industrial minerals processed by comminution fall into two classes: coarse products (10^3 to 30×10^3 μm) produced by crushing, and fine (10 to 10^3 μm) and ultra-fine products (10^{-1} to 10 μm) produced by grinding. In comminution, crushing involves both coarse and fine crushing, and grinding, both coarse grinding (75–1000 μm) and fine grinding (≤45 μm).

Comminution and classification are allied operations, using equipment as described in Table 1 (Zheng & Zu, 2006).

2.2. Separation and purification

Most of industrial minerals (such as limestone, calcite, marble, dolomite, gypsum, barite, talc, pyrophyllite, chlorite, bentonite, illite, wollastonite, hard-kaolinite and quartzite) are processed by simple manual or mechanical sorting, although other minerals such as asbestos, graphite, kaolin clay, diatomite, bentonite, quartz, mica, garnet, cyanite, sillimanite, andalusite, vermiculite, magnesite, feldspar, rutile, zircon sand, fluorite, phosphorus lime, sylvite, etc., need to be purified at the same time.

Air separation and sieve classification are applied to processing asbestos, while other methods like flotation or/and chemical methods (leaching with acid or alkali, and calcination) are utilized to treat graphite and gravity separation (i.e., hydrocyclone, centrifugal classification), high-intensity magnetic separation (HIMS), high-gradient magnetic separation (HGMS), super-conducting HGMS, leaching and de-ferrization are used to purify kaolin clay. Special technologies are used in the treatment of diatomite, i.e., dispersion by scrubbing, sands removal by classification and clay separation by selective sedimentation. Quartz is purified by acid leaching followed by washing. Treatment of mica involves sorting, abrasive separation, air separation, and gravity separation. Gravity separation (i.e., shaking table) is also used to process garnet. Sillimanite and cyanite are mainly processed by flotation after desliming. For processing feldspar, magnetic separation is primarily used for removing ferric impurities, and flotation for separating quartz from feldspar. Air or water separation can be used to separate vermiculite, after expansion from heavier gangue minerals. Magnesite is mainly processed by hot separation after controlled calcination. It employs electrical, magnetic, and/or gravity methods to separate rutile from zircon–quartz sands. The main method for treating fluorite and talc is flotation (Zheng, 2005).

2.3. Surface modification

Surface modification, which is used to produce fillers from industrial minerals for plastic, rubber, adhesive, polymer or its composites, paint, pigment, etc., is an important technology to improve the performance of powders. This technology involves surface chemical modification, sedimentation reaction modification and layer-inserted modification, either wet or dry. The chemicals used could be either organic or inorganic. The equipment used could be a continuous powder surface modifier, a batch heat-agitated machine, a vortex mill, a reaction vessel, etc., as illustrated in Table 2 (Zheng, 2007). So far, the modification technology has been far behind engineering requirements, and the production/application of effective chemicals as surface

Table 1
Current equipment for comminution/classification in China

	Comminution	Classification
Crushing	Jaw crusher, hammer crusher, impact crusher, cone crusher, roll crusher, etc.	Stationary screen (grizzly), vibrating screen, plane shaking screen, etc.
Grinding/pulverizing	Tumbling mill, rod mill, pebble mill, raymond bowl mill, roller mill, gyratory mill, column mill, vibration mill, tower mill, centrifuge mill, mechanical impact mill, vertical roller mill, etc.	Linear vibration screen, double-axis vibrating screen, high-frequency vibration screen, probability screen, cyclone-fine screen, hydro-cyclone, screw classifier, hydraulic classifier, cyclone classifier, impeller classifier, suspended screen, etc.
Ultra-fine grinding	Jet mill, pearl or agitation mill, grinding–peeling mill, sand mill, vibration mill, ball mill, vertical roll mill, ring roll mill, high-velocity impact mill, colloid mill, planet ball mill, etc.	Air-turbo classifier, horizontal screw discharge centrifuge, plate type centrifuge, small-diameter hydro-cyclone (bank)