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The Effect of Grinding Additives on Stirred Media Milling of Talc

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Abstract

Grinding additives were widely used to reduce the viscosity of the mineral particles during grinding. The aim of this study was to investigate submicron range of talc with and without grinding additives using a vertical stirred media mill. Two different grinding additives that an organic polymeric-anionic dispersant sodium salt of polycarboxylic acid (PCASS) and an inorganic-anionic dispersant sodium hexametaphosphate (SHMP) were used and their effect of dosages (wt %; 0- 0.05- 0.1- 0.2- 0.4- 1.2 and 2.4) was investigated.

In this study, a systematic study by using high density yttria stabilized zirconia (ZrO_2) grinding media (1 mm) on wet grinding of talc (d_{50}=6 µm) powders to produce submicron particles was performed in a lab-scale (750 ml) stirred media mill. Experimental results were evaluated based on the average particle size (d_{50}), specific energy consumption (kWh/t) reduction ratio and the specific surface area (m^2/gr).

Two grinding additives were detected to be effective for submicron grinding of talc. But, SHMP was detected to be the most effective grinding additive.

Keywords: *Talc, Stirred Media Mill, Wet Grinding, Grinding Additives*

1. Introduction

Stirred media mills draw attention in recent years because of easier operation, higher grinding rate, lower energy consumption and ability for grinding into the submicron and nano range [1-7]. There are two approaches for production of submicron and nano range particles: i- bottom-up and ii- top-down. This study is associated with top-down approach. Wet grinding and dry grinding are two plausible options in top down approach. This experimental study shows regard to the wet grinding process for production of submicron and nano range particles.

The submicron and nano range particles have recently been very important in many industries such as mineral, pigments, paint, metallurgical, ceramic, electronic and pharmaceutical. In view of this growing importance, grinding effectiveness is also of great importance. One way of improving grinding energy effectiveness in submicron range is use of grinding additives. Choi et al. [8] found that grinding additives reduced the energy consumed in a stirred media mill and increased the fineness of the ground particles. Hasegawa et al. [9] also showed that grinding additives used are quite effective due to the increase in flowability and the reagglomeration control of submicron particles. There are two mechanisms for preventing agglomeration. One mechanism is the change of the surface and mechanical properties of individual particles such as a reduction of surface energy. The other mechanism is change in arrangement of their flow in suspension [2, 8, 9-11]. Atesok et al. [12] studied the effect of grinding additives and found that grinding additives decrease energy consumption by increasing the fluidity. Numerous investigations have been conducted on the production of submicron and nanoparticles of different materials in stirred media mill in the literature [13-16]. On the other hand, little attention has been given to assessing specific energy consumption depending on the grinding additives in a wet grinding process.

In this study, the effectiveness of selected additives on the wet grinding of talc was studied as a function of additive type and dosage in a vertical stirred media mill.

2. Experimental

Talc (d_{50}=6 µm) sample obtained from Mikron's Company Nigde, Turkey was used for grinding experiments. Chemical analysis (by X-ray fluorescence) of the sample and physical characteristics of the calcite samples are shown in Table 1 and Table 2, respectively. The specific gravity of talc sample was determined by using a pycnometer and found to be 2780 kg/m3.

Table 1. Chemical composition of the talc used in experiments (wt %)

SiO_2	MgO	CaO	Fe_2O_3	Al_2O_3	LOI (1050 C°)
61	31	0,7	0,3	0,5	93,5

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Table 2. Physical characteristics of the talc samples

Real density (kg/m^3)	Refractive index	d_{50} (µm)	d_{97} (µm)	Specific surface area (m^2/g)
2780	1.57	6	21.23	1.46

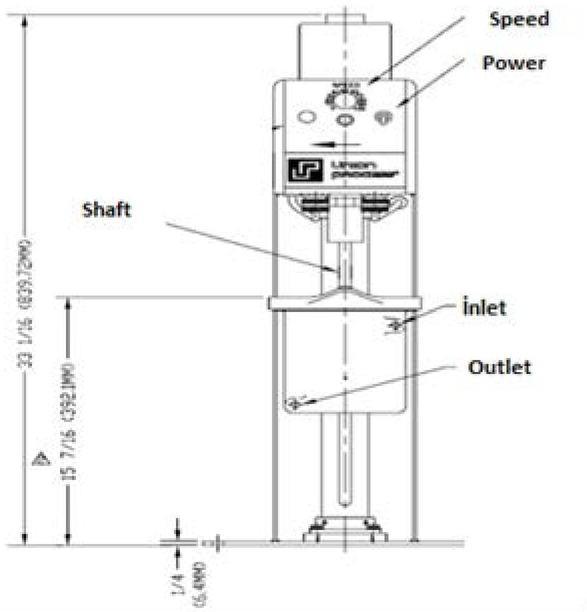

Fig. 1. The schematic diagram of vertical stirred media mill

In this work, stirrer-tip speed (vt) = 600 rpm, grinding media size=1 mm and grinding media loading 70% and grinding time 120. All these parameters were selected based on our preliminary experiments [17] and capabilities of mill system. Two different grinding additives that an organic polymeric-anionic dispersant sodium salt of polycarboxylic acid and an inorganic-anionic dispersant sodium hexametaphosphate were used and their effect of dosage was investigated. They were added in the form of liquid.

The specific surface area (m^2/gr) (S_w) derived from Lecoq et al. [18] is:

$$S_w = 6/[\rho_s * d(3,2)] \quad (1)$$

The particle size measurements of the ground products and feed were carried out by Mastersizer 2000 (Malvern Co., Ltd., UK). Mastersizer 2000 was used as a laser diffraction apparatus in this study. The equipment can measure the particle size of suspensions and dry powders. Before determining particle size, samples of the suspensions to be diluted. The equipment measurement range of the particle size between 0.002 and 2000 µm under certain conditions.

The energy consumed by the mill was measured by a voltomat meter called a Rev 2580 (Rev Ritter GmBH, Deutschland). Specific energy consumption was calculated by the following Eq. (2):

$$E_m = (E-E_0)/ m_p \quad (2)$$

Where m_p the product mass, E is is the energy used at the time t and E_0 is the no-load energy.

The reduction ratio of calcite for each milling parameter was calculated from the following equation:

$$\text{Reduction ratio} = F_{50} / P_{50} \quad (3)$$

Where F_{50} and P_{50} are the mean particle size of the feed (µm) and the product, respectively.

3. Results and discussion

3.1 Change of Average Particle Size

Fig. 2 shows the average particle size distribution of products obtained for grinding additives dosage. The average particle size of ground products was decreased with the increase of additives dosage from 0.05 to 2.4% by weight of the solids. Beyond this dosage for two chemical additives an increasing trend of fineness was observed. Hence 2.4% of additive concentration can be chosen as the best dosage for further studies. SHMP was found to be among the best additive for improving the average particle size. The positive effect of grinding additives on grinding performance is evident experimentally. SHMP compared to PCAAS could reach lower sizes at the same dosage. SHMP was determined to be the most effective grinding additives in terms of the average particle size.

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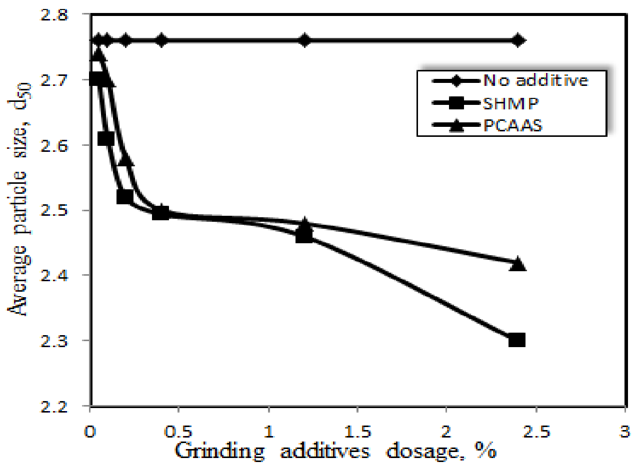

Fig. 2. Grinding additives dosage versus average particle size

3.2 Change of Specific Energy Consumption

Fig. 3 shows the relationship between the grinding additives dosage and the specific energy consumption. The specific energy consumption is decreased as the additive dosage is increased. When the results of the experiments are examined, the energy consumption of talc without additives that 829.38 kWh/t decreased to 592 kWh/t using SHMP dosage of 2.4%. Thus, energy savings of 237.38 kWh/t has been achieved. With the use of PCAAS dosage of 2.4%, energy consumption has decreased to 708 kWh/t and energy saving of 121.38 kWh/t has been achieved. Hence, it was confirmed that the specific energy consumption improved in the presence of grinding additives.

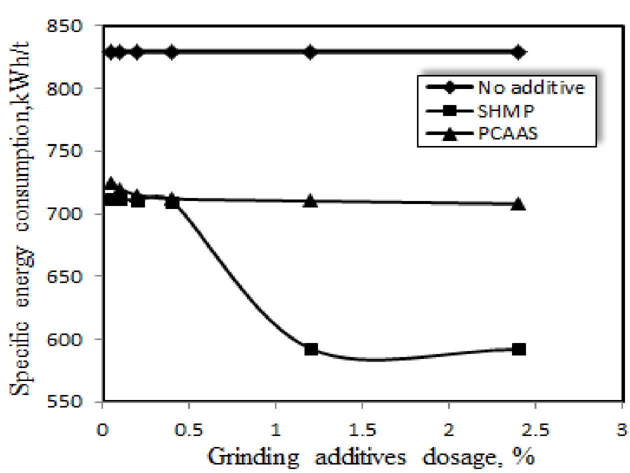

Fig. 3. Grinding additives dosage versus specific energy consumption

3.3 Change of Reduction Ratio

Fig. 4 shows the effect of the type and dosage of grinding additive on the reduction ratio of talc. Reduction ratio without grinding additives was 2.17. It is evident from Fig.4 that it showed a tendency to increase with two grinding additives. Reduction ratio for adding grinding additive dosage of 2.4% was increased 2.61 and 2.48 for SHMP and PCAAS, respectively. In the absence of agglomeration the grinding can proceed to a finer region and reduction ratio increases. This experimental result showed that grinding additives coat the particles and prevent agglomeration.

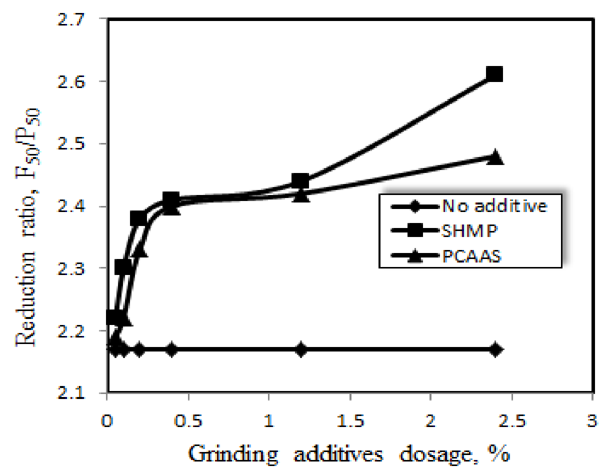

Fig. 4. Grinding additives dosage versus reduction ratio

3.3 Change of Specific Surface Area

The specific surface area of talc differed with the two kinds of additives, as shown in Fig. 4. The specific surface area of ground products is increased with the increase of additives dosage from 0.05 to 2.4% by weight of the solids. Specific surface area without grinding additives was 3.36 m^2/gr. It is evident from Fig. 5 that specific surface area was increased 4.03 and 3.83 m^2/gr for SHMP and PCAAS, respectively. It was found that the grinding additives have an important effect on the specific surface area. However, SHMP was more effective than PCAAS.

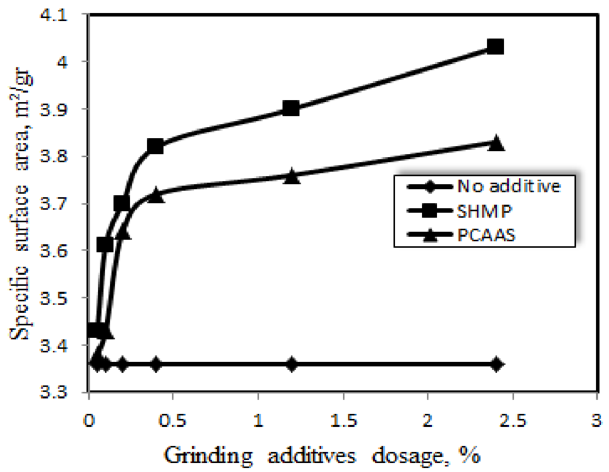

Fig. 5. Grinding additives dosage versus specific surface area

4. Conclusions

A series of experimental study were carried out with and without grinding additives using vertical stirred media mill. Effects of two different grinding additives that an organic polymeric-anionic dispersant sodium salt of polycarboxylic acid (PCAAS) and an inorganic-anionic dispersant sodium hexametaphosphate (SHMP) on average particle size (d_{50}), specific energy consumption, reduction ratio and specific surface area were examined. Two grinding additives were detected to be effective for submicron grinding of talc. But, SHMP was detected to be the most effective grinding additives in terms of average particle size, specific energy consumption, reduction ratio and specific surface area. It was verified that grinding performance of talc improved in the presence of grinding additives.

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