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Morphological Character of Blasted Talc Particles on Talc Flotation

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Abstract -In this study, blasting method was applied to modify the morphology of particles. The extent of blasting was changed at different nozzle pressures through which shape factor and roughness of particles and their corresponding flotation recoveries were investigated. Performance of un-blasted and blasted particles in the system was measured by floating the particles of different characters in a micro-flotation cell. The results of these tests were correlated with shape factors and roughness values of particles that were analysed with Image Analysis, SEM and Optical Profilometer methods. It is shown that particles of higher angularity and roughness exhibited better floatability.

***Keywords*:** Morphology, Blasting, Micro-Flotation, Recovery, Roughness

1. Introduction

In recent years, most of the investigations on flotation processes have been devoted to particle morphology and its related effects on flotation recovery (Ulusoy et al., 2003; Kursun et al., 2006; Koh et al., 2009 Rezai et al., 2010;; Verelli et al., 2011, Verelli et al., 2014). Of these, shape factors and roughness parameters have become prominent where various hypotheses were developed and some of them were experimentally proven in time. The literature data relevant to this subject generally questions the influence of grinding on the characteristics of particles and the variations on morphology of particles in terms of roundness, elongation ratio, angularity, relative width and roughness are mainly linked with the grinding conditions (Yekeler et al., 2004; Hicyilmaz et al., 2004). Towards this aim, as described in a recent publication (Guven et al., 2015) basic dimensional parameters like length, breadth, width and the ratios between these units are measured and used for calculation of shape factors and other morphological parameters (Sarkar and Chaudhuri, 1994; Meloy and Williams, 1994; Singh and Ramakrishnan, 1996 as cited in Guven et al., 2015). As mentioned above, to emphasize the significance of grinding and its influences on particle morphology, a plethora of research have been conducted which make possible to develop an understanding of different forces like impact, breakup and jamming during these processes. However, apart from grinding and any kind of size reduction processes, several methods are also available for obtaining particles having different morphological properties.

Sand blasting treatment is one of these methods generally applied with abrasive particles to surfaces. This method is used for surface strengthening, cleaning and rust removal from surfaces (Li et al., 1998, Djurovic et al. 1999 as cited in Guven et al., 2015). Thus, based on our knowledge about blasting and particle morphology, the effect of blasting parameters on particles except from target surfaces have not been extensively studied and evaluated in the flotation literature.

In this contribution, the effects of blasting on morphology of talc particles and the relevant flotation recovery values with respect to these parameters were studied. In addition, the variations on particle morphology were investigated in detail as a function of nozzle pressure while other parameters were kept constant.

2. Materials and Methods

2. 1. Sample Preparation

The talc sample from Niğde (Turkey) was used in experimental studies and analysed by XRF analysis. The composition of 61.12 % SiO_2, 32.40 % MgO indicated that the sample was pure enough to compare the morphological properties and accordingly micro flotation recoveries after blasting process.

Firstly, the sample was crushed by a jaw crusher to obtain particles below 1 mm in size for the blasting experiments. Following the crushing process, the crushed material (hereafter un-blasted) was screened for 30 minutes with Fritch Ro-TAP sieve and particles with -150×106 microns in size were separated for shape factor, roughness and micro-flotation studies.

For blasting experiments, a series of tests were adopted with the uniquely designed sand blasting machine (Fig 1) as described in our previous publications (Guven et al., 2014, Guven et al., 2015). Hence, 100 g of un-blasted sample was fed to the blasting machine with an air stream fan across a high Mn-Stainless steel plate where the diameter of nozzle (d) used was 2 cm. The feed speed and the distance between plate and nozzle (L) were taken constant as (0.94 g/s) and 14 cm, respectively.

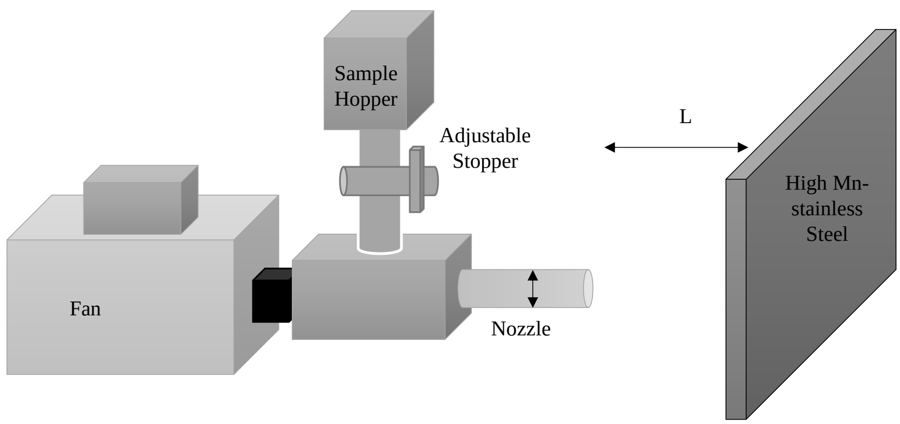

Fig. 1. Schematic illustration of the sand blasting equipment and orientation of plate

After sand blasting, the same screening procedure was applied on the blasted sample and likewise other crushing process and particles in the size range of -150×106 microns were separated for micro-flotation and shape factor analysis.

2. 2. Sample Characterization by Image Analysis

The shape factors of both un-blasted and blasted samples were analysed using Leica QWin Image Analyze Program (Leica QWin User Manual, 1995) based on the particle projections obtained from the photographs. The roundness (Ro) and angularity (A) values of about 90 particles were automatically calculated by the image analysis software by utilizing the equations defined as follows (Forssberg et al., 1985):

$$\text{Roundness (Ro)} = \frac{4\pi A}{P^2} \quad (1)$$

$$\text{Angularity (A)} = \frac{P^2}{4\pi A} \quad (2)$$

Where “P” is perimeter, “A” is the area of particles. In addition to the shape factors, the roughness parameter for both un-blasted and blasted samples was analysed by using ZYGO New View 7100 Model optical profilometer. In this method, the measurement of height variations in non-contact mode is mainly carried out with using the wave properties of light to compare the optical difference between sample surface and a reference surface. In addition, both un-blasted and blasted samples were analysed using QUANTA FEG250 Scanning Electron Microscope (here after SEM) at magnifications higher than 1500X in order to detect the morphological changes on the surfaces.

2. 3. Micro-Flotation Experiments

The micro-flotation tests were performed using a 150 cm^3 micro-flotation column cell (25×220 mm) with a ceramic frit (pore size of 15 μm) which was mounted on a magnetic stirrer and a magnetic bar used for agitation. The tests were conducted at natural pH value of 7.3 with 1 g of talc sample (both un-blasted and blasted). After conditioning for 10 min, the samples were floated for 1 min using N_2 gas at a flow rate of 50 cm^3/min. The flotation tests were evaluated by weighing the amount of particles in both float and sink products by gravimetric analysis. It is worth to mention that all experiments were repeated at least three times and the average recovery for each series was presented.

3. Results and Discussion

3. 1. Micro-Flotation Experiments With The Blasted And Un-Blasted Talc Particles

Many papers in the literature have been dedicated to the effect of morphological parameters in particular those on talc flotation (Kursun et al., 2006, Ulusoy et al., 2011). Most of these studies have been dwelled on the influence of only grinding conditions and shape factors on natural hydrophobicity. In this study, apart from the flotation systems as column or conventional, the effect of different shape factors occurred after blasting and their effect on flotation recovery was studied by performing micro-flotation tests as a function of nozzle pressure.

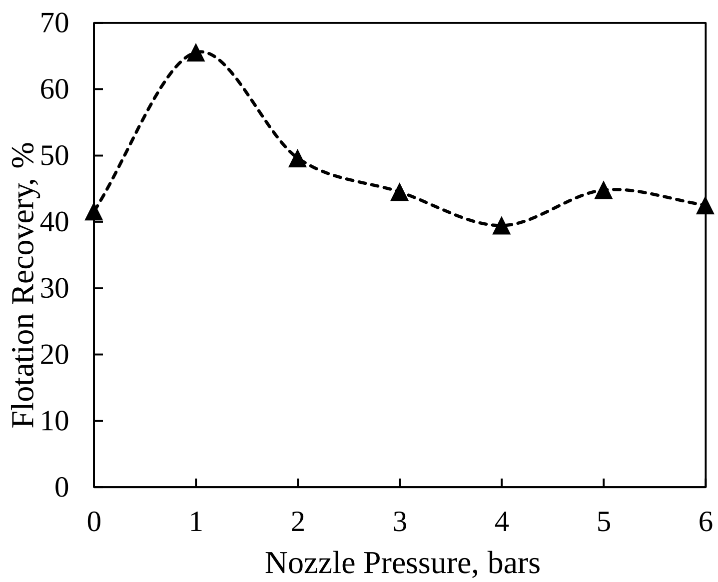

Fig. 2. Flotation recoveries as a function of nozzle pressure bar.

As seen from Fig 2, the recovery of about 41 % was obtained with the un-blasted sample. Besides, blasting the sample at 1 bar nozzle pressure increased the recovery up to 68 %, and then decreased it gradually down to 42% at 6 bars. In our previous studies with the same method for quartz and glass bead particles, a similar trend was obtained for blasting effect in different nozzle pressures and flotation recoveries (Guven et al., 2014, Guven et al., 2015). However it is worth to note that most likely due to the structural differences of particles, flotation recoveries became maximum after blasting at different nozzle pressures.

3. 2. Correlation Between Particle Morphology and Flotation Recovery

Image Analysis (hereafter IA), SEM and profilometer analyses were used to analyse the effect of nozzle pressure on the particle morphology of the samples and correlated with the flotation recoveries. The results are presented in Table 1 along with the SEM images of the samples given in Fig 3.

Table. 1. Shape factors and roughness coefficients for both un-blasted and blasted talc particles.

Nozzle Pressure, bar	Roundness	Angularity	Roughness Parameters	
			RMS	Ra
0	0.753	1.329	4.268	3.645
1	0.676	1.477	5.507	4.491
2	0.709	1.411	7.874	6.239
3	0.720	1.389	4.655	3.200
4	0.721	1.387	6.501	5.130
5	0.720	1.388	5.110	4.396
6	0.750	1.330	3.792	2.814

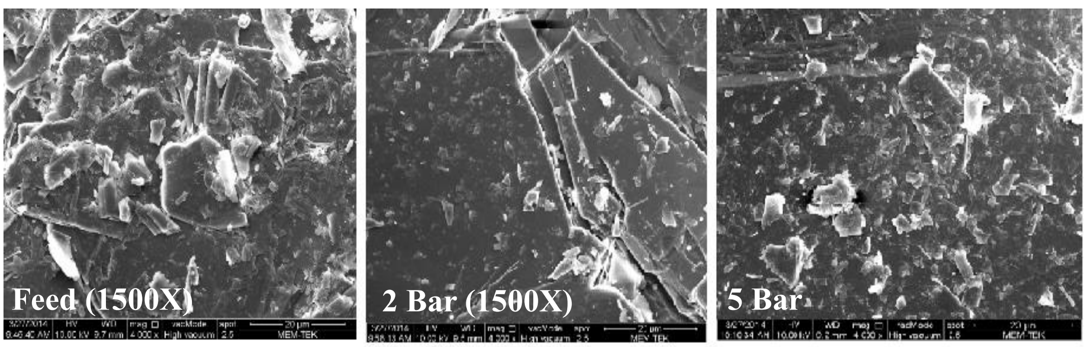

Fig. 3. SEM images of the samples (a) Un-blasted sample (1500X magnification) (b) blasted sample at 2 bars (1500X magnification) (c) blasted sample at 5 bars (1500X magnification)

In Table 1, it was shown that the structure of talc mineral became more angular upon increasing the pressure up to 1 bar above which it progressively became rounder. Additionally, considering soft and easily dispersible structure of talc mineral, the amount of fine material in the product of blasted material might increase its proportion at higher pressures. Accordingly, this situation may lead to the increase of residue on the particle surface which in turn may affect the smoothness of the particles. In Fig 4, the correlation between angularity values presented in Table 1 and flotation recoveries is shown. As it can be clearly seen from Fig 4 that there is a strong correlation between angularity and recoveries which is in line with the results reported in literature (Fillipov et al., 1999, Ulusoy et al., 2011, Rezai et al., 2010, Verelli et al., 2014).

Most of the studies in the literature have been conducted on the effect of grinding conditions related to shape factors where relatively angular particles were produced in rod mills in comparison to other grinding systems. In this manner, Hicyilmaz et al. (Hicyilmaz et al., 2004), investigated the effects of the shape properties on the wettability based separation processes for ground talc particles. They found that the maximum flotation recovery of 65 % can be obtained with the feed material presenting 1.090 angularity value after grinding in a rod mill. In addition, it was also shown that significant differences between flotation recoveries could be efficiently obtained by relatively small differences on shape factors. Beside other parameters in flotation, these results can be well ascribed to the degree of particle-bubble interaction, in other words increasing the collision probability resulted in higher flotation recoveries for angular particles. Accordingly, in a recent publication (Verelli et al., 2014), this phenomena was extensively discussed and experimentally proven by the induction time measurements with borosilicate particles having different shape factors. In short, they suggested that the induction time for attachment was significantly reduced in the case of angular particles. Another publication of the same research team also showed that in contrast to the well-known hypothesis of constant induction period for a given particle and air bubble under the same conditions may change upon the particle's approach trajectory to the bubble (Verelli et al., 2012).

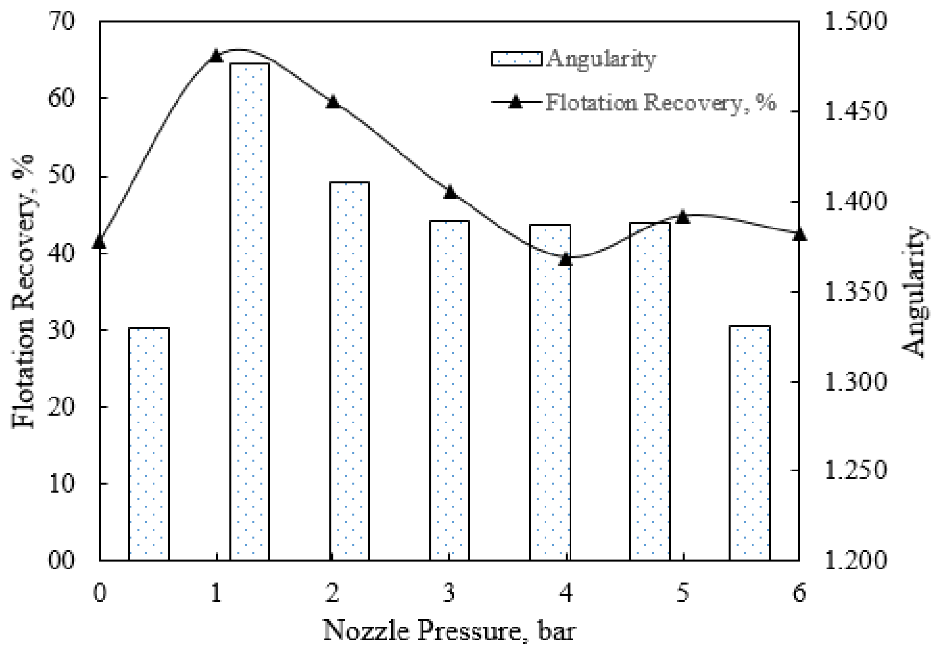

Fig. 4. The correlation between angularity and flotation recoveries as a function of nozzle pressures

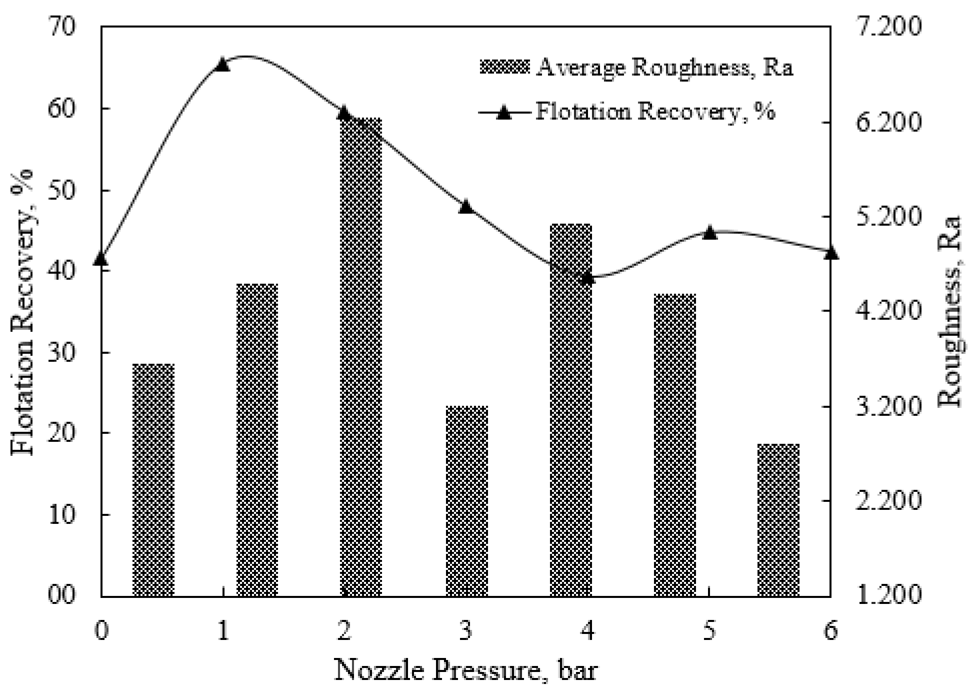

Fig. 5. Correlation between average roughness and flotation recoveries as a function of nozzle pressure

On the other hand, the trend between roughness values and flotation recoveries was not linear as obtained for shape factors (see Fig 5).

Although these results are in accordance with the previous findings in literature (Kursun and Ulusoy, 2006), our previous results for quartz and glass bead particles indicated that any increase on roughness values after blasting resulted in higher flotation recoveries which also well correlated with the shape factors. One possible explanation for this kind of results can be the structural differences between minerals during the blasting process where talc particles may be affected less than other samples due to their laminar structure.

4. Conclusions

An alternative approach to grinding conditions was developed for changing the morphological properties of minerals in terms of roughness and shape factors. In addition, the micro-flotation experiments were conducted for blasted samples under different nozzle pressures and the results of these tests were compared with un-blasted particles. The results of different analysis methods as IA, SEM and Profilometer evidently suggested that increasing the nozzle pressure up to 1 bar resulted in more angular particles and consequently higher flotation recoveries in agreement with the previously reported literature on rod mill grinding (Kursun & Ulusoy 2006).

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