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Experimental Studies on Effect of Grinding Additives in Size Reduction Process

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Abstract : In the present study, an attempt has been made to study whether the size reduction process of various solid materials can effectively be influenced by various chemicals which are mixed into the mill contents to be crushed and size reduction is carried out, which results in increased surface area for the same energy consumption without and with grinding aids of various concentrations. From the experimental results, it is pragmatic that the reduction ratio and specific surface area are increased when the concentration of chemical aids and soaking time is increased. In addition to this, an attempt has been made to study the size distribution of the ground particles for which Rosin-Rammler-Bennet distribution function has been considered to be a good fit. The correlation for dispersion constant has also been developed and compared with the experimental results.
Keywords: Grinding aids, Rosin-Rammler-Bennet distribution function, Dispersion constant, Distribution constant .

Introduction

The grinding process plays a very important role in mineral processing[1,2] as well as other industry branches like the construction industry,ceramic processing,cement,pigments and paints,ceramics, pharma ceuticals, etc. Ball mills operated in dry or wet mode are frequently used for fine miling, since they are able to handle rather coarse feeds (several millimetres), reducing the particle size down to 10 micrometer, with reasonably low power consumptions[3]. Grinding is used to reduce the size of solids with a vision to create large surface area. The purpose of the size reduction is not only to make "little ones out of big ones" when the effectiveness can be measured by the degree of fineness of the product, but also to product of the desired size or size range. The size reduction is used to increase in reactivity due to large surface area, easy handling and transportation[1]. During a grinding process, the main part of the energy input is dissipated in heat loss instead of being used to create new surface[8,9]. Since grinding is an energy consuming process, therefore this becomes a vital chore to develop the energy consumption inside the grinding mill. Therefore to reduce the grinding costs continuing studies have been performed in both laboratory and plant scale[4]. One possibility of promoting the grinding process lies in the use of grinding aids[5]. Previous literature works[6-8] confirms that in size reduction operation operations some of the chemicals are influencing significantly.though there are numereous studies reporting tha advantages effects of grinding aids. No scientific explanation has yet been suggested to explain the behaviour of grinding aids[9-12]. To explain the effect of grinding aids several mechanism are given. These are based on surface energy reduction, surface hardness modification and change of flow of particles in the mill[12]. The energy requirement for fine grinding increases, partly because a layer of very fine particles cause a cushioning effect between the balls, and between the ball and material. Addition of grinding aids inhibits this

effect and consequently provides more efficient grinding[13]. As it is known, grinding is a complex process, a single mechanism cannot be expected to be responsible for explaing the influence of different types of grinding aids. Numerousequations have been developed in the past in order to describe the size distribution of the product deriving from grinding process.out ofwhich Rosin- Rammler- Bennet distribution equation is probably the most widely used because oif its capability of satisfactorily describing the size distribution of ground particles. Using cumulative mass fraction (y) retained on the sieves and the particle size (d), the values of dispersion constant (n) and distribution constant (b) of the Rosin Rammler Bennet distribution equation have also been found. The objective of the present work is to study the influence of various chemicals such as ammonia and sodium hydroxide are investigated as grindings aids on the grinding of the limestone and Bauxite.

Experimentation

The experimental mill used was a laboratory scale ball mill of 150 mm dia170 mm length.giving a total volume of 3000 cc, with steel balls of 25mm dia., so as to occupy 50% of the ball mill volume and an operating speed of 60 rpm, which is 70% of the critical speed of the ball mill. The feed size of the material used was of a single size interval of -16 mm + 12.5 mm and was carefully prepared by a series of mechanical operations like jaw crusher, roll crusher, vibratory screens and standard test sieves.the feed charge ia fixed based on optimum conditions suggested for ball milling which is 50% of the void volume of the ball charge.for the present study, the following operating conditions are as follows:

The volume of the ball mill	:3000 cm^3
Ball mill diameter	: 150mm
Ball mill length	: 170mm
ball diameter	: 25mm
Ball mill speed	: 60 rpm (70% of the critical speed of the ball mill)
Ball charge	:50% of the ball mill volume
No. of revolutions of the mill	: 100
Random packing voidage	: 0.4
Bulk density of the feed sample	:1.42g/cc
Amount of feed	: 425 g
Soaking Period	:0, 5,10,15, 20 and 25 min.

425 gm of the sample was taken accurately and the grinding tests were carriedout first without grinding aids and then with the desired concentration of grinding aids for a known period of soaking time. The grinding aids are 10%, 20% and 30% (by volume) of ammonia and caustic soda solutuions of 0.1N,0.5N and 1N strength.the soaking period varied as 5 min,10 min, 15 min, 20 min and 25 min. The treated samples were filtered and kept over night to dry in a $CaCl_2$ desicator. Care was taken to ensure that the sample was completely wet. The dried sample was subjected for grinding in ball mill at standard conditions specified in the above part. The ground product was then sieved in a standard sieve shaker using BSS sieves. The sieved sample was analyzed and reduction ratio, new surface area and specific surface are created were calculated. These results were compared with the sample without any additive and samples of varying soaking periods and additives of various concentrations.

Results and Discussion

After the grinding process in the ball mill, the treated and untreated samples are sieved into the particle size ranges of 18/25, 25/36, 36/52, 52/60, 60/72, 72/100, 100/200 mesh BSS, having the corresponding values of 0.85, 0.6, 0.425, 0.306, 0.276, 0.212, 0.147 and 0.072 mm respectively.

Rosin- Rammler- Bennet distribution plot:

Using cumulative mass fraction (y) retained on the each sieves and the particle size (d) ,the values of dispersion constant (n) and distribution constant (b) of Rosin- Rammler- Bennet distribution equation, $y=\exp[-(b*d)^n]$ are calculated.The plot called "Rosin- Rammler- Bennet distribution plot" has been plotted between ln [-ln y] and ln (d) for different materials soaked in various grinding aids of various soaking periods are shown in Figure No.1 to Figure No.4.From these plots it is clear that for all the materials,slopes are positive everywhere and also it is observed that the slope gets increased slightly with the increasing soaking periods which means the dispersion constant increases.

Figure 1. Rosin –Rammler-Bennet plot for Limestone (0.5N NaOH)

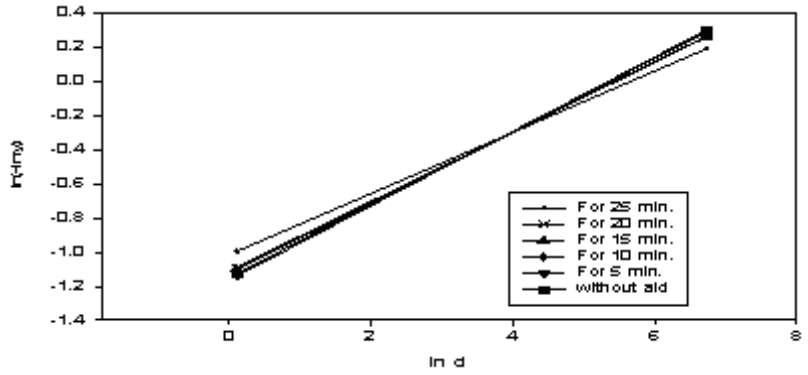


Figure 2. Rosin –Rammler-Bennet plot for Mica (5% NH_3)

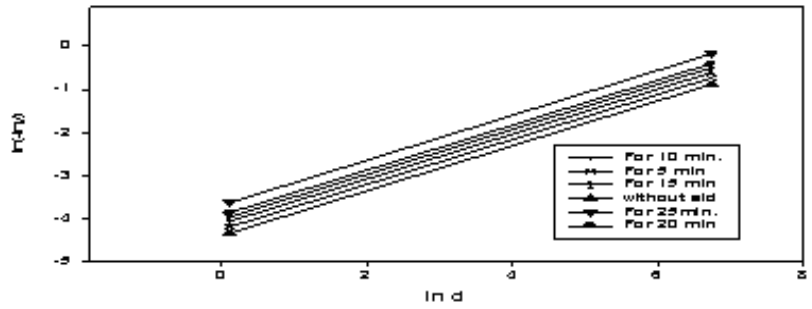


Figure 3. Rosin –Rammler-Bennet plot for Mica (15% NH_3)

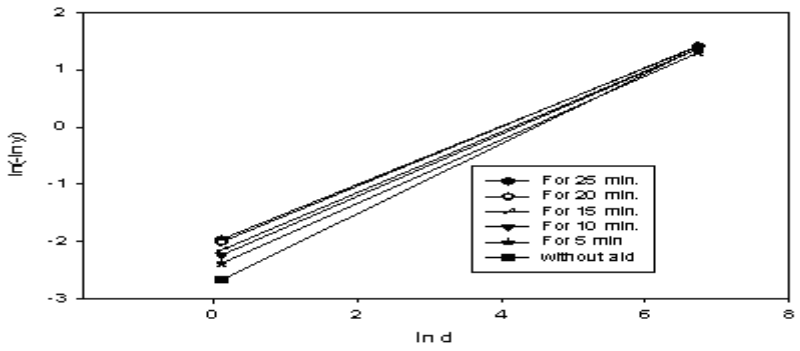
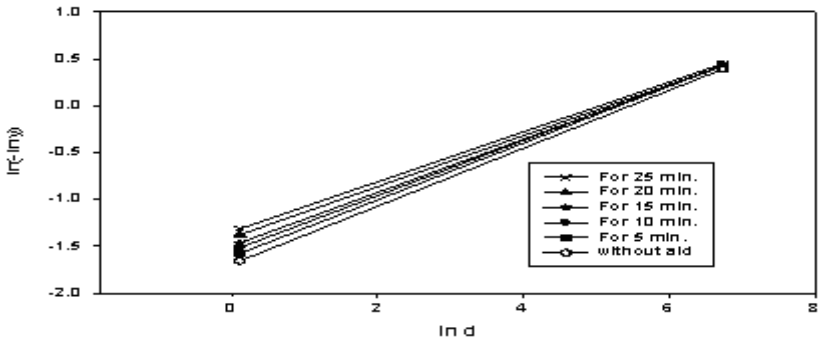


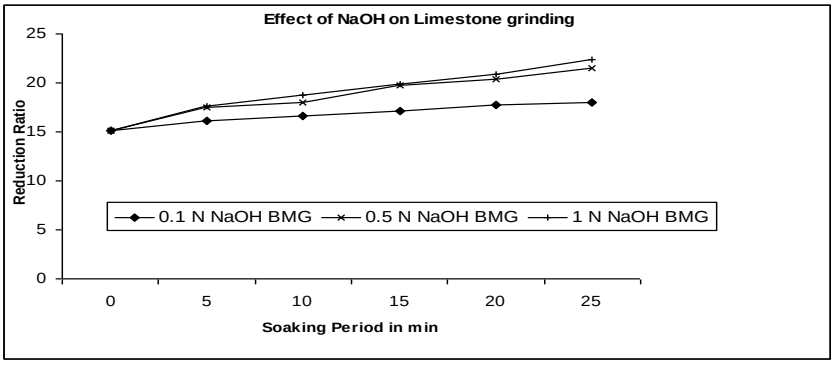
Figure 4. Rosin –Rammler-Bennet plot for Bauxite (0.5N NaOH)



Influence Of Soaking Period On Reduction Ratio And Specific Surface Area:

Figure 5 reveals the comparative studies of influence of Sodium Hydroxide on reduction ratio of Limestone.

Figure 5.Influence of Sodium Hydroxide on reduction ratio of Limestone



When comparing 1N and 0.5 N NaOH, we can see the increase upto 0.87% for Ball Mill Grinding processes. When comparing 0.5N NaOH with 0.1N NaOH, we can see the increase upto 3.46%. From the results it is observed that Specific Surface Area for Limestone with various concentrations and it is observed that the Specific Surface Area increases for all the concentrations. Comparing 1N NaOH with 0.5N NaOH, Specific Surface Area increases upto 92 mm^2/g. When comparing 0.5N NaOH and 0.1N NaOH, it is observed that it increase upto 379 mm^2/g.

From the above results we can see that for BMG, Specific Surface Area increases with increase in concentration of NaOH. From the above results we can concluded that the rate of increase in Reduction Ratio is good between 0.5N and 0.1N NaOH. Figure 6 explains the variation of specific surface area for Mica with various concentrations and soaking time.

Figure 6. Influence of Ammonia on specific surface area for Mica

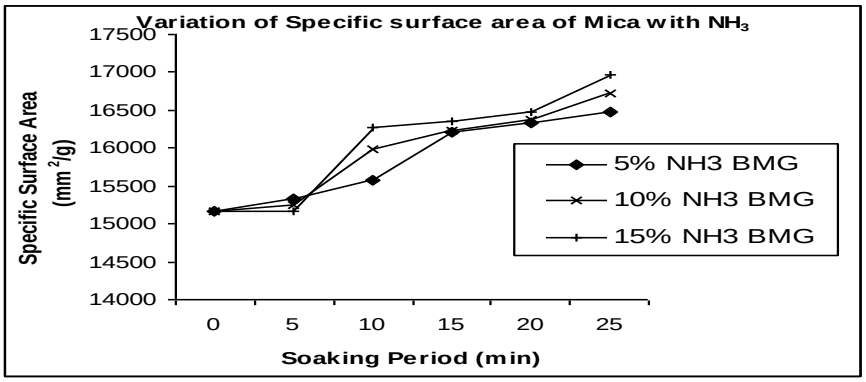


Figure 7. Influence of Sodium Hydroxide on specific surface area for Bauxite

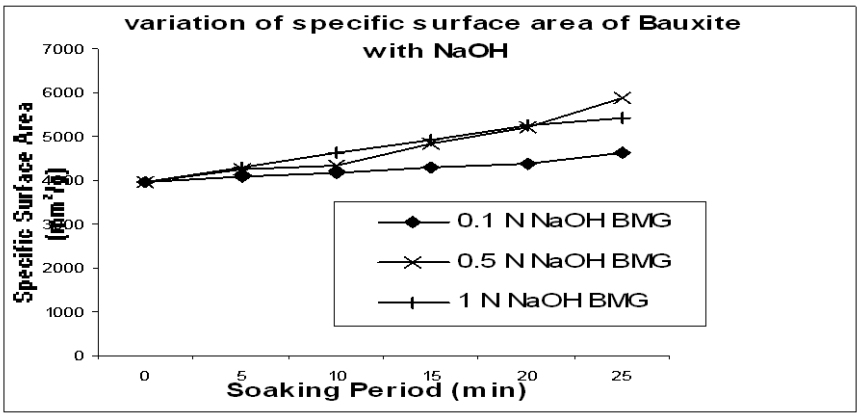
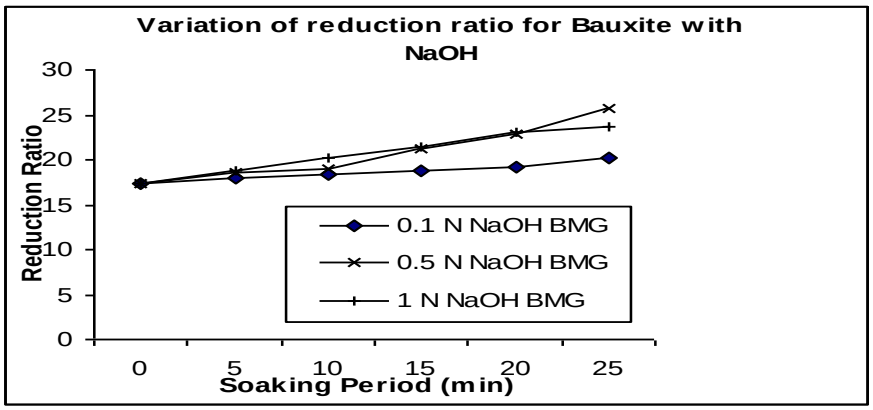


Figure 7 and figure 8 shows the variation of Reduction Ratio and specific surface area for Bauxite with various concentrations and soaking time. By comparing 1N NaOH and 0.5N NaOH, the reduction ratio is increases upto 1.16%. When comparing 0.5N and 0.1N NaOH, it is found that it increases upto 5.41%. From the above studies we can find that for BMG 0.5N NaOH additive gives good effect. It can be found that the increase in Reduction Ratio is almost same for concentrations after 0.5N NaOH for bauxite.Figure 8 shows the variation of specific surface area for bauxite under various conditions and specific surface area of bauxite is increases upto 277 mm^2/g. When comparing the results of 0.5N and 0.1N NaOH, it is clear that specific surface area increases upto 1235 mm^2/g. From these studies, it is concluded that the increase in specific surface area can be best for 0.5N NaOH.

Figure 8. Influence of Sodium Hydroxide on reduction ratio for Bauxite



The unknown values of dispersion constant (n) were calculated by using Linear Regression analysis technique. For all the readings, dispersion constant (n) and Distribution constant (b) were calculated and plotted for various chemical additives used at different soaking periods are shown in Figure 9 and Figure 10.From these plots, it is observed that both the dispersion constant (n) and Distribution constant (b) increases linearly with soaking period, irrespective of the nature of the chemicals used for the present study.

Figure 9. Influence of Sodium Hydroxide on Distribution constant for limestone

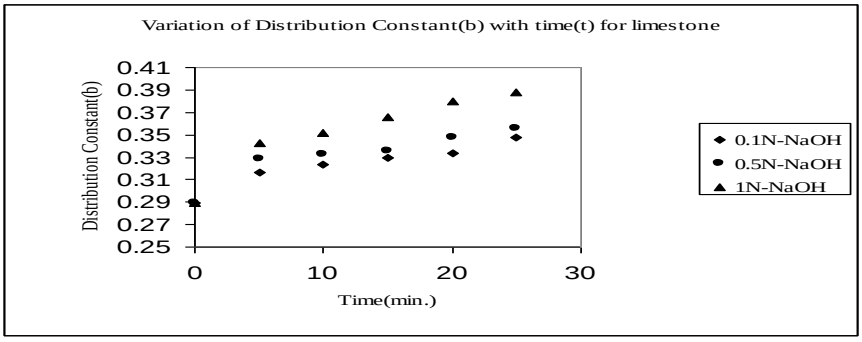
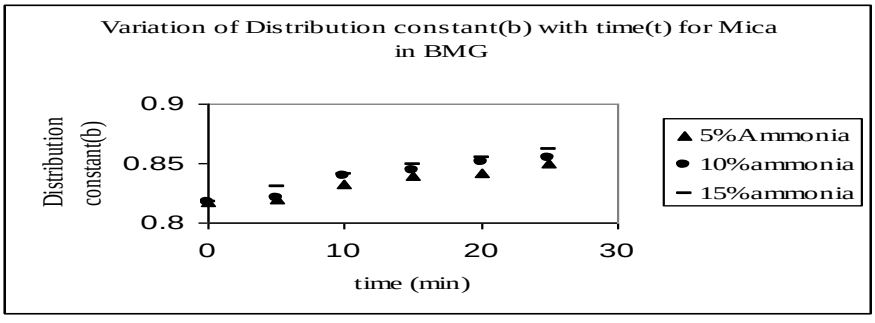


Figure 10. Influence of Ammonia on Distribution constant for Mica



The correlation between dispersion constant (n) and soaking period (t) has been calculated as

$$n=0.31704(t)^{0.0112} \quad (1)$$

and in this equation time[1].t is expressed in minutes and in the range of 5 min to 25 minutes. Similarly, attempt has been made to find the relationship among distribution constant (b) and soaking period (t) for various chemicals.From the results, it is observed that distribution constant (b) increases with increase in soaking period (t) and also this variation has been found to be linear. By using Linear Regression analysis. The relationship has been found to be,

$$b=0.5640 + 0.00446\ t \quad (2)$$

In this equation[2], time 't' is in the range of 5 min to 25 minutes.the effect of soaking time is also reflected through the equation[2] where 'b' increases linearly with time.the absolute size cobstant 'a'(=1/b) decreases which means the production of more fines.

Conclusion

In the present work, an attempt has been made to reduce significantly the particle size by grinding aids on various materials. Using the cumulative analysis, size distribution of the ground particles were calculated for which Rosin-Rammler-Bennet distribution function has been found to be a good fit. The dispersion co-efficient (n) and absolute size constant (a=1/b) of the Rosin-Rammler-Bennet distribution functions $y = \exp(-(b*d)^n)$ greatly depended on the soaking period. From the experimental results it is concluded that all three solutions used for the present study report a favorable effect to the grinding of materials. The experimental study illustrates that the process of size reduction can effectively be influenced by grinding aids which results in increase surface area creation for the same energy consumption of with and without grinding aids. Finally, it is accomplished that Sodium Hydroxide and ammonia solution are import a beneficial effect to the grinding of Limestone, Mica and Bauxite.

Nomenclature

a	Absolute size constant,m
b	Distribution-constant(=1/a),m^{-1}
d	Particle size , mm
n	Dispersion constant or co-efficient
t	Soaking period,min
y	Cumulative mass fraction retained on the sieves.

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