

Influence of Lime Particle Size on Ph Modification of Gold Ores

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Abstract:- Varying amounts of lime from different batches have been used in the modification of pH of gold ores of consistent mineralogical composition. This paper investigated a possible cause of the variation. Particle size analysis of 5 different batches of lime supplied to a mine in South-Western Ghana was carried out. Batch 4 was found to contain the highest amount of fines while batch 2 contained the highest amount of coarse particles. A sample of gold ore from the same mine was pulverized and pulped at 45% solids. Bottle roll tests were carried out to examine the effects of the various batches of lime and different size ranges of each batch on the modification of pH of the gold ore. pH of the gold ore increased on the addition of lime from the various batches examined. Batch 4 increased pH at the fastest rate whilst batch two increased pH at the slowest rate. The results indicated that pH modification ability of lime decreased with increasing particle size of lime. 0.1 g of (-106 +0) μm size of lime was required to increase pH of the ore from 7.58 to 8.71 in 10 minutes whilst 0.2 g of (-1000 +500) μm sized lime only increased pH from 7.58 to 8.67 in 20 minutes. The most efficient particle size range of lime for effective pH modification, with respect to the ore investigated is (-150 +0) μm .

Keywords: Lime, modification, pH, particle size.

I. INTRODUCTION

Lime is extensively used in the recovery of gold. Quick lime finds its application in classification circuits (thickeners) and leaching circuits. In the cyanide leaching process, lime is used for pH control and to prevent hydrolysis of sodium cyanide, a costly dissolution reagent (Ejenstam, 2010). As a basic requirement for a suitable leaching environment, its quality is of importance to the end users.

Lime is produced from Limestone (CaCO_3). According to Boynton (1980) and Oates (1998), the kind of organisms that flourish in the environment in which limestone is formed highly affects the composition of the limestone even though limestone is mainly formed in warm, shallow and still waters. Therefore, limestone may either be classified as calcitic or dolomitic (Boynton, 1980 and Oates, 1998). Douglas (1969) stated that Limestone with magnesium carbonate content in excess of 20 percent are generally called dolomite, while those containing more than 96 percent calcium carbonate are considered calcitic. Lime production involves three main processes: stone preparation, calcinations, and hydration (Anon., 2013a). Quicklime is obtained after calcination and consists of the oxides of calcium and magnesium (Anon., 2013b). It is crystalline with degree of porosity varying from 18 to 54 % depending on the structure of the limestone, temperature and severity of calcination (Boynton, 1980). The primary forms of quicklime and their compositions are given in Table 1.

Table 1 Composition of Forms of Quicklime (Anon., 2013b)

Forms of Quicklime	Composition
<i>High Calcium Quicklime</i>	0 to 5 percent magnesium carbonate
<i>Dolomitic Quicklime</i>	35 to 46 percent magnesium carbonate
<i>High Calcium Hydrated Lime</i>	72 to 74 percent calcium oxide and 23 to 24 percent chemically combined water
<i>Dolomitic Hydrated Lime (normal)</i>	46 to 48 percent calcium oxide, 33 to 34 percent magnesium oxide, and 15 to 17 percent chemically combined water.
<i>Dolomitic hydrated lime (pressure)</i>	40 to 42 percent calcium oxide, 29 to 30 percent magnesium oxide, and 25 to 27 percent chemically combined water

Particle size exerts some influence on the solubility of quicklime, particularly when quicklime is introduced into water. As the average diameter of the particles diminishes, its dissolution increases, since surface area is increases (Boynton, 1980).

The mine studied uses high calcium hydrated lime for its pH modification. Lime received by the mine has size composition range of (-1000 +0) μm . At the mine, quick lime is used to condition leach feed material to an optimum pH range of 10.2 – 10.5 before leaching is carried out, depending on the ore type. It has been observed that varying amounts of lime is consumed to achieve the conditioning of ore with consistent mineralogy. The average lime consumption of the mine from 2008 to 2012 was 0.86 kg/t. In 2012, a budget of 0.65 kg/t made was exceeded by 0.16 kg/t.

The objective of this research was to investigate a possible cause of the variation in the amount of lime used to modify gold ore of consistent mineralogy. Hence, the particle size distribution of quicklime used at the selected mine in Ghana was investigated to establish the pH modification ability of each size fraction. Sieve analyses were conducted using sieves with aperture sizes ranging between 106 μm and 500 μm . Bottle roll tests were also carried out to ascertain the effects of different batches of Lime supplied to the mine, the effect of the various particle size ranges of each batch of lime on pH modification and the overall effect of all size fractions from all batches of lime supplied to the mine. Consequently, the optimum particle size for effective pH modification was to be determined.

II. MATERIALS, METHODS USED

2.1 Materials Used

Gold ore samples of known mineralogical composition from the same source, a mine in South-West Ghana, were ground to 80% passing 75 μm and pulped to 45% solids for all bottle roll tests in this work. Initial pH of pulp samples prepared for all tests were recorded. Lime samples of different dates of supply were also obtained from the mine. The work was categorized into three stages thus, particle size analysis of various batches of lime, effect of various batches of lime on pH modification and the effect of particle size of lime on pH modification.

2.2 Particle Size Analysis of Various Batches of Lime

A 500 g sample of lime from each of five different batches supplied to the mine in south-west Ghana was taken for the test work. Particle size analysis of each batch of lime was done using 500 μm , 212 μm , 150 μm , and -106 μm test sieves and an electronic vibrator. The vibrator was set at frequency of 40 revolutions per minute for a period of five (5) minutes and the resulting weight of undersize and oversize materials of the various screens were recorded. The various size ranges obtained were as follows; (-1000 +500) μm , (-500 +212) μm , (-212 +150) μm , (-150 +106 μm) and (-106 +0) μm .

2.3 Determination of the Effect of Various Batches of Lime on pH modification

Pulp of 45% solids from milled gold ore was prepared for five bottles and labeled batch 1, batch 2, batch 3, batch 4 and batch 5. A 0.1 g sample of each batch of lime was introduced into the bottles with their respective labels and rolled for 10 minutes until stable pH attained. Procedure was repeated by adding 0.1 g of lime each time.

2.4 Determination of the Effect of Particle Size of Lime on pH modification

The same quantity of a 45% solids pulp was prepared from the milled gold ore and poured into five bottles labelled with the size fractions from the size analysis. (-1000 +500) μm , (-500 +212) μm , (-212 +150) μm , (-150 +106) μm and (-106 +0) μm . A 0.1 g portion of each size fraction of the lime was introduced into their respective bottles and rolled until stable pH was attained within time interval of ten (10) minutes. Procedure was repeated varying the amount of lime added to the pulp, thus addition of 0.1 g at a time interval of ten (10) minutes until stable pH was attained.

III. RESULTS AND DISCUSSIONS

3.1 Particle size Distribution of Various Batches of Lime

Results of particle size distribution tests, carried out on 5 batches of lime that were supplied to the mine, are shown in Fig. 1. It was observed that the different batches had different particle size distribution. Batch 1 was observed to have 7.93 % within particle size range of (-106 +0) μm , 22.06 % had particle size range of (-150 +106) μm , 39.88 % had particle size range of (-212 +150) μm and 60.26 % had particle size range of (-500 +212) μm . Analysis of batch 2 of the lime gave the following results; 3.08 % had particle size range of (-106 +0) μm . 6.02 % had particle size range of (-150 +106) μm , 21.37 % had particle size range of (-212 +150)

μm and 54.99 % had particle size range of (-500 +212) μm . Upon similar analysis on batch 3, the following size ranges were obtained; 7.11 % (-106 +0) μm , 18.9 % (-150 +106) μm , 36.76 % (-212 +150) μm and 62.15 % (-500 +212) μm . Batch 4 had 10.10 % falling within the particle size range of (-106 +0) μm , 25.66 % had particle size range of (-150 +106) μm , 45.16 % had particle size range of (-212 +150) μm and 67.42 % had particle size range of (-500 +212) μm . Batch 5 also had 1.07 % particle size range of (-106 +0) μm , 31.71 % had particle size range of (-150 +106) μm , 45.16 % had particle size range of (-212 +150) μm and 61.65 % had particle size range of (-500 +212) μm . These results indicate that batch 4 contained the highest amount of fines while batch 2 contained the highest amount of coarse particles. In increasing order of particle sizes, Batch 4 < Batch 1 < Batch 3 < Batch 5 < Batch 2.

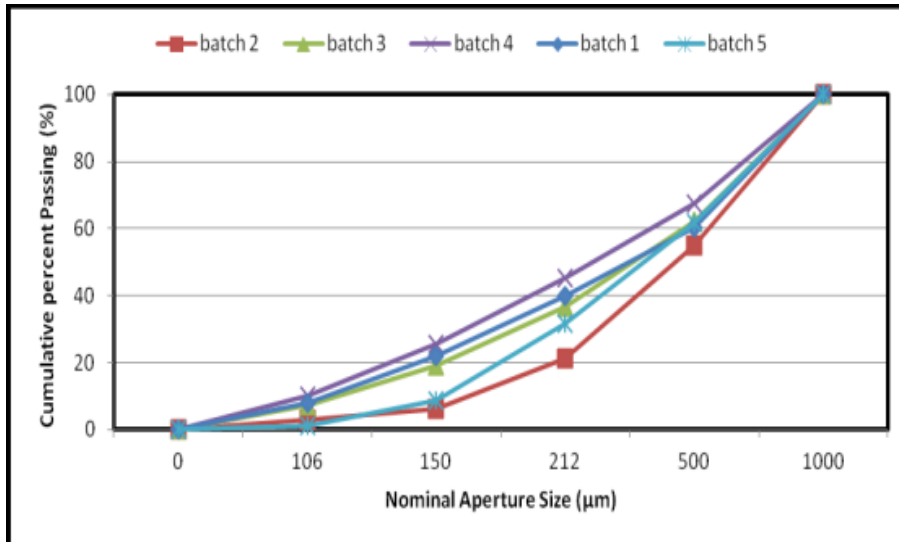


Fig. 1 A Graph Showing Cumulative Percent Passing Nominal Aperture Size for the Five Batches of Lime 3.2 Effect of Each Batch of Lime on pH Modification

The pH modification abilities of the various batches of lime are shown in Fig. 2. It was observed that, Batch 4 increased pH at the fastest rate while Batch 2 increased pH at the slowest rate. 0.4 g of lime from Batch 4 increased pH of the gold ore from 7.5 to 9.8, whilst the same amount of lime from batch 2 only increased pH of the gold ore from 7.5 to 8.54. This is attributed to the fact that Batch 4 had the highest distribution of fines while the reverse was observed for Batch 2. The finer the lime, the larger its surface area. Finer lime has the ability to modify pH at a faster rate.

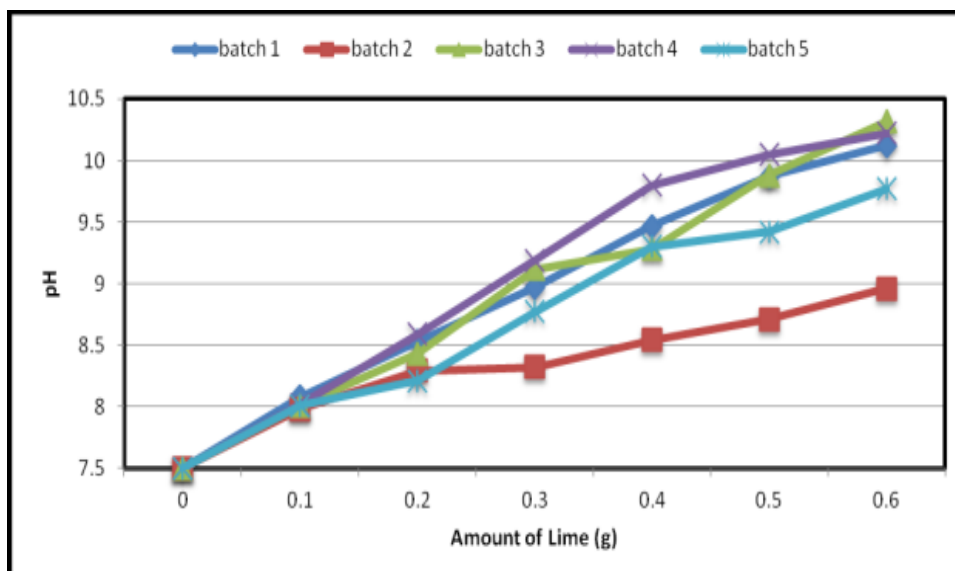


Fig. 2 Effect of various batches of lime on pH modification

3.3 Effect of Various Particle Size Fractions of Lime on pH Modification

Figs. 3 and 4 present the effect of the various Particle Size Fractions of Batches 2 and 4 of Lime on pH Modification of gold ore used respectively.

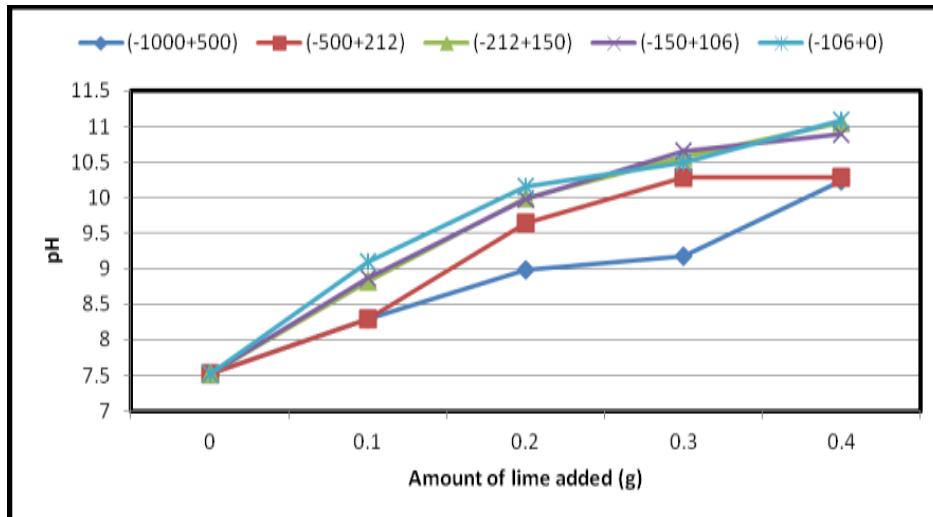


Fig. 3 A graph showing the pH modification ability of various size fractions of lime from Batch 2

As expected, it was observed generally that, pH increased with increasing lime addition. Addition of lime to a pulp increases the pH, irrespective of the particle size. These tests also showed that, pH modification ability of lime decreased with increasing particle size of lime. From Fig. 3, it was observed that 0.3 g of (-106 +0) μm size of lime from batch 2 was required to increase pH of the ore from 7.53 to 10.5. Same amount of lime of particle size (-1000 +500) μm from the same batch only increased pH from 7.53 to 9.18 within the same time period. Similar trends were observed from tests carried out on the various size fractions from different batches of lime. Fig. 4 shows the pH modifying ability of the various size ranges of Batch 4. Hence, lesser amount of lime with finer particles was required to increase pH of the gold ore compared to lime with coarser particles.

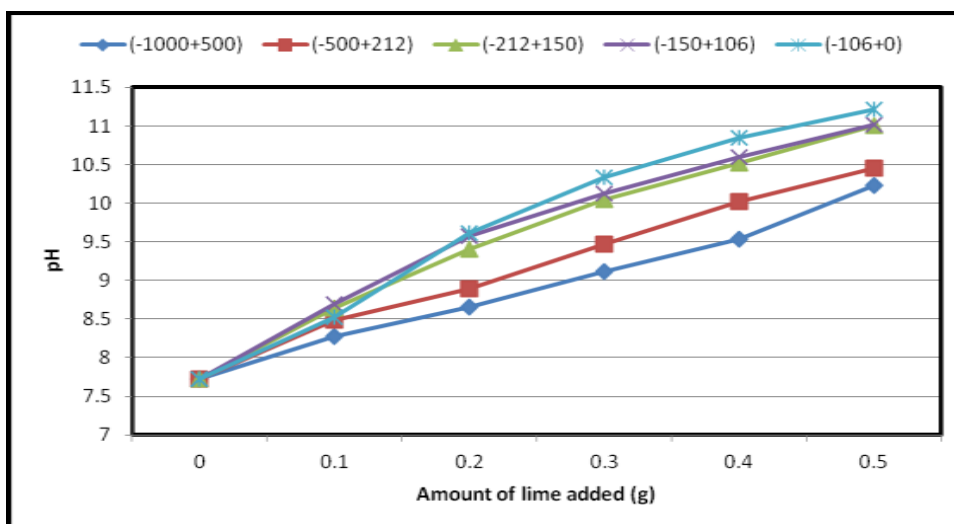


Fig. 4 A graph showing the pH modification ability of various sizes of lime from Batch 4

II. CONCLUSIONS

Lime particle size has significant effect on pH modification. The finer the lime, the faster its ability to increase pH since fine particle sizes have higher specific surface area. Course particles of lime modify pH at a relatively slower rate. The most efficient size range for effective pH modification for the lime, with respect to the ore investigated is (-150 +0) μm. Finer lime also results in lower lime consumption for pH modification. Hence, relatively smaller amount of fine particle sized lime can be used to modify pH of larger volumes of pulp of gold ores to be treated on a plant.

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