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THE IMPROVEMENT OF THE EFFICIENCY OF AN ALUMINOSILICATE CRUSHING CIRCUIT

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Abstract

Crushing plants that process different types of raw materials can be difficult to operate efficiently because of the differences in the characteristics of the input materials. The aluminosilicate plant grinding circuit studied has been operated without a screening of the primary crusher product and a proper definition of the plant's apparent crushing capacity. In this study, samples of chamotte and bauxite were crushed at gape sizes of 35 and 17 mm, respectively and their maximum feed rates and particle size distribution determined. The results obtained showed that chamotte and bauxite were fed at the maximum feed rates of 8.3 and 6.3 tons/h, respectively. In addition, it was found that secondary crushing without scalping was inefficient as the percentages of undersizes obtained increased only marginally due to the choking of the secondary crusher. The introduction a scalping screen for the jaw crusher discharge was, however, found to increase the plant's crushing capacities for chamotte and bauxite to 29 and 16.8 tons/h, respectively.

Key words: *crushing plant; materials; capacity; screening; undersize.*

1. Introduction

The purpose of any crushing circuit is size reduction. It then follows that the degree of size reduction must be moderated in some ways as to produce a circuit product which meets some size related criterion. Screens are used to classify the minerals into their sizes. Crushing circuits are either open or closed. Open circuits are those in which the crushing device breaks the material and passes it directly to the next process stage without sizing. In closed circuit, the broken material must meet some particle size criterion before it is allowed to continue downstream and the crushing machine is therefore closed by a sizing device, the oversize material being recycled to the crusher for further breakage. The material that is flowing in the closed loop between the crushing device and the screen is called the re-circulating load. Complex crushing circuits will incorporate such arrangements as are needed to achieve the desired result at the lowest capital and operating costs. Open crushing circuit is often used to achieve an initial degree of size reduction ahead of a closed circuit, which then completes the size reduction and controls product size. Closed circuits are used where the single stage crushing process is relatively inefficient and several cycles of breakage are required [1].

Closed circuits are often a more energy efficient way of generating a product of a required size, though this depends on the product size criterion. A major advantage of

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closed circuit crushing is greater flexibility given to the crushing plant as the crusher can be operated at wider settings, thus altering the size distribution of the product and making selective cut on the screen. The sizing devices in crushing circuits strongly influence the performance of the circuit as they determine the recycle loads, the circuit capacity and the final product size. Crushing performance can mainly be evaluated based on reduction ratios.

Industrial screening is usually done with vibramech screens. The vibramech screens such as Schenck vibrator are suitable for wet screening, fine dry screening, high speed de-watering and trash removal applications. The drive consists of two counter rotating out-of-balance motors mounted on a drive beam. The drive motors phase together to give a linear vibration along the drive line. This gives a force to each particle on the deck causing stratification of the material bed. Large particles move to the surface, while undersize fall through deck aperture [2]. In gravity flow hopper, the geometry and internal wall friction characteristics in conjunction with the flow properties of the bulk solid establishes the type of discharge flow pattern and maximum potential rate of discharge. Vibrating feeders, such as vibramech are extensively used in controlling the discharge of bulk solids from bins and stockpiles and directing these materials onto the conveyor belts [7].

Wills and Napier-Munn [4] and Bearman and Briggs[5] emphasized feed size distribution and feed rate as having significant impact on crusher performance. Industrial sizing is largely utilized for size separations from 300 mm down to about 40 μm, though the efficiency rapidly decreases with the fineness of the ore particles. The most used methods to describe screen performance are those which define efficiency based on the recovery of material at a given size or the mass of misplaced material in each product [3]. Aluminosilicate refractories contain alumina and silica as their main constituents. They are classified according to alumina contents and types are corundum, bauxite, andalusite and chamotte. Chamotte contains 40 to 42% alumina and bauxite 75 to 90% alumina [5, 6]. Bauxite and chamotte have been used as aggregates for making concretes with apparent density and apparent porosity of 2.98 g/cm3 and 17% for bauxite and 2.07 and 29% for chamotte, respectively [8]. On the Mohs hardness scale, alumina and silica have hardness values of 9 and 7, respectively [9]. The hardness of chamotte and bauxite has been reported to be between 2 to 2.5 and 8 to 9, respectively depending on the alumina content [10].

In the current set up of the aluminosilicate crushing plant studied, the primary jaw crusher feeds the drier and the dried raw material were fed to the secondary gyratory crusher without undergoing classification. In this work, the efficiency of crushing in the aluminosilicate plant was determined and appropriate change incorporated to improve it.

2. Materials and methods

2.1. Materials

The Aluminosilicate plant studied treats tons of bauxite and chamotte ores daily. The raw chamotte was sourced in South Africa, while bauxite was imported from China.

2.2. Methods

About 1 ton of chamotte sample was fed directly into the jaw crusher at the gape size of 35 mm. The feed material was then crushed in the jaw crusher and the product was screened with a hand screen consisting of a nest of 6.7, 5, 3 and 1 mm screens to obtain the size distribution. The procedure was repeated but at the gape size of 17 mm. The procedure was again repeated but with the chamotte sample fed through a vibramech screen to determine the feed rate. The latter test was carried out with about 10 tons of chamotte. The jaw crusher product was fed to the secondary gyratory crusher without screening as in the aluminosilicate plant default setting and the product of the secondary crushing stage screened to obtain the undersizes. The whole procedure was further repeated but with the secondary scalping screening of the gyratory crusher feed input. The preceding test series were again repeated but with bauxite as the input raw material.

3. Results and discussion

Fig. 1 show the old plant set up in which the primary crusher (jaw crusher) fed the drier and the dried raw material was sent to the gyratory feed bin without classification. The revised crushing circuit having scalping included to screen the jaw crusher product so that the undersize are removed before the product was delivered to the gyratory crusher is presented in Fig. 2.

Figures 3 and 4 show the screening results obtained when the chamotte samples were crushed with the gape sizes of 17, 35 mm and with vibramech screening.

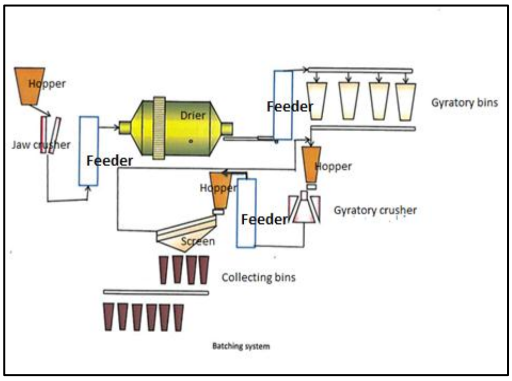

Figure 1. Aluminosilicate crushing plant process flowsheet without primary crusher product scalping

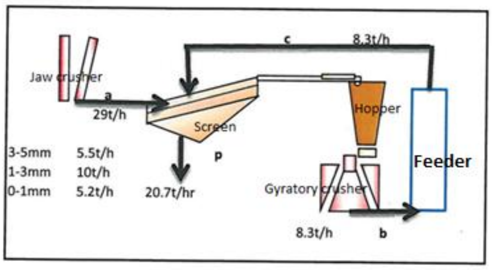

Figure 2. Aluminosilicate crushing plant with primary crusher product scalping for Chamotte

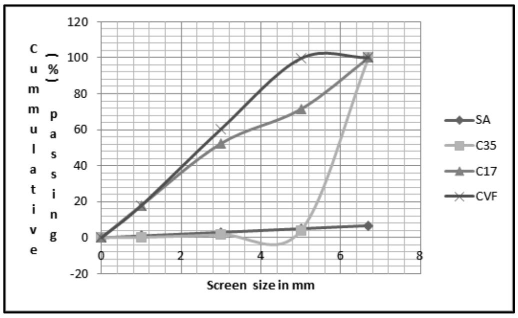

Figure 3. Particle size distribution of chamotte at 35 mm (C35), 17 mm (C17) and with vibramech feeding (CVF) at different sieve apertures (SA)

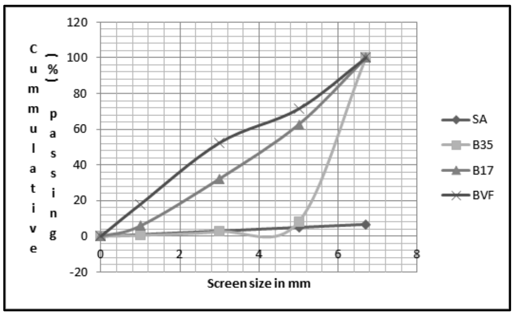

Figure 4. Particle size distribution of bauxite at 35 mm (B35), 17 mm (B17) and with vibramech feeding (BVF) at different sieve apertures (SA)

The results obtained showed that the screen undersizes for the 35 mm gape products were all lower than those of 17 mm with and without vibramech feeding. The vibramech feeding of the gyratory crusher also produced better screen undersizes at all screen sizes but its oversizes were very close to those of 17 mm gape size up to about 2 mm screen size. The results obtained on bauxite also showed a similar trend but with vibramech feed undersizes better at all screen sizes. In addition, the vibramech screening gave chamotte and bauxite feed rates of 8.3 and 6.3 t/h, respectively. These results thus showed that the vibramech screening at the primary crushing stage produced higher grinding efficiency in the circuit and should be incorporated into an aluminosilicate plant grinding system. The results also showed the difficulty in operating a crushing plant that treats different raw materials. In general hard materials like bauxite require low feed rates and small gape sizes, while softer ones like chamotte can be processed with high feed rates. This is due to autogeneous crushing that occurs during the crushing of softer material. On the hard material, there is not much autogeneous crushing between particles thus altering the particle size distribution leading to higher re-circulating load [3, 4].

Figures 5 and 6 show the weight of chamotte and bauxite feeds recovered in tons/hour as a function of the feed material. It was observed in Fig. 5, that about 20.7 tons more of chamotte was recovered per hour with the grinding circuit that incorporated secondary screening before gyratory crushing. It was also observed that the recovery at the new grinding circuit was higher at all screen sizes in comparison with the old grinding circuit and showed maximum and minimum recoveries of 10 and 5.5 tons/h at 2 and 4 mm screen sizes, respectively. It was also observed in Fig.6, that about 10.6 tons more of bauxite was recovered per hour with the grinding circuit that incorporated secondary screening before gyratory crushing. The scalping of the jaw crusher product was observed to increase the aluminosilicate plant's crushing capacity for chamotte and bauxite to about 29 and 16.8 t/h, respectively. It has been reported [11] that scalping for a jaw crusher increases the crushing plant capacity and lower energy consumption. In a simulated example, it was found that the removal of scalping reduced plant capacity by over 40%. The results obtained thus strongly showed that the jaw crusher primary product be screened to remove the undersize so that only the oversize is sent to the gyratory crusher [12, 13].

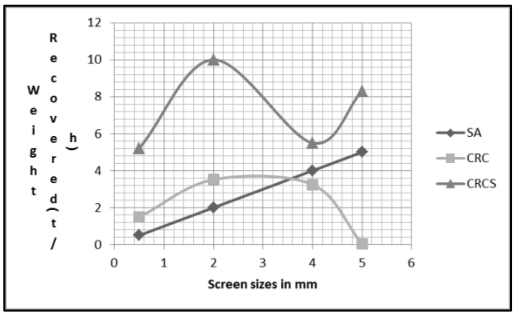

Figure 5. Weight of chamotte feed recovered (ton/hr) on the current grinding circuit (CRC) and new grinding circuit with scalping (CRCS) at different sieve apertures (SA)

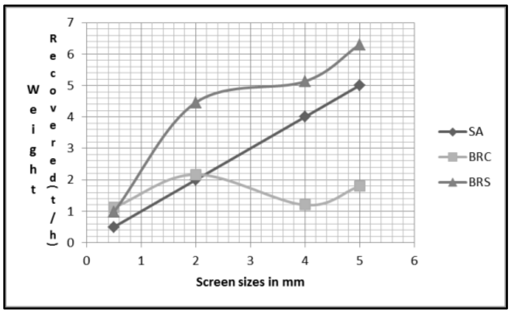

Figure 6. Weight of bauxite feed recovered (ton/hr) on the current grinding circuit (BRC) and new grinding circuit with scalping (BRS) at different sieve apertures (SA)

It was also observed that the recovery at the new grinding circuit (Fig. 2) was higher at all screen sizes in comparison with the old grinding circuit (Fig. 1) and showed a continuing increase up to the highest sieve size. These results confirm bauxite as a harder material than chamotte with its lower overall recovery per hour and that the modified grinding circuit produced much higher grinding efficiency than the old grinding system.

Figures 7, 8 and 9 showed the weight % of the feed and the recovered chamotte and bauxite at the various screen sizes.

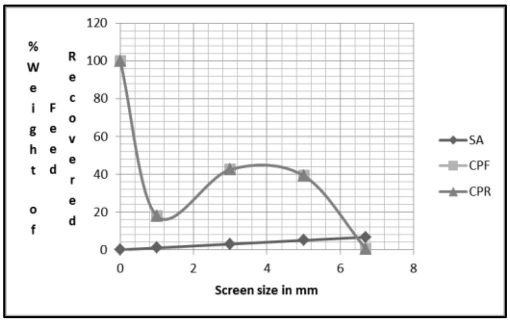

Figure 7. Weight % of chamotte feed (CPF) and recovered (CPR)

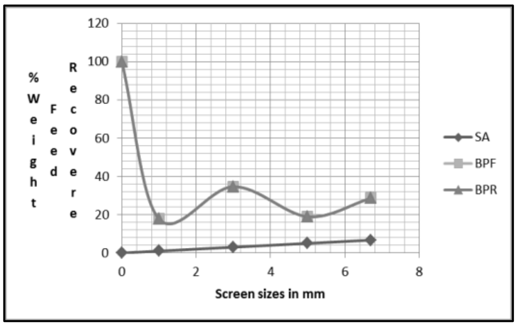

Figure 8. Weight % of bauxite feed (BPF) and recovered (BPR)

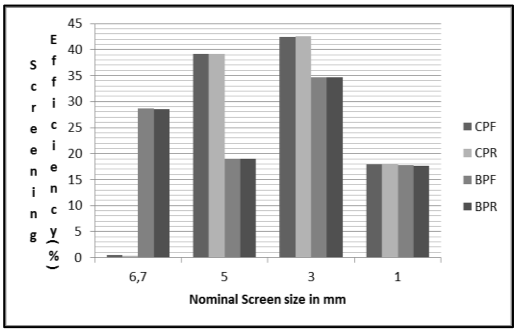

Figure 9. Screen % for chamotte and bauxite as recovered (CPR and BPR) from their feeds (CPF and BPF)

It was observed that the screening efficiencies for the two materials were high, with the feed composition virtually equal with the recovered weights at various screen sizes. For the 6.7 mm screen size, the efficiency obtained was slightly lower for chamotte because its coarse fraction tends to break during screening thus producing finer particles.

4. Conclusions

In this study, samples of chamotte and bauxite were crushed at gape sizes of 35 and 17 mm and their maximum feed rates and particle size distribution determined. The results obtained showed that chamotte and bauxite were fed at the maximum feed rates of 8.3 and 6.3 tons/h. In addition, it was found that secondary crushing was inefficient as the percentages of undersizes obtained increased only marginally due to the choking of the secondary crusher by the primary stage undersize fractions not removed. The introduction of a scalping screen for the jaw crusher discharge was, however, found to increase the plant's crushing capacities for chamotte and bauxite to 29 and 16.8 tons/h, respectively.

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