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Particle Size Reduction on Cuttings Dryer Screen Machines

INTRODUCTION

Concern has been expressed over the amount of size reduction that occurs to solids treated on cuttings dryer screens operated at 7.3 G's. As requested, I have performed power and size reduction calculations using data from a test referred to as Jones Bower Well No. 1 with size analysis data dated 20 January 1998. The objectives of the work were to (1) determine the power required by a size reduction system to reduce the 80-percent passing size of the feed by one mesh size and (2) determine the amount of size reduction that could theoretically occur if all the power could be used efficiently in size reduction.

Knowing the work index of the material and the 80-percent passing sizes of the feed and product in a size reduction system, it is possible to calculate the unit power required to accomplish the size reduction. The feed rate to the system in short tons per hour multiplied by the unit power then gives the total net power required to accomplish the desired size reduction. Similarly, knowing the power input to a system, the material work index and the 80-percent passing size of the feed, the 80-percent passing size of the product can be calculated. The calculations are based on Bond's Third Theory of Comminution, which has been universally accepted as being capable of providing reasonably accurate predictions of both power requirements and degree of size reduction in mineral grinding system.

Assumptions used and calculation details are provided.

<u>CONCLUSIONS</u>

If the feed to two cuttings dryer screens is 6.32 short tons per hour and the 80-percent passing size of the feed is 195 microns, the power required to reduce the 80-percent passing size to 137 microns (one mesh size equivalent in the square root of 2 series) is 27.8 kW or 37.3 HP. This assumes that the power is applied to the shale material in a way that achieves size reduction such as occurs in a rotating mill with steel balls as grinding media. Since the gross power applied to two cuttings dryers to achieve 7.3 G's is only 10 HP (maximum), and since the power is <u>not</u> used in a way that is conducive to particle size reduction, it has to be concluded that very little size reduction could be taking place on the cuttings dryers.

A size reduction calculation was done by creating the hypothetical situation where all the power input to the four vibrators on two dryers was translated into size reduction energy (which is impossible because most of the energy is expended in accelerating the screen frame and because the particles are free to be accelerated in the <u>same</u> direction without being confined or compressed between surfaces of grinding media). However, if all the power could be translated into useful size reduction, the 80-percent passing size of the product would only be 162 microns or 33 microns finer than the feed. This is a reduction ratio of only 1.2, which is quite small. Therefore, one must conclude that in reality, the amount of size reduction occurring on the cuttings dryers must be negligible.

Even if up to 10% of the total applied power were used in size reduction, the 80% passing size of the product would only be 4 microns finer than the feed to the system.

<u>Additional comments by Ron Morrison</u>

A size reduction of 33 microns (from 195 down to 162) still fits between a DX 50 (API D-16 of 231 microns) and a DX 70 (API D-16 of 158 microns). The size reduction also fits between a HP 60 (API D-16 of 207 microns) and a HP 70 (API D-16 of 158 microns). Therefore, if screens finer than seventy (70) mesh are used on cuttings with this particle size distribution, no effect would be seen in the cuttings discharge rate from the shaker screens. All other factors being held constant (mud properties, cuttings load, and flow rate) the increase in performance of being able to run one or two screen meshes finer more than offsets any disadvantage of minimal solids degradation.

By using Jim's calculations I ran some numbers for 80% passing at 74 microns in the feed at the same feed rates. If all the horsepower (100%) were used in size reduction the 80% passing size would be reduced to 66 microns (a reduction of 8 microns). Red blood corpuscles are 7.5 microns or .00029 inches in diameter. Pollen in the air ranges in size from 10 to 100 microns. If 10% of the horsepower was used in size reduction the 80% passing size would be reduced from 74 microns down to 73 microns (1 micron or .000394"). The Human eye can not see a <u>40 micron</u> (.001575") size particle.

BASIS AND ASSUMPTIONS

The following data and assumptions were used in performing the calculations:

1. The system consisted of two (2) cuttings dryer screens in parallel operated at 7.3 G's with two (2) 2.5 HP motors on each machine.

2. The total feed to the two (2) dryers was 6.32 dry short tons of solids per hour.

3. The 80% passing size of the feed to the dryers is 195 microns (Core Laboratories, File No. 57161-12373 dated 20 January 1998).

4. The work index (W_i) for shale is 16.4 (reference: SME Mineral Processing Handbook, Volume 1, Page 3A-27, 1985, Society of Mining engineers).

5. The Bond equation used is as follows:

$$W = \frac{10W_i}{\sqrt{P}} - \frac{10W_i}{\sqrt{F}}$$

Where W = Net power input as kWh per short ton
W_I = Work index in kWh per short ton
F = 80% passing size of feed in microns
P = 80% passing size of product in microns

To calculate the product size, the above equation can be rearranged to:

$$P = \left(\frac{10W_i\sqrt{F}}{W\sqrt{F} + 10W_i} \right)^2$$

CALCULATIONS

1. Calculate the power required to reduce the size analysis of the feed by one mesh size equivalent.

F = 195 microns

$P = 195\frac{1}{\sqrt{2}}$ = 137 microns

$$W = \frac{10W_i}{\sqrt{P}} - \frac{10W_i}{\sqrt{F}} = \frac{10(16.4)}{\sqrt{137}} - \frac{10(16.4)}{\sqrt{195}} = 4.4\,kWh/st$$

Total power required = $6.32\,st/h \times 4.4\,kWh/st = 27.8\,kW$ or $37.3\,hp$

2. Calculate theoretical size reduction if <u>all</u> applied power could be effectively used in size reduction.

(a) $$W = \frac{7.46\ kW}{6.32\ st/h} = 1.18\ kWh/st$$

(b) $$P = \left(\frac{10W_i\sqrt{F}}{W\sqrt{F} + 10W_i}\right)^2 = \left(\frac{10(16.4)\sqrt{195}}{1.18\sqrt{195} + 10(16.4)}\right)^2 = 162\ \text{Microns}$$

Therefore, if all applied power could go into size reduction, the 80% passing size of the product would only be 33 microns finer than the feed. In reality only a negligible portion of the applied power could conceivably go into particle breakage. Therefore, we must conclude that the amount of size reduction occurring on a cuttings dryer screen is almost negligible.

3. Calculate size reduction assuming that up to 10% of the applied power could go into size reduction.

$$W = 0.1(1.18) = 0.118\,kWh/st$$

$$P = \left(\frac{10(16.4)\sqrt{195}}{0.118\sqrt{195} + 10(16.4)}\right)^2 = 191\ \text{Microns}$$

DISCUSSION

Size reduction in mineral processing operations is accomplished with various types of crushers, autogenous mills, rod mills and ball mills. In all of these systems, power is applied to the crusher or mill and particles are broken by being “compressed” between crushing surfaces, between grinding media (balls, for example) or between media and mill surfaces. Even where attrition is the major grinding mechanism, compression between surfaces is required.

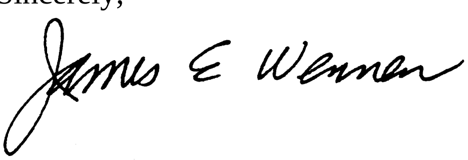
The Bond equation referred to earlier has been used for well over forty years now both to predict the energy requirements for various grinding applications and to assess the performance of operating systems. The work index (Wi) is a relative value that describes the resistance of a given material to breakage; this parameter can be determined using standard grindability test equipment. Its theoretical definition is the amount of energy in kWh per short ton to break material from infinitely large size to 80% passing 100 microns. In the Bond equation, the 80% passing sizes of the feed and product are used to calculate the energy required for a given situation.

The kind of situation that exists in crushing and grinding systems simply cannot occur on a vibrating screen such as a cuttings dryer. Despite the fact that a force of 7.3 G’s is applied to the screen surface, this is essentially an unconfined system with all the particles being accelerated in the same direction. Therefore, even if a large particle collides with a smaller particle, they are both being accelerated in the same direction and neither particle is being confined. The screen surface can also collide with particles but, again, no confinement is occurring; the particles are free to move in the direction they are being accelerated.

Even if 10% of the applied energy were expended in performing size reduction, the 80% passing size of the product would only be 4 microns finer than the feed to the system. This certainly has to be considered to be insignificant.

If you have any questions, please contact me.

Sincerely,



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