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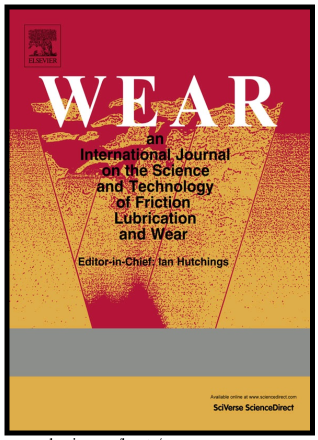

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PII: S0043-1648(17)31365-0
DOI: https://doi.org/10.1016/j.wear.2017.12.004
Reference: WEA102311

To appear in: *Wear*

Received date: 12 September 2017
Revised date: 4 December 2017
Accepted date: 4 December 2017

Cite this article as: Juuso Terva, Veli-Tapani Kuokkala, Kati Valtonen and Pekka Siitonen, Effects of compression and sliding on the wear and energy consumption in mineral crushing, *Wear,* https://doi.org/10.1016/j.wear.2017.12.004

Effects of compression and sliding on the wear and energy consumption in mineral crushing

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Abstract

The majority of the operating costs of commercial crushing are caused by the power consumption and the wear part maintenance. Better understanding of the variables affecting the compressive crushing is needed when aiming to lower the operational costs of material comminution. The gouging or high stress wear tests are commonly conducted with laboratory sized jaw or cone crushers that do not allow easy alteration of the movement or geometry of the wear surfaces. Therefore, a new innovative jaw crusher-type wear tester was designed especially for wear and mineral property research. The modular jaws of the developed dual pivoted jaw crusher allows flexible selection of jaw geometry, which is independent of the selectable compressive and sliding movements of the jaws. The narrow jaw design produces extensive wear in the specimens even when small amounts of abrasive are crushed. The reference tests with a structural steel show excellent repeatability of the wear loss and energy measurements during the tests. The results with varying sliding movement of the jaws showed linear dependency between the wear of the jaw plates and energy spent. A method to separate the energy spent in wear from the energy spent in comminution is also described in this paper.

Keywords: Wear testing, Contact mechanics, Three-body abrasion, Mining, Mineral processing, Jaw crusher

1. Introduction

The high energy consumption of crushing is one of the main motivations to study the comminution of minerals. Tromans [1] listed several examples of energy consumption per country, showing that the energy spent in comminution constituted 1 % - 16.7 % of the total energy consumed by the industry. The exact value depends on the proportion of the mining industry to the total industry sector. The high energy consumption of the mining industry originates from the poor efficiency of crushing and grinding, as most of the energy used by different types of crushers is dissipated as heat and only a few percent is used for the surface energy increase due to comminution [1].

The high maintenance costs caused by changing the wear parts of the crushing equipment are another motivation for the research of crushing processes. In mineral processing and aggregate production, the process of comminution involves several stages of crushing. For compressive crushing, gyratory, jaw and cone crushers are used in the primary, secondary and tertiary stages of crushing, the jaw crusher being designed to crush rock particles between a fixed and a moving plate.

The main objective of this paper was to investigate how the approaching of the crushing surfaces involved in the compressive crushing affects the required amount of energy and how the wear of the crushing surfaces correlates with the measured energy consumption. The study concentrates on the geometry and movement of a jaw crusher equipment. The main components of a jaw crusher are the supporting frame, a stationary jaw plate fixed to a supporting frame, and a moving jaw plate with its supports. A motor is used to rotate a flywheel connected to an eccentric axle, which is used to cause the rocking motion of the moving jaw. The movement pattern is different depending on the type of the jaw crusher. Jaw crushers are manufactured in various sizes, and the jaw width can vary from a few centimeters of the laboratory sized units to 1.5 meters in the largest crushing units. The size of the equipment defines the possible size range of the feed that can be crushed. Other important design factors are the capacity and the size reduction ratio of the feed and the product.

The single toggle jaw crusher is the most common type of crusher, where the eccentric motion produces elliptical movement at the lower end of the moving jaw. The vertical movement of the jaw allows high capacity of rock but initiates sliding of the rock along the jaw plates, which increases the wear rate [2]. The wear rate is higher near the release end (lowest part) of the jaws, where smaller rocks are crushed in a narrow gap between the jaws. The approach of the moving jaw near the release end has a large vertical movement component, which causes sliding of the rock on the jaw plates and increases the wear rate of the plates.

Wear tests are conducted as full or pilot scale field tests, or make use of the smaller laboratory sized units for better control of the test environment. The jaw crusher tests have a relatively good repeatability, when the operation is properly controlled and a sufficient amount of abrasive is comminuted in the test. The wear rates of the jaw plates in a test can be affected

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