PARAMETERS AFFECTING ULTRA-FINE GRINDING OF TALC ORE

By

Eng. Abdullah Mohamed El-Bendary Hassan

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
MINING ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT

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PARAMETERS AFFECTING ULTRA-FINE GRINDING OF TALC ORE

Key Words:

Stirred Mills; Ultra-fine grinding; Planetary mill; Ultra-Fine Talc Uses and Specifications; Functional Fillers.

Summary:

Fine and ultra-fine grinding have several applications in most of industrial fields such as advanced ceramics, porcelain, cement, paper coating, plastic and pigments. The selling price of ultra-fine minerals is highly increased compared with conventional ground minerals. Different industrial minerals that are most frequently used as fillers and extenders are alumina hydrate, barite, calcium carbonate, diatomite, kaolin, mica, talc, and wollastonite. Stirred ball mills (attritor mill) are much more efficient for fine grinding and regrinding than conventional tumbling mills. Conventional milling requires long retention time and tremendous energy input for micron size production. This work aims to study the parameters affecting ultra-fine grinding of Egyptian talc from Shalatin locality of the Eastern Desert to produce an ultra-finer product less than ten microns using an attritor mill in order to be used as a filler material for different industrial applications such as paints, plastics, paper coating, and other advanced applications.

Acknowledgment

I would like to express my deep regards and sincere gratitude to Prof. Dr. Salah El-Din El-Mofty, Faculty of Engineering, Cairo University for his close supervision, and valuable stimulating guidance and fruitful discussion throughout this study.

I cannot pay the suitable gratitude to my supervisor Prof. Dr. Mohamed Kamal Abdel-Rahman, Head of Mineral Processing Laboratory, Central Metallurgical Research and Development Institute (CMRDI), for his guidance, patience and support.

Also, I offer my sincerest gratitude to Prof. Dr. Mohamed Abdel-Daym, professor of mineral processing, (CMRDI), for his kind assistance and support.

Last but not least, special thanks to the staff of Mineral Processing Laboratory, CMRDI.

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Abstract

This work aims to study the parameters affecting ultra fine grinding of an Egyptian talc to produce particle size less than 10 microns in order to be used as a filler material for different industrial applications such as paints, plastics, paper coating, and other advanced applications. The experimental program involves attrition scrubbing, wet and dry grinding on crushed talc (less than 6630 microns) using attritor mill. The dry grinding was carried out using both attritor and planetary mills. In case of attritor dry grinding process, two schematic models were carried out, the first one is dry grinding followed by air classification, the second one was two step dry grinding. The studied parameters were grinding time, media size, stirrer speed, solid in the slurry content, media to talc ratio by volume, and mill filling.

The results showed that in attrition scrubbing, about 65% by weight with d_{90} and d_{50} 29 and 10 µm was obtained with 8.5 % loss of ignition, 88 % ISO brightness and 94 % whiteness compared with a 11.4 % loss of ignition, 83 % ISO brightness and 91 % whiteness in the feed. In wet grinding about 96 % by weight with maximum size reduction d_{90} and d_{50} are 12 µm, 3.8 µm. The ultra fine grinding using attritor mill followed by an air classifier showed that 78.5% by weight with d_{90} & d_{50} 19 µm and 7.8 µm separated at the maximum motor speed. Meanwhile the two steps grinding in attritor mill showed that about 95.5 % by weight with d_{90} and d_{50} are 14.4 µm, 4.2 µm. In case of dry grinding using planetary mill a ground product with d_{90} and d_{50} are 13.6 µm, 4.3 µm was obtained. The scanning electron microscope of ultra-fine grinding showed that distortion of platy structure occurred after 180 min and size of d_{90} & d_{50} 12 µm, 3.8 µm in wet grinding and after 90 min and size of d_{90} & d_{50} 12 µm, 3.8 µm in dry grinding. Therefore, in order to keep the platy structure and crystallinity of talc to be used as a filler material in different industrial applications such as plastic and paint industries it is recommended not to grind talc more than the above mentioned times.

The submicron ultra-fine grinding products of Egyptian talc could be used in different industrial filler applications such as paints, ceramic and paper coating.

Chapter 1: Introduction

1.1. Background

Fine and ultra-fine grinding are very important in many industrial fields such as advanced ceramics, porcelain, cement, paper coating, plastic and pigments. Ultra-fine grinding of minerals is so essential for production of filler for different industrial applications. The selling price of ultra-fine minerals is highly increased compared with conventional ground minerals. There is a growing demand for ultra-fine minerals as fillers in most industries. The objective of using these industrial minerals is also to improve the performance of many products and to reduce their manufacturing costs. Different industrial minerals that are most frequently used as filler and extenders are alumina hydrate, barite, calcium carbonate, diatomite, kaolin, mica, talc, and wollastonite. In plastic industry calcium carbonate and kaolin are usually added to plastics to impart impact strength, or to provide thermal stability. Platy minerals such as talc and mica improve flexural strength. In paper industry white minerals such as kaolin, talc, and calcium carbonate used as filler and coating pigments. These minerals are also widely used as filler in paint industry. For most of industrial applications, these minerals must be ground to submicron sizes. Ultra-fine ground talc less than 10 microns is used in different applications. In the plastics platy talc in ultra-fine size is used to improve its mechanical and surface properties such as stretch resistance. In the paper industry talc is used as fillers, to control pitch and stickies and in coating formulation .In oil paints talc is used as an extender and suspending agent. In recent years ultrafine grinding to the submicron range become essential due to the development of the new functional materials such as new ceramics and electronic materials for various industrial fields. The most famous ultrafine grinders are fluid energy mills such as jet mill and agitated mills such as stirred media mills [1].

Stirred ball mills (attritor mill) are much more efficient for fine grinding and regrinding than conventional tumbling mills where conventional mills require long retention time and tremendous energy input for micron size production. Stirred media mills have the ability to produce extremely fine powders with narrow particle size distributions, this feature is so important in fillers and pigments [2, 3]. Attrition grinding can also be used as a pre-concentration method in talc mineral processing industry. Further removal of carbonates and the separation of talc from chlorite can be obtained by flotation process.

1.2. Thesis objectives

The main object of this thesis is to understand the influence of different parameters on ultra-fine grinding (<10 micron) of Egyptian talc from Shalatin locality of the Eastern Desert. An attritor mill (wet and dry) is used to achieve the desired size which is utilized as a filler material for different industrial applications such as paints, plastics and paper coating. This work will also study the availability of talc pre-concentration by attrition technique. Additionally the study covers the effect of grinding by using attritor mill on talc morphology and structural changes. Finally a comparative ultra-fine grinding of white sand and calcium carbonate is studied at the optimum conditions obtained during talc ultra-fine grinding.

Chapter 2: Literature Review

2.1. Ultra-fine grinding technologies

In recent years, ultrafine grinding to the submicron range become essential due to the development of the new functional materials such as new ceramics and electronic materials for various industrial fields [4, 5]. The most famous ultrafine grinders are fluid energy mills such as jet mills and agitated mills such as stirred media mills [1]. Jet mill was first developed for producing particle size less than 100 microns and having a high degree of purity. Its design incorporates a horizontal cylindrical grinding chamber having fluid jets which enter tangentially. Feed materials enter by way of a venture arrangement. Grinding is achieved by multiple particle/particle interaction [6]. Jet mills stress a material by entraining particles in a gas stream and impingent the particles on a hard surface or against each other (figure 2.1). Jet mills are extensively used in the pharmaceutical industry due to their ability to produce fine particles without the wear of mechanical parts [1]. Although the jet mill has several advantages, but it is still an energy intensive process as only 2- 5% of the energy supplied is used to create new surfaces Mebtoul et al [7]. Nakach et al [8] disclosed the opposed fluidized bed jet mill disadvantages such as poor particle size and its distribution, expensive, low capacity, mechanically complex and requires regular maintenance.

Another type of mills used to produce ultra-fine particle size, are the stirred media mills, which are similar to ball mills except they contain an agitator, which supplies the necessary energy to the grounded particles instead of rotation of the vessel. The agitator allows the media to collide with a much higher force than is possible in the conventional ball mill [1]. The importance of stirred media mills increases steadily, because of an increasing demand for ultra-fine particles. In many cases, the grinding by a stirred ball mill (attritor mill) to submicron range has been applied commercially. Because of their easy operation, simple construction, high grinding rate and low energy consumption compared with the other fine grinding machines, stirred ball mills recently have received more and more attention [4, 5].

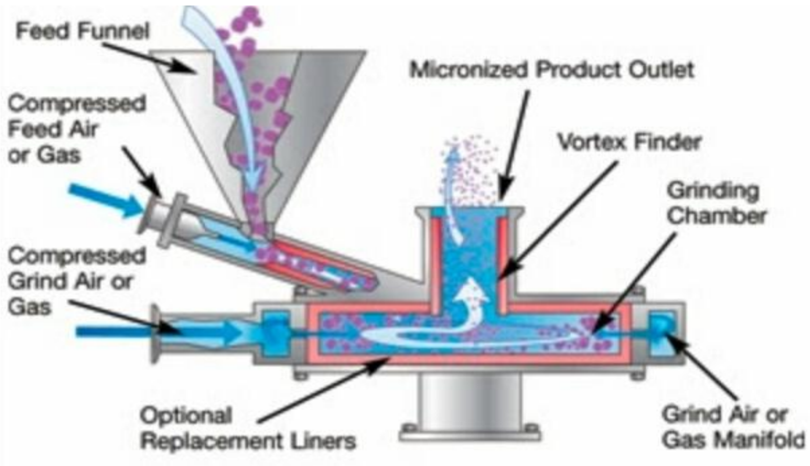

Figure 2.1: Jet mill

2.2. Stirred mill

Stirred mill technology was applied in the ultra-fine grinding process in the pigment industry and it has wide applications in other industrial fields such as pharmaceuticals, ceramics, and chemical industries [9, 10]. It consists of a water cooled grinding tank, charged with media and agitated with a central impeller. Impact and attrition grinding occurs by the collision of the media with tank walls and collision of media with itself [11]. In stirred mill (attritor mill) the power providing (input) is directly used for driving of agitating media which is the key of grinding efficiency. The most advantage is that the grinding does not take place against the tank walls. So it enables little wear on the walls, and leading to longer service life of the vessel. Attritor mill could be used in wet or dry process. In wet grinding the impact action is created by the constant grinding media impinging due to its irregular movement. Shearing action is created as a result of spinning of the media in different rotations due to its random movement and, therefore, exerting shearing forces on the adjacent slurry. As a result, both liquid shearing force and media impact force are present. Such combined shearing and impact forces results in a great size reduction as well as good dispersion. Meanwhile, in dry milling the process is achieved by expanded moving bed of grinding media. This condition is described as kinematic porosity figure 2.2. The particles are subjected to various forces such as impact, rotational, tumbling, and shear; therefore, micron ranges fine powders can be easily obtained. Additionally, a combination of these forces creates more spherical particles than other impact-type milling equipment [12]

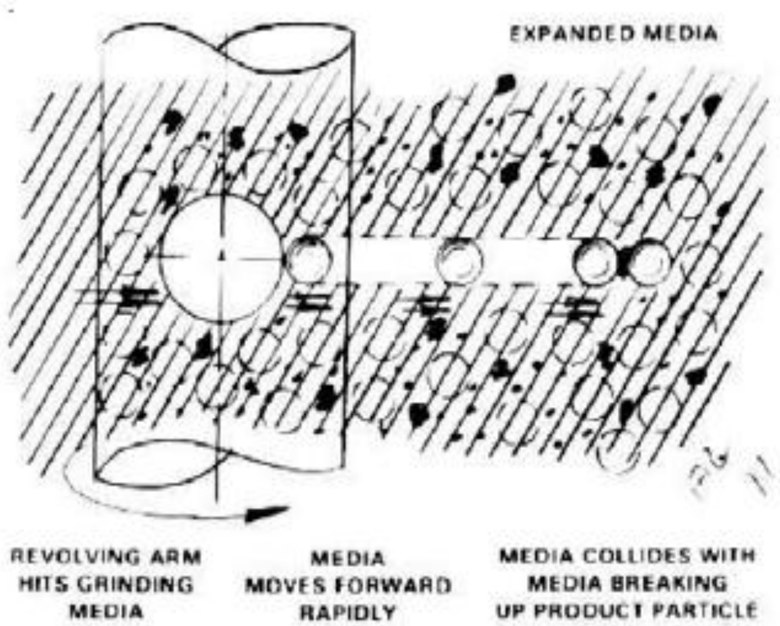

Figure 2.2: Media collisions with agitator arms and milled particles

There are two different classes of stirred mills that can be referred to as slow milling speed or high speed. The first class includes tower mill or Vertimill and