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COMPLETE MILLING TECHNOLOGIES OF DIFFERENT VALUABLE MATERIALS

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1. INTRODUCTION

In different technological processes, despite their peculiarity, there always arises one and the same matter – basic materials reducing to inner and external transformation with which to gain expected results.

Milling of materials is one of the main technological processes beside thermal treatment, pressure or sub-pressure processes and fractionation. To provide the next stages of technology, the milling is essential because it provides, usually, a prerequisite for physical, chemical and thermo-chemical basic processes.

If it's needed to reduce particles during the technological process, in this paper is given information how to select grinding equipment and the type of grinding that can treat particles to medium fineness needed, as well as factors to consider when selecting equipment.

2. MEDIUM AND REAL FINENESS

Present paper sizes up crushers, which break material lumps to improve material processing and handling, covers components and operation of common crusher types, factors to consider, how to select crushing technologies, how to use a crusher to reduce large lumps of various materials to a consistent size. Traditionally seen as a slow-speed, coarse-reduction machine, today the crusher is finding application in higher speed operations with finer discharge sizes. What's more, crusher applications have been extended beyond hard, friable materials to rubbery, even sticky lumps. Outlining some crushing basics, including how the rotor- and hammer-mills work and various design factors that affect these milling-machines use. The main importance is to control product real fineness (not just medium fineness) in a milling-process and how to maximize the milling capacity (Sannik&Erg, 1990).

A properly designed processing system, a roller- or hammer-mills can economically and efficiently grind (or pulverize) a range of solid materials to varying degrees of fineness.

Most powders that are part of our everyday lives, in the medicines we use, the foods we eat, and the plastic parts in the appliances and computers we operate, start out as larger particles or agglomerates that must be reduced to a specified size.

But each dry bulk material has its own characteristics, and these determine which type of size reduction machine is suited to reducing it.

A dry attrition mill is a versatile fine-grinding unit that can handle several materials under many conditions. Common applications include grinding ceramic powders, pigments, chemicals, food products, plastics and rubber, minerals, metal powders, glass frits, fibres, and cellulose. The mill can also blend dissimilar materials, coat particles with additives or disperse the additives during grinding, and provide mechanical alloying. Conditions that can be varied during mill operation include the grinding media type, size, and ratio to material, material feed-rate, and grinding speed.

Using the materials which can be overheated during grinding, is needed to use size reduction equipment with liquid carbon dioxide or liquid nitrogen.

3. IDEAS OF PROPER MILLING

The main problems for proper milling are:

- to gain material which is with needed faction and crushing grade, because the exactitude of grinding level is important for the quality of the materials that are going into recycling, and also therefore the price of these materials.
- grindability of materials.
- the throughput-rate and working capability of the milling machine. This depends mainly on attrition firmness of cutting tools and other elements in crushing-zone.
- the need for multiple-stage or graded crushing and different devices, because the level of its unification is low.
- high speed allows for processing of highly fibrous, temperature sensitive and other difficult samples.

Several theoretical laws apply to solving size reduction problems. Kick's law states that the work for a given reduction ratio is the same, irrespective of the starting size. Rittingler's law states that work is proportional to the size produced. And Bond's law states that work is inversely proportional to the square of the particle diameter. These commonly quoted statements seem obvious and have proven true for some applications, but they don't produce a formula you can apply to all size reduction problems. When part of a properly designed processing system, a roller- or hammer-mill can economically and efficiently grind (or pulverize) a range of solid materials to varying degrees of fineness.

The planetary-mills employ a 2-way planetary action to grind rapidly by both impact and friction, resulting in very narrow

These mills are also versatile: they can simultaneously grind, classify, dry, and convey materials. (Tümanok&Kulu 1999)

4. TYPES OF MILLING AND MACHINERY

Types of milling divides depends on crushing grades are primary crushing, coarse crushing, crushing, fine-grinded crushing, fine or extra-fine milling. There is an extra method for pre-shredding.
The wide-spread types of milling-machines are ball crushers, and mills, beater and hammer-mills, screw- and roll-presses, cone-type crushers, jaw- and clod crushers, cutters or slicers with knife-shafts with one or multiple shears, colloid- or other centrifugal-type mills, rotor-rotor and rotor-stator-type mills and disk-mills.
It is known that pre-grinding and/or multi-step grinding is positive and most common method.
Material shredders (**pre-shredding**) provide the first step for many processing operations by reducing extremely bulky and non-friable materials to smaller sizes. Though shredders are fairly new types of size reduction equipment, they provide many benefits, including high power and efficiency, for a range of applications.
The jaw crusher comes with fixed and eccentrically-movable tempered tool steel jaws and side walls. It is driven by powerful overload-protected motor with flywheel. Feed material up to 100...150 mm size is reduced to 1 to 15mm product (**coarse crushing**). The angle between jaws may be varied to suit material types.
Disk- mill reduces feed material 20mm or smaller to product as fine as 100µm (**fine grinding**). Samples are pulverized by feeding between stationary and slowly rotating grinding disks with radial graduated teeth. Material is gravity-fed to the centre of the stationary disk and is progressively ground finer as it moves with the sloped grinding teeth until discharged at the outer edge of the disks. Product size is set by simple adjustment of a reproducible gap setting (while running, if desired) with reference scale.
Crushers, hammer-mills, and lump breakers are excellent for reducing brittle materials (**primary- or coarse crushing**). But if materials are non-friable, or not brittle enough to be easily rubbed, crumbled, or pulverized into powder, is needed a milling-machine to reduce the material to smaller pieces (**fine milling**).
Rotor-rotor and rotor-stator mills type disintegrator grind continuously, reducing solids to particle sizes in the low-micron to submicron range (**extra fine milling**). These types of mills grind and classify the material particles simultaneously by using the principle of centrifugal force.
These grinders combine impact and shearing stresses from high-speed multi-toothed steel rotors to rapidly and quietly grind soft to medium-hard and fibrous materials. The rotary action is preferred mortar grinding for most organic samples to overcome their elastic structure and prevent sample adhesion. Fineness of grind in rotor-rotor mills is determined by several circumstances and available in a variety of sizes, 0.001 to 10 mm. (Sannik&Erg,1990)
Colloid-mill can rapidly grind materials to colloidal fineness of 1 µm and below by developing high grinding energy via planetary actions. Units may be used for dry or wet grinding of soft to hard/brittle materials or for mixing, homogenizing and emulsifying suspensions and pastes. product size range. In planetary action, bowls rotate opposite to direction of the bowl platform rotation, and centrifugal forces alternately add and subtract.
Grinding balls roll halfway around bowls, then are thrown across bowls to impact opposite walls at high speed. Grinding is further intensified by interaction of balls. High energy planetary action gives a narrow product size range in much shorter grinding times than possible with conventional ball mills with gravity tumbling. The use of grinding bowls and are equipped with membrane keypad for programming, control, and display of grinding times and speeds. The machines with single grinding bowl station with an adjustable counterbalance to stabilize operation. There are new models with features such as a synchronous, toothed belt drive to guarantee a slip-free and constant transmission ratio between the bowls and main disc, periodic automatic reverse to improve grinding results, and an integral fan located in the grinding chamber for additional cooling to permit a longer grinding process. This unit is ideal for rapid batch-wise grinding down to colloidal fineness of dry material, as well as material in suspension.

The position of cutting tools classifies the machines. For example - vertical mechanism (colloid-mill, dismembrator), horizontal mechanism (knife-shafts, screw-press, disintegrator) and no fixed or for free-working-regime-oriented tools.

5. ROTOR-TYPE MILLS

In the 80's of the 20th century the rotor-rotor-type mills-activators were very popular and unique experimental machines because they unified good and not so good characteristics of many different machines.
A term rather loosely used, but generally applied to a machine which breaks up and reduces materials by impact, as distinct from one which grinds between rollers, or amongst a mass of loose balls in a rotating drum.
There are another, more modern types of fine-crushing machines – cage type disintegrators and hammer-mills. Among the substances broken up and ground more or less finely in rotor and rotor-rotor mills are coal, coke, slag, sand, shale, limestone, pitch, plaster, starch, clay, shells, gypsum, barites, rock salt, glue, bark, soap, bones, fertilizers, animal foods, brick-bats, stone, iron oxide, rubber and other products.
In the grinding machines type disintegrator and hammer-mill the crushing takes place when a free flying particle collides with the grinding body (hammers, bars, beaters). In grinding machines of this type two kinds of processing can be realized: by straight or inclined collision.
In the cage type disintegrator, in which the reel or cage of steel bars (grinding bodies) revolves within a cage turning in the opposite directions. These machines have a couple of cages, one within the other, composed of steel bars, which revolve in opposite directions.
The multi-stepped rotor mill includes two rotors with rows of grinding bodies. The "classical" grinding bodies have been made from round bar, nowadays rotor mill can have large range of beaters included the plates with a working plane inclined to the radius of the angle 0…90º. (Tümanok, 1975)

The steel-materials used for building these machines (hammers, screen, grinding bodies, steel plates of cover can be renewed when worn through.

The grinding product in a rotor mill, as in a disintegrator, thrown in is violently hurled about between the bars and broken up into the more or less desired state of fineness, falls on a layer of particles moving along a cylindrical cover, where it's placed under attrition and collisions with other particles flying from crushing-zone.

The main influence to the material fed trough the hopper to the centre of cages is thrown with great violence amongst the bars and which broken this stuff up.
A particles accelerated, runs into the working plane with a relative velocity. The slipping of a particle on the working plane can be described by equations (Tümanok,1975).
The speed of revolution ranges in various machines is 300 to 10 000 revolutions per minute.
For fine disintegration a machine with duplicated – triplicated sets of cages is employed.
The more fibrous materials such as chips, rubber, asbestos, leather, herbs, etc.. may be shredded up by a machine consisting of a set of revolving knives flying past a set of stationary ones, but in other cases pure impact is the disintegrating medium.
In the process of accelerating of particle in concentric zone between cutting tools was possible to gain cavitations-effect, peculiar for instance the colloid-mill. (Tümanok, 1973)
When particles fell on the cutting element or on body of working-zone, the result was like process in hammer-mill – beating and crushing.
The particles moved on in the ground of cutting tools, rotors and body. In the process they are attrited like in ball-crushers.
The bigger particles moving form one process-round to the next one when they will slice and smash like in a mincer.
The additional effects for activate the particles are bouncing, vibration and fractionation.
An important subject is the technology of milling, which consists of multiple phenomena – rubbing, attrition, cavitations, hitting, bouncing, vibration, smashing, influence of centrifugal-power, speeding of particles, fractionizing, etc.

6. HAMMER-MILL'S ADVANTAGES AND DISADVANTAGES

The target of the study is to gain optimized regimes and to minimize the number of crushing stages to reach necessary grinding-levels using the more common machinery.
The hammer-mill classes grinding and crushing machines are latter being the more powerful. In this type of mill the material smashes into small pieces against the breaking bodies, cover and screen. Any large piece unable to pass trough the screen are picked up by the hammers and thrown once more against the breaking bodies. Hammer or beater machines consist of a revolving set of swing-hammers which beat the material small with the cover.
The disintegrating action may occur while the material is "in the air", or when it's smashed against steel blocks (breaking bodies) within the strongly built cover. As the hammers whirl round at about a thousand(s) revolutions a minute they catch the material fed into hopper and hurl it against the bodies, the rebound being caught by succeeding hammers. The material is finally reduced to the fineness required before it can pass through the screen.

Excessive hammer wear and vibration are symptoms of common hammer-mill problems that not only increase maintenance costs, but can impair the unit's operation and reduce its capacity.
After outlining some hammer-mill basics, including how a hammer-mill works and various design factors that affect hammer-mill maintenance, could be possible to describe how to correct common hammer- mill problems.

According to some estimates, as many as 60 to 70 percent of the hammer-mills in use today have been improperly designed or installed or are improperly maintained, resulting in problems that raise hammer-mill maintenance costs and reduce capacity.
While several types of wear can affect the technological equipment, size reduction equipment is most often affected by either abrasive wear or impact wear and often by both. The wear can lead to frequent replacement or refurbishment of equipment surfaces and components, such as liners, hammers, and crusher rolls, increasing the operation's downtime and maintenance costs.

7. CONCLUSION

Grinding is the most power-intensive phase of various technologies, whenever reproducible grinding conditions, short grinding times, precise results, loss-free milling and dust-free operation are required, the perfect mill and technology should be chosen. The analysis of components of the material's resistance to grinding gives the possibility of a new technique for grinding intensification.
Milling technologies is not only the device itself but also "know-how" of application on different types of equipment.

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