MEDIA MILLING FOR CHEMICAL APPLICATIONS

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I. INTRODUCTION

In this paper, we are going to discuss media milling technologies as they relate to chemical applications and the chemical industry. Chemical applications cover a broad spectrum of physicochemical knowledge of materials, chemical processes, and the operations used in the chemical industry including media milling technology. Media milling technology finds significance in three major areas of solid chemical processing. The first area is particle size reduction of chemicals. The second is the mixing and milling of several chemicals to form new chemical compounds. The third area is the activation or liberation of chemical raw materials. With media milling's wide range of application in the chemical industry, proper selection of media milling equipment becomes vital.

There are many different types of media mills, some grinding equipment, such as ball mills, are more suitable for coarse materials. These mills use "large" media ranging in size from 20mm and up to produce material about ten microns to mesh sizes. Other mills, such as Attritors, are more appropriate for "mid-range" size particles. Attritors utilize media from 3 to10mm to produce material ranging in size from approximately one to ten microns. The latest advancements in milling technology target applications that require ultra fine sub-micron grinding. These high performance small media mills produce sub-micron particle sizes by using beads ranging in size from 0.1 to 1mm.

The first small media mill was a vertical sand mill developed by E.I. du Pont in the 1950's. Since that time, new milling technologies have emerged, from shot mills to horizontal mills, to narrow-gap mills, to the most recent developed high-speed circulation mills.

II. MEDIA AND MILL SELECTIONS

As mentioned earlier, different types of mills are suitable for different processing requirements. There are several important factors to consider when selecting grinding mill types and media sizes. Generally the coarser the feed material, the larger and denser the grinding media should be. Larger and heavier media is required due to the greater impact forces that can be generated. Final particle size should also be considered. The finer the end particle size that is required, the smaller the grinding media should be. Small media is effective for finer end particle sizes due to the greater surface area that is available to perform the fine grinding.

Some manufacturing processes utilize the advantages of combining complementary milling technologies. One example of an efficient process would be to use a mill such as an Attritor to perform the first stage of grinding. The final polishing grind would then be achieved using a small media mill. This two-stage process maximizes the efficiency of the two milling technologies.

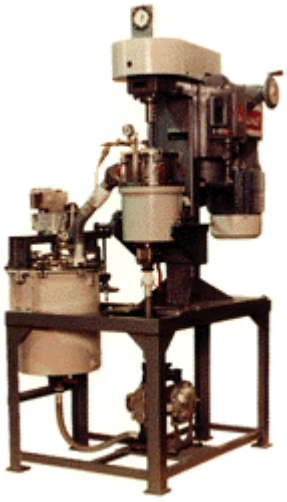
Another important area for consideration during mill and media selection is material of construction. When processing chemicals, it is often necessary that the mill contact parts be as inert and contamination-free as possible. In these instances mill contact parts and grinding media can be manufactured from various types of stainless steel or ceramics. Some of the mill parts also can be lined or coated with different types of polymers.

III. HIGH CIRCULATION MILLS (ATTRITOR AND NEW, SMALL MEDIA QC-MILL)

CIRCULATION ATTRITORS – Q MACHINES

In recent years, many paint and mill manufacturers have focused much of their attention towards a "new" type of "high circulation rate grinding" to achieve superior dispersions. In actuality, this "high circulation rate grinding" is not a "new" technology. In 1976 Dr. Andrew Szegvari (the founder of UNION PROCESS) obtained a patent for this fast circulation rate grinding. Based on this technology, the Q Attritor (Fig. 1) was designed and manufactured. For many years, hundreds of different industries have implemented the Q Attritor in their grinding processes successfully.

Fig. 1



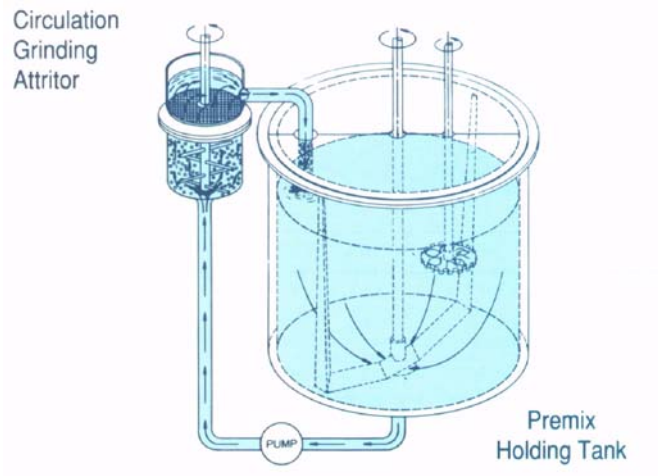


Fig. 2

The Q Attritor combines a grinding mill with a large holding tank equipped with both a high-speed disperser and a low speed sweep blade. (Fig. 2). The mill is designed for high circulation rate grinding. The entire contents of the holding tank are passed through the milling chamber at least once every 7.5 minutes or about 8 times per hour. This high pumping rate results in a uniform dispersion, narrow particle size distribution and faster grinding. The media size range used in the Q Attritor is from 3mm to 10mm.

DMQ ATTRITOR

The DMQ is the newest member of the small media mill family. It is a hybrid of the Deltamill and the QC mills. Like the Deltamill, it utilizes Delta discs. This proprietary design eliminates shaft whip and mill vibration, while providing much greater random media motion for improved milling efficiency. The mill is designed to accommodate media from 0.3mm to 1.0mm.

As with the Deltamill, the discs are indexed to provide directed and uniform media distribution throughout the mill chamber. The mill can be used in both continuous and circulation modes. All of the mills can be produced with metal-free components for certain ceramic applications where that may be a consideration.

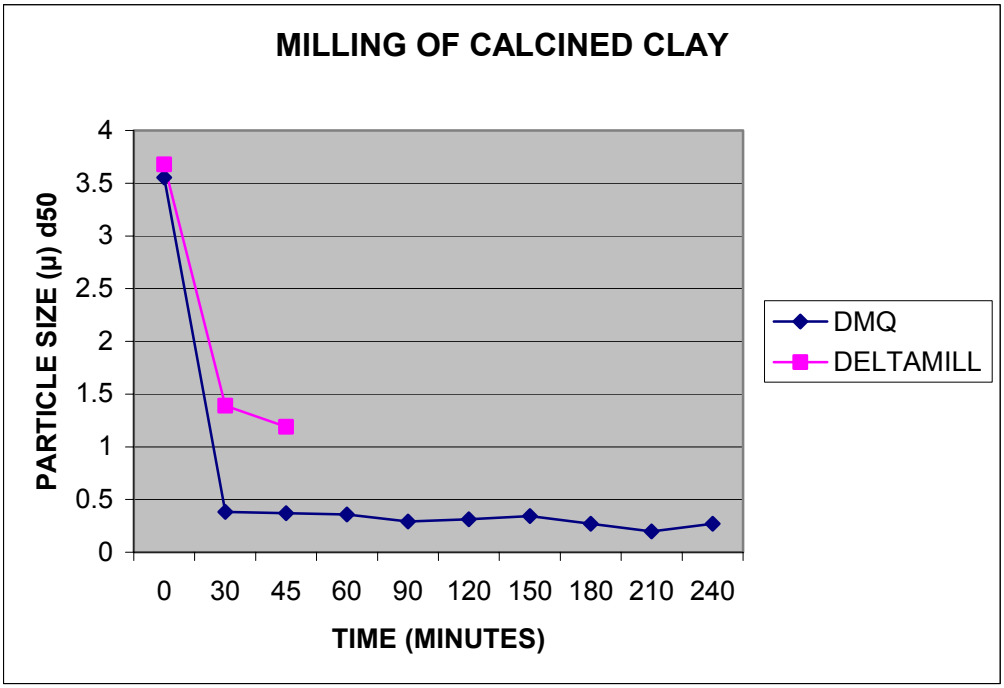
The mill incorporates the separator design like that used in the QC mill. It consists of a series of rings with the appropriately sized spacer between them and is thicker than the older wedge wire screen. This new design virtually eliminates plugging of the screen.

Thanks to this rugged and large open screen area positioned at the end of the mill, servicing and cleaning are much easier than with other mills. It's a simple matter to pull the cover off the end of the mill, which readily exposes the separator for servicing.

ADVANTAGES OF THE DMQ MILL

1. Operates in circulation or continuous mode
2. Uses media from 1 mm to 0.3 mm
3. Delta discs eliminate shaft whip and mill vibration
4. Delta discs provide greater random media motion
5. Indexed discs provide uniform media distribution
6. Service is fast and easy
7. More durable screening mechanism
8. Milling efficiency is improved

The graph shows the increased efficiency of the DMQ mill vs. the Deltamill grinding calcined clay with a starting size of 3.6 to 3.7µ.



V. DRY GRINDING MILLS IN BATCH OR CONTINUOUS MODE (SD AND HSA ATTRITORS)

Dry grind processing is ideal for products with particle size specifications of 2 to 3 microns average or larger. Dry grinding has many potential cost saving benefits. Dry processing can reduce transportation costs as materials can be shipped without additional liquid weight. It can also reduce production costs and energy as there is no need to remove liquid from the final product. Dry grinding can also eliminate the costs associated with the disposal of waste liquids, which has become increasingly expensive due to stricter environmental regulations.

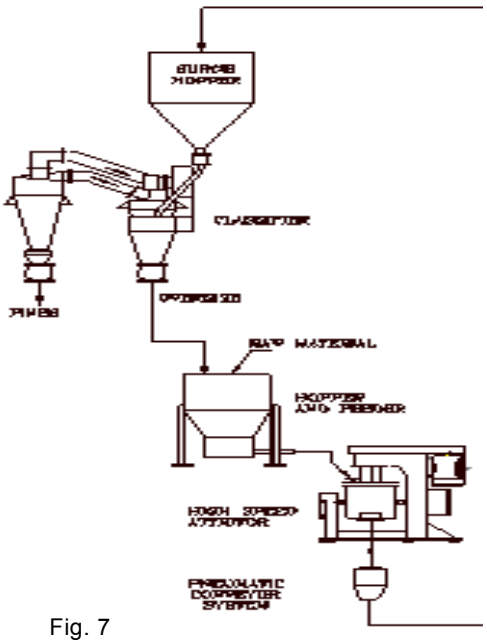


Fig. 7

SD ATTRITORS The SD machines can be operated in either batch or continuous mode. The shaft RPM runs from 75 –500. This series of machines is suitable for harder-to-grind material such as metal powders, metal carbides, and glass frits. The media used in SD machines generally range in size from 5 - 13mm. The feed material size for these machines can be as coarse as 1/2". The end product size can be as fine as 2-3 microns if operated in a batch mode.

Fig. 6

The SD Attritor is also used to make dispersion strengthened metal (DSM). In this process (known as mechanical alloying or cold welding), the kinematics porosity results in grinding media breaking the metals and additives into small particles first, then beating them together to form agglomerates. By repeating the process, the various metals are evenly mixed and dispersed to form a new composition of alloy (DSM).

Pigment industries also use SD Attritors to dry grind some pigments for their color development.

HSA ATTRITORS - (HIGH SPEED ATTRITORS)

The HSA Attritors (see Fig. 6) are a new line of small media dry grinding mills developed from the original SD Attritors (Dry Grind Attritors).

The HSA series uses 2 - 3mm small media and operates at a much higher speed, generally from 400 - 2000 RPM. These machines also feature a unique patented design concept, which includes a new shaft/arm configuration and side discharge screens. This special design combination allows mills to continuously produce fine powders, which are discharged from the mill by centrifugal force. However, due to the small media size that is used, the feed materials are limited to 40 mesh and finer. The end products from these continuous mills generally are in the 2 - 5 micron range.

Both the SD and HSA mills can be set up with air classifiers or screeners to form a closed grinding process loop. By continuously classifying out the fines and re-feeding the oversize material back to the mill, one can achieve very efficient and sharp particle size distribution grinds. (See Fig. 7)

COMMON APPLICATIONS FOR DRY GRIND ATTRITORS:

- Ceramics
- Chemicals
- Coal & Coke
- Fibers & Cellulose
- Food Products
- Glass Frits

- Mechanical Alloying
- Metal Powders
- Pigments
- Metal Oxides
- Minerals
- Plastics & Rubber

VI. SPECIAL FGD APPLICATIONS (CLS AND CL ATTRITORS)

In recent years Union Process has developed and provided a line of lime slaking and limestone grinding machines for the use of FGD (Flue gas Desulfurization) systems.

Both the CLS (lime slaking machines) and the CL (limestone grinding machines) systems incorporate a mill, a separation tank, mill recirculation pump, mill product tank, hydrocyclone feed pumps and hydrocyclones. (See Fig. 8)

Fig. 8

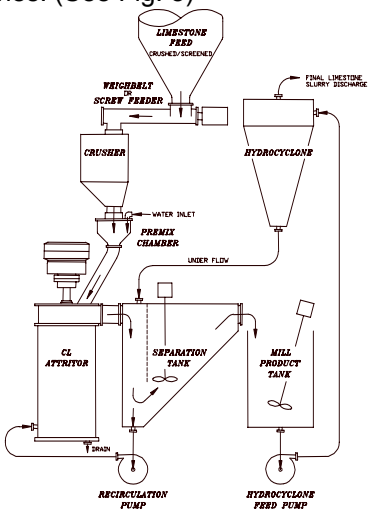
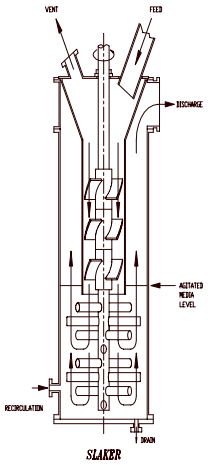


Fig. 9



During processing lime slaking or milling limestone, both solid material and water are continuously fed from the top of the mill through a specially designed feed housing. This funnel shaped housing has a cylindrical extension, which projects into the grinding vessel of the mill. The shaft of the mill extends down through the housing and the cylindrical extension with the media agitator arms being disposed just beneath the extension. (See Fig. 9)

The grinding balls used in both CL and CLS machines are 51200 chrome steel or through-harden carbon steel. The fineness requirement in FGD systems generally is 95% < 325 mesh, therefore the CLS lime slaking machines generally use 5/16” or 3/8” balls to grind down the grids, and the CL limestone grinding machines utilizes 1/2” balls to allow the limestone feed up to 1/4”.

The power consumption of these high efficiency CL and CLS Attritors is relatively low. For example, a CL machine equipped with a 150 hp motor produced 9.75 tons per hour of 95% < 325 mesh limestone, this equates to a specific energy based on the mill installed motor power of only 11.5 KWH/T.

VII. SUMMARY

In addition to a full line of production milling equipment, Union Process Inc. also manufactures many different types of research and laboratory model mills. These laboratory models are very useful tools for determining feasibility and testing different formulations under various grinding conditions.

Union Process not only can provide a wide range of grinding mills, but can also provide the “know-how” and support to meet customers’ specific requirements.