

# **ADVANCES IN SMALL MEDIA MILLING**

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**Presented at the Western Coatings Federation**  
**Monthly Dinner Meetings**  
**Winter 2005**



## ADVANCES IN SMALL MEDIA MILLING

At one time, the coating manufacturer had few choices at his disposal. If the coating had to be ground there were stone mills, ball mills and later three roll mills. Each had advantages and limitations, but every other coating manufacturer used one or the other type of the same equipment. There were also far fewer choices of raw materials than there are today. That put everyone on about the same footing. Now the equation has changed considerably through the introduction of new and improved raw materials and improved manufacturing equipment.

The use of stone mills ended, for all practical purposes, many years ago. They were far too slow and presented major problems due to the generation of extreme heat if they were used to produce very fine dispersions. Fires were not uncommon with stone mills with the largely flammable vehicle systems, which were the only ones available when stone mills were popular. There were also limitations to how finely stone mills could grind the product.

Three roll mills and ball mills largely replaced stone mills and were able to provide higher quality dispersions. There are applications yet today where they are used to produce dispersions, although the newer types of dispersion equipment are more efficient and more cost effective if used properly. The major advantage that ball mills have is that they will eventually make an acceptable product if allowed to operate for a long enough time. They also require little skill to operate; one simply charges them and turns them on. At some point in time the dispersion will reach a point where longer operations of the mill doesn't result in a significant further improvement in the dispersion quality. That is both their strong point and their weak point at the same time.

An evolution began in paint and coatings manufacturing during the industrial expansion that began about 1950. The introduction of "easy dispersing" pigments, high speed dispersers, sand mills, small media mills and the "stirred ball mills" (Attritors) made it possible to produce better dispersions in less time than was previously possible using the older methods while expending less manpower and energy to do so. All of the newer methods of fine milling involve the use of very much smaller media to accomplish the milling step.

Over the last thirty years there has been a growing awareness that mills using some type of smaller media can produce the dispersions needed for manufacturing coatings more efficiently, and much faster than ball mills. The vast majority of people directly involved in producing dispersions for the coatings market now generally agree that small media mills of one type or another are the preferred method to produce pigment dispersions to a finer particle size. Both the circulation (Model Q) Attritors and small media mills use much smaller diameter media than do ball mills, which is why they are able to produce finer dispersions faster.

Small media is generally defined as 3mm down to .25mm, but mills are now available to utilize media as small as 0.1mm. Small media milling provides several advantages over larger sizes:

1. It puts more energy into the process;
2. It has a greater ability to break down attractive forces holding together agglomerates;
3. It provides better quality control;
4. It increases the throughput through the mill.

## COMPARISON OF GRINDING MILLS

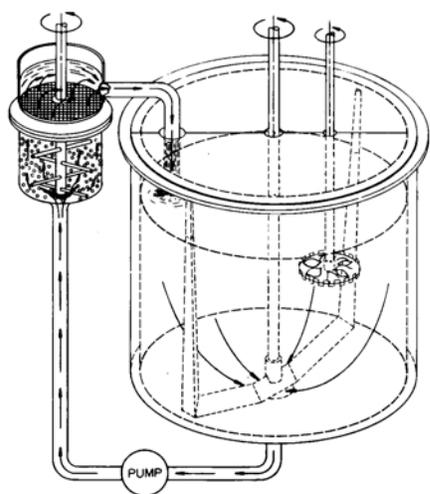
TYPE OF MILL	MEDIA SIZE	RPM	TIP SPEED (fpm)
Ball Mill	1/2" and Larger	10 - 50	
Attritor	1/8" to 3/8"	75 - 450	600 - 1000
Sand Mill	1/64" to 1/8"	800 - 1200	2000 - 3000
Small Media Mill	0.1mm to 3mm	100 - 175	1000 - 3000
High Speed Disperser		1200 - 1800	5000 - 6000

### CIRCULATION ATTRITOR ("Q" MACHINES)

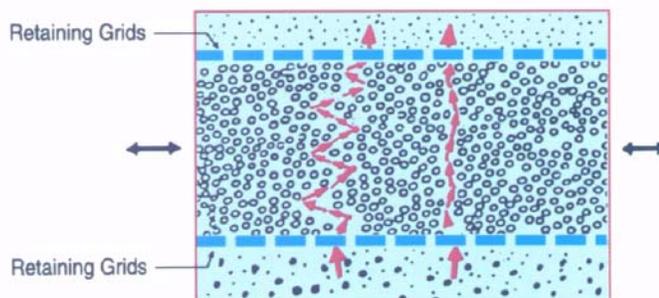
The "Q" Attritor takes advantage of Stokes Law of Settling. By passing the slurry upward through a bed of agitated balls, the smaller pigment particles are carried more rapidly through the media bed than the larger particles. The larger particles remain in the media bed longer to receive the greater milling action needed to disperse them finely. Stokes Law of Settling explains why this is so. To assure that all pigment particles are dispersed as fully and uniformly as possible, the batch of material is pumped repeatedly through the Attritor at high velocity and returned to the mixing tank. Dispersions containing only particles below a couple of microns (near 8 Hegman) in size are possible with the Q-Attritor if the equivalent of ten passes are made. That is, the entire volume of the tank will be pumped through the media bed at a high velocity for enough time to equal up to ten individual passes.

This system is a combination of an Attritor and a holding tank that is generally 10 times the size of the Attritor. One of the essential requirements of the Q-Attritor system is the high circulation (or pumping) rate. The entire contents of the holding tank are passed through the Attritor at least once every 7-8 minutes.

At this rapid speed, the premixed slurry is pumped through a confined media bed. The media act as a dynamic sieve, allowing the fines to pass through quickly, while the coarser particles follow a more tortuous path and are ground finer. The slurry can be continuously monitored, additional ingredients can be added to the premix tank at any time during the grinding, and the processing can be terminated precisely.



*Passage Of A Small & Large Particle Through A Layer Of Agitated Media*



One advantage of the circulation system is that large quantities of material can be handled with a smaller investment of grinding media and Attritor equipment. Another advantage of the “Q” Attritor is better temperature control, which is achievable for two reasons:

1. The holding tank is jacketed for cooling or heating and acts as a heat sink.
2. The slurry passes through the grinding chamber very quickly (20-30 seconds per pass), therefore having less time to heat up.

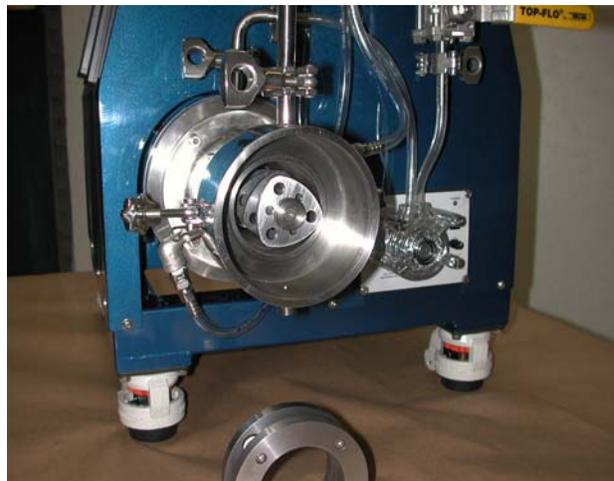
These advantages are very important when the grinding chamber is lined with plastic or rubber for metal-contamination-free processing.

### **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.

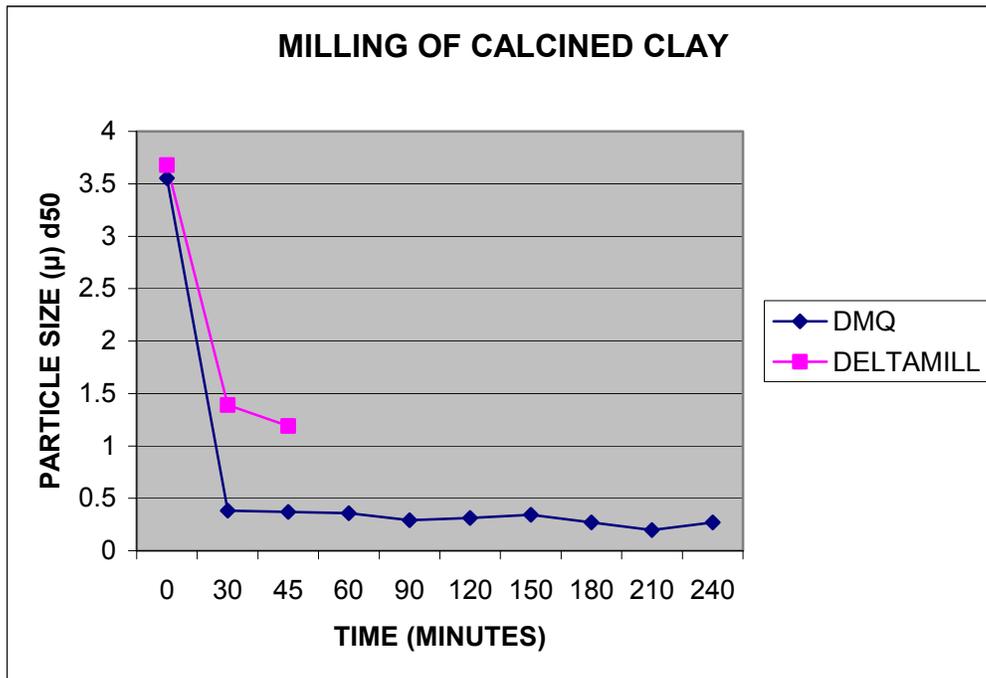
Thanks to this rugged and large open screen area positioned at the end of the mill, servicing and cleaning are much easier than with other mills. It's a simple matter to pull the cover off the end of the mill, which readily exposes the separator for servicing.



### **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 typical horizontal mill grinding calcined clay with a starting size of 3.6 to 3.7 $\mu$ .



### **ATTRITOR GRINDING MEDIA TYPES:**

Selection of grinding media depends upon several factors, some of which are interrelated.

- **Specific gravity.** In general, high density media give better results. The media should be more dense than the material to be ground. Also, highly viscous materials require media with higher density to prevent floating.
- **Initial feed size.** Smaller media cannot easily break up large particles.
- **Final particle size.** Smaller media are more efficient when ultrafine particles are desired.
- **Hardness.** The harder the media the lesser the contamination and consequently, the longer the wear.
- **pH.** Some strong acid or basic material may react with certain metallic media.
- **Discoloration.** For instance, white material should remain white.
- **Contamination.** The material resulting from the wear of the media does not affect the product or can be removed by a magnetic separator, chemically, or in a sintering process.
- **Cost.** Media that may be 2-3 times more expensive may wear better, sometimes 5-6 times longer, therefore, well worth the extra cost in the long run.

Following is a list of types of grinding media typically used in the Attritor:

Through-hardened carbon steel	Aluminum oxide
Chrome steel	Steatite
440C Stainless steel	Tungsten carbide
Zirconium silicate	Silicon nitride
Zirconium oxide (MgO or Y <sub>2</sub> O <sub>3</sub> stabilized)	Silicon carbide

## SUMMARY

### I. ADVANTAGES

1. Fast, efficient and reliable fine grinding
2. Versatility of the process
3. Low power consumption
4. Machine tank jacketed for cooling or heating temperature control
5. Easy and safe to operate
6. Low maintenance
7. Compact design, small plant area required

### II. LIMITATIONS

1. Feed material size should be in the 44 to 250 $\mu$  range for "Q" Attritors.
2. Feed material size should be in the 20 to 30 $\mu$  range for "DM" and "DMQ" Attritors.

## General Rules of Thumb of Size Reduction

1. A specific type of machine (with fixed media, fixed operating conditions, and/or fixed equipment parameters) is most efficient in grinding a certain type of material with a certain range of feed size.
2. Size reduction over a large size reduction ration, for example (feed size/product size) $>10.0$ , is most efficiently accomplished by using a series of grinding stages, such as grinding machines in series, the same machine used several times in sequence, or machines combined with classification steps.

3. There is no single machine type that will grind large particles to a very fine material efficiently by repeating or prolonging the process in the same machine.
4. To avoid over grinding of material that is already smaller than some desired size, this fine material should be removed as soon as possible by classification. This process can increase grinding throughput.
5. Uniform feed size can improve grinding efficiency a great deal.
6. Production is increased and the specific energy reduced only when a grinding circuit is operated so that the size distribution is the most steep on a Schulman plot (i.e. the most narrow size range).

With higher and higher standards required by paint and coating industries, fine grinding/particle size reduction has become one of the most important factors for success. Over the years Union Process has proven to be a leader in assisting customers to achieve these milling tasks. With our in-house testing facility, we are ***continually expanding the possibilities for size reduction.***