

**ATTRITORS AND FERRITE GRINDING APPLICATIONS**

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### THE EFFECTS OF THE 1992-1993 EL NIÑO ON THE TROPICAL RAIN FOREST

In today's electronic world, the demand for high quality ferrite products is rising rapidly. There are several types of ferrites and the preparation of all these is similar; the principal difference is in the raw material used. Figure 1 shows the basic steps of the process.

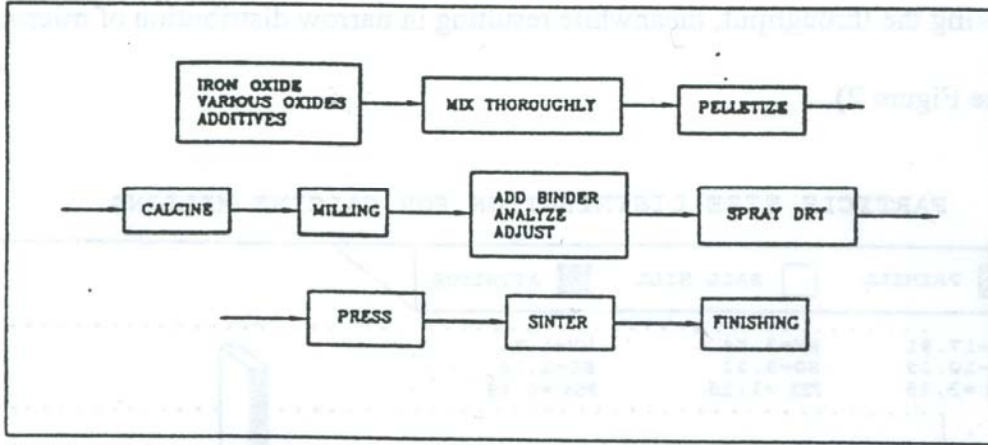


FIGURE 1

The magnetic characteristics and quality of the ferrite products are very greatly determined by the following factors:

- (1) Good formulation
- (2) Purities in raw material
- (3) Thorough mixing
- (4) Fine particle size and narrow distribution of milled powder
- (5) Pressed densities prior to sintering
- (6) Sintering profile and control
- (7) Repeatability and consistency of each process step

Since powder preparation is a major key point of the ferrite manufacturing, milling processes and equipment design also become top criteria for success.

Other than conventional ball mills, the Attritor invented by Dr. Andrew Szegvari has found an important place in the ferrite industry. Attritor processing has many advantages over ball mill grinding. Most importantly, it offers efficient grinding, thus shortening the milling time, increasing the throughput, meanwhile resulting in narrow distribution of micron fine powders (see Figure 2).

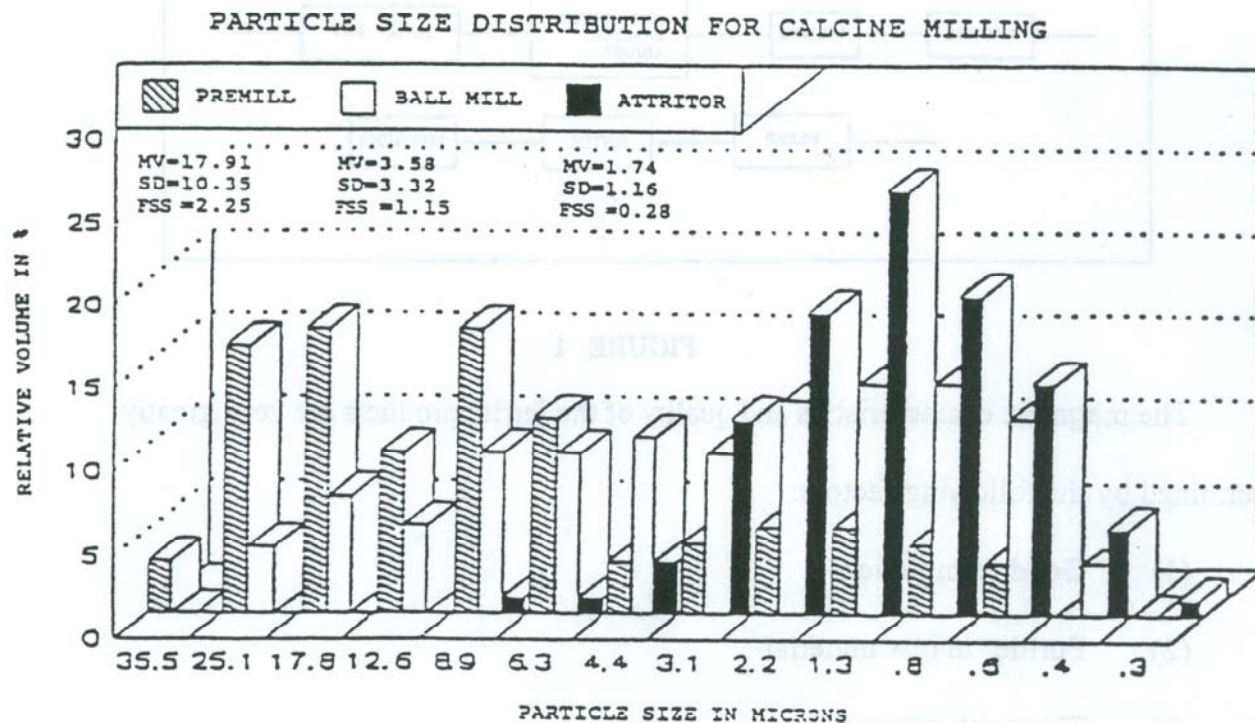


FIGURE 2

## ATTRITOR PRINCIPLES

Although there are three types of Attritors (batch, continuous, circulation), the basic principles are the same. The Attritor is a grinding mill containing internally agitated balls. Therefore, the Attritor has been generically referred to as a "stirred ball mill."



The material to be ground is charged or pumped into the stationary tank filled with grinding media, then both material and media are agitated by a rotating central shaft with a set of horizontal arms.

In general, the tip speeds of the Attritor arms are 18,000 to 30,000 centimeters per minute, but the "HSA" (newly designed High Speed Attritor) is operated 4 or 5 times faster. The media sizes used in the Attritor are from 2mm to 10mm. The media types used in the ceramic industry include alumina, zirconia, zirconium silicates, steatite, silicon nitride, silicon carbide, tungsten carbide, mullite and glass. With the combinations of speed (arm tip speed) and masses (media weight), the Attritor action creates both powerful impact and shearing forces (see Figure 3). This combined momentum energy results in very efficient size reduction.

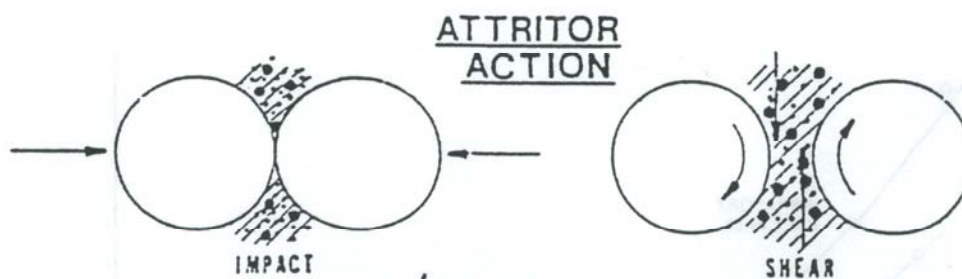


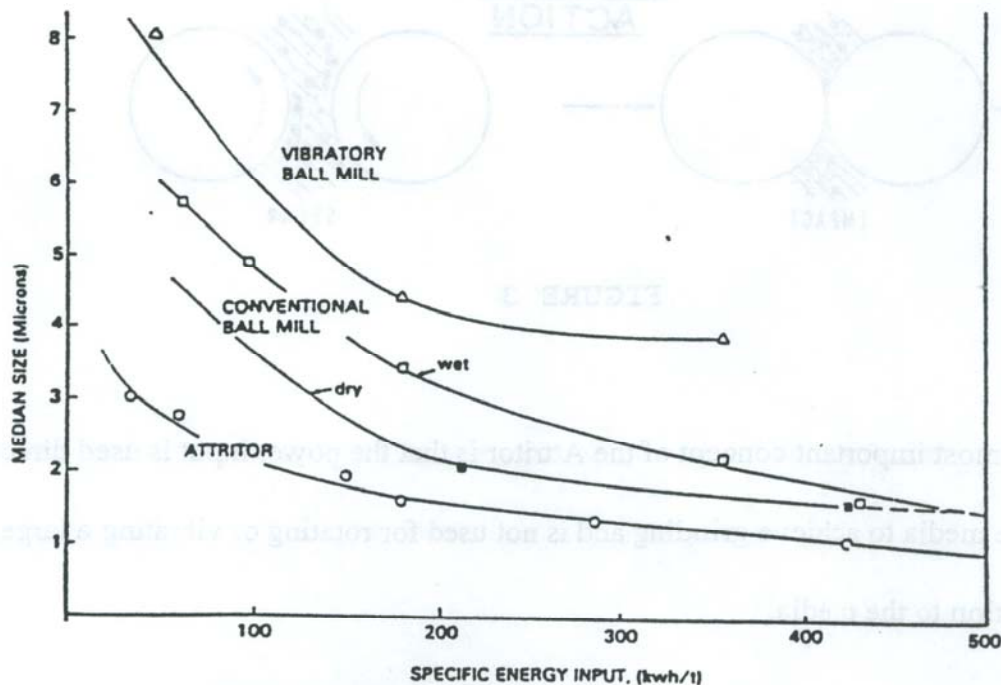
FIGURE 3

The most important concept of the Attritor is that the power input is used directly for agitating the media to achieve grinding and is not used for rotating or vibrating a large, heavy tank in addition to the media.

Figure 4 shows the comparison of the effectiveness of various grinding devices for the ultrafine grinding of pima chalcopryrite concentrate.

The top curve represents data from the vibratory ball mill; the middle two curves are obtained from conventional ball mills; the bottom curve is obtained from the Attritor. As you can see, for specific energy input around 10 kwh/T, the median particle size achieved through the use of Attritors is nearly 50% smaller than that obtained from conventional ball mills, and is about 33% smaller than that obtained from vibratory mills.

Moreover, for specific energy input exceeding 200 kwh/T, Attritors continue to grind into the sub-micron range, while the other two machines can no longer effectively produce any small particles. Consequently, the time required in the Attritor is much shorter.



Comparison of the effectiveness of various grinding devices for the ultrafine grinding of Pima chalcopryrite concentrate. Herbst and Sepulveda, "Fundamentals of Fine and Ultrafine Grinding in a Stirred Ball Mill, Proc. Powder & Bulk Solids Conf., Chicago, IL, May 1978.

FIGURE 4

## PROCESSING FERRITE WITH ATTRITOR SYSTEMS

Lately, narrower property range specifications of ferrite products and the evolution of faster, efficient Attritor milling techniques have made it essential to have a tighter control over the entire grinding process.

There are several new concepts and techniques which have developed in the industry:

- (1) Using the total energy input instead of time to monitor the milling process.

Attritors can be equipped with a torque sensor on the shaft. The torque sensor measures precise energy input being expended in the grinding chamber. This energy input reading provides excellent control over milling, independent of milling conditions. Milling condition variables include agitator arm and media wear, changing rheology of the slurry, etc.

- (2) Precisely weigh out formulation, also premix a large batch, then pump into several Attritors for milling. This process eliminates variations between small batches and provides uniform final powders (see Figure 5).

- (3) An extremely clean machine and carefully monitored media loading between batches.

For a very high grade of ferrite products, some manufacturers choose to screen out undersize media, flush the machine, and reload a full charge of media between batches (see Figure 6).



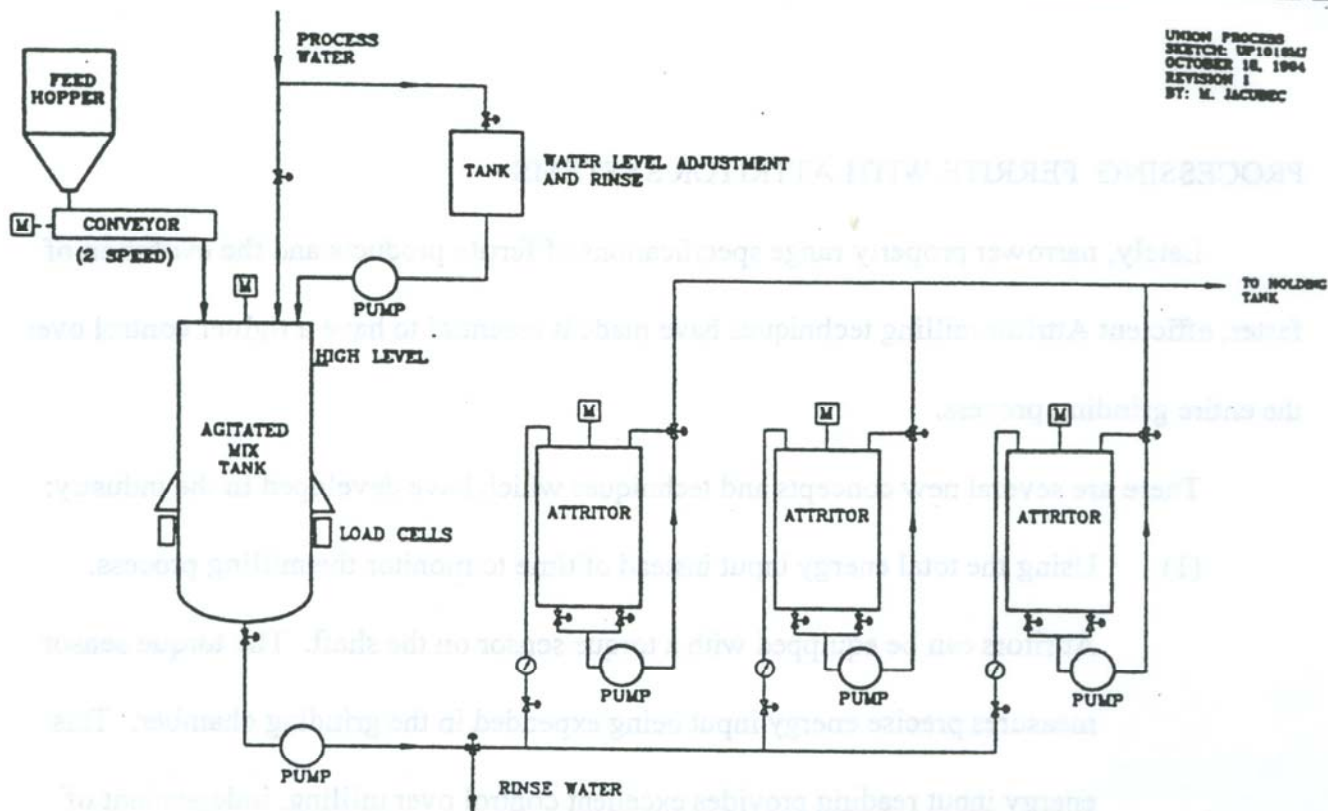


FIGURE 5

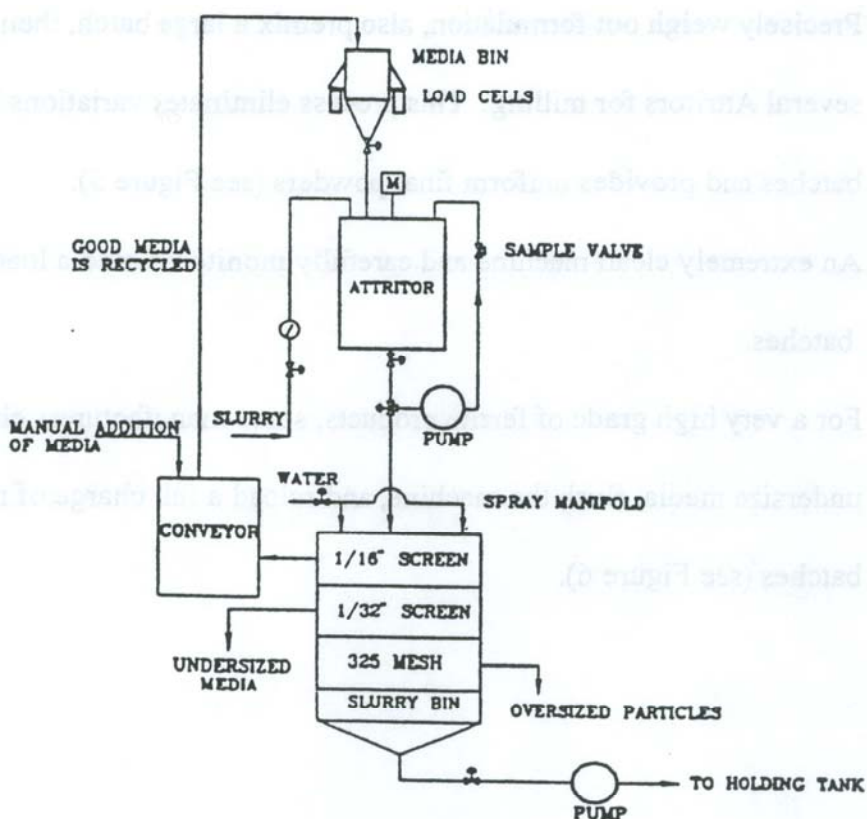


FIGURE 6

- (4) Instead of traditional dry mixing of raw material ( $\text{Fe}_2\text{O}_3$ ,  $\text{ZnO}$ ,  $\text{MnO}$ ,  $\text{MnCO}_3$ ,  $\text{MgO}$ ,  $\text{NiO}$ ,  $\text{CuO}$ , additives, etc.) some companies choose to use the Q-Attritor with a large holding tank to do more extensive wet mixing (see Figure 7).

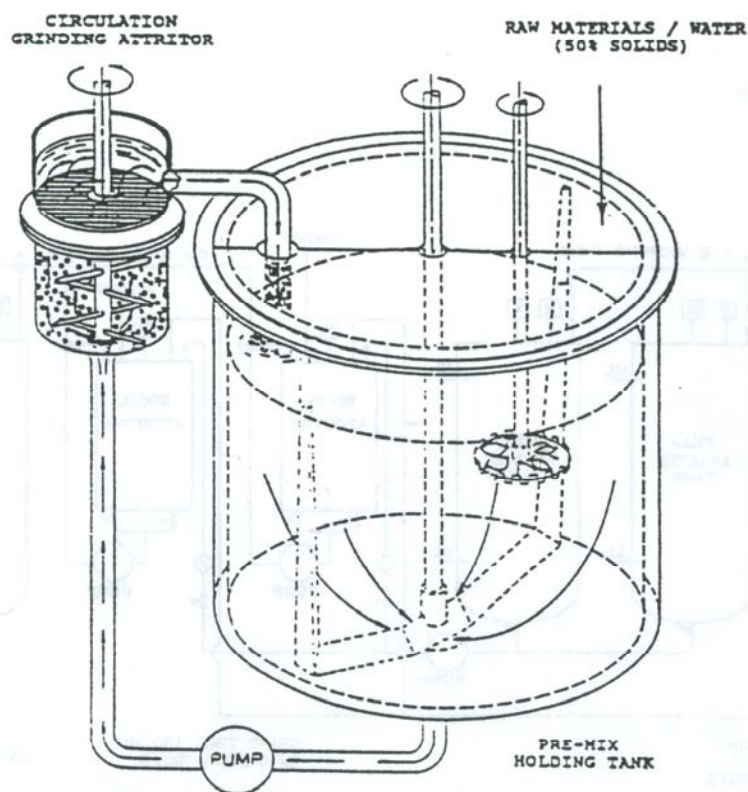


FIGURE 7

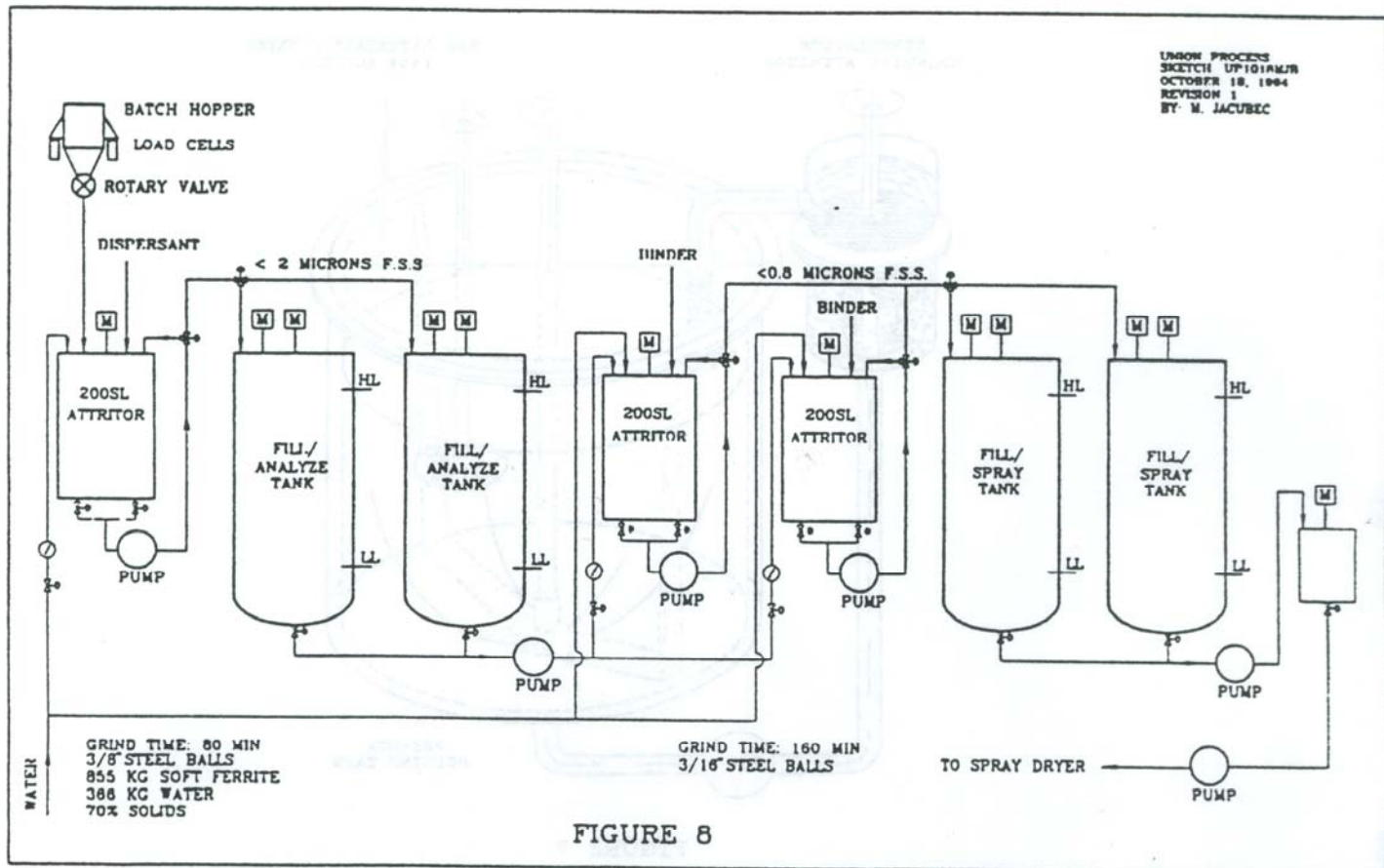
## PROCESS SYSTEM EXAMPLES

- (1) Two-step wet grinding with batch SL-Attritors (see Figure 8).

Larger  $3/8$ " steel balls were selected for first stage, coarse grinding  $2\mu$  F.S.S., smaller  $3/16$ " steel balls were used for second stage fine grinding to  $0.8\mu$  F.S.S. If even finer size ferrite is desired, one can reduce the solids percent,

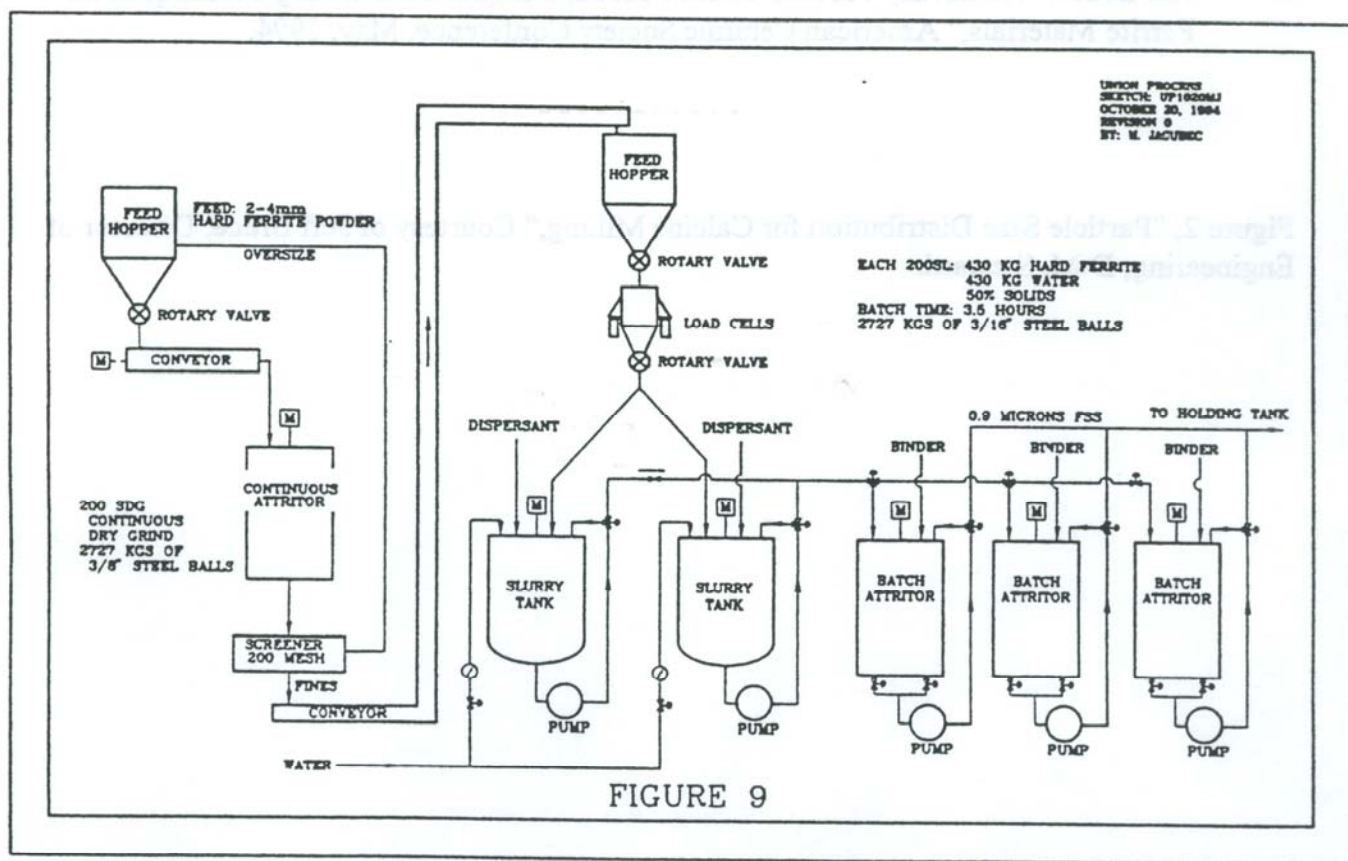


add additional dispersant, lower the slurry viscosity, then go on to third stage  
grind with 1/8" steel balls. Given sufficient time, this process can achieve  
0.5 - 0.6 $\mu$  final ferrite powder.



- (2) Combination process with SDG dry grind Attritor and SL wet grind Attritor  
(see Figure 9).

In this case, a dry grind 200-SDG Attritor was set up in continuous mode to pregrind ferrite to -200 mesh prior to final grind in the wet 200-SL Attritors.



## SUMMARY

Milled ferrite powder size and distribution is one of the major factors determining the properties of the final ferrite product. Over the years, the Attritor has proven itself to be an excellent piece of equipment to achieve this milling task.

## REFERENCES

1. J. L. Sepulveda, "A Detailed Study of Stirred Ball Milling," Ph.D. Thesis, 1979, Metallurgy Dept., University of Utah.
2. R. Goodson, L. Sheehan, F. Larson, "Correlating WC Grain Size Analysis Techniques With Attritor Mill Monitoring in Cemented Carbides," International Journal of Refractory & Hard Metals, Vol. 4, No. 3., Sept. 1985.
3. Jeff Bruce, "Achieving Process Control Through Improved Grinding Techniques for Ferrite Materials," American Ceramic Society Conference, May, 1994.

Figure 2, "Particle Size Distribution for Calcine Milling," Courtesy of Jeff Bruce, Director of Engineering, D.M. Steward.

