Superior Milling Technology for Grit Control Applications
- A Market Oriented Product Development -

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Abstract
Hosokawa Micron International Inc., a global provider of systems and equipment related to materials science and engineering, is a leader and innovator in the powder processing technology. The company has a long tradition in product development with customer needs in mind. Many milling machines developed in the past decades are still primary workhorses in industries today. This article introduces the history of the company, its product development organization and its trademark products developed in the past. As an example, a recent successful development of Mikro E-ACM® Mill for grit control applications was elucidated in details. In addition, some new product developments were also presented. Product development with market demands and customers’ requirements in mind is the basis of sustainable business growth. The company’s Product Development Team will continue playing a significant role to develop new products and improve the performance of existing products for customers in the USA.

1. Introduction
Hosokawa Micron International Inc. (a.k.a. Hosokawa Micron Powder Systems) is an operating unit of Hosokawa Micron Group located in Summit, NJ USA, a global provider of systems and equipment related to materials science and engineering. The company was originally established as The Pulverizing Machinery Company in 1923 and two of the Company’s products become today’s industrial standards for particle size reduction – The Mikro Pulverizer®, a high speed hammer screen mill, and the Mikro ACM®, a mechanical impact mill with an integral air classifier. The company joined Hosokawa Micron Group and became its designated powder processing business center for all operations in North and South America in 1985. Since then, the Company has added the Micron, Alpine, Vrieco-Nauta, Majac product lines to the original Mikro product line and has expanded its facilities to offer greater design, process technology and demonstration capabilities.

Continuing the tradition as a leader and innovator in the milling technology, Hosokawa Micron International Inc. has a Product Development Team to constantly review and renew the performance of Hosokawa Micron equipment in consideration of market trends. The Product Development Team includes members from management, sales, engineering and test lab, so that the feasibility of new ideas on the product development can be discussed and tested in a timely manner. More importantly, the newly developed equipment can be scaled up for commercialization quickly once its performance is validated.

As an example of product development at the Hosokawa Micron International Inc., we would first like to elaborate the development of Mikro E-ACM® Mill (E-ACM) for grit control applications. The E-ACM development started off modifying the existing milling equipment based on market demands and its commercialization was able to complete in a short period of time with the team efforts.
2. Background of E-ACM Development

In carbon black industry, manufacturers are becoming more difficult to compete in the market with commodity products. Global economic concerns, uncertainty in the marketplace for industrial and consumer products, fluctuating oil prices and more recent governmental environmental regulations are all contributing to increased production costs, falling demand for rubber products and eroding revenues/profit margins. One way to emerge from the conundrum of low profit commodity manufacturing may be to seek new or emerging markets with value-added niche products. In the case of carbon black, its grit and residue level is one important quality parameter by which the value of a product is measured. If a manufacturer could develop an economical method to produce cleaner, near grit-free carbon black, then it could perhaps target those alternative markets by offering something that might add strength, durability, and enhanced performance to products. The manufacturer could command higher prices, generating more revenue and higher profit margins.

Hosokawa Micron International Inc. has been offering mills such as Mikro Pulverizer® and Mikro ACM® for milling the grits in the carbon black for decades. The Mikro Pulverizer®, a hammer and screen mill, utilizes hammers to crush the grits in carbon black and static screen to control residence time of carbon black in the mill and the particle size of end products. The size of the screen affects the end product size as well as capacity. In this case, screens are not only an inefficient method to control particle size but are also a weak point in the system, susceptible to breakage from foreign tramp material or over-feeding of carbon black.

Usually, Mikro Pulverizer® produces grit levels about 100ppm +325 Mesh for most grades of carbon black feed and its product quality is often measured in terms of residues at +35 Mesh and +325 Mesh. As to Mikro ACM® Mill (ACM), instead of static screen, it is equipped with an integral air classifier for easy particle size control of products, and can meet the requirements of abrasion and adhesion protection. In this case, product grit level 20~30ppm +325 Mesh for most grades of carbon black feed can be achieved.

With the endeavors to develop a superior milling technology for carbon black manufacturers to create value-added products, Hosokawa Micron International Inc. first developed Mikro-LGM® Long Gap Mill (LGM) to manufacture non-grit or cleaner/near grit-free carbon black(s) in early 2000s. While the mill can produce various grade of carbon black at a grit level close to 0ppm +325 Mesh, its capital and maintenance costs are still relatively high and need to be reduced for niche applications. The Company’s Product Development Team has started reviewing the design of LGM and developing a proto-type E-ACM in late 2000s.

3. Milling Technology Review

The LGM employs two mechanical stressing mechanisms to reduce the size of the particles. Its primary milling mechanism is particle-to-particle attrition caused by the vortices created by the passing tip of the beater blades in close proximity to the multiple deflector liner. Its secondary milling mechanism is mechanical impact caused by the direct contact of the hammers/beater blades against the air entrained particles.

The combined stressing mechanism accounts for approximately 70 to 80% attrition and 20-30% impact. Residence time of particles in the mill is greatly increased, as they dispersed in a single main air stream must pass through a series of stacked rotors prior to being presented to a dynamic air classifier. Besides, the classification zone is the key to the success of the LGM for carbon black applications, which employing a co-axial dynamic air classifier in conjunction with the external recirculation of oversize particles.

The highly efficient air classifier operates at a high revolution as the stacked rotors yielding a ultra-fine cut point. Oversize particles rejected by the air classifier exit the mill through a controlled outlet gate. In addition, the LGM is equipped with a proprietary eductor system, developed to return rejected oversize particles back to the stacked rotor assembly for further milling.

By rejecting oversize particles externally, end products with unprecedented low grit levels are realized. The LGM has the merit of producing most grades of
carbon black at a grit level as low as 1~2ppm +500 Mesh. However, for the applications of commodity carbon black, the LGM is over-killed for the milling operation. The Product Development Team at the Hosokawa Micron International Inc. evaluated the cost of energy consumption versus the quality of carbon black for customers and combined the unique features of LGM (such as feeding from below the rotor disc and externally recirculating the oversize particles) and ACM (such as variable speed dynamic classifier) to develop E-ACM for those carbon black applications which require a cleaner product, but not quite to LGM standards.

The E-ACM design includes a rotor with special plate hammers and a multiple deflector liner, which change the combined stressing mechanism to approximately 80% by mechanical impact and 20% by particle-particle attrition and reduce rotor load and maintenance costs significantly.

Also, the E-ACM is equipped with an integral variable speed dynamic air classifier in its elongated mill chamber without traditional ACM-type shroud baffle and an external oversize particle recirculation system with eductor. These prevent material build-up on the shroud baffle, enhance cyclonic pre-classification effect and achieve superior grit level control for carbon black. The E-ACM and its process flow pattern are shown in Figure 1 below. Similar to the LGM operation, feed material dispersed in the primary air stream from the bag filter of the carbon black reactor is routed under the impact rotor and is conveyed through a specific annular gap between the plate hammers and liner (i.e. grinding zone). The milled particles pass from the grinding zone through the elongated E-ACM chamber to an independently driven air classifier. The air classifier operates at a required tip speed; oversize particles are rejected by the classifier and exit the mill through an adjustable outlet gate with an eductor system, specially developed to return the rejected oversize particles back to the primary mill inlet/grinding zone.

The E-ACM design practically combines the cost and air classification advantages of ACM and superior grit milling advantage of LGM. It is a considerable improvement...
from existing size reduction technologies whether it is a hammer/screen mill or other type of mechanical impact mill with integral air classifier in the grit reduction applications for low density materials such as carbon black. Also, the E-ACM is designed to operate in hot process gas streams typically in the range of 100 to 260˚C, and can be installed in-line, downstream of the primary bag filter(s) in the carbon black production plant. The in-line E-ACM Mill requires very little floor space and the need for additional ancillary components, hence minimizing construction and installation costs.

4. Typical Performance of Mikro E-ACM® on Grit Reduction

Table 1 and Table 2 are the data from both lab tests and current production mills. As shown in the tables, the performance of E-ACM is dependent upon the level of grit and type of grit in the feed material. Therefore, it is imperative that confirmation trials are performed on a pilot scale mill to establish milling parameters, capacity, and product quality.

However, as a rule of thumb, we are confident that carbon black with feed grit levels at 50, 100, 400, and 700ppm can be milled to a product with grit levels at 5, 20, 30, and 100ppm respectively by E-ACM.

5. Process Integration of Mikro E-ACM®

In a carbon black production plant, the E-ACM can be installed either offline with dedicated conveying and pneumatic ancillaries as shown in Figure 2 or in-line after the reactor bag filters as shown in Figure 3. If installed in-line, the E-ACM can be sized to meet the capacity of various grades of carbon black to be processed. The size of the E-ACM can be determined from testing. Often, a particular grade of carbon black is conveyed from the bag filter of reactor to the mill at a specific air volume to carbon black ratio.

The E-ACM can be configured to meet the process criteria and produce carbon black with the desired specifications. Typically, depending on the grade of carbon black and desired end product quality, the E-ACM can be offered with the capacities ranging from 200kg/h to approximately 10t/h.

Table 3 shows the examples of energy consumption of production scale E-ACM systems, which are clearly superior to other carbon black grit reduction methods.

5. Conclusions

Mikro E-ACM® Mill is a big improvement over high-speed hammer/screen mills and other air classifier mills for producing near grit-free carbon blacks. It has large
throughput capacity, versatile, and can be retrofitted in-line in an existing process. It satisfies market demands and creates higher profit margins for carbon black manufacturers. Once again, putting customer’s interests first is proven to be the key of a successful product development. So far, the E-ACM has already generated over 5-million-USD sales since 2013 from the carbon black market alone. We expect many more E-ACM orders for years to come.

With the same effort as in the E-ACM development, Product Development Team at Hosokawa Micron International Inc. also works on other product development projects. To name a few, in addition to the continued performance improvement for the E-ACM, we also work on projects to update US-based pulverizes, air jet sieves and jet mills. Few years ago, based on Mikro Pulverizer®, we developed Mikro UMP® Universal Pulverizer, which can equip with stirred-up hammers, rigid knife hammers or pin discs, and its 2-inch small lab model (Mikro® LPM-2), as shown in Figure 4 and Figure 5 below. The Mikro® LPM-2 is the most popular counter-top pin mill for drug development by far.

Also, we introduced a new Mikro Air Jet Sieve® this year. In addition to totally new look as shown in Figure 6, it integrates an analysis computer with touch screen controls and user-friendly software. We are getting very positive feedback from customers and anticipate a boost to our air jet sieve sales with this new addition.

Furthermore, we are close to completing the installation of Mikro-Jet Mill for customer trial at our Test Center as shown in Figure 7. The new jet mill is a Majac Opposed Jet Mill with a modernized integral dynamic classifier. With targeted applications in mind, the jet mill is to be developed for a niche particle micronization application.

In conclusion, Hosokawa Micron International Inc. is fully aware of the importance of Research and Development on sustainable business growth. With the market demands and customers’ requirements in mind, its Product Development Team will continue playing a significant role to develop new products and improve the performance of existing products for customers in the USA.