SELECTING THE RIGHT BLADE TO OPTIMIZE

The key to solving tough blending problems and meeting ambitious goals for throughput and product quality is often unconventional thinking. Faced with the challenge of blending a slurry of extremely dense materials, then drying the batch to form a light, fluffy powder, your first thought would probably be to rely on a traditional vacuum dryer. As the density of the ingredients rises, conventional wisdom tells us to reduce batch size to minimum levels, or slow down the blending rate to enable the hard-working blender/dryer to handle the job. In extreme cases, you might also reinforce the unit with such additions as a heavy-duty drive system and more wear-resistant materials of construction. But many processors are finding that instead of sticking to predictable solutions, a completely different kind of blender/dryer can handle the heaviest of materials easily and produce dramatic gains in end-product quality and throughput.

Specifically, they have discovered that in many high-density applications the aggressive mixing action of a double planetary mixer, combined with carefully controlled heat and vacuum, can transform the mixer into a vacuum dryer/granulator that can outperform familiar blender/dryers by a wide margin.

Tungsten carbide

During the last several decades, the demand for extremely tough and durable materials has exploded in industries worldwide. Wherever surfaces are subjected to intense heat, impact, compression, friction and other stresses, a high performance material can provide critical protection to improve performance and prolong operating life. The immense benefits offered by these materials are apparent today in markets from aerospace and automotive manufacturing to industrial tools and machinery.

Perhaps the best known of these high performance materials is tungsten carbide. The introduction of tungsten carbide more than 50 years ago helped to revolutionize productivity in hundreds of industries. When tungsten carbide was first used in cutting tools, the cutting speed for turning and milling steel increased from 80 ft/min., to 800 ft/min. In the mining industry, tungsten carbide tips on rock drills increased the life of the drill by a factor of 10 over steel-based drilling tools.

Today, the virtues of tungsten carbide are well understood, and the industry is intensely competitive. Manufacturers compete in a mature market where contracts hinge on fast delivery and extremely subtle differences in product quality. A 48-hour advantage in filling a production order is often decisive in securing a contract. Especially since tungsten carbide parts are subjected to such extreme conditions, the quality of each part is measured on a microscopic level because microscopic flaws can ultimately lead to catastrophic failures in use.

The most successful and aggressive competitors in this industry are constantly re-evaluating their processing equipment and techniques, and asking themselves the same tough questions:

- How can we adjust our present equipment or manufacturing techniques to make our process more productive and shorten our delivery times?
- What's the best way to increase throughput while maintaining product quality?
- Can we improve product quality at the same time?
- What alternatives have we overlooked?

DESIGN YOUR MIXING PROCESS

Heavyweight technology for high-density blending and drying

Operating in McKeesport and Kittanning, Pennsylvania, Vista Metals, Inc., manufactures tungsten carbide "preforms" in what is often called the world capitol of the tungsten carbide industry. (See sidebar, p. 6) The company is a specialist in the shaping and sintering of intricate preforms for customers in a multitude of industries. To meet the requirements of so many applications, Vista Metals offers a broad range of tungsten carbide materials, blends of tungsten carbide and cobalt and/or nickel in precise formulations. The company can provide tungsten carbide preforms in almost any strength or hardness, including parts that approach the hardness of diamonds.

Because the company uses an advanced "sinter HIP" process in manufacturing, it delivers a product that is virtually 100% free of microscopic voids. This record of superb product quality is balanced with a reputation for flexibility and quick turnaround.

"Our customers count on us when they need both quality and fast product delivery, whether the order is large or small," says Robert Carr, plant manager at Vista Metals. "We routinely make deliveries in less than two weeks, and we can provide a 4-day turnaround for customers that need super-fast delivery." With a production line designed for versatility, Vista Metals handles high-volume jobs as easily as single-piece orders for special parts.

Like most companies producing tungsten carbide, Vista Metals relied for years on traditional conical tumbling driers. Each steam-jacketed dryer held only a small, 100 pound batch of material, and each drying cycle consumed 6 to 8 hours. (Tungsten carbide powder weighs, on average, about 400 lb per cubic

The double planetary vacuum dryer/granulator dries 600 pounds of tungsten carbide in about 1-1/4 hour at Vista Metals.

Using the sinter hip process, Vista offers a product that is 100% free of microscopic voids.

foot, or 56 lb. per gallon.)

During the process, the mixture tended to collect and cake on the walls of the dryer, then flake off into the mixture. Cleaning was difficult and time-consuming. Production was slow during the drying cycle and delayed for lengthy cleaning afterward to ward off batch-to-batch contamination. Processing costs were unnecessarily high. As competition became more intense, the company quickly identified the drying process as an ideal place to cut costs and improve performance.

The search began for a more productive approach to vacuum drying and it soon led to Charles Ross & Son Company, a worldwide manufacturer of equipment for mixing, blending and drying, headquartered in Hauppauge, New York.

"The breadth of both the Ross product line and the depth of their engineering experience opened up new possibilities for us," says Carr. "Our engineers were able to test quite a variety of equipment in the Ross lab, and they found that our drying process was really much better suited to a double planetary vacuum mixer than to a conventional blender/dryer."

According to Doug Cohen, VP of Technology at Ross, the production requirements of this drying application and the density of the ingredients require a more powerful form of agitation than an ordinary

Tungsten from a Russian mine shaft to the factory floor

Most tungsten carbide has its beginning deep in the underground tungsten mines of China and Russia. A rare element and one of the heaviest metals on earth, tungsten is found in slender threads woven in rock beneath the younger mountain chains of the world in the Alps, the Himalayas, and the circum-Pacific belt. The mined rock contains less than 1% workable ore, which is crushed and milled to liberate precious tungsten mineral crystals. When this tungsten concentrate is processed chemically, it yields the tungsten raw material most often traded in the international marketplace.

After further processing, tungsten metal powder is blended with pure carbon powder, charged into a refractory crucible and carburized at approximately 2,800°F to form tungsten carbide.

At this point, companies like Vista Metals optimize the mechanical properties of tungsten carbide end-products by adding binding agents such as cobalt or nickel in precise proportions. These metal powders are milled together — using a solvent such as heptane or hexane as a wet milling medium — until each tungsten carbide particle is uniformly coated with binder. A small amount of paraffin is typically introduced, and the slurry is conveyed through a 250-mesh screen into a vacuum double planetary mixer/dryer for further blending and drying.

In this critical stage, heat is applied and the solvent is removed. As the mixture is transformed into a paste and finally a powder, heat within the batch is carefully monitored. Dual planetary blades continuously sweep through the vessel and prevent the formation of localized zones of dangerously high heat. Even distribution of heat within the vessel and efficient heat transfer is extremely important, since the powder is flammable.

During the process, engineers at Vista Metals visually monitor the progress of the batch through inspection ports. They also watch for changes in load on the drive system to recognize key milestones in the process.

"The resulting powder is compacted into tungsten carbide billets or rounds," says Carr, "then cut and machined to near net shape, leaving minimal stock to be removed by our customers." Sintering at temperatures between 2,500°F and 2,750°F consolidates the parts to near 100% density and allows grinding to final tolerances.

vacuum blender/dryer can provide.

"The double planetary mixer is an extremely powerful mixer that applies positive mixing action kneading and breaking the mass apart," says Cohen. "As the blades sweep through the vessel, they constantly divide and recombine the material. With their flow-inducing cross-section and close blade-to-wall tolerances, the blades constantly move material away from the vessel wall and bottom, and promote efficient heat transfer.

"The intensity of the mixing action produces a fast cycle and a fluffy, finished powder that compares favorably with a fine pharmaceutical granulation in terms of its consistency and accuracy. Some traditional dryers might eventually produce similar results, but only in very long batch cycles and in small batch sizes.

"We have observed the same results in other industries and applications such as the blending and drying of many varieties of blended metal powders and binders used in sprayable, high performance metal coatings. There, too, the high-density of the materials requires a powerful mixer/dryer and extremely close control over the batch parameters during the cycle. Batch temperatures and moisture content at each stage are critical to achieve the right final granulation. The fine powders that result are similar to the tungsten carbide powders produced at Vista Metals; at the end of cycle they are quite fluffy and extremely uniform in both size and composition."

From pharmaceuticals to tungsten carbide powder

Long used in the pharmaceutical industry for high-quality granulation, these double planetary vacuum dryer/granulators feature unique triangular-sectioned blades that promote axial and radial flow through high-density materials and keep the vessel walls clean. Each blade rotates on its own axis, while they rotate together on a common axis.

Left: blade motion during 1 revolution. Center: 3 revolutions. Right: After only 36 revolutions, the blades of the mixer have contacted virtually the entire batch.

"Our double planetary mixers function as super vacuum driers and granulators," says Carr. "First we do our blending and milling in an attritor. Then we send the slurry through a screen and into the double planetary mixers.

"The orbital mixing pattern of the double planetary mixer keeps the powder and fluid in constant motion," explains Carr, "so the distribution of all constituents is extremely even. The system is entirely closed, and we are able to reclaim more than 95% of our solvent, easily exceeding EPA regulations and helping to ensure a safe working environment in our plant."

According to Carr, Vista Metals now uses two double planetary vacuum dryers/granulators, working two shifts. Each operates with a batch capacity of 600 pounds of the tungsten carbide/heptane slurry —about six times the capacity of the company's former dryers. Each double planetary dryer requires about 1-1/4 hours to complete the cycle and produce a thoroughly dried powder.

"The double planetary saves us an enormous amount of time and money," he says, "almost five hours with every batch, and that doesn't include the time we used to devote to cleaning between batches. Our final granulation is extremely uniform in size, moisture content, and the encapsulation of each tungsten carbide particle. This uniformity is absolutely crucial, because the slightest flaw in the granulation can lead to the failure of a customer's part."

For more information on the mixers and dryers, contact Charles Ross and Son Company at 800-243-ROSS or email sales@mixers.com

Circle 200

Specification considerations

When planning the purchase of a double planetary vacuum dryer/granulator for your process, be sure to consider the following design issues as you develop specifications with the manufacturer:

- **Drive system:** One size does not fit all! The drive must be matched to your application—the density of the material you are mixing, your target batch capacity and cycle time. This is especially true of large batches and higher levels of production.
- **Variable Speed:** Variable speed will let you begin mixing high-density materials at slow speed and high torque, and then increase the speed as conditions may require.
- **Blade Shape:** The shape and cross-section of the blades determines the flow created as the stirring device moves through high-density batches, its ability to scrape the sidewalls and bottom of the vessel, and the energy input required to drive the blades through high-density materials. This affects batch capacity, cycle time, heat transfer, and power consumption.
- **Seals:** All seals used in the equipment must co-exist peacefully with your solvent. Confirm the compatibility of all elastomers exposed to solvents in your process!
- **Test:** The purchase of virtually any vacuum mixer, blender or dryer should follow extensive testing in a testing laboratory, using your ingredients. Test a variety of stirrer designs, and evaluate the results of each test with quantitative, analytical equipment. Be sure to choose the right equipment before you buy it!