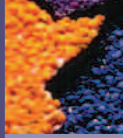


# Flow of Solids

Bulk Solids: Science / Engineering / Design

The Newsletter for Jenike & Johanson, Inc.  
**Spring 2001**



## The Inside View

Spring is here and that can only mean one thing - time for the annual Powder Show in Chicago. (Hopefully, it also means that the snow will soon be gone from outside our offices, here in Westford, Massachusetts) This year we have added "Advanced Topics in Solids Handling" to the list of courses that we regularly present at the Powder Show. We hope to see you there.

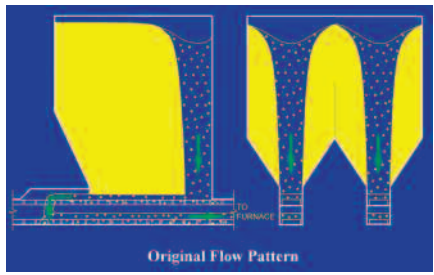
As always, we hope you find this issue of our newsletter to be informative and useful. We welcome your comments and suggestions, and we hope that you will utilize our experience and services when you have a bulk solids handling or processing application.

*John W. Carson*  
John W. Carson, Ph.D.,  
President, Jenike & Johanson, Inc.

## Flash Furnace Feed System Redesign at BHP Copper

### Background

Demands for increased production from existing flash smelting furnaces have led to increased concentrate burner feed rates and the use of more finely ground concentrates. Unfortunately, feeding finer materials at higher rates increases the likelihood of erratic flow or even flooding from the furnace charge bin, usually located above the furnace. The safe and efficient operation of any flash smelting furnace depends on a continuous, non-pulsating feed of dry charge mix, at an accurately controlled rate.

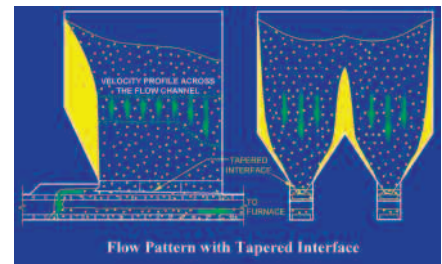


is not fully effective, as is almost always the case when a drag chain is used as a feeder.

### Initial Solution

In a mass flow bin, all the solids flow without stagnant regions, whenever any solids are withdrawn. Advantages of mass flow bins include: uniform flow, feed density independent of the head of solids in the bin, a first-in-first-out flow sequence, ensuring uniform residence time and increased time available for deaeration; and minimization of segregation effects.

When major flooding problems first occurred, there was no time to convert the bin to mass flow. To get the furnace back into operation quickly, Jenike & Johanson, Inc. (J&J) recommended a tapered interface piece be fitted between the hopper outlet and the drag chain. This dramatically improved bin operation by creating a much larger flow channel. Maintaining bin contents at between 320 tons and 550



tons eliminated flooding and achieved a reasonably smooth feed to the burner. Operations continued in this mode for the next 10 years.

### The Initial Problem

The first six months of furnace operation were plagued by serious flooding problems. The fine concentrate sometimes became aerated during discharge from the bin and flowed like a fluid at very high, uncontrollable rates to the burner. This resulted in upset conditions at the concentrate burner, leading to poor furnace metallurgy. Serious flooding problems also caused a large buildup in the waste heat boiler, which required a lengthy furnace shutdown for removal.

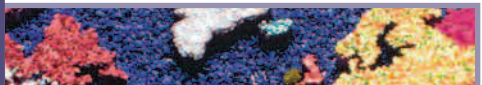
The flow pattern in the dry charge bin was funnel flow, which occurs when a hopper is not sufficiently steep and smooth to force material to slide along the walls, or when the outlet of a bin

### The New Problem

To increase the smelting capacity of the flash furnace, the capacity and reliability of the dry charge storage and feed system had to be increased. For the May 1999 scheduled flash smelter furnace rebuild, BHP defined the following performance criteria:

- 360 metric tons of live operating capacity in the storage bin;
- steady, uniform feed to the burner at a nominal rate of 220 dry metric tons per hour;

continued on page 2



# Flash Furnace Feed System Redesign at BHP Copper



- minimized probability of flooding;
- minimized particle segregation effects;
- selection of feeders to reduce maintenance costs.

Fine powders may be handled by keeping them fluidized or by preventing fluidization and handling the solid in a contact bed. Powder flow properties and required feed consistency drive the choice. To achieve the required feed rate accuracy to the concentrate burner, the decision was made to use a mass flow bin with sufficient capacity to allow enough time for fluidized material to deaerate during storage before being discharged through the feeder.

J&J tested a number of concentrate-flux mixes to determine the flow properties to be used in designing a suitable mass flow bin. Tests run with a Jenike Shear Tester showed that the minimum outlet dimension required to prevent formation of an arch in a wedge shaped mass flow hopper was only 0.1 ft., even after three days storage at rest. Thus, the bin outlet dimensions were set by flow rate considerations.



Wall friction angles were determined on several surfaces, but 2B finish, stainless steel sheet was found to be the best hopper lining material, requiring the least steep hopper slopes for mass flow and thereby maximizing storage capacity within the limited amount of available headroom.

A bin outlet must be large enough to achieve the required discharge rate. The maximum flow rate of a fine powder through the outlet of a mass flow bin is low compared with that of a coarse, granular solid. Permeability values are used to calculate critical, steady-state discharge rates from mass flow hoppers, as well as the time required for fine powders to deaerate and settle in bins. The copper concentrate-flux mix has a very low permeability, so J&J performed a two-phase gas-solids analysis to ensure that material would flow from the bin in a steady flow mode. The maximum flow rate calculated was 350 dry metric tons per hour, which is considerably higher than that required by BHP.

## The Solution

J&J recommended removing the existing pant-leg hopper arrangement, installing four mass flow hoppers, and lining all interior sloping surfaces with stainless steel sheet with a 2B surface finish. This design provides a bin with 370 metric tons of effective live capacity. A minimum level of 110 tons of material in the bin was set, providing a 30-minute minimum retention time for deaeration (110 ton/220 tph).

To achieve a uniform velocity profile in the new mass flow bin, J&J evaluated the use of STAMET multi-disc feeders coupled with air slides. STAMET feeders utilize an innovative design with a single moving part that provides evenly metered output across the full width of the outlet. This unique design allows easy metering and feeding of a wide range of materials, including fine powders, at low to very high rates. The feeders are extremely rugged and experience very little wear, even with abrasive materials.

Because this type of feeder was new to the copper industry and there were few, if any, existing installations in any industry handling fine powders at high feed rates, J&J constructed a 1/6th scale model of a one-quarter section of the bin. The tests verified that the STAMET feeder produced a mass flow pattern with a uniform velocity profile in the bin. Flow from the discharge of the air slide was steady, without pulsations. The test rig was run at rates as high as 80 kg/min., which, for the full-size facility, is equivalent to more than three times the design requirement. The tests demonstrated that the combination of a mass flow bin, STAMET feeder, and air slide is a robust system suitable for feeding the hot furnace charge at high rates to the concentrate burner.

The structural and mechanical design engineering for the modification was performed by H.G. Engineering, Ltd. The multi-disc feeders were supplied by Carlingview Technologies, Ltd., under license to STAMET, Inc. Construction management for the project was undertaken by Fluor Daniel.

Due to a drop in the market price for copper, this new system has not yet become operational. However, if/when it does start up, they can be confident it will perform as intended.

Please refer to page 4, for information on how to obtain a copy of the complete paper, from which this article is summarized.



## Behind the Scenes: Meet Roger Barnum

Title: Project Engineer

Joined J&J: 1996

Job Description: Roger consults with a wide variety of clients, but with a focus on the pharmaceutical industry.

His projects have involved on-site assessments, orienting staff on the principles of solids handling, and providing recommendations for process and equipment changes to solve or prevent problems such as weight variations, dusting and product loss, segregation

by component or particle size, and erratic or no flow.

Of note: Roger received his B.S. in mechanical engineering from Rensselaer Polytechnic Institute in 1989, graduating cum laude. Before joining J&J, Roger worked as a process engineer making electronic components, and as a design engineer for a manufacturer of automated machinery. He is also an avid player of ultimate frisbee and ice hockey.

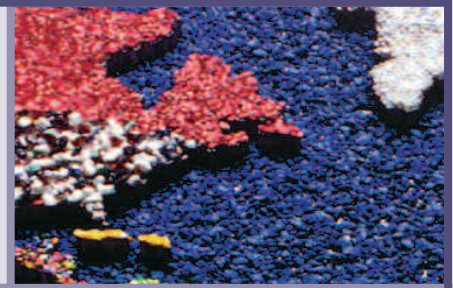
**"I am always intrigued at how solids handling problems can transcend industries that otherwise would never have any connection. At J&J, we have the opportunity to apply our years of research and experience in solving problems, across these boundaries, with proven methods. I enjoy seeing the reaction when our clients realize how a concept, used successfully for a completely different industry, will help them in theirs."**



## Enhanced Testing Capabilities

Proper testing can eliminate the trial-and-error approach to designing bulk solids handling systems. At Jenike & Johanson, we recognize the importance of duplicating process conditions, during testing. To this end, we have enhanced the capabilities of our pneumatic conveying test equipment to provide inlet gas temperatures ranging from 45°F to 500°F. Fluidization tests can now be run at temperatures up to 800°F.

Let us put our experience to work for you.



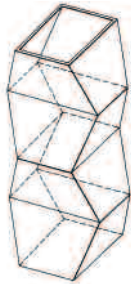
## Patents awarded for **Converging/Diverging** bin and **Removable BINSERT®**

### Converging/Diverging Bin

T. Anthony ("Tony") Royal, vice president of technology for Jenike & Johanson, and David Craig, senior project engineer/R&D, were recently awarded a patent for the innovative design of a bulk solids storage vessel.

#### Background

Many bulk solids, when stored at rest, become more difficult to discharge from the vessels they are stored in. Quite often, the materials will form an arch over the outlet of the vessel, and not discharge at all. Sometimes, this is due to an increase in density and related cohesive strength, as the material settles with time, in the vessel. One potential solution is to keep the material constantly in motion, by continuously discharging material from the vessel. This approach does not work, however, when the material gains strength quickly, and the storage vessel has a large vertical cylinder section. The material in this section moves downward as a solid plug, so there is no relative motion between particles. They are essentially at rest, and can gain in cohesive strength.



#### Invention advantages

The unique, patented vessel design eliminates the vertical section of a typical vessel, where there is no interparticle motion. By properly converging and diverging the walls, the particles can be kept in constant motion, relative to each other, thereby preventing any significant gain in cohesive strength, and the related flow problems. The proper design of such a vessel depends

highly on the flow characteristics of the material to be handled, and the application requirements.

### Removable BINSERT®

Eric Bengtson, project engineer, was awarded a patent for the design of a removable BINSERT®.

#### Background

The BINSERT® is a cone-in-cone design that has been used to solve many bulk solids handling problems over the years. Depending on the application, a properly designed BINSERT® system is capable of dramatically reducing segregation, eliminating erratic flow, or providing in-bin blending. Some additional benefits of the BINSERT® are reduced headroom (compared to more conventional designs), and its use as a retrofit for existing vessels that are not performing as required.



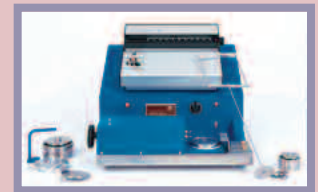
BINSERT® designs are frequently used in portable containers for pharmaceutical applications, where headroom is critical. While the design solves numerous flow problems, the presence of the inner cone makes complete and thorough cleaning difficult.

#### Invention advantages

The new patented design allows for the easy removal of the inner cone for cleaning. Repositioning the inner cone, after cleaning, is also critical to obtain the required flow pattern. The unique locking design ensures that the cone is securely locked in the proper location.

## Q&A with

**Q** In researching test equipment used for the determination of powder flowability, I have come across several devices. Which one do I really need?



**A** Many new easy-to-use testers have become available for measuring "flow properties." Unfortunately, simplified testers usually provide results that are only suited for comparing relative differences between materials. They do not provide parameters for the design of bulk solids handling equipment. The standard for providing the proper design parameters is still the Jenike Shear Tester (ASTM D6128). The Jenike-Schulze Ring Shear Tester is the exception, providing simplified testing while maintaining the necessary information for proper design of bulk solids handling equipment.

If you have any bulk solids handling questions, or if you have suggestions for future articles, please contact:

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Fax: 978-392-9980

## Did you know?

If you have "free" pneumatic conveying tests conducted by an equipment vendor, you will be told how their equipment can be made to work for you. This is not always the best solution, and may end up costing you more in the long run. Jenike & Johanson can establish pneumatic conveying parameters for your material, and based on your system requirements, provide an objective evaluation that is not dependent on a particular vendor's equipment. At Jenike & Johanson, you always work with an engineer, not a salesman.

# Flow-of-Solids Industry Calendar

"You get the benefit of years of experience."  
"Instructors were very knowledgeable, well prepared, and professional"  
- From course attendee evaluations of recent Jenike & Johanson presentations



**May 7-10, 2001,  
Chicago, IL**  
26th annual Powder  
and Bulk Solids  
Conference/Exhibition.



Jenike & Johanson  
personnel will present the following seminars and  
workshops<sup>†</sup>:

- Solve Solids Flow Problems in Bins & Hoppers
- Design of Transfer Chutes to Minimize Buildup, Abrasive Wear, and Dust Generation
- How to Select or Troubleshoot Volumetric and Gravimetric Feeders to Ensure Reliable Flow
- Blending and Segregation and their Effects on Product Quality
- Advanced Topics in Solids Handling

Stop by and see us at booth 1255.

**May 17, 2001, New  
Orleans, LA**

2001 International  
Conference on Powder  
Metallurgy & Particulate  
Materials (PM2TEC 2001).



Brian Pittenger, senior  
consultant with Jenike & Johanson, will be the  
chairman of a technical session titled, "Advanced  
Powder Compaction Modeling."

**May 21-23, 2001, San Diego, CA**

Institute for International Research. Jim  
Prescott, senior consultant with Jenike & Johanson  
will be presenting a session titled, "Under-  
standing the Role of Blend Uniformity in Process  
Validation."

**May 21-23, 2001, Las Vegas, NV**

"Advanced Practices in Pharmaceutical Tablet  
and Capsule Manufacturing" course offered by  
the University of Wisconsin, Madison, Depart-  
ment of Engineering Professional Development.

Jim Prescott, senior consultant with Jenike &  
Johanson will be presenting a session titled,  
"Troubleshooting Blend and Content Uniformity  
Problems."

**July 11-12, 2001, Toronto, Canada**

AIChE course, Flow of Solids in Bins, Hoppers,  
Chutes, and Feeders<sup>††</sup>.

**July 13, 2001, Toronto, Canada**

AIChE course, Pneumatic Conveying of Bulk  
Solids<sup>††</sup>.

**October 4-5, 2001,  
Miami, FL**

Industrial Processing  
Expo. Eric Maynard,  
project engineer/educa-  
tion coordinator with Jenike & Johanson will  
present a seminar titled, "Solve Solids Flow Prob-  
lems in Bins and Hoppers."<sup>†</sup>



**October 21-25, 2001, Denver, CO**

American Association of Pharmaceutical Scien-  
tists (AAPS) Annual Meeting and Exposition.  
Talk to one of our engineers at booth 2243.

**October 24-25, 2001, Orlando, FL**

AIChE course, Flow of Solids in Bins, Hoppers,  
Chutes, and Feeders<sup>††</sup>.

**October 26, 2001, Orlando, FL**

AIChE course, Pneumatic Conveying of Bulk  
Solids<sup>††</sup>.

<sup>†</sup>To register, contact Reed Exposition Companies,  
(203) 840-5848, or visit [www.reedexpo.com](http://www.reedexpo.com).

<sup>††</sup>To register, contact AIChE, (800) 242-4363, or visit  
[www.aiche.org](http://www.aiche.org).

## Hot Off the Press

**Redesigning the Flash Furnace Feed  
System at BHP Copper**

by D.J. Goodwill, D.M. Jones, and T.A.  
Royal, Presented at Copper 99-Cobre  
99 International Conference, Volume V  
- Smelting Operations and Advances

**A Solid Dosage and Blend Content  
Uniformity Troubleshooting Diagram**

by J.K. Prescott, T.P. Garcia, *Pharma-  
ceutical Technology North America*,  
Vol 25 No. 3, March 2001, p. 68-88.

**Ensuring Reliable Flow of Gypsum at  
LaFarge's Joppa Cement Plant**

by E.P. Maynard, C. Szabo, Presented  
at Global Gypsum Conference 2000,  
San Francisco

**Silo Failures: Case Histories and  
Lessons Learned**

by J.W. Carson, Proceedings of The  
3rd Israeli Conference for Conveying  
and Handling of Particulate Solids, Vol.  
1, p. 4.1-4.11, 2000.

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