Flow of Solids

JENIKE & JOHANSON INCORPORATED

Bulk Solids: Science / Engineering / Design

The Newsletter of Jenike & Johanson, Inc.

Spring 2002

Hot Lime Feed System Problems Solved at Paper Mill

Background

Weyerhaeuser Company's New Bern, NC facility operates a 1,000 ton per day bleached pulp mill. As part of the process, reburned lime exits a kiln, is crushed, then conveyed to a hot lime storage bin. Hot, reburned lime is then metered with fresh lime from a separate bin, to a slaker to begin recausticizing.

Problems were encountered maintaining reliable feed from the hot lime bin. To solve the problems, a joint effort was made between Jenike & Johanson, Inc., and a Weyerhaeuser team of technical, operating, and maintenance personnel.

The Problem

The hot lime bin was designed with a small square discharge opening and a single shaft screw feeder. Hot and fresh lime were then fed into a mixing screw conveyor, which emptied into a screw conveyor to the slaker. The short discharge neck between the hot lime bin and screw feeder was subject to frequent flow interruptions. Pneumatic vibrators were rarely successful in re-establishing flow. About half of the pluggages could be cleared through the use of high pressure air hoses; however, this caused fine dust to escape from the bin/feeder flange and around the feeder cover. The standard procedure for the remaining pluggages was for the operator to employ a sledgehammer on the side of the discharge neck.

This response to pluggages was repeated many times every shift, exposing operating personnel to potential safety incidents, and creating an environmental concern due to the discharge of fine lime dust to the surrounding area. The pluggages also caused swings in slaker operation, which carried through to the causticizers, resulting in inconsistent liquor quality.

The Investigation

Jenike & Johanson was asked to visit the site and provide recommendations for correcting the plugging problem. During the site visit, an infrared temperature probe was used to measure the temperature of the hopper exterior. At the bin outlet, this temperature was measured to be approximately 800°F. Just above this outlet, the temperature had dropped to less than 200°F. This dramatic decrease indicated that material was stagnant in regions above the bin outlet, or in other words, the hopper was exhibiting a funnel flow discharge pattern.

In funnel flow, the sloping hopper walls of a bin are not steep enough and smooth enough for material to flow along them. Under these conditions, particles slide on themselves rather than the hopper walls, and an internal flow channel develops. If the material has sufficient cohesive strength, the non-flowing material will not slide into the flowing channel, resulting in the formation of stable ratholes. Funnel flow also results in a first-in last-out flow sequence, and flooding of fine materials due to insufficient residence time in the bin. Despite the numerous problems associated with funnel flow, many bins in use are funnel flow, since the choice of

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The Inside View

We continue to add to our capabilities to better serve you, our clients. Susan Lozon has joined our San Luis Obispo staff as a structural/project engineer. Recently we expanded our Westford lab to include four new test rooms and a containment room for testing hazardous materials. New equipment includes a laser particle size analyzer, high temperature shear tester capable of reaching temperatures of 2000°F with an ability to control the atmosphere in the tester, a high temperature fluidization rig, and a vacuum oven. We remain committed to providing value and being responsive to your needs.

John W. Carson

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

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Hot Lime Feed System Problems Solved at Paper Mill

discharge pattern is often not considered in the design. The alternate, mass flow, can eliminate most of the problems associated with funnel flow.

The Solution

To prevent the pluggage problems, conversion of at least a portion of the hopper to mass flow, with a larger and more robust outlet size and shape, was necessary. It was not practical, nor required, to redesign the bin for complete mass flow, as flow properties tests (conducted using our unique furnace tester) showed ratholing was not a concern for larger diameter outlets. The approach that was agreed upon involved replacing the existing cone, below the 8 ft. diameter, with a transition hopper designed for mass flow, resulting in an expanded flow arrangement. Such a change would enlarge the flow channel to at least an 8 ft. diameter, or about six times its previous size. For this arrangement to be successful, it was also necessary to replace the existing feeder with a properly designed mass flow screw feeder so that the entire outlet would remain active.

A transition hopper design was selected with an outlet width large enough to overcome arching. Wall angles were selected based on wall friction test results for 304 stainless steel sheet with a 2B finish. The 2B finish is typically available only in sheet thicknesses; however, plate thickness was desired due to concerns with liner separation or buckling at such high temperatures. A source for this material in 1/4 in. plate thickness was found, and further wall friction testing with the hot lime confirmed that it would be sufficiently smooth to promote flow along it at the desired angles.

A dual 14 in. mass flow screw feeder was selected for use. The augers were designed with an increase in capacity in the direction of feed to accomplish the goal of withdrawing material from the entire outlet area. These features include a conical shaft section near the back of the screw to gradually reduce the shaft diameter, as well as an expansion of pitch closer to the front of the screw.

Implementation

The hot lime feed system changes were implemented during an annual outage in 1999. Due to our experience in making such equipment and our ability to meet the required schedule, we were chosen to fabricate the dual 14 in. screw feeder, transition hopper, and a shutoff gate. We also provided detail design drawings for the modifications to be undertaken by plant personnel. Weyerhaeuser personnel executed the installation plan efficiently and without problems, resulting in a flawless startup that was on time.

Considerable experience has been gained with the new equipment since its installation. It was important for the plant to have a means to shut the hopper off from the metering screw should maintenance require dropping the feeder out. Any sort of solid gate mechanism was precluded early in the design process because of clearance issues, expense, and fear that if not used over time it might not be functional when needed. We proposed a pin gate design that would induce bridging across the hopper and stop flow, which was included with the feeder as part of its supply. An opportunity to use the gate with hot lime came just a year after installation when the screw feeder had to be dropped for maintenance. Except for some fines that initially flowed between the pins, the gate was successful in stopping flow.

The Result

A few months after start-up, the bottom of the feeder trough, which resembles side-by-side barrels of a shotgun, began to distort and crack along its seam, due to the severe duty and heat of hot lime service. Some temporary repairs were executed, and the feeder continued in operation until the next shutdown. Meanwhile, we redesigned and provided a replacement trough. After an inspection one year later, the trough still looked good inside and out.

The original screws are still in operation, without any pluggages occurring in the bin. The video camera that was required to monitor the old arrangement, to ensure that hot lime flow was maintained, was gladly retired.

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

Send an email message with your mailing address to newsletter@jenike.com for a free model demonstrating mass flow and funnel flow silo discharge patterns.

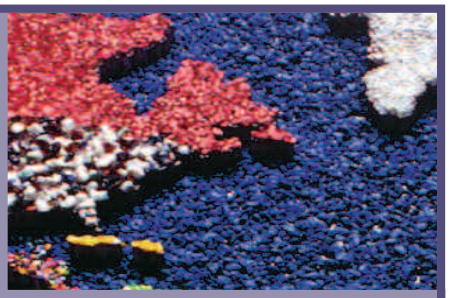
Behind the Scenes: Meet Rod Hossfeld

Title: Sr. Project Engineer
Joined J&J: 1978
Job Description: Rod consults with clients in all industries, but with a focus on energy. He has worked with hundreds of clients, solving problems ranging from minimizing particle attrition with special letdown chutes (food and energy industries) to ensuring reliable flow in large coal bunkers.
Of note: Rod received his BS in mechanical engineering from the University of Massachusetts in 1972 and MS in 1974.

"I am constantly being reminded how important proper design is to ensuring an uninterrupted supply of fuel to a power plant boiler. 1978 brought the energy crisis to J&J when frozen coal shut down a major power producer. Clean coal technologies and the use of waste coals, like gob and culm, have brought to the forefront the importance of reliable material flow in bunkers. And the use of PRB coal with its self-ignition tendencies, dramatically demonstrates the need for mass flow design in eliminating stagnant regions that foster coal fires."

GKN Sinter Metals wins Honda quality award

GKN Sinter Metals' Germantown, Wisconsin plant won a quality award from Honda's North American Operations for shipping more than 1.2 million P/M main bearing caps defect-free in 2000. GKN is one of only 23 North American suppliers recognized by Honda. We congratulate our client, GKN, on their diligent efforts to seek out and eliminate product variation, thereby achieving such a high mark of excellence in quality from Honda. Information on how to approach and eliminate powder flow variations is available in our case study with GKN. See pg. 4 for how to obtain a copy.



NFPA standards reduce solid fuel fire hazards with bunker design requirements

Background

At J&J, we often discuss the benefits of handling a bulk material in a vessel designed for mass flow, and the problems associated with funnel flow. One funnel flow problem, which usually goes unmentioned, is coal fires. While not necessarily unique to coal handling, hot spots and spontaneous combustion occur too frequently at coal handling facilities.

The National Fire Protection Association (NFPA) recognizes this as a problem and has produced guidelines for handling coal. In particular, NFPA 8503 Standard for Pulverized Fuel Systems, discusses the need for proper system design beginning with the raw fuel bunker, upstream of the pulverizer.

NFPA Specifications

In section 2-6.5.1 of the standard, it specifies that the raw fuel bunker "...shall be designed to provide the following:

(a) An uninterrupted flow of fuel being handled at a controlled rate.

(b) A flow pattern in which arching and ratholing (piping) are avoided."

In other words, a mass flow design is required for the raw fuel bunker. To ensure a mass flow design, the flow properties or material handing characteristics must be determined through testing.

The standard further specifies in section 2-6.5.1.1, "The bunker outlet feeder(s) shall be coordinated with the bunker to avoid the probability that improper feeder selection will result in altering the bunker flow characteristics as specified in 2-6.5.1 (a) or (b).

Again, this translates to the need for a feeder capable of ensuring that the flow pattern in the bunker remains mass flow, as designed.

As an example, in the case of a bunker with a slotted outlet having a belt feeder, a proper feeder interface is required. An improper design will cause material to be fed from only one end of the bunker outlet, creating a stagnant region above the area that is not feeding. A proper belt feeder interface will provide feed from the entire bunker outlet area, keeping the bunker, originally designed for mass flow, operating in mass flow.

Additional Comments

Many coal handling facilities are concerned about the use of plastic, or polyethylene, liners that are often recommended to obtain mass flow. The concern is that in the event of a fire, the plastic will burn. However, if the liner is properly used to obtain mass flow, and the bunker is used regularly, fires will not occur because there is no stagnant material capable of spontaneously combusting.

At J&J, we have had almost 500 individual projects involving coal handling. Our recommendations are always based on the flow properties of the coal being handled, and the application requirements. Let us put our experience to work for you, to not only meet NFPA standards, but to improve the performance of your handling system.

Did you know?

Published "standards" for the flowability of materials such as coal can be reasonable for some rough approximations, but your application and handling conditions are unique. The only way to know the real flowability of the materials you handle is to have tests conducted, duplicating your process conditions. Periods of storage at rest, moisture content extremes, and particle size distribution can greatly alter the handleability. Jenike & Johanson has the most experience and capabilities when it comes to testing at representative conditions, and providing recommendations that will solve your problems, as well as fit your needs.

Q&A with J&J

Q A polished finish has been recommended for the interior of a new coal silo we are having installed. If we use a rougher, less expensive surface, won't the coal eventually polish it?

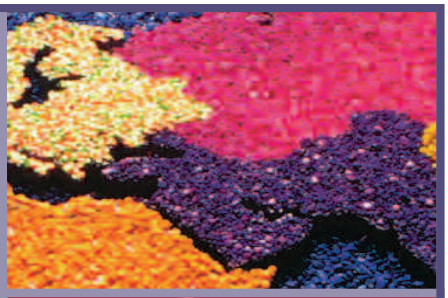
A No. For the material to flow along the walls and polish them, mass flow is required. However, mass flow will not occur with a rough, frictional surface. (Testing is required to establish the proper wall angles to obtain mass flow for a given bulk material, wall material, and surface finish.) By starting with a surface that is more frictional than that determined to be required for mass flow, the material will discharge in a funnel flow pattern with no material moving along the walls. Under these conditions, the surface will not polish or wear, and flow problems associated with funnel flow will remain.

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

Flow of Solids® Newsletter
Jenike & Johanson, Inc.
One Technology Park Drive
Westford, MA 01886-3189
E-mail: newsletter@jenike.com
Voice: 978-392-0300
Fax: 978-392-9980

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 6-9, 2002, Chicago, IL
27th annual Powder and Bulk Solids Conference/Exhibition. Presentations by Jenike & Johanson personnel†:
- Solve Solids Flow Problems in Bins & Hoppers
- Design of Transfer Chutes to Minimize Buildup, Abrasive Wear, and Dust Generation
- Fine Powders: Reliably Handling Bulk Solids that Can Behave like Fluids
- 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 15110.

May 7, 2002, Farmington, PA
Fluid Bed 2002 Conference. Rod Hossfeld, senior project engineer with J&J, will present, *Solid Fuel Handling: Everything you need to know - in 45 minutes*.

May 12-15, 2002, Miami, FL
North and South American Cement Conference. Eric Maynard, project engineer with J&J, will present, *Environmental Compliance in the Cement Industry: How to Design Transfer Chutes to Eliminate Dusting and Spillage.*

May 20, 2002, Las Vegas, NV
Advanced Practices in Pharmaceutical Tablet and Capsule Technology. Roger Barnum, project engineer with J&J, will present, *Using Particle Technology to Avoid Powder Caking*.

May 21, 2002, Boston, MA
Advances in Process Validation. Jim Prescott, senior consultant with J&J, will present, *Understanding the Role of Blend Uniformity in Process Validation.*

June 5-7, 2002, San Antonio, TX
August 7-9, 2002, Chicago, IL
October 16-18, 2002, Houston, TX
AIChE courses, *Flow of Solids in Bins, Hoppers, Chutes, and Feeders*, and, *Pneumatic Conveying of Bulk Solids*††.

June 15, 2002, Anaheim, CA
Institute of Food Technologists. Scott Clement, project engineer with J&J, will present, *Blending and Segregation of Food Powders*

June 16-21, 2002, Orlando, FL
2002 International Conference on Powder Metallurgy & Particulate Materials (PM2TEC 2002). Brian Pittenger, senior consultant with J&J, will chair two technical sessions on modeling, compaction, and FEM.

July 22-25, 2002, Syndey, Australia
World Congress on Particle Technology IV. Herman Purutyan, vice president with J&J, will present, *Solids Handling Issues in Thermal Drying Processes*. Also, a joint paper, *A Preliminary Investigation Concerning the Effect of Particle Shape on a Powder's Flow Properties*, will be presented by Mark Bumiller of Malvern.

July 29-30, 2002, San Francisco, CA
August 12-13, 2002, Boston, MA
August 19-20, 2002, Chicago, IL
Institute for International Research. Jim Prescott, senior consultant with J&J, will present, *Powder Flow and Its Effect on Product Uniformity*.

†To register, contact Reed Exposition Companies, (203) 840-5848, or visit www.reedexpo.com.
††To register, contact AIChE, (800) 242-4363, or visit www.aiche.org.
More complete course information is available at www.jenike.com/pages/education/dates.html

Hot Off the Press

Case History: Paper Mill Solves Problem Feeding Hot Lime
by R.A. Barnum and T. Brinson

Technique for Optimizing Powder Handling in P/M Parts Production
by B.H. Pittenger, H. Purutyan, C. Dietz, T. Campbell, and T. Geiman

Don't Get Stuck on Sludge Handling
by J.W. Carson

Silo Failures: Case Histories and Lessons Learned
by J.W. Carson

Reliable Handling of Gypsum Products Using Proven Bulk Solids Technologies
by E.P. Maynard

Solids Handling Issues in Thermal Drying Processes
by H. Purutyan, T.G. Troxel, and J.W. Carson

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East Coast, USA
Jenike & Johanson, Inc.
One Technology Park Drive
Westford, MA
01886-3189 USA
Voice: (978) 392-0300
Fax: (978) 392-9980

West Coast, USA
Jenike & Johanson, Inc.
3485 Empresa Drive
San Luis Obispo, CA
93401-7328 USA
Voice: (805) 541-0901
Fax: (805) 541-4680

Canada
Jenike & Johanson, Ltd.
400 Carlingview Drive
Toronto, Ontario
M9W 5X9 Canada
Voice: (416) 674-8595
Fax: (416) 674-8520

South America
Jenike & Johanson, Chile S.A.
Av. Libertad 798, Of. 701
Viña del Mar, Chile
Voice: (+56) 32 690 596
Fax: (+56) 32 690 596

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