JENIKE & JOHANSON
Bulk Solids: Science/Engineering/Design

Flow of Solids

Spring 2009 Newsletter

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Glensanda: A World Class Coastal Super Quarry

Jenike & Johanson has been helping the Glensanda quarry with various projects since 1989. This article discusses how Jenike & Johanson solved flow problems in a 60,000 tonne hillside bin.

Glensanda, one of the largest and most technologically advanced aggregate quarrying and shipping operations in the world, is located on the banks of beautiful Loch Linnhe in the Western Highlands of Scotland.

The quarry, formerly owned by Foster Yeoman Ltd, is now part of Aggregate Industries Limited, a member of Holcim, following its acquisition in 2006. It has reserves in excess of 800 million tonnes and ships high quality crushed granite to markets in the UK, Europe and the Americas.

President's Message

In these challenging economic times, it is reasonable to ask, "What is the role for a specialized engineering firm?" I can't speak for others, but I can tell you several of the ways that we at Jenike & Johanson can be of significant benefit to you.

For one, we can identify waste and inefficiency in your operation, showing you how to lower your production costs through improved handling, storing and processing of your bulk solids. Maybe the excess resources needed to keep your bulk solids moving can be reduced or even eliminated by implementing some relatively inexpensive design changes. Maybe you can utilize less expensive raw materials if your handling and storage system was upgraded to be able to accommodate them. We have seen payback in such projects often measured in months, not years.

(Presidents Message Cont. on page 2)

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

Process Overview

Granite is quarried at the 500m level and loaded to a large primary crusher that feeds a 300m-deep, 3.8m-diameter shaft, known as the 'Glory Hole'. Reciprocating plate feeders at the base of the glory hole feed the –225mm crushed granite to a 1.8 km horizontal tunnel belt conveyor that delivers the rock to a 500,000 t stockpile. Next, material is conveyed to secondary and tertiary crushing and screening operations and from there to massive 60,000 t capacity storage bins cut out from the hillside.

The glory hole provides a long-term solution to both economic and environmental aspects of the extraction of the deposit. The quarry is a crater, with only the uppermost benches visible from a distance. The primary crushing station level and glory hole collar are progressively lowered as the deposit is mined. The tunnel is a permanent installation for the life of the project. The stone is crushed and screened into sizes demanded by the market and stored in the hillside bins ready for ship loading.

The granite is exported using bulk vessels such as the Yeoman Bridge, which, at the time of it completion in 2000, was the world's largest self-unloading vessel, with a capacity of 97,000 t. The reclaim, blending and shiploading facilities are rated at 6,000t/h, which means a typical 85,000 t cargo can loaded at the harbor in under 24 hours.

(Presidents Message Cont.)

We can improve the quality of your products, which usually translates into fewer customer complaints and less product rejects. Utilizing lessons we have learned from thousands of industrial projects over the past 40+ years that we have been in business, we know how to create uniform blends, control segregation, achieve consistent and reliable flow – all of which are essential to achieving consistent product quality.

Slow times provide great opportunities to fine tune processes and gear up for future growth. Our engineers are highly trained in how to quickly identify reliable, cost effective solutions to your most difficult bulk solids handling, storage and processing needs.
Call to see how we can solve your most challenging bulk solids problems – or design new facilities to avoid them.

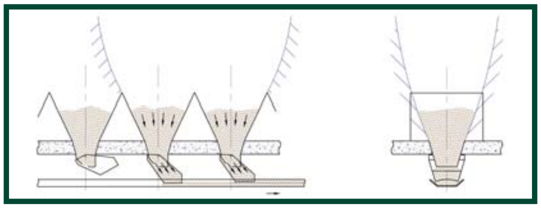
On-Site Assessment

Mr. David Yeoman invited Jenike and Johanson engineers to visit the quarry shortly after start up in January 1989 to solve flow problems in a difficult to handle sub-base storage bin. Since that time, our engineers have visited the quarry frequently and have provided flow property testing and functional design recommendations for plant expansions and modifications involving bins and feeders.

The most recent of these projects began in 2004 with a call from Mr. Neil Hyde of Hyde Project Engineering (HPE). Foster Yeoman Ltd had just retained Neil's company to provide necessary consulting engineering and design services to bring existing hillside bin #4 into service. Sixty thousand tonnes of live storage capacity were required for moist granite dust, and this must be available on demand to load ships at 6,000 t/h. Neil promptly retained Jenike and Johanson Ltd to test granite dust samples and to recommend a tunnel reclaim system that would provide flow rate linearity with respect to reclaim belt speed. The flat bottom floor of bin #4 is about 5m wide.

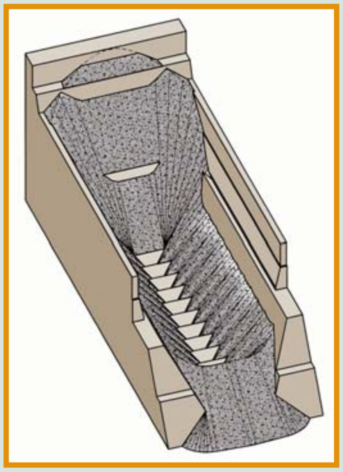
Stockpile Recommendations

We recommended that the reinforced concrete reclaim tunnel should have a single line of ten, wedge-shaped mass flow hoppers set in the roof, feeding a 2m wide variable speed belt conveyor. Directly beneath each hopper is an emergency shut off gate, below which is a proprietary 'swing-type' flow control gate. The belt conveyor acts in the same way as a belt feeder in the flow control gate design developed by HPE and Jenike & Johanson (see diagram and photo below).



Above the tunnel roof, steep-sided tent shaped inserts (often referred to as 'hog-backs') run between adjacent hoppers across the width of the bin floor. Their purpose is to extend the sloping sides of the mass flow hoppers upwards so that adjacent flow channels intersect, thus preventing a stable rathole from forming. This design approach is a good example of an expanded flow pattern: a series of mass flow hoppers forming a slotted outlet beneath a flat-bottomed funnel flow bin.

Glensanda: A World Class Coastal Super Quarry



Glensanda quarry operators specified that the moisture content of the incoming dust would not exceed 1.5%. This was an important stipulation to ensure reliable flow, as our flow tests on dust samples at higher moisture levels showed it to be cohesive, with a strong tendency to both arch and rathole in funnel flow bins.

Key Goal

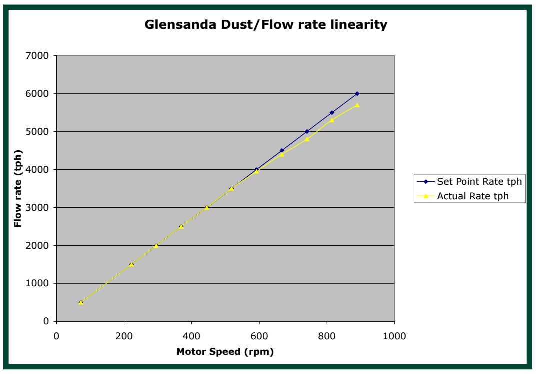
A key goal in this project was to achieve flow rate uniformity as a function of conveyor belt speed (or motor rpm), as this would then permit accurate blending with other stone sizes to produce an 'end-product' with the required granulometry.

All too often, a feeder or control gate is selected and sized solely on its ability to move material with no regard to the capability of the material to flow through the hopper outlet onto the feeder. To meet the design requirements for a feeder or control gate, it is crucially important that the minimum achievable gravity flow rate (i.e. the limiting discharge rate) through a hopper outlet exceeds the specified mechanical operating capacity of the feeder or gate.

Based on the measured flow properties (i.e. bulk density, cohesive strength, permeability and compressibility) of a 'worst-case' granite dust sample, we predicted that the flow rate from a single flow-control gate would increase linearly up to a maximum rate of 3,000 t/h. However, our calculations also showed that doubling the belt speed from 1.5 m/s to 3.0 m/s would only increase the limiting discharge rate from 3,000 t/h to 3,200 t/h. This is a typical example of a limiting discharge rate condition. To increase the flow rate linearity up to the 6,000 t/h required, we recommended operating a pair of adjacent gates in tandem.

Project Results

The project, built in accordance with our recommendations, has been operating very successfully for three years. Actual measurements of flow rate versus speed for two gates operating in tandem are shown below. Flow rate linearity is excellent.

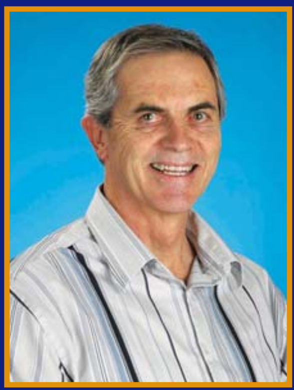


David Lamb, AI's Deputy Works Manager stated that the project had achieved all its key milestones realizing significant operational and financial targets:

- Live recovery from the bin exactly as Jenike & Johanson prediction of 60,000 tonnes
- Flow rate of 6000 tph easily met
- Linearity achieved in the 500 tph - 3,500 tph range thus ensuring blended products meet their product grading specification
- Totally eliminated the need for the excavators to move circa 400,000 tonnes/annum of 'dead' material to the feeder openings of the old storage bin
- Totally eliminated the need for excavators to 'supercharge' the old storage bin with 170,000 tonnes/annum material
- Allowed shipping planners the flexibility to store sufficiently large quantities of the product and ship to suitable market locations. This alone has realised savings circa £750,000 per annum

The involvement of Jenike & Johanson at the project planning stage has once again provided a high return on investment. Only with sound research data and engineering input can a project of this importance proceed with confidence in the eventual outcome

Behind the Scenes: David Stuart Dick



David Stuart Dick joined Jenike & Johanson in 1982 from South Africa where he trained as a civil/structural engineer. He has worked on a wide range of bulk solids handling and feeding projects around the world. His ability and wide experience are well used at Jenike & Johanson.

Jenike & Johanson has a unique lab in San Luis Obispo that we use to develop state of the art technologies for complex bulk solids handling applications. We help clients develop their process technologies that often revolve around the solids handling aspects. In an incubator-like setting, with skilled fabricators, designers and engineers, Jenike & Johanson can find and prove solutions to bulk solids handling challenges.

"I really enjoy solving difficult problems and it is a bonus to be able to demonstrate a working solution to a client with the actual material under process conditions."

Modeling Cutting-Edge Solids Handling Processes

Are you developing a unique process or a challenging solids handling application?

Does your system have to work flawlessly from day one?

Do you want to confirm that the design change you are contemplating will indeed have the desired effect?

If the answer is yes to any of the above, then there is likely great value to conducting modeling studies.

We have both the expertise and the facilities to conduct such modeling studies. Some of the unique and challenging modeling projects we have done include:

- Feeding a sticky, cohesive powder at extreme low flow rates (1 gm/min)
- Feeding a reactor with a metal "rain" with continuous high accuracy and uniformity
- Uniformly micro-dosing of a seasoning mixture continuously
- Aligning and counting of pharmaceutical tablets in a high speed filler
- Wet chemical cake feeding and conveying in a pneumatic conveying line
- High speed filling of ammunition cartridges
- Controlled highly abrasive material feed into a furnace
- Large scale and particle shear testing (>2 inch particles)

Our California facility, with experienced engineers and technicians, specializes in modeling processes in whole or in part. If you would like to discuss how we could assist you by modeling your process, validate your designs, or develop designs for challenging applications, please contact a Jenike and Johanson engineer at mail09@jenike.com.

Three dimensional physical model of colored granular beads flowing through a hopper with lower conical insert.

Model shows the relative velocity between particles.
Creating physical models like the one above is a highly effective method of understanding particle flow behavior, especially when the residence time distribution of the particles must be controlled.

Flow of Solids Industry Calendar

February 24-26, 2009 St. Louis, MO - by Natoli
Jenike & Johanson, Inc. engineers will present the following courses:
- Analyzing and solving dose uniformity problems

March 4-6, 2009 Houston, TX - by ASME/AIChE
J&J engineers will present the following ASME/AIChE courses*:
- Flow of Solids in Bins, Hoppers, Chutes, and Feeders
- Pneumatic Conveying of Bulk Solids

March 11-12, 2009 Charlotte, NC - by PTX South
Jenike & Johanson, Inc. engineers will present the following courses:
- Blending and segregation and their effects on quality
- Troubleshooting pneumatic conveying systems

March 25-26, 2009 Mississauga, Ontario - by Jenike & Johanson
Jenike & Johanson, Ltd. Engineers will present the following course:
- Flow of Solids in Bins, Hoppers, Chutes and Feeders

April 29-30, 2009 Atlanta, GA - by PBE SE Conference
Jenike & Johanson, Inc. engineers will present the following courses:
- Blending and segregation and their effects on quality
- Powder flow and silo/feeder design

May 20-22, 2009 San Diego, CA - by ASME/AIChE
J&J engineers will present the following ASME/AIChE courses*:
- Flow of Solids in Bins, Hoppers, Chutes, and Feeders
- Pneumatic Conveying of Bulk Solids

June 1, 2009 Palm Springs, CA - by IEEE-IAS/PCA
J&J engineers will present a 1 day tutorial at 2009 IEEE-IAS/PCA Cement Industry Technical Conference

July 23, 2009 Tyngsboro, MA - by Jenike & Johanson
J&J engineers will present the 6th annual 1 day "Solids Handling: Lab, Lecture and Lunch"

*For more information, please visit www.asme.org.

Off the Press

How to Minimize Feed Segregation to an Agglomerator
by J.W. Carson and B.H. Pittenger

Blender Selection and Avoidance of Post-Blender Segregation
by E.P. Maynard

Startup and Running Forces on Bulk Solids Feeders: Experimental Findings Versus Available Models
by C. Holmes, MSA Bradley, AR Reed and RJ Berry

Effective Design of Belt Feeder Interfaces to Achieve Reliable Operation
by J.W. Carson, F. M. Cabrejos and M. Rulff

Preventing Solids Flow Problems at Breweries
by R.A. Barnum

Successful Stockpile Operation
by E.P. Maynard

Prevent Caking and Unintended Agglomeration
by G.J. Mehos and S.A. Clement

Preparing the Removal of Low-Level Radioactive Waste – Predicting the Flow Behavior of Solids after Fifty Years Storage Using Sampling and Flowabilities Studies
By B.H. Pittenger, J.W. Carson and M. Griffin

Unloading Pressure Discharge Trucks
by F. M. Cabrejos and T.G. Troxel

Purge and Conditioning Vessels for Bulk Solids
by G.J. Mehos

Solving Costly Limestone Flow Problems at Titan Cement
by E.P. Maynard and J. Chavez-Sagarnaga

Developing Solid Oral Dosage Forms
by T.J. Baxter and J.K. Prescott

*For more info on these, please send an email to: mail09@jenike.com

Web Site: www.jenike.com Email: mail09@jenike.com

East Coast, USA
Jenike & Johanson, Inc.
400 Business Park Drive
Tyngsboro, MA
01879-1077 USA
Voice: (978) 649-3300
Fax: (978) 649-3399

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.
5955 Airport Road, Suite 100
Mississauga, Ontario
L4V 1R9 Canada
Tel: 905-694-9769
Fax: 905-694-9809

South America
Jenike & Johanson, Chile S.A.
Av. Libertad 798, Of. 501
Viña del Mar, Chile
Phone: 011 56 322 690 596
Fax: 011 56 322 690 596