



### Table of Contents

Research Extends Understanding of Loads Exerted on Belt Feeders .....	1
CEO's Message .....	1
Working with Slurries? .....	4
Behind the Scenes: Meet LeRoy Baldwin .....	6
Congratulations to Dr. John Carson .....	7
Behind the Scenes: Meet Jayant Khambekar .....	8
Client Recommendations of Jenike & Johanson .....	9
Flow of Solids Industry Calendar .....	10
Off the Press.....	10

### Research Extends Understanding Of Loads Exerted On Belt Feeders

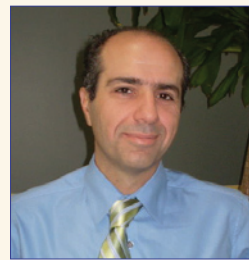
Corin Holmes, from our Toronto office, recently submitted a thesis in partial fulfillment of the requirements of the University of Greenwich (England) for the Degree of Master of Science in Engineering. It is titled "Startup and Running Loads (Forces) Exerted by Bulk Materials on Belt Feeders – A Comparison Between Experimental Results and Predictive Models".

Using a fully instrumented test rig that he designed and built, Corin measured vertical and horizontal (shear) forces acting on a belt feeder during startup and steady-state running. He compared the results to various published predictions.

Corin conducted the test program in two phases. In the first phase, he investigated several variables using a cohesive sand: bin fill rate, belt speed, belt profile (u-trough or flat), and nose type (vertical wall or 45° nose, both with circular cutout).

In the second phase, he ran tests using a cohesive clay powder and bone-dry beach gravel. In this phase of testing he fixed the belt speed, and he used only the 45° nose

### CEO's Message



Herman Purutyan, CEO  
Jenike & Johanson, Inc.

We at Jenike & Johanson thrive on solving our clients' toughest solids handling problems. Seeing a solids handling system we designed work as intended is exhilarating, and never gets old,

even though we've been designing such systems for 45 years for thousands of clients all over the world. Being able to make a positive impact on our clients – as expressed in notes from clients printed in this issue, is endlessly satisfying. Our success would not have been possible absent dedicated employees, a few of whom you'll meet in this issue. We take pride in the fact that the tenures of most of our employees are measured in decades.

We are also fortunate to have the visionary leadership of our President John Carson. Last year we celebrated John's 25th year as our President. Under John's leadership Jenike & Johanson became the foremost engineering company specializing in bulk solids handling, serving clients in all corners of the world.

If you have a tough material handling challenge, we'd love to help. Contact our engineers at any one of our four offices to discuss how we can be of assistance.

and flat belt profile. He varied fill rate, number of refills, and time at rest.

## Test results

Despite significant scatter in test results, they seem to indicate that the presence of a 45° nose increases the loads seen by the feeder, a factor not incorporated in any of the published predictive models. This is probably, in part, because of the longer outlet length associated with the nose. It could also be explained by the nose causing a wedge effect, which pushes material down onto the belt. Despite the higher loads, it has been well established that a nose at the front of a belt feeder interface has a beneficial effect on flow, in that it allows for a more gradual



Side view of test rig

change in the direction of movement of the material near the front of the hopper from vertical to horizontal.

Some other indications from Corin's results:

- Both vertical and horizontal forces increase with increased bin filling rate, which is not surprising.
- A bulk material's characteristics (compressibility, cohesive strength, and frictional properties) play a major role with respect to feeder loads.

- Maintaining an adequate head of material above the outlet is beneficial in keeping feeder loads low.

## Comparison with predictive models

The literature contains several methods to predict startup and steady-state vertical loads at a bin outlet. Some of these methods include hopper end-wall effects, but most do not.



View of a test rig from discharge end of a belt

Comparing predicted to measured vertical loads, Corin found that predicted start-up loads ranged from overly conservative (predicting values as high as six times the maximum measured), to not conservative enough (predicting values about 40% less than those measured). Clearly, using the start-up values of vertical loads as predicted by various published models and, in turn, start-up shear force is very unsatisfactory. Furthermore, no single model provided accurate predictions for steady-state vertical load covering a wide range of flow properties.

In sizing a feeder drive, the overriding practical requirement is that it must provide enough power to extract the bulk material through the outlet of the bin during both the startup phase and steady state. It is reasonable to expect that the

force required to shear a bulk solid can be estimated by multiplying the vertical force by an internal coefficient of friction. There is not, however, a consensus on how to determine this coefficient of friction value.

Although the data is limited, Corin found a nearly one-to-one correlation between the vertical force predicted by the Jenike model and the measured maximum horizontal force during steady-state. This ratio can be considered as a ‘pseudo’ coefficient of friction value.

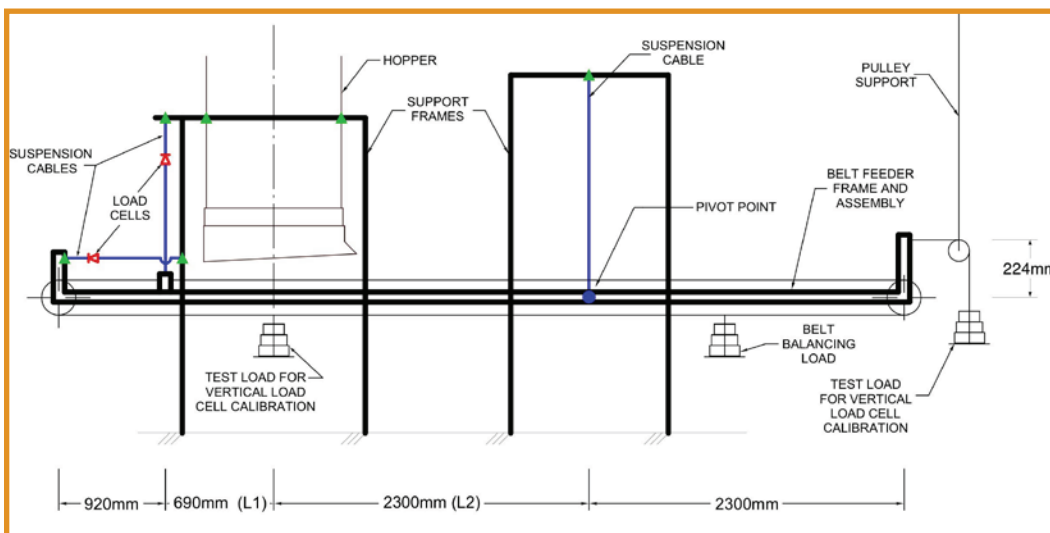
From a design and operational standpoint, the ability to be able to predict the maximum horizontal startup force is of greater importance than the steady-state horizontal force or the vertical force during startup or steady-state. Corin calculated the ratio of measured horizontal startup to steady-state forces for each run and found that the values ranged from 0.87 to 3.5. Based

on this, he suggested that a reasonable approach for arriving at a conservative horizontal startup force for design purposes would be to use Jenike’s method for calculating steady-state vertical force, multiply this by a coefficient of friction value of 1.0, then use a startup factor of 3.5.

### J&J’s experience

Corin’s research further adds to J&J’s knowledge base for designing belt and apron feeders and their hopper interfaces. The engineers at J&J have over 500 man-years of combined practical experience designing such feeders, including estimating startup and steady-state loads. This experience includes design of some of the largest belt and apron feeders in the world. Our success rate with this work has been exceptionally high, with satisfied clients around the world.

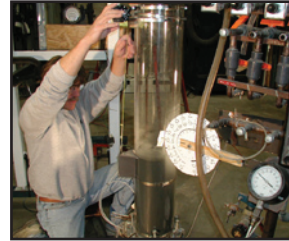
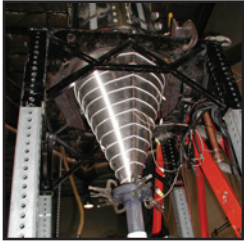
If you are having problems with an existing belt or apron feeder, or if you have plans to install a new one, the engineers at J&J are ready to assist you.



Schematic of test rig support system

## Working With Slurries? Review These Projects Completed By Jenike & Johanson

Over the years, Jenike & Johanson has worked on a number of projects involving slurries for a wide variety of materials found in mining, energy, and food applications. The following is a sampling of work discussing problems in the field and the subsequent solution offered by Jenike & Johanson.



- J&J designed and supplied a 400 gallon sediment holding tank for a crude oil refinery. Sediment and wash-down water are pumped to the tank. As the sediment settles, the water overflows to a larger tank. Each night the sediment must be remixed with a controlled amount of water to allow it to be pumped away for further processing or disposal. This long term solution has worked reliably for a number of years.
- A client developed an on-stream catalyst replacement process used in residue hydrotreaters. After commissioning several commercial units, they came to J&J for help in designing larger units and to improve the cost effectiveness of their design. As part of the project, J&J ran tests on samples of the catalyst simulating operating conditions of over 700°F and 2000 psig.
- A client planning a commercial scale gas-to-liquid conversion process using a proprietary catalyst came to J&J for assistance. One of the critical steps in the commercial plant is periodic reactivation of the catalyst. The first step in the reactivation process is separating the catalyst from the slurry extracted from the reactors. J&J ran tests on the slurry at 300°F, designed and built a settling tank to separate the granular catalyst from the reactor slurry prior to regeneration, and designed and built a model of the catalyst recovery system.
- A client was experiencing pluggage problems in a petroleum coke gasifier. The problems occurred in the quench chamber at the bottom of the gasifier that handles slag mixed with water at about 500°F and over 900 psig. J&J ran tests to measure wall friction, and designed and built a one-quarter scale model of the quench chamber with recirculation system in order to analyze the problem and develop recommendations.
- J&J ran experiments to determine the feasibility of conveying water-saturated sand through a water layer using a steeply inclined screw conveyor system. From these tests J&J developed a recommendation for the most cost-effective and reliable way to implement this system.
- J&J conducted wall friction tests on samples of wood chips submerged

in black liquor to determine the wall angles needed for mass flow.

- J&J consulted with a client in the design of a coal beneficiation plant. The process consists of heating coal in a high pressure (750 psig), high temperature (750°F) environment to drive off volatiles. The reactor design allows most of the coal to reach the required temperature relatively quickly. However, coal in the lower cone does not have heat transfer surfaces to heat it, so “cone heating water” is sprayed onto the coal during the process. This combined with water and tars squeezed out of the coal above, and the resulting liquids are expected to discharge through a coal retention device in the lower cone. J&J designed and performed model studies on this system and assisted the client in plant startup.
- A client produces a product used in beverage manufacturing. Customers complained of handling difficulties with this product, so J&J was asked to assist in identifying ways to improve its handling characteristics. The client concluded that allowing the product to age in a hot chemical bath prior to final processing would produce a harder particle, and hence more free flowing product. J&J ran tests on the in-process material under hot, submerged conditions and designed a continuous-flow aging vessel to produce a first-in, first-out flow pattern with minimum velocity gradients so as to provide uniform aging time.
- J&J consulted with a client in the design of a pseudo-continuous regeneration system for ion exchange resin. The resin is used in the production of fructose and dextrose. Spent resin used to be taken to a separate vessel for regeneration. The new process involved streamlining the system to make the regeneration pseudo-continuous.
- A client was experiencing problems with a zinc concentrate slurry storage tank with the conical bottom. Material built up on the sloping sides of the tank. From time to time, the build-up sloughed off and caused the outlet to plug. J&J ran submerged chute tests on a variety of hopper wall liners. Changes to the tank outlet, and an epoxy coating on the cone surface, solved the problems.
- A client, wishing to treat effluent from an ore preparation plant, wanted to install collection tanks ahead of some thickeners. J&J laboratory tests indicated that the suspended solids settled rapidly, but could be put back into the suspension easily, providing they were not left at rest for more than 24 hours. However, extended periods at rest led to tremendous strength gain. J&J recommended relocating the fill points to the corners to introduce more agitation, changing the flat bottom pump box to a conical hopper with bottom discharge and also addition of an insert to increase velocities in the area of the pump box.
- A mining client was conveying a non-ferrous metal concentrate slurry (pulp) from mill to smelter 5 days/week, but the smelter operated 7 days/week. Three 1000 ton tanks, each with hemispherical bottoms, were being used to store the pulp for weekend supply. Typically, the tank bottoms became plugged in two months of operation and took several days of intense labor to clean.

J&J ran submerged flow function and wall friction tests on a variety of pulp samples to determine how to best modify the tank bottoms to achieve a self-cleaning design.

The projects described above are just a small sampling of the work J&J has done with slurries and suspensions of many types of material. With the ability to work with high temperatures and pressures and to run tests in submerged conditions, Jenike & Johanson offers a solution specific to your needs.

Contact us at [mail11@jenike.com](mailto:mail11@jenike.com) or visit our web site at [www.jenike.com](http://www.jenike.com) if you would like help with your bulk solids handling.



Fluidization characteristics test column

## Behind the Scenes: Meet LeRoy Baldwin

A Senior Shop Technician with J&J since 1988, LeRoy builds working models and prototypes of solids handling design solutions developed by our engineers to test and demonstrate solutions to solids flow problems. He also fabricates custom designed equipment and runs our pneumatic conveying characteristic and attrition tests, drop attrition tests, wear tests, and fluidization tests.

“Some of my favorite projects involve fabricating equipment for pharmaceutical or food processing companies. One of my favorite jobs was producing a J&J designed hopper with six mass flow outlets for a food company. It was a satisfying technical and craftsmanship challenge. The best part of my job is being able to work with my hands among a great group of people who have such a wide range of professional and technical skills.” His experience and attention to detail helps ensure a successful project outcome.

LeRoy possesses a Bachelor of Science degree in Mechanical Engineering from Cal Poly University, San Luis Obispo.



## Congratulations to Dr. John Carson on his 40th Anniversary at Jenike & Johanson



Jenike & Johanson is pleased to honor Dr. John Carson, President, on his 40th anniversary at Jenike & Johanson. John joined Jenike & Johanson full-time in 1970 while previously interning in 1967 when J&J was in the basement of Dr. Jenike's house. His organizational ability and vision have played a key role in developing Jenike & Johanson to its present position, and his technical ability and wide experience in the field of storage and flow of solids have been

recognized worldwide. He has published more than 100 articles and lectured on various topics dealing with solids flow, including bin and feeder design, flow of fine powders, design of purge vessels, and structural failures of silos. Besides being a founding member of AIChE's Powder Technology Forum, he belongs to ASME, ASCE, and ASTM International, where he is chair of subcommittee D18.24, "Characterization and Handling of Powders and Bulk Solids." John received his Bachelor's degree from Northeastern University and a PhD from MIT, both in Mechanical Engineering. We asked John to reflect on his time at Jenike & Johanson:

### What was your most memorable project?

There have been many, but one that is fresh in my mind involved working with one of the world's largest petrochemical firms in designing all the solids handling equipment for a new catalyst manufacturing plant – their first in over 40 years. This involved systems to handle incoming raw materials, intermediates within the plant, and final products prior to shipment to customers. There were numerous technical challenges because they wanted to avoid problems that they had lived with for years at their existing plants. Watching this project progress from concept to design to building and successful startup was very rewarding.

### How has the science of bulk solids handling evolved over the past 40 years?

Certainly this is an evolving field, with many challenges still remaining. Two areas where significant progress has been made are in the understanding of silo loads and also two-phase (solid/gas and solid/liquid) flow phenomena. I'm proud of the pioneering work of J&J engineers in pushing the boundaries in these and many other areas of bulk solids technology.

Congratulations to Dr. John Carson on his 40th Anniversary at Jenike & Johanson

## What was the most difficult bulk solid you have worked with?

This is a tough question, since no clients send us “easy” problems to solve. In terms of difficult flowing bulk solids, tar sands immediately come to mind. This material is extremely cohesive and viscous, and it must be handled at flow rates well in excess of 10,000 ton/hr. Other difficult-to-handle solids include hollow plastic microspheres having a bulk density less than 1 lb/ft<sup>3</sup>, or highly segregating blends of free-flowing materials that must be blended uniformly and then handled without segregating. We have solved these and many other seemingly impossible problems for our clients.

## What trends do you foresee in the industry?

Probably the most significant trend is in the use of computer simulation of bulk solids handling systems. We at J&J have been actively involved for years in Discrete Element Modeling and Finite Element Analysis. As computer power increases these tools become more powerful, and their usage becomes more widespread. The key is choosing appropriate modeling parameters and recognizing limits of this technology. I’ve seen too many instances of people jumping to conclusions based on “pretty pictures” that these programs can produce. No computer can replicate the “real world” or replace a trained solids flow engineer with decades of experience.

## Behind the Scenes: Meet Jayant Khambekar, Ph.D.

Jayant Khambekar is about to begin his fifth year at J&J as a Project Engineer. Since joining J&J, Jayant has participated in various technological efforts that help put us ahead of the curve, such as Discrete Element Modeling, advancement of Dr. Jenike’s theory of flow of bulk solids and development of new testing techniques.

Jayant’s main responsibilities involve making on-site assessments to fully understand problem sources and providing engineering solutions to various bulk material handling and processing problems. While he has worked on more than 100 projects in various industries ranging from pharmaceuticals, food, chemicals and mining, his focus is on coal handling and the power industry.

*“Flow problems like arching, ratholing, erratic flow and segregation often upset production processes and can be quite costly. I enjoy applying J&J’s years of experience to eliminate these issues for our clients. By being involved in the project from early on, we can ensure that flow problems don’t develop; thus saving future frustrations.”*

Jayant holds a Ph.D. in Mechanical Engineering from Worcester Polytechnic Institute, Worcester, Massachusetts. He obtained his Bachelor’s degree in Mechanical Engineering from the Government College of Engineering, Pune, India.



## Client Recommendations of Jenike & Johanson

This first recommendation comes from Novo Nordisk for a powder handling project. Eric Maynard, Senior Consultant, was the lead project manager for this work.

*“Eric has consulted one of my project teams on a powder handling challenge in a tableting process in the pharmaceutical industry. His involvement was crucial for the success of the project, and a highly pleasant experience for the team members. Most crucially, Eric brought lots of experience in powder handling, and a well-balanced combination of in-depth knowledge and an eye for practical solutions. Eric made these accessible to us through his communication skills. He explained his points clearly and profoundly, both on the phone, in telecons and via mail. But we saw him at his best on the shop floor, where he easily built rapport to engineers, operators, and managers alike. He dispensed knowledge in a way that made people eager to learn, rather than feeling dumb. His pleasant nature helped the team keep spirits high during long work days. He listened well and gathered not only technical information, but also a valuable understanding of the social structure and change management needs of the project. I would be delighted to have another occasion to work with him.”*

**Antje Christensen, Project Director  
Biopharm CMC Project Office**

This next recommendation discusses how Jenike & Johanson's expertise in silo design prevented possible problems in a new silo complex.

*“In 1980, as part of my final year in my engineering degree, I did a dissertation on silo theory & design. This involved considerable research ( 6 months of reading all types of books & articles on the subject ) to compile a “state-of-the-art” manual for silo design. I then joined a company (Keeve Steyn & Partners, in South Africa) that were experts in silo design. For 2 years I designed funnel-flow silos based on Janssen's theory, without any problem. The design was well proven, and the bins had very shallow hoppers. We then got requests for silos with steep hoppers (for final products - milling industry, and for coal silos). At the end of 1982 I completed the detailed design for a silo complex of 18 contiguous bins, with steep hoppers, to be cast by sliding formwork. The design was based on the German code DIN 1055 (Janssen's theory for funnel flow). The contractor was on site, the reinforcing ready, and the slide due to start. A “Jenike” discussion paper on silo theory & design had just been published and given to me. It showed how little we actually knew about silos.*

*It made me realize that I was dealing with mass-flow, and that the wall & hopper pressures were much higher than what I had calculated. We had to double the amount of wall reinforcing. Your company prevented me from making a mistake that would have had serious consequences. Hence, my sincere thank you to Jenike & Johanson. We were able to rectify the design just in time. We also learnt the name of the real experts on silos: Jenike & Johanson.*

**Victor Lopes, Chartered Engineer and Regional Director  
Michael Punch & Partners**

## Flow of Solids Industry Calendar

March 8 - 10, 2011 Houston Texas - by ASME/AIChE  
J&J engineers will present the following ASME/AIChE courses\*:  
**Flow Of Solids In Bins, Hoppers**  
**Pneumatic Conveying Of Bulk Solids**

April 8, 2011 Mumbai, India - by Bulk Solids India  
J&J engineers will present the following workshop:  
**Silo & Feeder Design For Reliable Flow**

May 10 - 12, 2011 San Francisco, California - by ASME/AIChE  
J&J engineers will present the following ASME/AIChE courses\*:  
**Flow Of Solids In Bins, Hoppers**  
**Pneumatic Conveying Of Bulk Solids**

May 23 - 25, 2011 Somerset, New Jersey - by P&BE  
J&J engineers will present courses on:  
**Flow Fundamentals, Feeders, Mixing & Segregation**

June 21- 23, 2011 Toronto, Canada - by PTX  
J&J engineers will present a course:  
**Fundamentals Of Silo & Feeder Design**

July 14, 2011 Tyngsboro, Massachusetts  
**One Day At J&J – Spend a day at J&J headquarters**

October 11 - 13, 2011 Denver, Colorado - by ASME/AIChE  
J&J engineers will present the following ASME/AIChE courses\*:  
**Flow Of Solids In Bins, Hoppers**  
**Pneumatic Conveying Of Bulk Solids**

November 1- 3, 2011 New York, New York - by ChemShow  
J&J engineers will present courses on:  
**Flow Fundamentals, Feeders, Pneumatic Conveying**

November (TBA) – San Luis Obispo, California  
**One Day At J&J – Spend a day at J&J's California office**

December 6 - 8, 2011 Atlanta, Georgia - by ASME/AIChE  
J&J engineers will present the following ASME/AIChE courses\*:  
**Flow Of Solids In Bins, Hoppers**  
**Pneumatic Conveying Of Bulk Solids**

\*For more information, please visit [aiche.org](http://aiche.org).

## Off the Press

**Going With The Flow**  
by R. Barnum and J. Khambekar,  
Pharmaceutical Processing, March 2010

**Modeling Particle Flows Through Storage & Handling Systems**  
by B. Pittenger, presented at PEPP 2010 World Congress  
Global Technology Update Forum,  
Zurich, Switzerland, June 13-15, 2010

**Critical Aspects Of Moving Bed Dryer Design & Operation**  
by G. Mehos, presented October 19, 2010 at  
ChemInnovations, Houston TX

**Predicting & Solving Flow Rate Concerns For A Roller  
Compaction Feed System**  
by T. Baxter, C. Galtress, B. Bengel, P. Hreimer, J. Prescott  
presented at AAPS (American Association  
Pharmaceutical Scientists) 2010 Annual Meeting,  
New Orleans, LA, November 17, 2010

**Development Of A Robust Manufacturing Process For A  
Highly Segregating Formulation**  
by T. Baxter, D. Pontious, C. Hernandez, R. Krishnan, J.  
Prescott, presented at AAPS (American Association  
Pharmaceutical Scientists) 2010 Annual Meeting,  
New Orleans, LA, November 17, 2010

**Caking Problems In Candy Manufacturing**  
by C. Hartford, G. Mehos, S. Clement,  
The Manufacturing Confectioner, December 2010

**A Case History: Improving Coal Feed Consistency To The CFB  
Boiler At Gilberton Power**  
by T. Baxter, J. Khambekar, J. Dudish, M. Yester,  
presented at Power-Gen International 2010 in  
Orlando, Florida, on December 15, 2010

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