



**KANSAS STATE**  
**UNIVERSITY**

Bulk Solids  
Innovation Center





# Outline

- History of Bulk Solids Handling at Salina
- About BSIC
- Industry Partnership
- Vision
- Research Capabilities
- Training Programs/Certified Courses
- Under-Graduate and Graduate Programs in Bulk Solids
- Consultancy (Contract Research)
- Networking Opportunity



# History of Bulk Solids Handling at Salina, Kansas

**Entrepreneurial – Inventive – Collaborative**

## **1940's:**

- Salina was one of the largest flour milling centers in the US.

## **1950's:**

- Bulk transit being developed for human consumption.
- Western Star Mill millers experiment with pneumatic conveying.
- Collaboration with local business-Salina Manufacturing Company
- Develop flour conveying algorithms based on science and physics.
- Product lines for pneumatic conveying are developed.

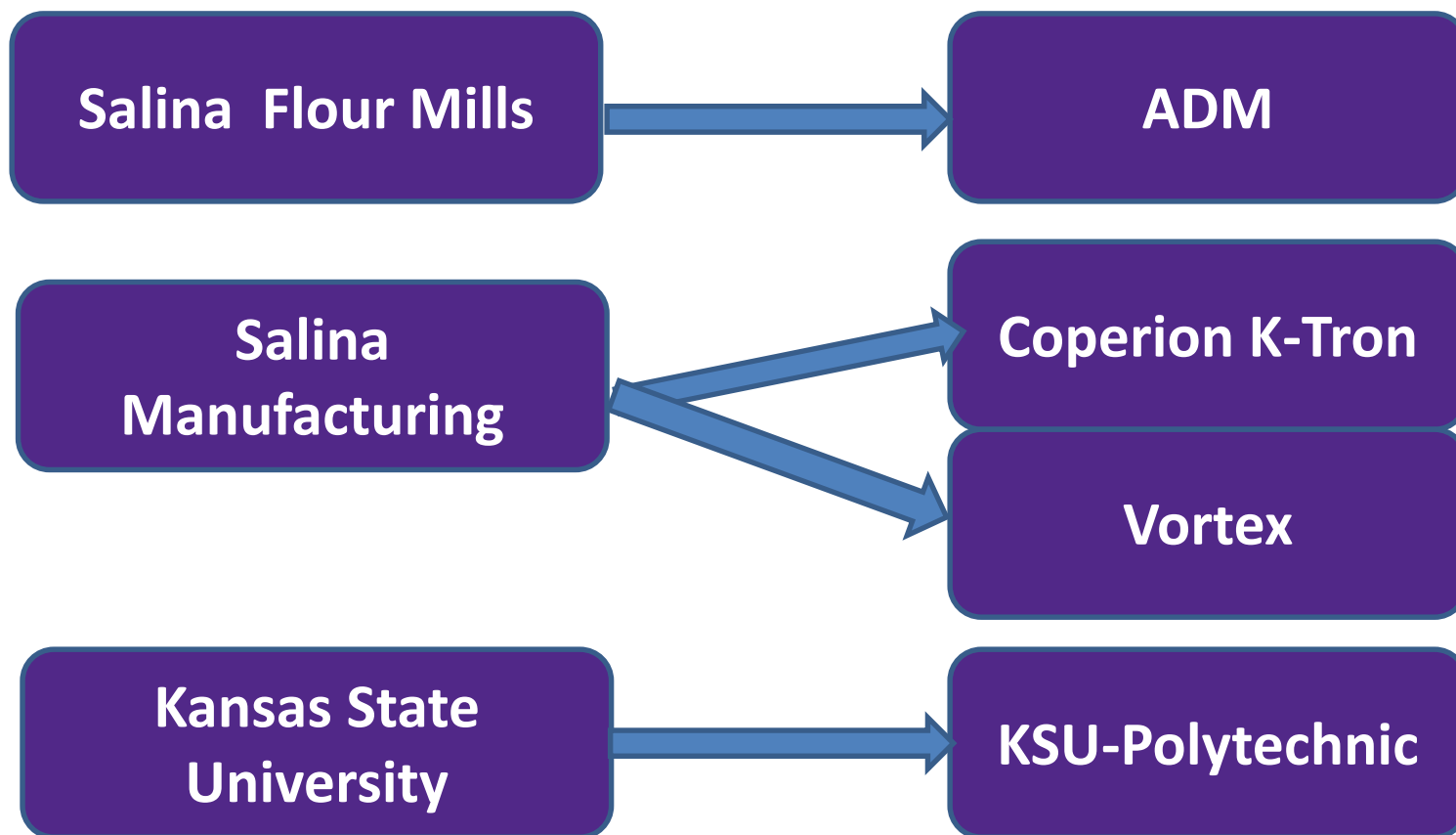
## **1960's:**

Salina Manufacturing further develop conveying algorithms for plastics, minerals, and chemicals



# History of Bulk Solids Handling at Salina, Kansas

**1970 to 2000:**





# History of Bulk Solids Handling at Salina, Kansas

## **2009:**

There was a talk by a group of people from KSU, Salina Chamber of Commerce, K-Tron and Vortex about a creating a center for bulk solids handling research and education

## **2014:**

With the help of federal, state and local government support along with \$2.5M of equipment donation from 25 different companies, at a cost over \$5M Bulk Solids Innovation Center ground was broken.

## **2015:**

KSU Bulk Solids Innovation Center was opened.





# Open House at BSIC





# About BSIC





# About BSIC

- Two story Building (13,000 ft<sup>2</sup>)
- Six laboratory Spaces for University and Industry Sponsored Research
- Training/Education, Conference and Lecture Rooms
- Material Property Test Lab
- Full Scale Bulk Solids Test Bay





# BSIC: Plan View



Full Scale Bulk Solids Test Lab



# Full Size Silo



Allows study of full sized storage and gravity flow, along with vertical conveying up to 65 feet to the top of silo



# Different Size Systems



**Dense Phase System**

Receiving  
Hopper

Feeding  
Hopper



**Dilute Phase System**





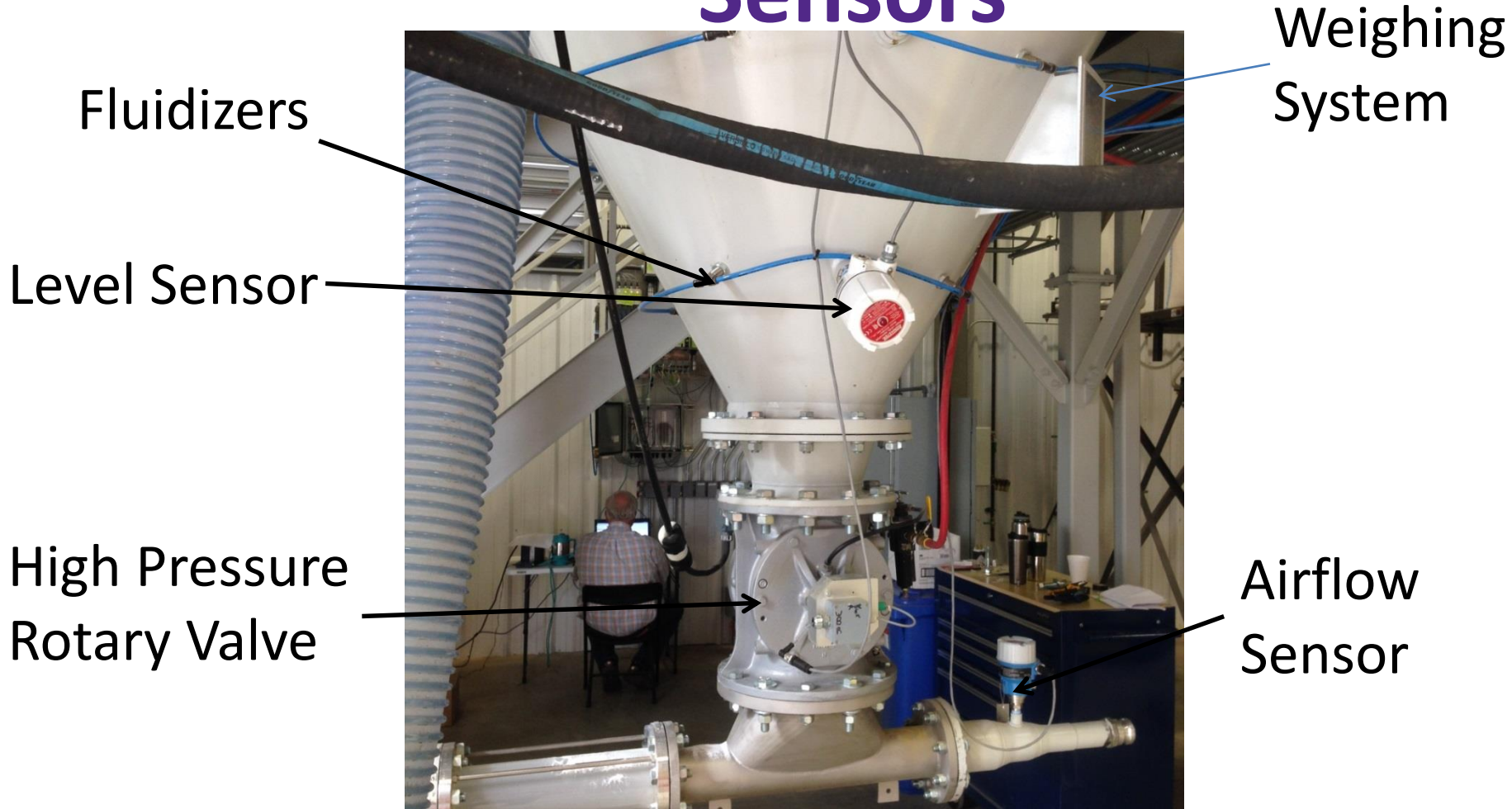
# Different Size Bins



Allows study of variable discharge geometries and flow aids  
Gravity flow study

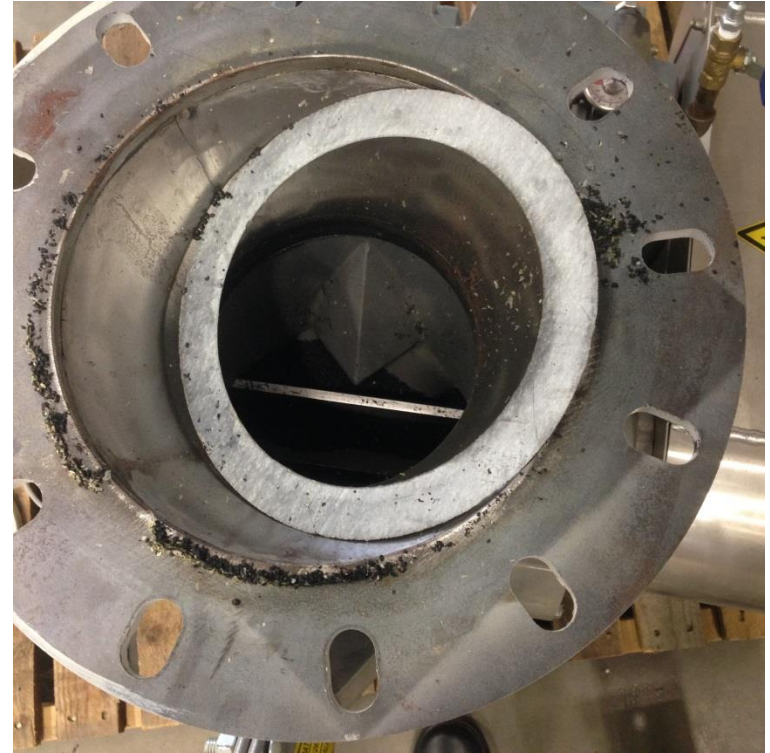


# Sophisticated Controls and Sensors





# Different Type Feeders







# Conveying Lines



**3", 4" and 6"**

Horizontal distance conveying up to 950 ft  
Vertical distance conveying up to 65 ft



# Vacuum Sequencing Set-up



# Pilot-Scale Pneumatic Conveying Demo System-Teaching Tool



Can visualize dilute and  
dense phase conveying





# Different Type of Feeders





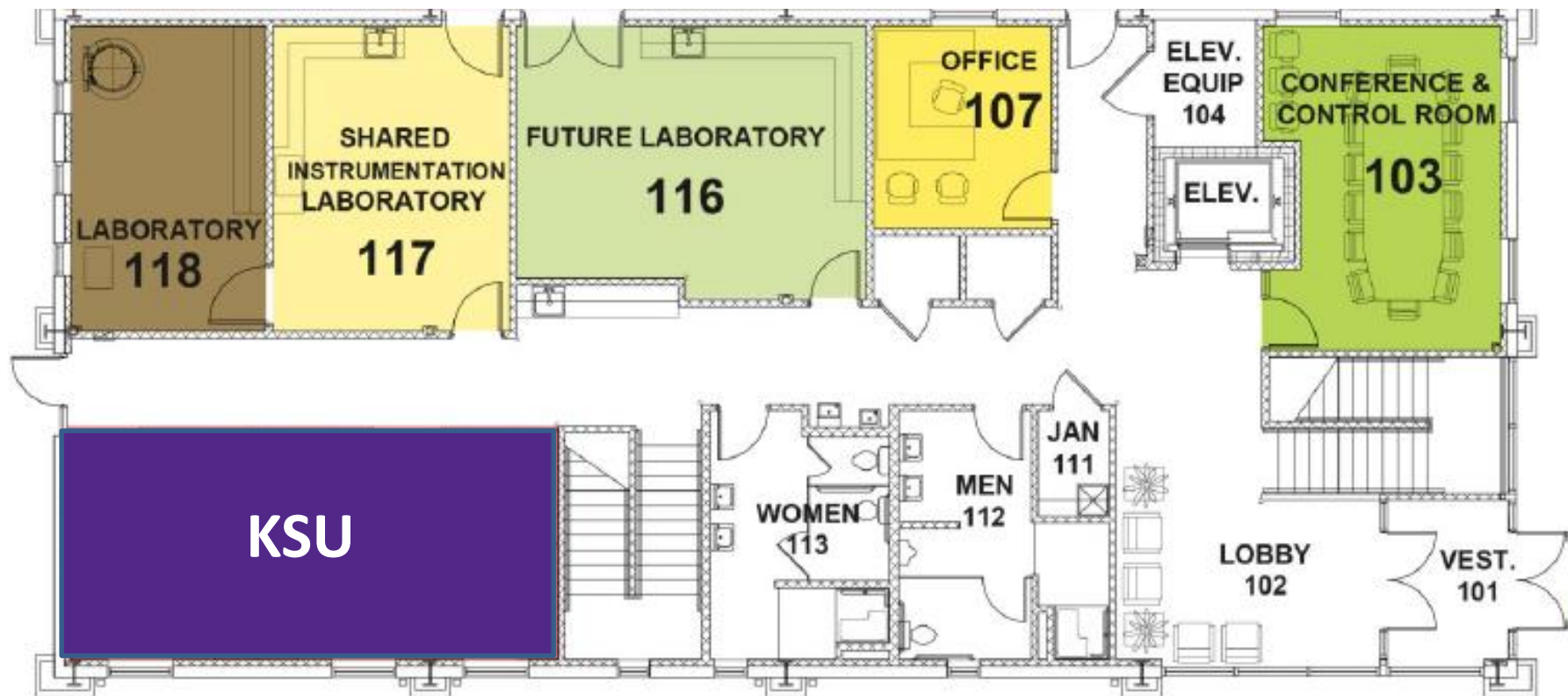
# Materials for Testing



The center can handle materials received by rail, truck, box, bags and bulk bags



# BSIC: Plan View







# BSIC: Plan View





# Experimental Data Monitoring & Acquisition

- It has controls, interfaces, monitoring, and data acquisition of all parameters.
- Real-time data from hundreds of sensors measuring parameters such as pressure, temperature, flow rate, velocity, amperage, power consumption, weight, and time.
- Data is stored on a server from which raw data, trending information, and graphs can be displayed.



# Material Property Test Lab



## Powder Flow Tester

- Flowability
- Wall Friction
- Bulk Density
- Time Consolidated flow function



# Material Property Test Lab

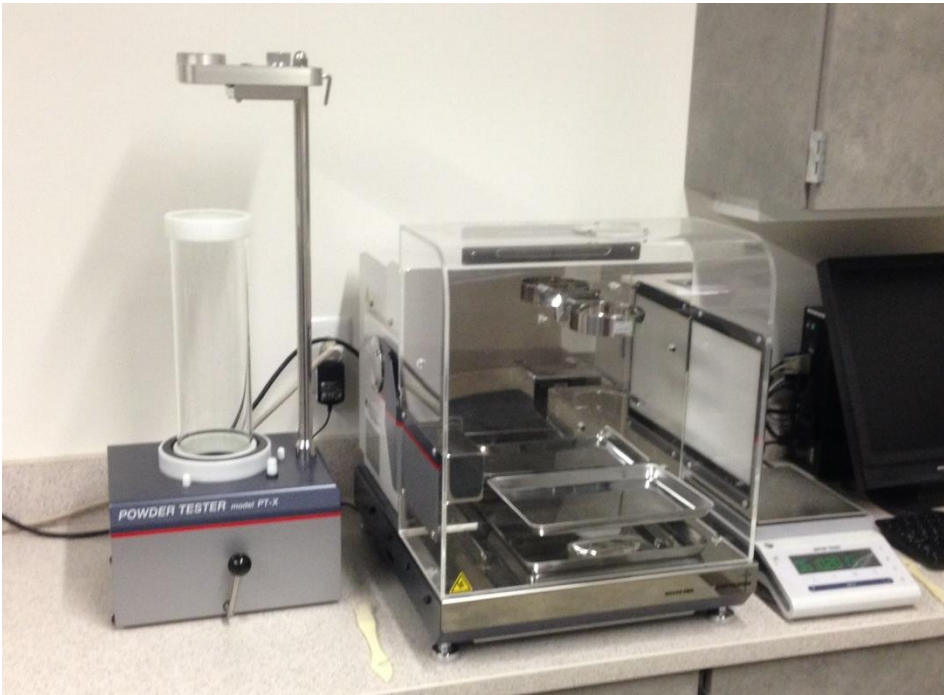


## Particle Size Analyzer

- Particle Size
- Particle Distribution
- Particle size range from 20  $\mu\text{m}$  to 4,750  $\mu\text{m}$



# Material Property Test Lab



## Powder Characteristics Tester

- Angle of repose
- Cohesion
- Compressibility
- Aerated and packed density
- Uniformity
- Dispersibility



Partnership:  
University,  
Government,  
Industry



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## Industry Partners







# Collaborative Partnership

## **Salina Economic Development Corporation**

- Owner of the KSU-BSIC
- Responsible for capital improvements and insurance

## **Industry partner commitment:**

- Provide and install all equipment and controls
- Maintain all equipment
- Maintain the facility
- Pay expenses: utilities, maintenance, upkeep, housekeeping, groundskeeping



# KSU's Role at BSIC:

## Coordinate all Research, Education, and Publicity

- Provide top level Research Candidates: Fellows, Doctoral Candidates, and Students
- Solicit research with industry
- Develop curricula and teach college courses on Bulk Solids
- Organize and publicize continuing education short courses for industry
- Coordinate publicity for the Center
- Maintain the website: **[bulksolids.k-state.edu](http://bulksolids.k-state.edu)**



# Vision

The Kansas State University Bulk Solids Innovation Center will be valued resource to companies that use or produce bulk solids or design systems for handling bulk solids.

The center will study and gain understanding of how to handle bulk solids, enhance efficiency and productiveness in those businesses operations

The center will do research, teaching and consultancy on bulk solids problems



# Dry Bulk Solid Materials

## Examples:

### Plastics:

Polyethylene  
Polypropylene  
PVC  
Nylon

### Chemicals:

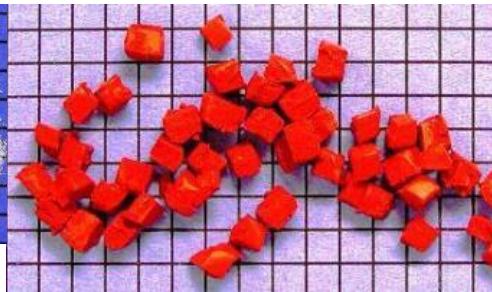
Calcium Carbonate  
Metal Oxides  
Stearates  
Dicalcium Phosphate

### Food:

Flour  
Sugar  
Coffee  
Peanuts

### Compounding:

Clay  
Wood Flour  
Mineral Fillers  
Titanium Dioxide





# Research Capabilities

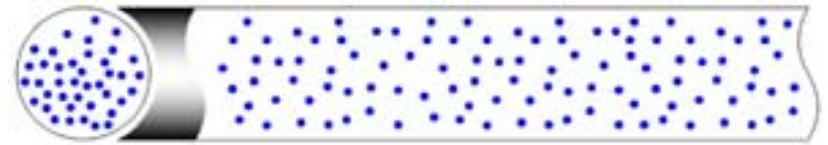
## Particle properties affect:

### A. Conveying Systems

The following flow types can be studied at this center

#### Dilute Phase

1. Vacuum
2. Pressure
3. Vacuum Sequencing



#### Problems in Dilute Phase Conveying

Attrition and wear

Segregation

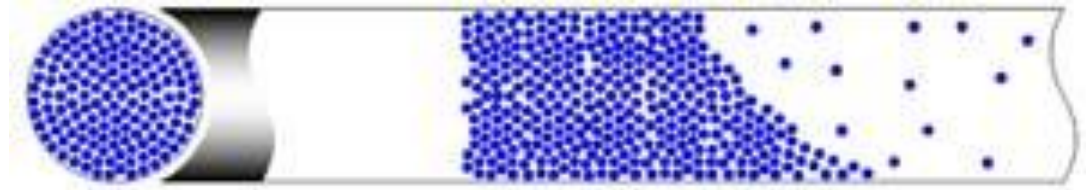


# Research Capabilities

Particle properties affect:

## A. Conveying Systems

### Dense Phase



1. Vacuum
2. Pressure Vessel
3. Rotary Valve

### Research on Dense Phase Conveying

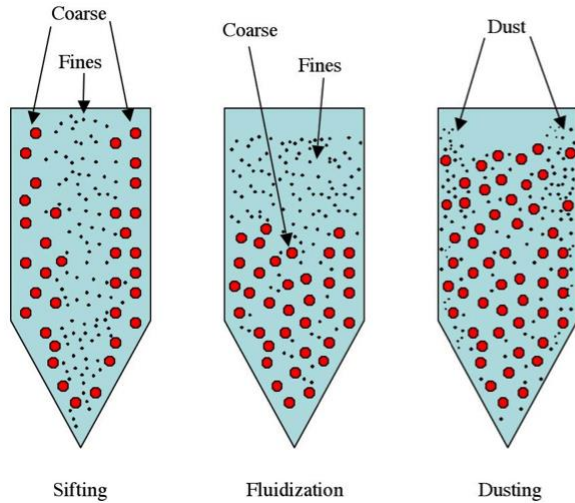
Reducing velocity to eliminate degradation and wear

Optimizing the pressure and airflow

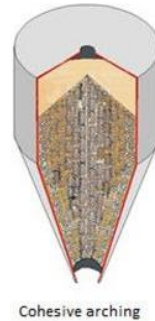




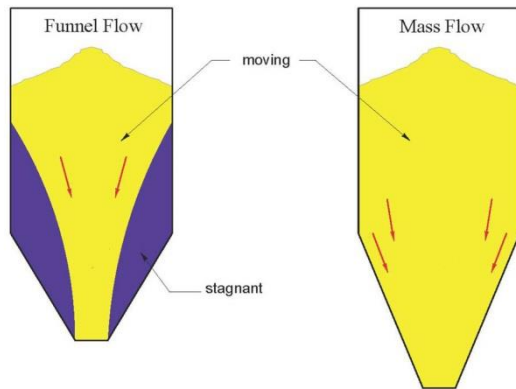
# Research Opportunities: Problems in Bulk Solids Handling



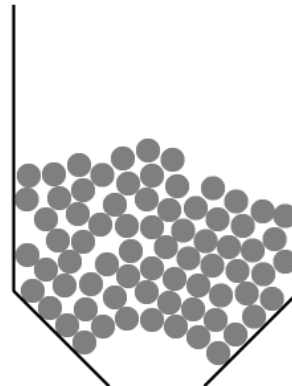
## Cohesive Arching



## Ratholing (Piping)



## Interlocking Arch





# Research Capabilities

Particle properties affect:

## **B. Process Systems**

1. Feeding, Weighing, Scaling
2. Silo Blending / Segregation
3. Gravity Flow
4. Particulate Air Filtration



# Research Capabilities

## Particle properties insights:

### **C. Bench Scale Material Characterization and Properties Testing**

- Particle size,
- Particle size distribution,
- Particle shape,
- Loose and compacted bulk density,
- Particle density,
- Angle of slide, Angle of repose,
- Angle of external friction,
- Angle of internal friction,
- Moisture content



# Research Capabilities

## Particle properties insights:

- Friability
- Agglomeration
- Adhesiveness
- Cohesiveness
- Abrasiveness
- Hardness
- Air retention
- Terminal velocity
- Saltation velocity
- Flowability
- Fluidizability
- Permeability





# Research Capabilities

## Particle properties insights:

### **D. Modeling**

### **CFD, FEM and Discrete Element Modeling of Bulk Solids Handling**

- Flow patterns
- Stress distribution
- Velocity profile
- Segregation patterns
- Particle distribution
- Power consumption



# Why Study Dry Bulk Solids?

- It is not well defined, like gases or liquids
- The fundamentals of bulk solids properties are not well understood
- Both Applied and Basic Research are needed
- A better understanding of bulk solids handling will help many industries



# Education

## **Continuing Ed / Professional Development Short Courses:**

Each course is 3 to 4 days, with comprehensive in-depth training from the most experienced instructors in the country. Courses include lectures, discussion, laboratory time, and considerable full-scale hands-on training.

### **Current course offerings** (see [www.bulk-solids.k-state.edu/profdev](http://www.bulk-solids.k-state.edu/profdev) )

- **Online Fundamentals of Bulk Solids Handling**
- **Pneumatic Conveying of Powders and Bulk Solids**
- **Refresher Course on Bulk Solids Handling**
- **Storage and Flow of Bulk Solids**



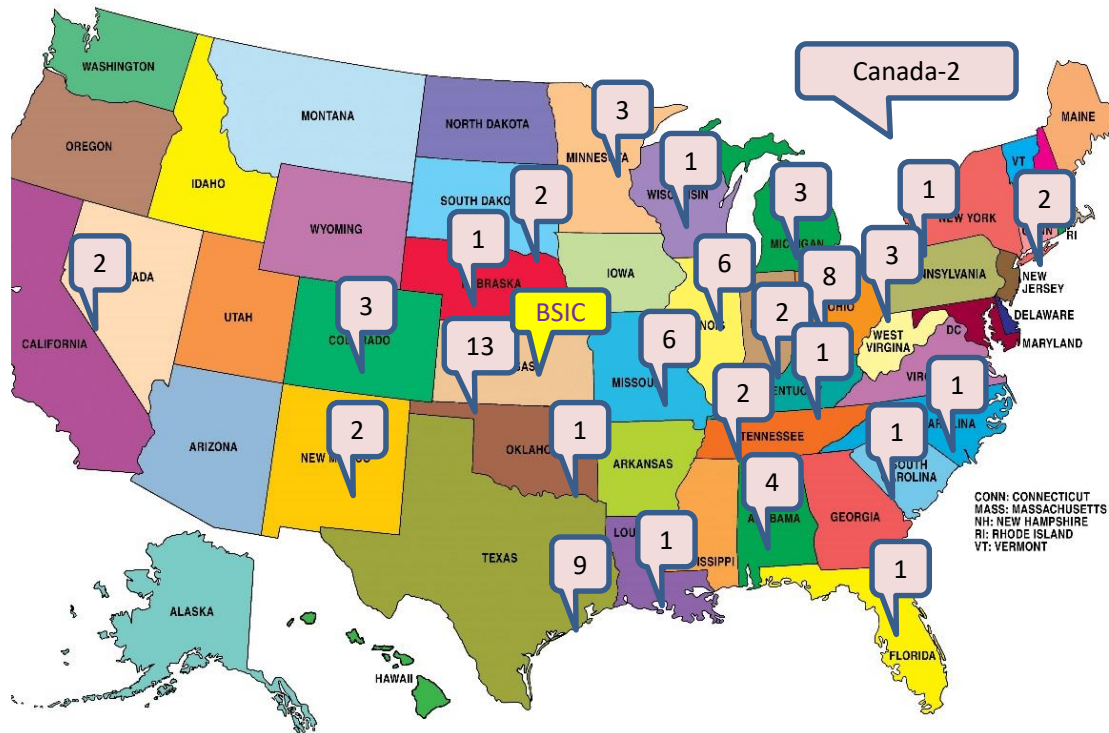
Short Courses Participants Details:  
2016: 79  
2017: 28 (Including March Registration)

Material Testing : 3 Companies

### The following company where people enrolled in the short courses

#### Company Names:

A Schulman  
ACME Constructors, Inc  
Archer Daniels Midland Co.  
Ascend  
Bergquist Company- A Henkel Company  
Bestolife Corp.  
BioMatrix Inc.  
Bonar Inc.  
Bridgestone  
BUNGE MILLING  
Bunge Milling  
Burrow Global  
Cargill  
Carlisle Syntec  
Cascade Eng. /noble polymer  
ChaDa Sales, Inc.  
Chemstress Consultant Co  
Chevron Energy Technology  
COLOR MASTER  
Continental Contitech  
Coorstek  
Coperion K-Tron  
CP Kelco  
Custom Equipment Design  
Ensign Equipment  
ExxonMobil Chemical  
Firestone Building Prod.  
Green Dot  
GSK  
Horizon/Miocene



#### Company Names:

J&M Tank Lines  
Kellogg Company  
Kice Industries  
Kiewit Engineering and Design Co  
Magnum Systems - Smoot Div  
Mars Chocolate NA  
Nestle Purina  
NOVA Chemicals (Canada) Ltd.  
Nutriliate  
Omya  
Phibro Animal Health Corp  
POET  
PolyOne  
POWER Engineers, Inc.  
Pulva Corporation  
Rehrig Pacific Company  
Saint Gobain  
Sasol  
Schenck Process  
Shell  
Styrolution  
Styrolution Americas LLC  
Teknor Apex  
Tinsley Company  
Traditional Medicinals  
Uniform Color Company  
University of Minnesota  
Vortex Valves  
WAM USA Inc  
Washington Mills  
Washington Penn Plastic Co  
Wenger Manufacturing Inc

Refresher Course: 52  
Pneumatic Conveying Course: 49  
Storage and Flow Course: 6

Online Course: 7





# Target People

- Technicians and Operators
- Engineers and Technical Directors
- Students
- Managers
- Researchers
- Manufacturers

Courses can be customized for a particular customer's need



# College Student Education

## **Near Future:**

### Undergrad Program

BS (Mechanical Engineering Technology) specialized in Bulk Solids

### Graduate Program

- MS (Powder and Bulk Solids)  
(regular, part-time and distance learning)
- PhD (Powder and Bulk Solids)  
(regular)

Student will work as part-time staff in the center and learn hands-on bulk solids problem and solution by working on different industrial projects



# Consultancy

## Contract Research:

Do research on specific problems for a particular industry and give recommendation for process improvement such as improving reliability and reducing the operational cost.

The research activity involves:

- Material property testing
- DEM modeling
- Large-scale flow study



# Networking

## **BSIC - a place of networking:**

- Industry equipment details and demonstration
- Bulk solids handling experts and users







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# Thank You

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