BULK VELOCITY METERING APPARATUS

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Abstract

This project details an engineering design presentation addressed by Mechanical Engineering Technology Students at Kansas State University Salina, for a local company. K-Tron, a leader in pneumatic conveying and feeing systems, presented the need for a more effective and consistent method to effectively test the saltation velocity of materials their customers desire to convey, before beginning the design process. Saltation velocity is defined as the actual gas velocity in a horizontal pipeline at which particles in a homogeneous mixture with the conveying gas will begin to fall out of the gas stream.

The test lab facility at K-Tron currently consists of a test line, which is a scaled down version of a real world conveying system. To test the saltation velocity, material is poured directly into the unpressurized test line, where it rests until air flow is introduced. Due to its stationary initial position, the airstream tends to flow right over the materials top surface. This testing method requires a higher air flow rate before the majority of the material can be suspended in the air stream, which causes engineers to overdesign a system for that material, increasing costs.

This project will explain the process the group utilized to design, build, and test an apparatus to eliminate this problem entirely by creating a metering system that allows a material to be dropped at a consistent rate into an already existing airstream.

Introduction

Pneumatic conveying systems transport bulk material throughout numerous industrial plants each day. The operation of pneumatically conveying these materials can be tedious and very costly. The goal of this project is to design, build, and test an apparatus for consistently metering material into an already constant air stream, where the lowest adequate saltation velocity can be found.

Technical Approach

A list of function requirements provided by K-Tron were combined into an extensive list of design specifications. An evaluation of alternative solutions identified a pneumatically operated slide gate valve to be the optimal solution to the problem. To provide a superior solution, all of the provided functional requirements were integrated into a compact, light weight, stainless steel design. This design consists of slide gate valve, onto which an acrylic vertical chamber is mounted on one side of the slide gate blade. A material chute was designed for the opposite side of the valve, to easily fasten it into the pre-existing test line.

Results

Test results conclude that each material tested with the new slide gate valve cut the flow or saltation velocity in half. This time difference was a direct result of the material being dropped into an already flowing air stream where it starts suspended, and remains that way. The results prove that the new design provides a more accurate way for K-Tron to compute saltation velocity. As a result, the provided system will enable a more adequate analysis for K-Tron employees to quote new systems for the customers in their field.

Old Method			
Material	**Material Weight (lb/cu.ft)**	**Flow Velocity (ft/min)**	**Time (s)**
Plastic Pellets	37	3600	2.83
	37	3600	3.16
	37	3600	3.03
Foundry Powder	92	6800	16.43
	92	6800	17.63
	92	6800	18.9

New Method			
Material	**Material Weight (lb/cu.ft)**	**Flow Velocity (ft/min)**	**Time (s)**
Plastic Pellets	37	3600	1.20
	37	3600	1.29
	37	3600	1.46
Foundry Powder	92	4400	6.33
	92	4800	3.63
	92	5200	2.36
	92	5600	1.81

Technical Accomplishments and Design Lessons Learned

Being able to retrofit the testing apparatus into the existing system was a challenge and our greatest accomplishment. The parameters and budget which K-Tron had set pushed us to examine various options of design and function to obtain one successful outcome within the time line. Our team was able to envision everyone's ideas and pool them together throughout this project; we believe this to be our greatest lesson learned involving design.

Conclusion

In conclusion all the design specifications were met to provide an innovative solution to K-Tron's design project. However, In the future, the design team would recommend automating the system to minimize human error, increasing efficiency and saltation velocity calculation accuracy. Recommendations provided by the team include using a programmable logic control (PLC) to control the DCV, and integrating a timer to start immediately when the valve is opened. A photo-eye sensor could also be designed and installed to detect the exact time when the material has traveled a set distance.

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BULK VELOCITY TEST METERING APPARATUS

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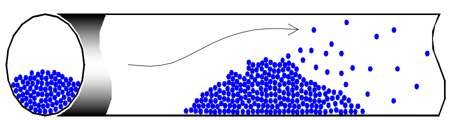
Introduction

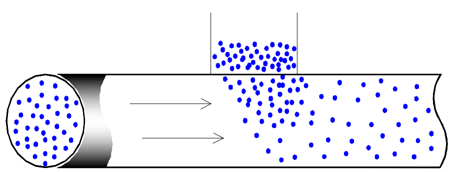
K-Tron designs and manufactures vacuum and pressure conveying equipment for pneumatically conveying bulk material in industrial processes. In order to effectively convey dry material, the air velocity at which the material remains suspended within an air stream, which is called saltation velocity, must be known. Finding the lowest adequate saltation velocity of a material is crucial to being competitive in the pressure conveying market. K-Tron currently finds the saltation velocity of a material by pouring it directly into the bottom of the convey line, then introducing air flow, and recording the time it takes the material to travel a set distance at that velocity.

Project Overview

This project is to design, build, and test an apparatus for consistently metering material into an already constant air stream, where the lowest adequate saltation velocity can be found. K-Tron Salina's current testing parameters require the material to be resting in the bottom of the test line before air flow is introduced, which requires higher air flow than necessary to suspend the material. This higher saltation velocity can mislead engineers into designing a system with more air flow than actually required for the application, which increases system costs.



Current Method



Ideal Method

Project Objective

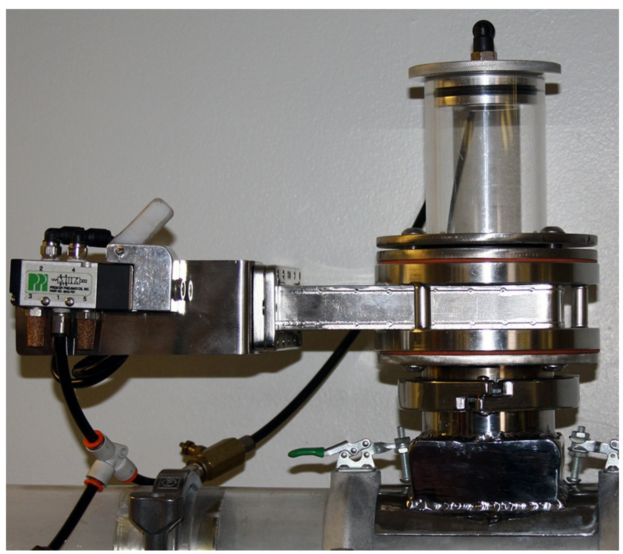
Build, install, and test a new metering apparatus for introducing 1/100 cu.ft. of material into an existing horizontal air stream. The unit should be sealed from the atmosphere, easily cleaned, must be removable, and incorporated into the existing test line. The apparatus must operate with pellet and powder bulk material, and be as compact and lightweight as possible. Stainless steel should be used throughout, in order to increase life and help with cleaning.

Solution

The final design was selected from a combination of individual initial concepts developed by the team. We incorporated the features from each concept best suited for the application into a final design. Providing a slide gate style valve allowed us to design a bulk velocity metering apparatus that ensured any material would flow from the chamber down into the air stream consistently every time. A pressure equalizing hose mounted into the cap enabled us to balance the pressure on both sides of the slide gate to eliminate any back pressure present in the system, which could cause material to drop inconsistently. The chamber on the metering apparatus is designed to simulate one section of a rotary airlock, which is used to meter material in real world situations.

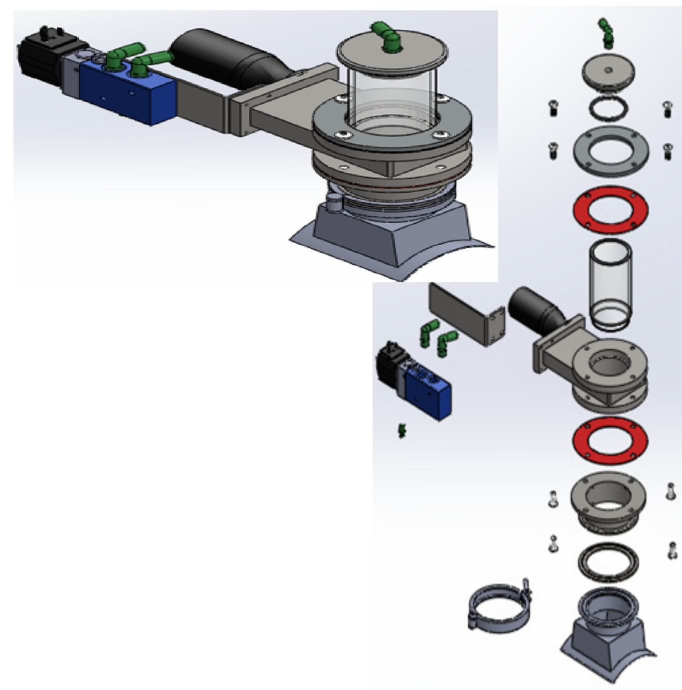
Results

In our tests, we performed K-Tron's saltation velocity test with their current method and then with our metering apparatus. Using the same material and same air flow velocity, we were able to cut the time it took for the material to travel an equal distance in half. Introducing the material into the already constant air stream allows for a much lower saltation velocity. Using a pneumatically controlled solenoid to actuate the valve allowed us to minimize human error, ensuring optimal consistency between materials, and allows for the opportunity to operate the system using a PLC in the future.



Conclusion

In conclusion, the new bulk velocity test metering apparatus is reliable, consistent, and light weight. We as a team are confident our design met, if not exceeded, each specification designated by K-Tron. As a result, the metering apparatus we designed will make performing the required saltation velocity test simpler, and will assist in providing more realistic saltation velocity values to engineers who are designing full scale systems.



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