Minimizing the Generation of Fines and Streamers Through Proper Pneumatic Conveying

D. Ryan Breese
Lyondell Chemical Company

Properly conveying polymer pellets throughout a production plant is critical for efficient operations. Generally, pellets are transferred via conveying air from one location to another. Such processes include unloading railcars and trucks into silos and moving pellets from silos to extruders. Often, the conveying systems are designed with the intent of minimizing installation costs and not maintaining product quality, resulting in the generation of unwanted fines and streamers. As a result, portions of the resin transfer system become plugged, causing unnecessary line down-time and a loss in productivity. By properly designing the conveying system, the generation of fines and streamers can be minimized, significantly reducing the chance for line plugs, cleaning filters, and unwanted down-time.

The goal of this presentation is to develop a general understanding of pneumatic conveying systems and equipment for the polymers industry. An overview of a typical plant's conveying system will be utilized and troubleshooting skills will be presented that will aid in the minimization of fines and streamers generation.

This presentation will begin by introducing two different types of flow, dilute and dense phase conveying. Doing so provides insight into the reasoning behind the design of most conveying systems and how line plugs can form. Next, the mechanism for the formation of fines and streamers will be discussed, with micrographs detailing specific characteristics of each. A typical conveying system and associated equipment will then be introduced. Significant discussion will focus on utilizing specialty elbows for the minimization of fines and streamer generation. In addition, specialty piping and cleaning equipment will be presented that can be incorporated into a pneumatic conveying system that aid in the removal of fines and streamers. General heuristics associated with pneumatic conveying system design, tips for minimizing fines and streamers generation, troubleshooting line plugs, increasing conveying capacity and minimizing wear will also be shared.

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Presented by:
Stephen Dehlinger P.E.
Consulting Engineer
Lyondell Chemical Company

Goals for Today!

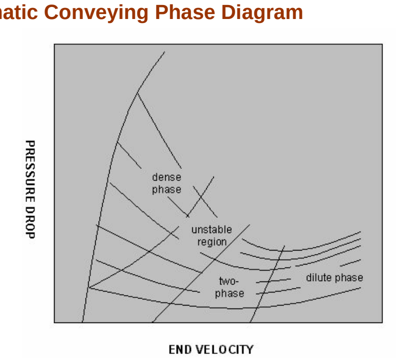
- **Develop:**
  - ***General understanding of pneumatic conveying systems and equipment***
  - ***Understanding of a typical plant's transfer system***
  - ***Troubleshooting skills for fines and streamers issues***

Fines and Streamer Example

What is Pneumatic Conveying?

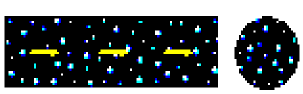
- **Moving objects with air**
  - ***Vacuum - Pull***
    - System pressure is less than atmospheric
      - *Vacuum cleaner*
      - *Drinking straw*
  - ***Pressure - Push***
    - System pressure is greater than atmospheric
      - *Leaf blower*
      - *Garden hose*

Pneumatic Conveying Phase Diagram

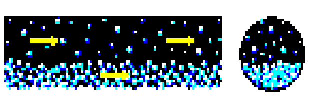


Dilute vs. Dense Phase

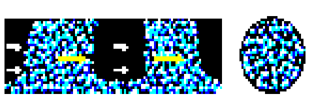
- ***Stream flow (dilute)***
  - Air/solids > 2.25



- ***Two-phase flow***
  - 2.25 < air/solids < 0.2

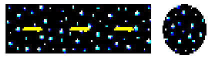


- ***Pulsed piston flow***
  - Air/solids < 0.2



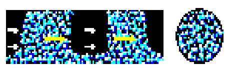
****Loadings ratio in units of scf of air/lbs of pellets***

Dilute Phase Conveying



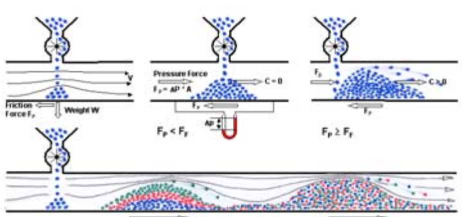
- Objects are suspended in the conveying air
- The transfer velocity is greater than the "saltation" velocity
- Low system pressures (< 14 psig)
- High air to solids loading ratios (> 2.25)
- High linear velocities (3,500 – 7,500 ft/min or greater)
- More destructive -- Mostly due to the high velocities
- Lower capital costs at startup
  - *Lower cost equipment/not rated for pressure system*
- Easier to operate
  - *Wider Δv range on phase diagram*

Dense Phase Conveying



- The transfer velocity is less than the "saltation" velocity at some point in the system
- High system pressures (14 – 90 psig)
- Low air to solids loading ratios (< 0.2)
- Low velocities but high pounds capacity (10^1 – 10^2 ft/min)
- Less destructive – A result of lower velocity
- Higher capital costs at startup
  - *Pressure rated lines, airlocks, valves, etc.*
- More difficult to operate (easier to plug)
  - *Narrower Δv range on phase diagram*

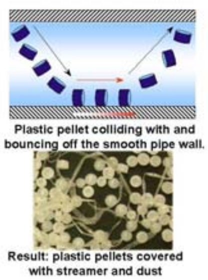
Dense Phase Conveying
Plug Development

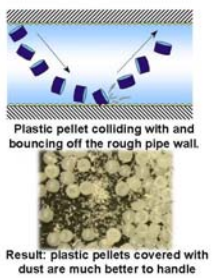


The Origin of Fines and Streamers

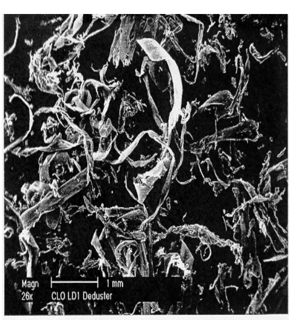
- **Coating of plastic on the inner wall of pipes**
  - ***Formed by heat generation between pellets and pipe wall which results in localized melting***
  - ***Energy = ½ mV²***
- **Skin peels off in strips**
  - ***Becomes streamers, angel hair, and fines***

Fines and Streamer Creation
Fines Easier to Remove





Fines Are "Mini-Streamers"



- **Most fines look like "mini-streamers" under a microscope.**
- **Most fines are generated by smearing and not tails.**
- **Breaking up of snakeskins forms angel hair and fines.**

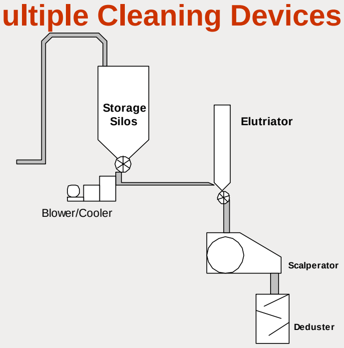
Typical Conveying System

- Feed vessel
- Feed point
  - *Pressure system: air lock (rotary valve)*
  - *Vacuum system: gate valve*
- Air mover (blower)
  - *Pressure: Mover at the solids pickup*
  - *Vacuum: Mover at the discharge vessel*
- Air cooler – Pressure Systems
  - *Located upstream to the pickup location*
  - *Concern with pressure systems due to the temperature rise induced by the blower*

Typical Conveying System, Continued

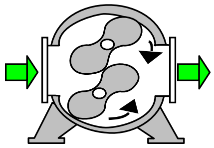
- Transfer line
  - *Including piping, elbows, and divert valves*
- Discharge vessel
  - *Extruder feed vessel*
  - *Railcar loading vessel*
- Particulate removal equipment
    - Bag filters (suction of vacuum blowers)
    - Dedusters (fines)
    - Elutriators (some fines and streamers)
    - Scalperators (fines and streamers)
    - Aspirators
  - *Tangential entry vessels (Cyclones) can generate streamers !*

Pellet Transfer System
Multiple Cleaning Devices



Lobe Blower (Positive Displacement)

- Ideal for long distances
- Horsepower increases as pressure increases (proportional to conveying rate)
- Ideal for varying pressure
  - *Wide variety of feed rates*
- Typically dilute phase



ROTORY "LOBE" BLOWER

Lobe Blower Operations

- Blower operates on differential pressure
- Constant volume of air per revolution
- Relief valves on discharge typically lift between 11 - 14 psig
- Higher pressures result in higher discharge temperatures
- To control air velocity:
  - *DO NOT starve the blower intake*
  - *Change rpm or install bleed off of blower discharge*

Rotary Feeders

- Typically operate between 10-30 rpm
  - *Higher speeds may not mean higher conveying rates*
    - Excessive rpms prevent pockets from filling
    - Venting of the rotary valve is important
    - Excessive Tip/End Clearance wastes conveying air.
    - Blow through can suspend pellets and prevent filling.
- High-pressure air locks are available

The Common Elbow

- Long radius bends
  - ***Lowest –ΔP***
    - ~20 ft of straight pipe
  - ***Generates streamers***
    - Pellets smear against the outermost wall of the elbow
    - Frictional heat causes the outer portion of the pellet to melt
      - Leaves a coating on the pipe
    - This coating peels off as snakeskins
      - Broken into angel hair and fines

Specialty Elbows

Hammertek Elbow

Dead End Tee

Pellbow

Gamma / UK Bend

Minimize pressure drop
Minimize streamers
Elbow life
Cost
Easy to installation
Space restrictions

Diamond Cut

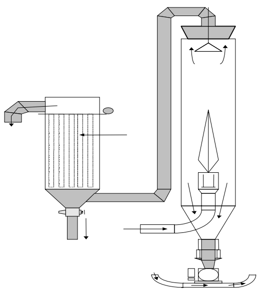
Specialty Piping

- Shot peened
  - ***Shot roughens the inside of the transfer pipe***
  - ***Roughening prevents the formation of snakeskins***
  - ***Helps with reducing large snakeskins but generates more fines***
  - ***Inexpensive initial cost, can have short life span with abrasive products.***
  - ***Rotating piping is effective at extending life.***

Specialty Piping

- Spiral grooved
  - ***Lip is machined into the inner wall of the pipe***
  - ***Lip acts as a speed bump***
    - Prevents the pellets from smearing
  - ***Expensive initial cost***
  - ***Has a substantially longer life span than peening***

Elutriators



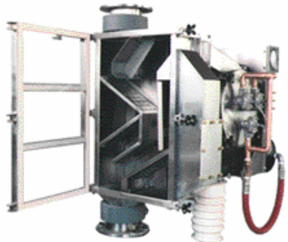
- **Crude removal of fines and streamers**
- **Pellets enter from the bottom and fall into a rotary feeder**
- **Fines become entrained in wash air and are pulled out from the top**

Scalperator

- ***Pellets and fines pass through a rotating perforated barrel***
- ***Streamers go over the reel and are removed.***
- ***Elutriation air removes fines and some streamers.***
- ***Wipers on reels require significant maintenance.***

Deduster

- *Pellets pass down tiers with countercurrent air removing fines*
- *Removes both fines and small streamers*



Ideal Pneumatic Conveying Conditions For Pellet Conveying

- ***Velocities***
  - Pickup = >3,500 ft/min for pressure
    = >4,000 ft/min for vacuum
  - Terminal (exit) should be less than 6,000 ft/min for attrition minimization.
  - Velocities can be reduced for smaller lines.
- ***Temperature***
  - As close to ambient as possible!
  - Temperatures above 100 °F are excessive for many products.

Designing Line Layout

- **Avoid inclined lines**
  - ***Keep lines horizontal and vertical***
- **Avoid bends and use direct paths**
- **Avoid installing elbows within close distances to each other**
  - ***Have a straight stretch between elbows***
  - ***Never use more than two bends in series***
- **Avoid bends within 23-30 pipe diameters from the pickup point**

Designs That Cause Line Plugs, Continued

- Air system
  - *Excessive solids content (rate)*
  - *Leaking equipment*
  - *Inefficiencies due to wear, plugged filters etc.*
- Material buildup in line
  - *Result of fine materials and moisture*
  - *Additives, etc.*

A line plug will typically be found about 40 D. downstream of a leak

Ways To Increase Capacity

- Minimize the number and/or install low pressure bends.
- Optimize solids to air ratios and possibly reduce air flow and velocities.
- Increase the line diameter near the end of the system – Step the line diameter.
- Install pressure/speed controller for Feeder.
- Minimize or eliminate flex hoses
- Check sloping lines for recycling of material
- Shorten the total conveying distance

Ways To Minimize Wear in Conveying Lines

- Wear:

$$\textit{Time to Failure} \propto (\textit{linear velocity})^{4.2}$$

- Reduce conveying velocities
- Use wear-resistant materials
- Minimize line length and number of bends

Top Five Reasons for Fines and Streamers Issues…

1. High transfer velocities
2. High conveying temperatures
   - *No cooler on pressure system*
3. Long radius bends in service
   - *Especially near the end of a conveying system*
4. No fines and streamers removal device
   - *Bag filter on vacuum suction*
5. No preventative maintenance for silo washing
   - *Rinse out silos at least semi-annually*

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Thank You

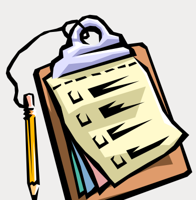
PRESENTED BY

Stephen Dehlinger

Consulting Engineer

Lyondell Chemical Company

Stephen.dehlinger@Equistar.com



Please remember to turn in your evaluation sheet...