Performance and Efficiency of Vacuum Conveying Systems for Highly Volatile Oil Spices: A Case Study

Introduction

Pneumatic conveying is a process for transferring bulk materials through pipes from one source to another using air as the conveying medium. The flow pattern in the pipes depends on the characteristics of the materials to be conveyed and the ratio of solids to air. A properly designed pneumatic conveying system offers a simple and economical means of transporting powders and granular materials at the factory or plant site.

Vacuum conveying systems are based on suction of powders from the pick-up point to the customer's process equipment viz. silo, hopper, mixer etc. (product is transferred in a timed manner to the vacuum receiver). At the end of the timed sequence, the discharge valve opens and the conveyed material is discharged into the process.

The most commonly employed technique in the food industry is dilute phase conveying in which the material is entrained in the air stream (air and product in a certain ratio). This technique can virtually convey any product regardless of particle size, shape or density and hence, is the most popular mode of vacuum conveying.

Advantages of Pneumatic Conveying Systems

- Relatively economical to install and operate
- Minimum degradation during product transfer (depending on the product characteristics)
- Little or no product exposure to the environment
- More environmentally acceptable and easy to maintain
- Transport of materials possible at relatively longer distances
- Excellent for multiple sources and multiple destinations
- Flexibility in terms of rerouting and expansion
- High reliability of system with comparatively fewer moving parts
- System customization possible based on customer requirements

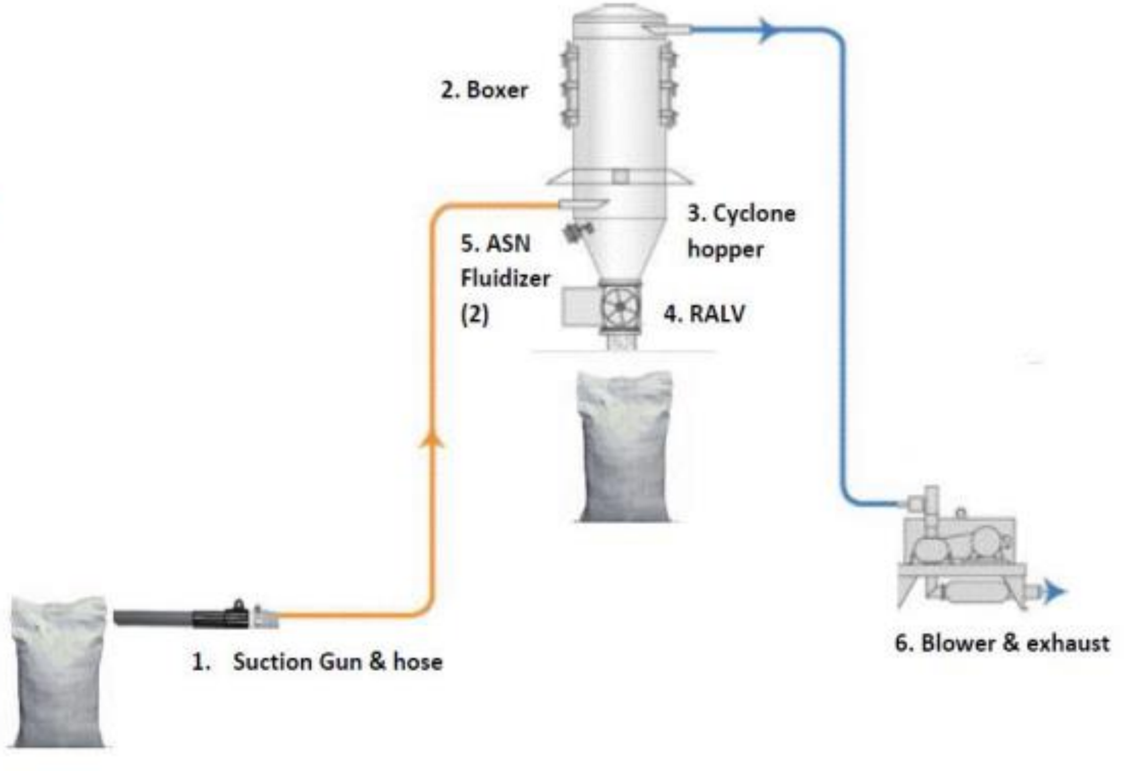
Challenge

A global food company approached Gansons to provide a suitable material handling solution for conveying spices. The company was encountering issues in conveying of highly volatile oil spices during formulation of their multi-spice mixture. In addition, the company wished to automate the entire process to minimize material waste and reduce manual intervention.

Solution

Gansons proposed the use of a vacuum conveying system for transfer of extremely volatile spices such as cumin and coriander. The setup is illustrated in Figure 1.

Figure 1: Setup of Vacuum Conveying System for Transfer of Cumin and Coriander



The vacuum transfer system included the following components:

1. **Suction Gun and Hose**: Used for material pickup through polypropylene bags.

2. Boxer: This is a highly efficient compact pneumatic conveyer used for transferring material from retaining hopper to filling hopper and consists of a single pleated filter unit (Filter size: 5 µm) (Figure 2).

3. Cyclone Hopper: Receiving hopper with single maintenance hole and material inlet at an inclination from horizontal for better cyclonic action (Figure 3).

4. Rotary Air Lock Valve (RALV): RALV-200 mm ø RALV with a housing vane clearance of 0.3 mm and quick cleaning. Rotary air lock valve is used in bulk handling systems to function as a rotary airlock seal and prevent backflow of material in a pressurized system (Figure 4).

5. ASN Fluidizer (Air Sweep Nozzles): Essentially a silo fluidizer, functioning as an antibridging and rat-hole disruption equipment. Compressed air actuated, pressure requirement - 4 bar (Figure 5).

6. Blower and Exhaust: Centrifugal type blower (Figure 6)
Make – Busch
Vacuum rating – 480 mbar
Drive – 2.2 KW, 6 A , 60 Hz
Ingress rating – IP 55

Figure 2: Image of a Boxer

Figure 3: Image of a Cyclone Hopper

Figure 4: Image of a Cyclone Hopper

Figure 5: Image of Air Sweep Nozzles

Figure 6: Image of Blower

Results

The design of the vacuum conveying system was based on parameters including material bulk density, physical characteristics of the product and process equipment. The system was used for conveying cumin and coriander (with high content of volatile oil) taking the actual process conditions into consideration. The cumin and coriander powders were heated from ambient conditions (33°C, 78% RH) to 48°C in the Gansons Nauta mixer to enable release of volatile oils and mimic the actual product characteristics during vacuum transfer. Powders were fed through the suction gun into the cyclone hopper (suction time: 165-300 sec; 5-10 cycles) with a blower drive load of 7A. The calculated pickup throughout for cumin and coriander based on inlet duct diameter were found to be 1,250 kg/hr and 750 kg/hr respectively. The leaks in the cyclone hopper due to improper maintenance hole position were arrested through silicone sealant. The powders were stored in the cyclone hopper for 45 minutes and discharged through RALV into a container (Figure 7). It was observed that in the absence of air sweep nozzles (ASN), the RALV was unable to discharge the material due to heavy bridging. When the ASN was operational (2 at 5 second time lag in each consecutive purge), entire material was discharged through the RALV, leaving no trace of material over the walls of the hopper (discharge throughput with for cumin: 2,720 Kg/hr and for coriander: 2,580 kg/hr).

Figure 7: Product Discharge through Rotary Air Lock Valves

Conclusion

The material handling solution provided by Gansons assisted the client in achieving vaccumized transfer of highly volatile oil spices using process equipment at desired throughput and minimum operational problems. Additionally, the system was also found to be apt for transferring other extremely volatile products such as cloves, cinnamon and cassia. Hence, the use of this system could enable smooth and continuous material conveying with minimum errors and ease of operation for the customer.

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