TECHNICAL PAPER

Pneumatic Conveying of Fragile Foods

by John M. Bell
Macawber Engineering

Published in:
Food Processing Magazine August 1997

SUMMARY

The containment of spillage and dusting from material handling systems has always been an important objective in the food processing industry. The paper describes the most effective methods of addressing this objective.

PNEUMATIC CONVEYING OF FRAGILE FOODS

The containment of spillage and dusting from material handling systems has always been an important objective in any process industry, writes John Bell, Mactenn Systems

In the food processing industry, the objective of containment can become paramount in order to prevent problems from pests and/or bacteria. Therefore, in the last twenty years or so, many companies have used pneumatic conveying systems for their material conveying requirements. Initially such systems were typically dilute-phase systems using rotary valves, and were used to convey powders and other materials where product degradation was not important. However, for many products where particle breakage was undesirable, dilute-phase systems were not suitable.

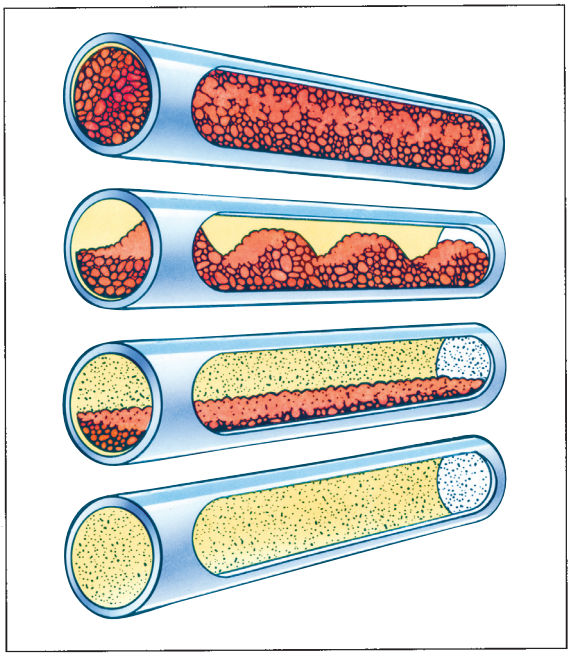
Conveying regimes

In recent years dense-phase systems have been increasingly used as an answer to both product degradation and spillage/dust containment. The four stable pneumatic conveying regimes first described by Jodlowski are well documented. Each regime can be identified by flow pattern, velocity and its relationship to the saltation velocity of material.

The four regimes are summarised as follows:

- *Dilute Phase*: Conveying occurs above the saltation velocity. Material is fully suspended in the air stream, and velocities are typically high. Both negative pressure and positive pressure systems of this type are common.
- *Continuous Dense Phase*: Conveying occurs below the saltation velocity. Material flow is in the form of a continuous moving bed, and velocities are substantially lower than for dilute phase.
- *Discontinuous Dense Phase*: Conveying is well below the saltation velocity. Material flow patterns can vary, but are basically a plug or series of plugs separated by air gaps. Velocity is lower than for continuous dense phase.
- *Solid Dense Phase*: Material is conveyed well below the saltation velocity. The pipeline is generally 80-100% full, and velocity is very low with an extrusion type flow.

For fragile food materials, dilute phase is not selected because of the high velocity. The dilute phase flow regime causes high levels of degradation, due mainly to impact breakage. While the continuous dense phase provides for a lower velocity, this may still be too high for many food products. Also material characteristics often determine the type of flow pattern available to the system designer. Generally only fluidisable powders can be conveyed in the continuous dense-phase regime. Degradation in the continuous dense-phase regime is caused by abrasion (material at the bed/pipe wall interface), and also high velocity impacts especially at the terminal end of the system.



Typical conveying regimes:
Solid dense phase **- very low material velocity, pipeline full of material, ideal for fragile materials, (top)**

Discontinuous dense phase **- low material velocity, with high line loading... material moves in plug flow fashion, suitable for most applications in which power economy, pipe erosion and material degradation issues are important, (second from top)**

Continuous dense phase **- higher velocity than discontinuous dense phase, but much more than dilute phase. Used for handling fluidisable powders, (second from bottom)**

Dilute phase **- material velocity above the saltation velocity, no upper limit to the velocity. Least attractive regime for operating economy, unsuitable for fragile or abrasive materials or materials with wide particle size distribution, (bottom)**

Levels of degradation

Many fragile materials will benefit from conveying in the discontinuous dense-phase regime since the velocities are much lower and impact breakages are reduced considerably. Also, since the material is conveyed in plugs, the amount of material exposed to the pipe wall is reduced, and abrasion effects are lower than for the moving bed type flow. Many powders and granular materials can be conveyed in plug flow with excellent results. These materials include granulated sugar, tea, milk products and non-dairy creamers, raisins and many others. However, for some products, even the low velocity plug flow systems may produce levels of degradation that are unacceptable. An example of this is peanuts.

Mactenn's American parent company, Macawber Engineering Inc., was approached by a major food processing company in Pennsylvania to convey raw, whole peanuts. Because of the roasting process, it was important that the peanuts were not broken or damaged in any way. Breakage and abrasion to the peanut can cause oil cells in the surface layers to rupture. The released oil is oxidised during the roasting process, and this can adversely affect shelf life. Also flavour is directly affected by the quality of the roast.

The company carried out a series of conveying trials at its Maryville, Tennessee testing centre. The target breakage rate was 3%, and conveying tests took place over 40 and 110 metres. The pneumatic conveying regime used for the tests was solid dense phase. The pipeline was maintained full to about the 90% level, and flow was observed to be clearly in an extrusion form. The resulting breakage levels were below 2%. A large conveying system was subsequently installed with a maximum conveying distance of approximately 50m. The system has performed well with breakages now in the 1% range.

In recent years the company has installed peanut systems with distances up to 125m handling raw, whole and split peanuts, blanched and roasted peanuts. The technology has now extended to handle almonds, hazelnuts, blown rice, various forms of cereal, oil impregnated pet foods and various breakfast cereals.

The company continues to research improved methods of handling very fragile materials, and can now also provide very low velocity vacuum systems for certain products and materials. □

An example of a solid dense phase vacuum conveyor which may be applied to bulk container emptying requirements. Material velocity is extremely low without any particle degradation. In this case shelled peanuts are conveyed from a bulk carrier without any degradation of the nut