Finger on the Pulse

The pneumatic conveying of many types of coated granules for the chemical, food, pharmaceutical and detergent industries was not possible in the past because of the unacceptably high product attrition rates during transport. A new pneumatic dense phase conveying system aims to avoid local blocking of the conveying pipe, thus ensuring free flowing and gentle conveying

In the chemical and food industries more and more spray granulated, spray dried and coated products are produced. They have better and easier product handling properties with enhanced dissolving characteristics. These products are often characterised by high specific surface areas and are sensitive to mechanical attrition. A defined and monodispersed shape of the granules is required. Grain size and particle distribution should not be changed. This not only requires the adaptation of the production process but also modifications to the product handling technology, usually involving pneumatic transport. Gentle conveying at low velocity is required.

To reach this goal, today's pneumatic conveying systems are running as close as possible to the pipe blocking limit. Nevertheless high reliability is important especially

when different materials or products with changing characteristics are to be conveyed by the same installation. In many cases starting off conveying with a full conveying line is required.

Design and control of pneumatic dense phase systems

The design of pneumatic dense phase conveyors is determined by the characteristics of the bulk solid materials, the plant requirements and conveying capacity, including:

- Air flow (cum/min), the amount of gas flow in the pipe during conveying.
- Gas velocity (m/sec)
- Product loading ratio (kg/kg), the mass of product divided by the mass of gas flowing in the pipe
- Bulk density, particle size, particle size distribution, cohesion factor, compressibility, particle shape, friction factor, etc.
- Gas type
- Characteristics of the plant such as horizontal length, number of bends and vertical sections
- Conveying capacity.

Advantages and limits of pneumatic dense phase conveyors

In comparison to manual and mechanical enclosed transport systems, pneumatic conveying has the following advantages:

- dust free and hygienic
- minimum labour, operation and maintenance costs
- high operational reliability
- easy adaptation to existing processes: pipe routing can be adapted to existing locations
- Comprehensive automation

For fragile products the traditional lean or dilute phase conveying installations have limitation with regard to product breakdown and therefore considerably slower and more gentle dense phase conveying systems such as the Pulse-Flow have been developed. This technology is a huge advancement due to the following advantages:

- gentle conveying in plugs without segregation.
- low gas consumption, allowing low-cost separators and filters;

advantageous for inert gas operation;
Operation with air from existing compressed air supplies is often possible.

- less abrasion on pipes and bends.
- considerable reduction in noise level
- long service life, no rotating parts
- short investment return period due to improved product quality and reliability

Pneumatic dense phase conveyors such as the Pulse-Flow‘ are used for both free flowing and cohesive powders, coarse-grained solids and granules at capacities up to 100 m3/h with conveying lines over 100 m length. These systems are working in flow regimes having the following characteristics:

r velocity :	2 to 12 m/sec
Product loading:	20 to 150 kg product/kg air
Pressure loss :	0.5 to 2 bar/100 m conveying distance

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All these factors influence the total pressure loss and the sectional pressure loss of the pneumatic conveying system:

■ Total pressure loss (bar) is the pressure required at the beginning of the conveying line.
■ The sectional pressure loss (bar) in longitudinal sections of the pipeline is responsible for the product attrition and for the continuous movement of the plugs, and depends mainly on the critical plug length.

Because of their physical properties not all bulk solids material can be transported by traditional dense phase conveyors. Some product characteristics such as compressibility, air permeability, particle size distribution and hardness etc, can make it difficult to convey gently. The goal was to develop a new dense phase conveying system which is capable of transferring materials without damage.

An additional physical property was introduced to understand the conveyabilty and the movement of the product plugs in the pipe: **The critical plug length**. The critical plug length is defined as the length of the plug, where the friction forces between the pipeline and the moving plug are larger than the impulse and pressure forces of the conveying gas. If this critical length is exceeded, the conveying may be stopped and the conveying line blocked. The value of the critical plug length is larger at the beginning of the pipe. At the end of the pipe the value is smaller due to the decrease of the pressure in the pipeline. The critical plug length is determined when pressure peaks are detected.

The design of any pneumatic dense phase conveying system considers the interaction between the characteristics of many different bulk solids, requirements of plant layout and the required throughput. By means of specially developed computer algorithms using non-linear relations dense phase conveying plants can be accurately calculated.

For the sectional pressure loss the algorithm is (I):

$$dp/dl = Fra * mb * (ds50/D)g * (rs/rl)d * (Tp/Tsline)e$$

(Fr = Froude number, m = product loading ratio, ds50/D = mean particle size/pipe size, rs/rl = bulk density/gas density,Tp/Tsline=pulsating time of the vessel / pulsating time, a,b,c,d,e are non-linear exponents)

Numerous tests in the Gericke test facility as well as some thousand conveying systems supplied into food, chemical, detergent and construction industry confirm the validity of the calculation algorithms.

Controlled plug length

In order to study the conveyability of sensitive granulated products several activator groups were installed into the Gericke dense phase test plant. Self controlled they feed pulsated air into the pipeline. The tests showed that the long plugs causing blockages and product attrition are divided into smaller plugs before they reach the critical plug length. In this way we are able to convey coated detergent granules by reducing the velocity by 30 to 50per cent. This improves product quality by reducing breakdown by 60 to 90per cent.

Based on these tests, the new self controlled dense phase conveyor type PulseLine was introduced for industrial applications (Patent pending). The activator groups are mounted onto the critical sections of the conveying line, where long plugs are expected to block the line. The activator groups cut the plugs, and are only activated when the critical plug length has been achieved. As soon as the plugs are shortened the conveyor operates slowly and gently and the activator groups are automatically turned off. The total additional air amount is minimized and the harmful acceleration of the plugs at the and of the line is eliminated. The result is a soft, continuous movement of the plugs in the conveying line.

Applications of the new dense phase conveyor PulseLine

Thanks to the individually connectable activator groups the new self controlled dense phase conveyor type PulseLine‘ has three main application areas:

■ Gentle conveying of fragile coated granules, spray dried granules, plastic additives and non compressible polydisperse powders for the chemical, food, pharmaceutical, detergent powder (fig.6), and construction industries.
■ The operational safety and the reliability of long conveying systems can be increased. New long distance dense phase conveyors for fragile products can be realized by increasing and optimising the number of the activator groups.
During the start up period of granulators and dryers, the materials to be conveyed have different hardness and other physical properties than during the production phase of the operation. The new dense phase conveyor is able to detect these changes and the self controlled activator groups come into operation.
■ For gentle re-start of the conveying system with filled conveying line.

The design of any pneumatic dense phase conveying system considers the interaction between the characteristics of many different bulk solids, requirements of plant layout and the required throughput

Several dense phase conveyors type PulseLine‘ have been successfully installed. Our industrial sized test plant is available for customers to test the pneumatic conveying of new or fragile products.

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