In different industries, conveying technologies have to transport bulk materials to the designated points of production or storage areas. The cement sector mainly uses mechanical or pneumatic systems and even though the latter have been used for more than a century in various sectors, there is still much demand for new models and the potential for improvement.

There are mainly pneumatic conveying systems in operation today which are based on developments, knowledge and studies from the 1960-70s. Considering improvements in other fields (i.e. material technologies and fluid mechanics) there is scope to optimise and substitute existing pneumatic systems with new technical ones. This can often result in sustainable energy savings and environmentally-friendly options.

**Basics**

The pneumatic transport of bulk materials in pipelines always means a pressure loss, which essentially differs from the pure pressure loss caused only by the air within the pipeline \(\Delta p\) and is usually based on the basic equation:

\[
\Delta p = \frac{\lambda \cdot \Delta l \cdot \rho \cdot L \cdot v^2}{d^2}
\]

For the examination of a two-phase (or gas-solid) flow within pipelines, different theories have been developed \(\lambda, \Delta l, \rho, L, d, v\). It is obvious that the characterisation and calculation of such systems particularly depend on the solid particles and their characteristics (see Figure 1). Furthermore, the characteristics of the piping influence the result.

If different types of solid bulk materials are compared, i.e. coal dust and refuse-derived fuel (RDF) or solid recovered fuel (SRF), it is obvious that ‘normal’ powdery bulk material like coal dust is much more homogeneous than, for example RDF, because the consistency and further characteristics of the particles is more defined. Even though the processing and production of RDF or SRF has improved in recent years, the wide range of consistencies and characteristics of single particles will always influence the pneumatic conveying. These include:

- particle density
- particle shape
- particle size
- particle surface
- piping: material, surface, diameter, length and trajectory
- velocity profile in the piping.

Due to these multiple and complex influences on a pneumatic system (two-phase flow system) it is almost impossible to calculate the exact pressure loss. Therefore, at its test centre Di Matteo has examined more than 400 different types of solid bulk materials, including ‘classic’ powdery bulk materials but particularly solid alternative fuels. For each type of bulk material examined the company recorded the specific relevant characteristics essentially for the design of a successful and stable working injection system.

The need for a stable and reliable injection system has become increasingly important. Considering the different characteristics of bulk materials, a flexible and adjustable injection system is needed which enables the operator to adjust the system to meet changes in operating conditions and materials. Di Matteo describes the possibilities for state-of-the-art pneumatic conveying and an injection system based on an injector rotary feeder.
pneumatic conveying system. Figure 1 shows the diagram for the characteristics of polythene pellets \(3\). Diagrams for other solid bulk materials have also been prepared by Di Matteo.

The operating range of rotary feeders is usually mainly in the area of the dilute phase and, depending on the specific characteristics of the solid bulk material, in the area of the low-velocity phase. Therefore, the majority of bulk materials can be conveyed with a starting velocity \(v_0 \geq 22-27\text{m/s}\), except in the cases of some special solid bulk materials like zinc oxide or mica.

Alternative fuels or RDF differ significantly from other powdery materials. Because of the wide range of particle density, shape and size, a mixture of low-velocity phase and dilute phase can occur within one pipe. Furthermore, alternative fuels tend to form agglomerates, which can lead also to blockages. Therefore, a pipe diameter no smaller than 100mm with an adequate air flow is usually recommended. Often the pneumatic conveying of alternative fuels is used to feed the material into a kiln (ie through the main burner or into the calciner). This is always realised by a dilute phase to achieve a better combustion and distribution within the process.

Considering the above, a stable pneumatic conveying system needs to be designed and tailor-made for the requested bulk material. Furthermore, a flexible system is needed to adjust the optimum operating point to the requirements.

### Characteristics of the Injector rotary feeder IZS

Depending on the specific characteristics of the specified bulk material, the injection into a pneumatic pipeline has previously been undertaken with injector conveyors, blower shoes or blow-through feeders. However, practical experience has shown that these systems are of only limited suitability for many bulk materials, especially in terms of RDF and other alternative fuels.

Furthermore, these systems can only be used for an exact and defined bulk material and must be designed accordingly so that an injector for powdery bulk materials cannot also be used for more granular materials like RDF. Flexibility is thus very limited.

Therefore, Di Matteo set itself the target to develop a flexible injection system for a wide range of different bulk materials, suitable for RDF and other alternative fuels but also suitable for powdery bulk materials like cement, bypass-dust, fly ash or kiln dust.

In the third generation, the ODM – Injector rotary feeder IZS\(^{®}\) combines the proven rotary feeder technology refined by Di Matteo with an injector to ensure a stable and reliable material injection into the piping. The injector principle is an integrated part of the rotary feeder (see Figure 2).

The IZS\(^{®}\) injector rotary feeder is a unique injection system thanks to its flexible and adjustable modular equipment suitable for almost any pneumatic conveying systems requirements.

The cellular rotor sealing system consists of a twin system, a hard and a soft seal, which can be adjusted to specific requirements by combining different available knives and soft sealing types. Therefore, the client can choose the optimum combination of sealings for their needs. This makes the IZS flexible for future because the sealings can be
changed and adjusted without changing the IZS itself. By using the hard seals, the IZS generally has the characteristics of a knife rotary feeder. The knives can be adjusted in the gap and are able to destroy oversized particles like wood or hard plastics. There are different types of knives available according to the modular design.

Furthermore, the combination of a hard seal with a soft seal against the housing makes a significant improvement in the sealing of the cellular rotor against the housing and at the same time provides high wear resistance. The new type of sealing system means that it is also possible, depending on the customers needs, to incorporate either just a soft seal or a hard seal. For high temperature operation, ie bypass-dust injection, there special seals are available. Therefore, the customer has equipment which is sustainable and optimal for a wide range of bulk materials.

According to requirements, all parts that come into contact with the bulk material are replaceable and made of special high-quality and wear-resistant materials.

Another significant feature is the varioJet-nozzle, an injector nozzle that can be adjusted during operation. This flexibility means that the unit can be set to suit the mode of the system’s operation, which makes it easy to compensate for larger feed quantities.

The leakage air can be minimised and the conveying air can be practically entirely utilised for the pneumatic conveying by carefully-controlled injection of the conveying air at high speed through the injector parallel to the axis of the cellular rotor. The behaviour of this combination had been investigated previously in laboratory trials.

Some examples of the test results are shown in Figure 4. In this diagram the static pressure (p<sub>static</sub>) is shown as a function of the distance ‘x’ from the entry of the conveying air into a chamber of the rotary feeder. It can be seen from this diagram that with the ‘traditional’ blow-through rotary feeder, ie a feeder without any nozzle, there is always a positive static pressure that causes the great ‘air leakage rate’ of the rotary feeder.

A negative static pressure that in practice almost completely suppresses the ‘air leakage rate’ was established at the wall over the entire length of the cell by optimising the air inlet nozzle. This can prevent problems with the inward transfer of lightweight alternative fuels. When these enter the cellular rotor they are often forced back in the direction of the feed shaft by the leakage air. This can cause blockages and segregation of the material. The internal pressure of the system opposing the entry of material into the feeder varies depending on the quantity being conveyed and distance covered. This is not the case with the new principle. The negative static pressure eliminates any blow-back of the material being conveyed. This approach has proved successful in industrial applications.

Thanks to the flexible design of the IZS® the varioJet-nozzle can be also dismounted, therefore the characteristics from the complete IZS® become like a normal, but really heavy-duty designed blow-through rotary feeder. So the IZS® gives flexibility to the operator from this point of view as well.

Conclusions

The IZS® ODM-Injector rotary feeder combines the advantages of blowing-through rotary valves and injector systems as well as the advantages of knife-rotary feeders and enables the operator to have just one piece of equipment for all requirements.

The combination of different systems into a single machine means that the disadvantages of the injector or blow-through valve are successfully eliminated.

The latest IZS, in its third generation, offers conveying rates of up to 30tph, depending on the material and other conditions. The unique modular design makes the IZS suitable for the efficient injection of alternative fuels as well as conventional bulk materials like cement bypass-dust and others.

With more than 600 installations worldwide the ODM-Injector rotary feeder IZS® is a proven component in Di Matteo's product portfolio of pneumatic conveying systems. It is also an essential component of the Di Matteo MultiFUEL-philosophy for the sustainable handling of alternative fuels.

References

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