Explosive Matter

By Chris Broadbent at DEC UK Ltd

New developments to tackle the problem of dust explosions during powder transfer and charging have progressed rapidly recently, as a potential new solution enters the market

The hazards of dust explosions encompass all segments of the industry. Some of the more common materials presenting a possible dust explosion hazard are pharmaceutical powders, dyes, fertilisers, foods, grain, insecticides, metals, paper, plastics and rubber. Explosions have occurred in buildings from dust on the floor, on ledges, and in equipment such as bins, blenders, collectors, conveyors, dryers, grinders, mixers, pneumatic transport and storage facilities.

Explosion Prevention

The Powder Transfer System (PTS) is an innovative solution to the problematic and often hazardous operations of powder transfer and powder charging associated with many process industries. The system is used to automatically introduce toxic, explosive or other types of powder to closed vessels containing dangerous vapours and liquids at any temperature.

The PTS is pressure-rated and installed directly onto the receiving process equipment, which are predominantly reaction and mixing vessels. By using a source of absolute vacuum and pressure, the PTS can transfer powders in the same way that liquids can be conveyed, over large distances (horizontal and vertical), in a variety of volumes, all in a safe, contained manner. This means that a powder room on the ground floor can be used to charge reactors at large distances and several floors up.

The PTS works for all powders regardless of their characteristics – even those that are extremely fine, lumpy or even solvent wet – as during the transfer of such materials the PTS will not modify the homogenity of the powder.

A full vacuum draws powder from the storage container – drums, bags, flexible intermediate bulk containers (FIBCs) or hoppers, for example – via a simple lance or suction hopper, and conveys it into the PTS cylindrical chamber. A flat filter membrane

Figure 1: Powder Transfer System

Images: DEC Group

Keywords

Powder Transfer System (PTS)

ATEX Directive

Isocharge Station

Figure 2: PTS installed on the nozzle of a reaction vessel

separates the chamber from the vacuum line, thus preventing powder reaching the vacuum pump. When the chamber is filled with powder, the vacuum valve closes and pressurised nitrogen, or another inert gas, is supplied to the chamber. Once an overpressure is created within the chamber, the powder is pneumatically discharged into the designated vessel as soon as the outlet valve is opened. The overpressure also prevents gas and vapour that may already be present within the reactor from rising back up into the PTS chamber. The source of pressure also serves to clean the filter membrane at the top of the chamber (in a reverse jet) after every cycle of the PTS, thus ensuring that each cycle performs under optimum conditions. Depending on the size of the PTS, a huge range of transfer capacities can be accommodated.

Ignition Sources

The PTS uses pneumatic logic to power the entire process. It forms a physical barrier between the designated receptacle and the PTS chamber, reducing the risk of explosive atmospheres developing without the need for isolation valves. The PTS eliminates most sources of ignition owing to the earthed, conductive components; the lack of moving parts, which excludes incendive mechanical sparks; and the pneumatic operation, which does not require a source of electricity or motors, removing the possibility of electrical sparks and hot surfaces becoming ignition sources.

Electrostatic discharge remains the only potential ignition source. However, this is avoided due to the plug flow of powder in the dense conveying phase through the hose into the PTS chamber. The usual ratio of powder to air is more than 100:1, which is well above the upper explosion limit of most powders. Due to the low conveying velocity, it has been calculated and measured that insufficient energy is created to form an electrostatic discharge, and therefore powders with minimum ignition energy (MIE) of less than 1mJ can be safely conveyed (1).

It is amazing that open manway charging of powders still occurs in a huge number of fine chemical and pharmaceutical plants. Operators are forced to wear heavy, hot and restricting air suits or hoods, which only protect them from inhalation of toxic powders and do nothing to protect them from the potential explosion hazards.

Oxygen enrichment of recipient vessels has the potential for explosion, which is an inherent problem of most powder transfer systems; the only exception is the PTS. A combination of the plug flow conveying, the vacuum within the PTS chamber and nitrogen inertion ensures that the oxygen concentration in the reactor remains below the limit where explosions are no longer possible.

The closed system also ensures that the European ATEX Directive's delimitation of zones does not apply to processes using the PTS system, unlike those utilising gravity-based methods. Problems associated with gravity charging include the formation of explosive atmospheres; the presence of ignition sources; bridging within the powder in a chute; cleansing; and validation. These systems are not inherent within the PTS.

ATEX Exemption

Historically, operations where powders are charged within reactors have resulted most conspicuously in fires and explosions; the risks are increased significantly where flammable solvents are also present within the process. A large proportion of such operations are still carried out manually, thus exposing the personnel involved to immense safety risks.

With or without the presence of flammable gases or vapours, the MIE of the powder and the method of transfer can create the risk of an explosion. In order to increase the safety of these processes, transfer of powders should be carried out in closed systems and the recipient vessel should be made inert. Every precaution should be taken during and after the transfer to maintain the lowest possible oxygen concentrations within the reactor, and the systems should be separated by a physical barrier.

Most gravity-based transfer systems offer poor levels of safety overall, and risks are further compounded by the nature of the material being transferred, as well as the process conditions. This is true to such an extent that an operation that is considered safe under one set of parameters can be de-stabilised by changing one small aspect of the system. The PTS system does not use gravity, eliminates oxygen from the powder, has a physical barrier between itself and the reactor during operation, and provides a safe solution for powder transfer, independent of the nature of the powder and the process parameters.

Support for the PTS to remain exempt from the ATEX Directive can be seen from the following excerpt (2):

"Since the *PTS – Powder Transfer System* does not have its own potential ignition source, it is in my opinion not subject to guideline 94/9/EC [the ATEX directive].

"If a hazard assessment of the *PTS – Powder Transfer System* cannot totally exclude the risk of an explosion due to e.g.:

- The temperature of the product to be conveyed
- Powder which ignites spontaneously when in contact with air
- The possibility of unwittingly imported smouldering combustion

measures to avoid explosions must be implemented according to guideline 98/37/EG (guidelines for machinery), appendix 1, paragraph 1.5.7."

Containment

In addition to the safe transfer of explosive powders and the reduction in operator manual handling, the transfer of highly toxic materials can also be achieved with the PTS, as it is a completely closed system

Figure 3: Isocharge Station for small and medium sized bags of powder

which offers protection to the operators, product and the environment. A number of different devices are available at the supply end of the hose, such as a mini glove box, for transfer of toxic powders from drums, or suction hoppers with integrated lump breakers for discharge from FIBCs or intermediate bulk containers (IBCs).

One of the most common problems is how to safely charge large quantities of small bags of powder which historically have been tipped into vessels through the manway – a potentially fatal operation. There has previously been no simple way of solving this charging problem. For this duty, the Isocharge Station has been developed.

Product Development

In the summer of 2009, GlaxoSmithKline (GSK) had an immediate and urgent requirement to produce large quantities of Relenza – an anti-viral medication – in response to a potential global health crisis. In order to facilitate this requirement, the refurbishment and upgrade of an existing installation was agreed for its Montrose plant. The PTS was already well established on site, being used in many production areas for the safe charging of potent powders to reaction vessels. So it came as no surprise that the PTS would also be used on this project. However, there was a specific requirement to charge up to twenty 10kg bags in less than 20 minutes, while protecting the operator to the same level as other high-containment equipment. To achieve the safe charging of this number of bags so quickly, something new was necessary.

Some earlier development had already been completed on the Isocharge Station. In the latter

Figure 4: Inside the main chamber – a hybrid of isolator and laminar flow booth

development stages, independent powder trials were conducted and containment levels of less than 1microg/m^3 (8hrTWA) were achieved. It was this open system that was of importance to GSK Montrose, because of the limited amount of time available to charge the full load of powder to the vessels.

The Isocharge Station is best described as a hybrid design, crossing laminar flow technology with a glove box isolator. It provides the operator with the protection of a gloved visor and the flexibility of an open laminar flow booth. The system consists of a stainless steel chamber which is open on one side, enabling the easy loading of bagged powder. This principal feature allows powder to be loaded into the chamber and charged safely with the door open. The containment level of 1microg/m^3 is achieved, and has been proven in this open condition through the unique design of the main chamber.

The open end is sized to provide an inlet air velocity of 0.7m/s; as the chamber size increases along its length, the air velocity steadily decreases until it levels out at approximately 0.3-0.4m/s at the point of opening the bag of powder. This ensures that there is a one-way air transfer from the room, through the chamber, exhaust plenum, filters and fan, and finally out to the atmosphere. Smoke tests show that eddies are created as the cross-sectional area of the chamber levels out; however, as soon as they move back along the slope of the chamber, the increase in air velocity quickly pulls them back to the centre of the chamber and out through the plenum. This bullet-shaped chamber means that high containment is achieved with the door open, and tests prove that containment is not improved any further by closing the door.

Designed to be used by either one or two operators, the chamber is loaded through the open end of the main chamber, then gloves are used to open the bags and pour the powder into the discharge hopper located in the chamber base. The base has an integrated discharge transition, with proximity switch-sensed removable grid for mounting a suction hopper.

For the safe removal of contaminated bags after emptying into the hopper, the Isocharge Station is supplied with a 150mm diameter endless liner port with a cover located through the chamber base. The powder is then discharged from the hopper by means of the PTS mounted on the receiving vessel. The PTS controls are linked to the Isocharge Station control panel so that the operator does not have to move away from the charging area during operation. This also has the added advantage that only one Isocharge Station is needed for a number of reactors.

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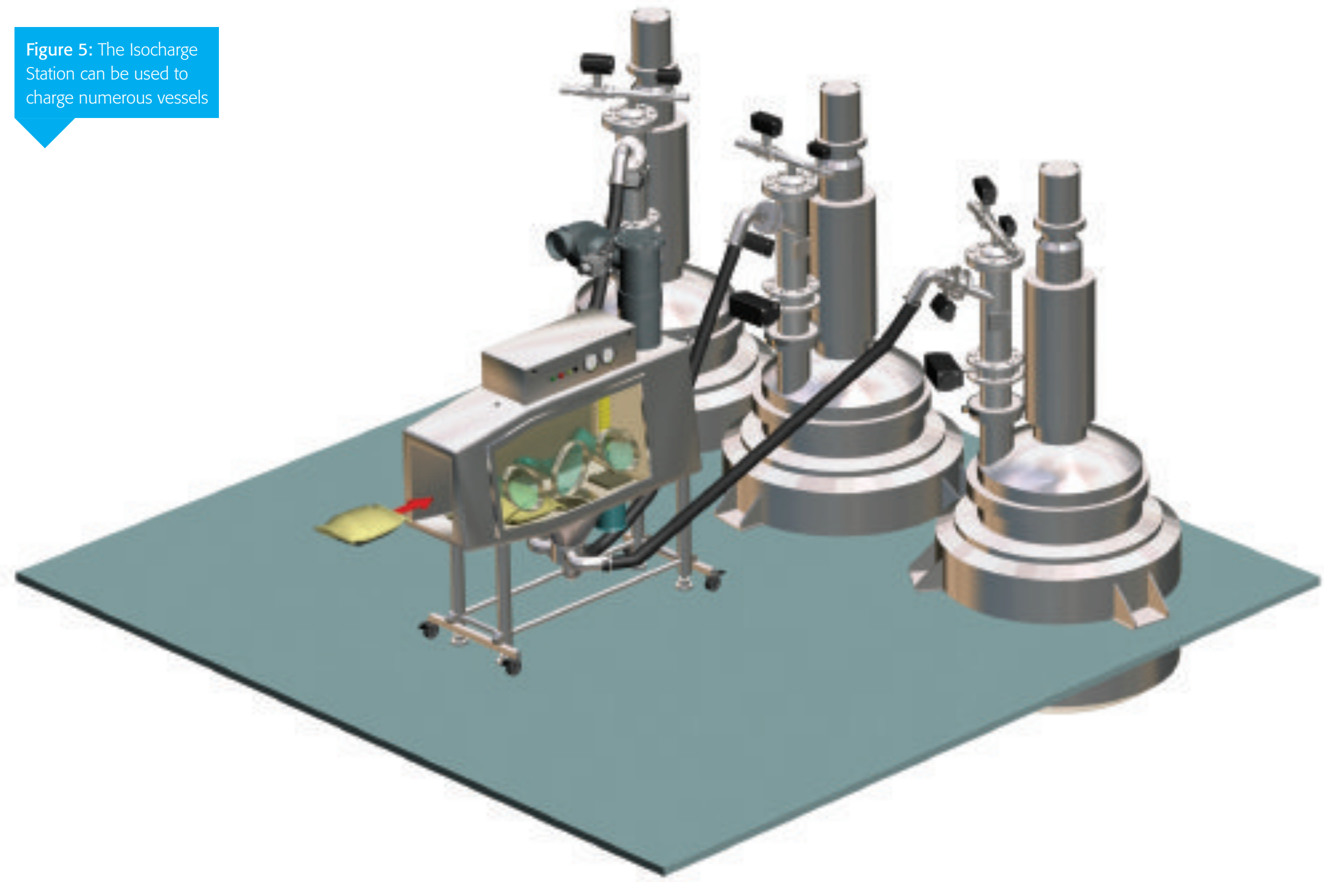
Figure 5: The Isocharge Station can be used to charge numerous vessels



Cleaning

A door is provided on the Isocharge Station and is only used during cleaning to prevent splashes outside the chamber. It includes a wash gun so that the operator can direct the cleaning spray to the soiled areas of the chamber. The washing fluids are then removed, either by sucking with the PTS or via a drain. The PTS – when fitted with the cold isostatic pressing (CIP) cover – is capable of charging liquids in exactly the same way as it charges powders. The required cleaning solution travels an identical course to the powder, sterilising as it goes. The CIP cover prevents any liquid reaching the safety filter and vacuum pump. After cleaning, the PTS is left running for 5-10 minutes simply sucking the air through the system, in order to dry everything so that it is ready for the next batch of powder.

For a final wipe-down, a top hinged glove ported visor is mounted to the front of the chamber, fitted with supporting gas struts for full easy access to all internal areas of the Isocharge Station.

Conclusion

GSK, having completed its own containment tests, are very happy with the results of the PTS and Isocharge Station technology, which enabled its operators to avoid having to resort to protective air suits. Evidently, the new development has much potential for future use.

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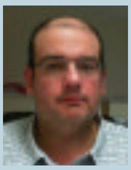

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