Reliable and cost-effective production in inert atmospheres

Preventing explosions by using inert gases

Dipl.-Eng. Hans-Joachim Risto

Inspite of ever tougher safety standards [1], many chemical and process engineering installations are still operated with a risk of explosion. Most explosive atmospheres consist of a suspension of combustible dust in air or of hydrocarbon vapours in air. However an explosion is only possible if three factors coincide at the same time: there must be enough oxygen in the atmosphere, a combustible substance must be present in a suitable concentration and the mixture must be ignited. By rendering the process atmosphere inert, i.e. by lowering the oxygen content in the atmosphere and adding an inert gas like nitrogen or carbon dioxide, the risk of explosion can be eliminated.

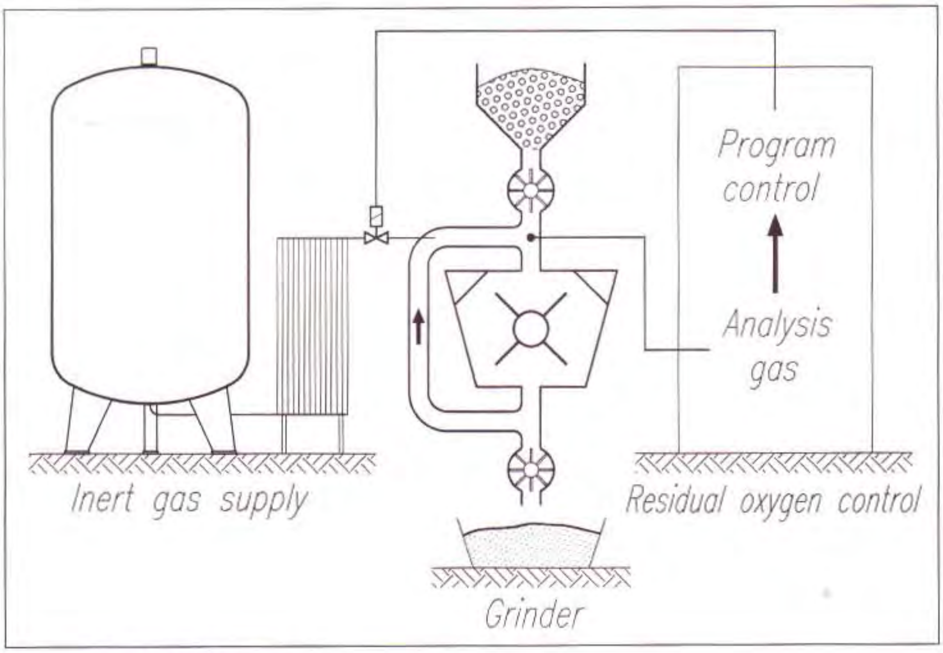

Fig. 1 Grinding in an inert atmosphere

Cost-effective production in inert atmospheres

The belief that inert atmospheres raise operating costs excessively is still widely held. This is largely due to experience with existing installations in which the inert gas is employed without control systems. To determine the operating parameters, operators often only calculate the dependence of the residual oxygen concentration on the added volume of inert gas and fix an equivalent value for long-term operation. In such an uncontrolled process, so much gas has to introduced that safety is assured even in the worst conceivable operating conditions. In most operating situations, however, this means that the amount of inert gas present is excessive.

The inert atmosphere process presented here takes this state of affairs as its point of departure. Its principle is to continuously monitor the residual oxygen concentration to ensure that a sufficient inert atmosphere is constantly present without overdosage.

Essential to the design of an economical inert atmosphere is that the process air is circulated. Such systems are preferably operated under slight excess pressure. Solids are thus best infed with cellular wheel or flap sluices. Equally important is that when the inert gas is fed into the closed system, gas is withdrawn at the same rate from the system. The currents of exhaust gas are often so heavily charged with product that an exhaust gas purification unit may have to be provided so that the installation complies with TA-Luft (Clean Air Directive) [2].

How installations with inert atmospheres work

The system can be broken down into three functional sectors:

- Inert gas supply: From a storage tank, the liquefied gas is taken, vaporized and fed into the production system through a solenoid valve.
- Production system: The system contains a comustible material in process air which is circulated. The material flows are separated by sluices.
- Residual oxygen control: This consists of an analysis gas preparation unit in which vaporized constituents are removed by condensation or dust particles are filtered out. The purified analysis gas then flows into the analyser where its residual oxygen concentration is measured. The measured value thereby obtained is then converted into an actuating signal for the controlled process.

If the program control system is restricted to these functions, it can be designed with relays. However, it is usually expendient to incorporate further safety functions or monitor several installations simultaneously. In this case a programmable logic control (SPS) should be employed so that the process engineering, product-specific and safety aspects peculiar to each installation can be taken into account.

Applications

Grinders

The characteristic feature of many fine-grinding units is that the process often demands a high gas throughput rate. Since the turbulences, frictions and mechanical loads are capable of causing ignition, it is obvious that

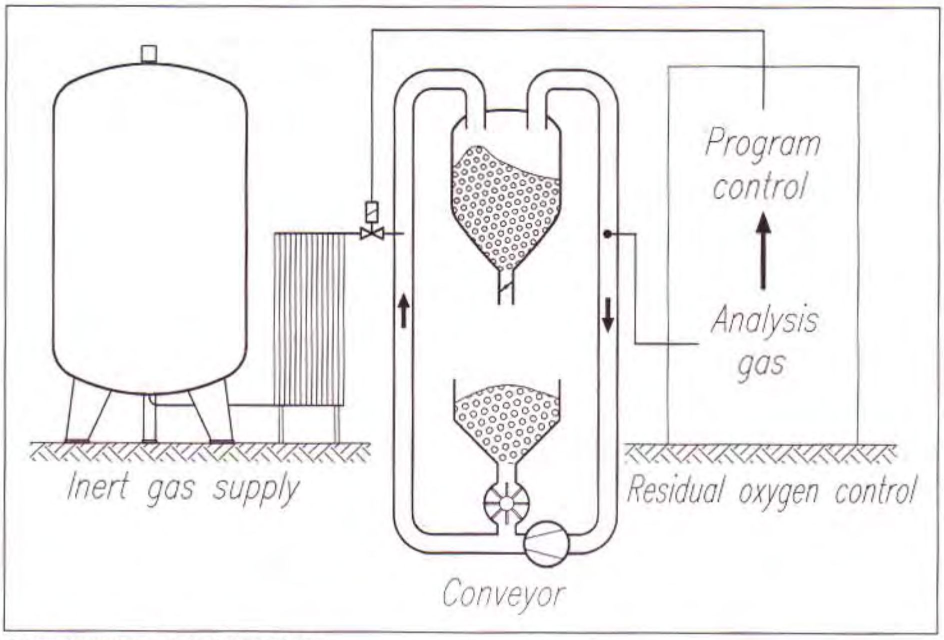

Fig. 2 Conveying in an inert atmosphere

grinding combustible materials carries a high risk. Such potentially hazardous materials include metals, coal, fertilizers and plastics.
With a air throughput rate of approx. 1000 m^3 h^{-1} and a residual oxygen concentration of 8% vol., a guide value of between 20 and 40 m^3 h^{-1} of inert gas may be needed in a well sealed system.
Before the process is restarted – after a product change, for instance – the grinding unit has to be flushed with three or four times its own volume of solution. It is also useful to incorporate this operation into the SPS program.
Another advantage of inert atmospheres is that the ground material is packed and stored together with the dry inert gas. This often improves quality.

Pneumatic conveyors

The functional principle of a pneumatic conveyor is similar to that of a grinding unit with a high air throughput rate.
Here, too, pourable goods are conveyed with high wall and body friction in a turbulent flow of gas. As granulates often contain a high share of dust, the three explosion factors are usually present. The danger potential is correspondingly high.
If an inert gas is employed as a handling medium, not only is the risk of explosion diminished, but the goods being handled are also subsequently stored in an inert atmosphere. Silo fires can thus be realiably prevented.

Mixers

Stirrers are widely used as mixing reactors for the production of adhesives and paints. Solvents are often employed and these can form explosive atmospheres with air.
To combat this problem, inert gas is fed into the container and gas is withdrawn from the mixer at the same rate to keep the pressure constant. This exhaust gas is charged with a high concentration of solvent and has to be purified accordingly to meet the requirements of TA-Luft [3].

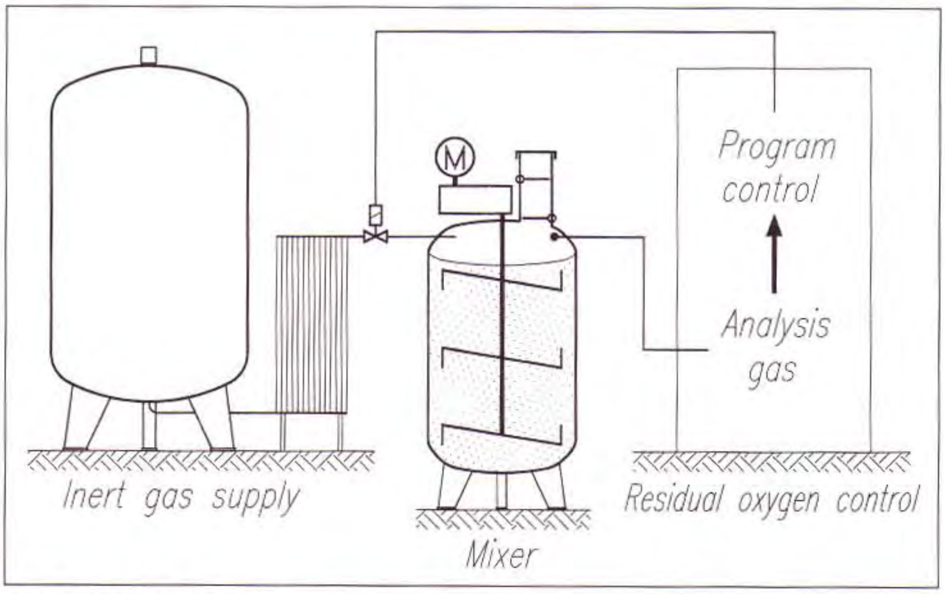

Fig. 3 Mixing in an inert atmosphere

If nitrogen is employed as the inert gas, the cooling potential of the low-temperature liquefied gas can be exploited for exhaust gas condensation. A major advantage, e.g. for afterburning, is that there are no solvent losses.
If a mixer is converted for operation in an inert atmosphere, it is important that the infeed sluices for the pourable goods form a tight seal. Firstly, in order to meet the MAK values (maximum concentrations at the place of work), they should provide a tight at the place of work), they should provide a tight seal to prevent emissions into the shop; and, secondly, their operation must not be impaired by product contamination [4].
Typical consumption rates for well sealed medium-size mixers and a residual oxygen concentration of 8% vol. can be achieved with 10 to 30 m^3 of inert gas per hour of operation.

Suitable inert gases

Basically, any non-combustible gas can be employed as the inert gas as long as it does not react with the product:

- nitrogen,
- carbon dioxide,
- noble gases,
- flue gases,
- water vapour.

Of the technical gases, nitrogen and carbon dioxide are not particular importance.
Nitrogen should always be given preference if a continuous supply of inert gas is required. This inert gas is stored liquefied at low temperature and, according to the process, can only be stored for a limited period without losses.
Carbon dioxide is an inert gas which is liquefied under pressure and can be stored under pressure without losses at ambient temperature. If a discontinuous supply of inert gas is required, carbon dioxide should be preferred.
In addition, the properties of the product should also be taken into account. For instance, dust explosions of aluminium powder are possible in a pure carbon dioxide atmosphere.
In designing new or converting existing production processes for operation in an inert atmosphere, the operator will be faced with a number of safety, process engineering and gas problems.
A South German industrial gas company offers its assistance in assessing production processes, running tests with the operator to determine the operating parameters and helping with installation and optimization.
Further information **cpp 267**

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