Economic Operation
OF CONTINUOUS FLOW DRYERS

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Rising energy costs are forcing operators to optimize all industrial processes which rely on high power consumption. One such application is the continuous flow dryer or drying oven, which is used in lacquering, coating and finishing processes to dry freshly coated surfaces quickly and reliably. This desire to reduce energy costs, however, must not conflict with the need for operational safety.

Explosion Hazards in Continuous Dryers

Inside a continuous flow dryer the solvent which is essential for the coating process is removed from the coating material (paint, adhesive etc.). These solvents, which tend to be combustible, vaporize and are removed by a continuous flow of air. The amount of solvent depends primarily on the process used, and is also affected by the proportion of solvent in the coating material, the applied coating thickness and the speed of the conveyer belt or feed rate of the foil to be coated. If too much solvent is placed in the oven or the air flow is insufficient, concentrations of solvent vapour can build up inside the continuous flow dryer which exceed the LEL (lower explosive limit) applicable to the solvent in question. Such hazardous situations arise as a result of incorrect operation or process errors. Studies have shown that increase rates of 10% LEL per second can be reached if, for example, material starts piling up on the conveyer belt or the ventilation system fails. This extremely quick change from safe to unsafe operation was the reason for standards to be drawn up which have to be complied with when planning and constructing continuous flow dryers.

Protective Features

EN 1539 stipulates that the maximum vapour concentration must not under any circumstances exceed a value of 50% LEL and that the alarm time must not be longer than 1.5 seconds

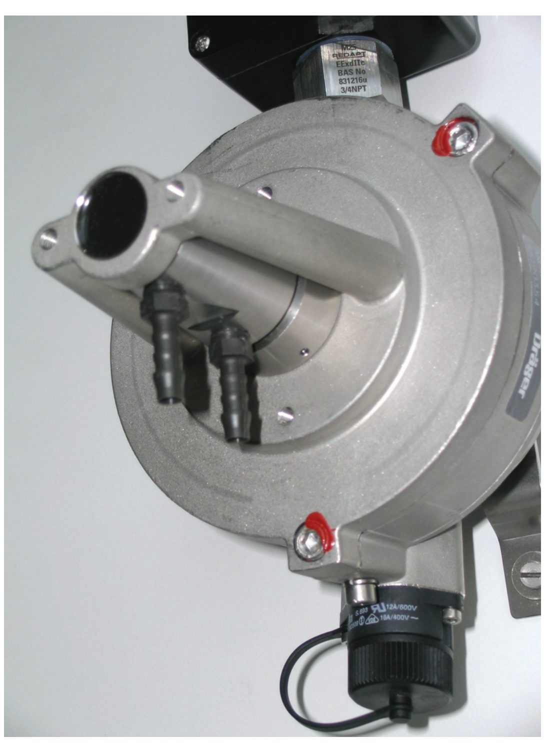

Figure 1: Dräger Polytron IR transmitter with newly designed process cuvette to shorten the t90 time

unless other appropriate measures are in place to maintain safe operation. The alarm time relates to the time which elapses from the moment a hazardous situation arises until such time as counteraction takes effect. For this reason, the atmosphere inside the continuous flow dryer must be permanently monitored by a suitable gas detection system and any necessary counteraction must be triggered automatically. Suitable measures may involve simply increasing the air flow rate or, in extreme situations, fully shutting down the plant and all electrical devices.

Process Control

To avoid such critical situations, the operating parameters of continuous flow dryers are calculated for maximum safety, i.e. with a large reserve. The values calculated for conveyer belt speed and air flow rate generally result in much lower concentrations than the applicable standards require. Continuous flow dryers, whose parameters were calculated for an operating concentration of 25% LEL, for example, often achieve concentrations of below 15% LEL in practice. Such continuous flow dryers are not nearly as economical in operation as they could be. They either work with too low conveyer belt speeds or too high air flows – and it is this high air flow which is responsible for the high energy costs, because more air than necessary has to be heated to the operating temperature of the dryer.

The only possible solution to this problem is to move away from open-loop control of the continuous flow dryer process and establish a proper system of closed-loop control, where the vapour concentration inside the dryer must be the controlled variable and the setting variables are the material and air flow rates. A process with this type of control means that values can be reliably kept well under the threshold values specified in the respective regulations, while at the same time increasing the cost-effectiveness of the dryer operation. Naturally, a prerequisite for the safe functioning of this type of control is the reliable and meaningful measurement of the concentration values.

Measurement Systems

For accuracy and speed, the ideal situation would involve taking a measurement directly above or very close to the conveyer belt. The disadvantage of this type of set-up, however, are the high costs of fitting a large number of detectors along the dryer and the fact that the information obtained about local concentrations which cannot be controlled would in some cases be fairly meaningless due to the fact that not every measurement point can be assigned its own independent ventilation system. Using fewer detectors to take measurements in the exhaust air ducts, on the other hand, provides a somewhat delayed picture of the concentration, but the various local concentrations have already balanced out so the process control system can use this value. With the aid of the process control, it is now possible to set the concentration in the continuous flow dryer such that it remains sufficiently below the shut-down threshold of 50% LEL on the one hand and, on the other hand, that the air flow rate is reduced to the necessary minimum.

According to the provisions of the aforementioned EN 1539, gas detection systems which ensure operational safety are not allowed to be used for closed-loop process control at the same time. This means that twice the number of measurement points is needed, though this is an investment which quickly pays for itself through lower energy costs.

The situation becomes more complicated when a continuous flow dryer is used for different coating processes. This generally also means different solvents, which in the majority of gas detection systems also requires recalibration to the new substance.

Expensive But Good

One exception to this are FIDs (flame ionization detectors) and FTAs (flame thermal analysis), which do not require recalibration due to the fact that they react to all hydrocarbons with more or less the same degree of sensitivity. This benefit, however, involves significantly higher purchasing and running costs, and both systems require a permanent gas supply (H2) to keep their "pilot light" running.

Economical Alternative

A much cheaper alternative in terms of purchase price and costs of ownership are sensors which function according to the heat of combustion principle – so-called catalytic Ex sensors. They work as part of a Wheatstone bridge which is unbalanced depending on the gas concentration. Because the sensitivity to the different solvent vapours varies, recalibration is generally required when the substance is changed. Unfortunately, it is not only the sensitivities to different substances which vary, but also the individual sensitivities between the sensors. This makes it virtually impossible to work with easy to handle substitute calibration gases to facilitate the calibration process. The calibrations would be too imprecise to operate a closed-loop control system with the measurement results. A further disadvantage of the catalytic sensors is their tendency to lose their sensitivity relatively quickly due to poisoning of the catalytic material at the measurement elements. Only sensors with operating currents specially adapted to this measurement task are able to achieve acceptable lifetimes.

Low-Cost but Good

Measurement systems based on infrared absorption are much better suited to the task in hand than catalytic sensors. They are poison-resistant and can withstand the conditions of process application. Like the catalytic sensors, IR sensors also react with varying levels of sensitivity to different substances, which means that the sensor will need to be recalibrated when there is a change of solvent in the continuous flow dryer.

Figure 2: The Dräger Polytron IR's new process cuvette reduces the enclosed volume of the measurement path to just approx. 28 ml

However, calibration of IR sensors is much easier to carry out because substitute gas calibration can be performed. Instead of complex apparatus for target gas calibration with solvent vapour, IR sensors can use calibration gases like propane. This is possible because the sensitivity ratios between the different substances do not change as a result of poisoning or ageing, as is the case with catalytic sensors.

In conventional IR transmitters, however, the measured values may under certain circumstances be relatively imprecise. This inaccuracy results from a non-optimized linearization of the IR sensor signal by the transmitter electronics in use. As a rule, the circuits only linearize the signal for a few standard gases. When the sensor is used for a gas other than one of these standard gases, the only possibility is to use a linearization which is as close as possible to that necessary. This means that the measurement is only really precise at the calibration point, i.e. at the concentration at which the transmitter was calibrated. An additional inaccuracy occurs as a result of the individual production tolerances between the sensors of a particular type. Slight differences in the absorption wavelength can produce significant differences in the sensitivity to a particular substance. This aspect is non-critical if the aim of the measurement is to ensure operational safety, but for improving energy efficiency this type of measurement is only of limited value.

Low-Cost but Even Better

Dräger Safety followed a quite different approach to preparing the measured value for its Polytron IR transmitter. This transmitter, unlike other IR transmitters, functions not only with the linearizations for a handful of standard gases, but currently uses 38 different internal absorption characteristics. The characteristics are determined individually for each transmitter and stored in a data memory called the gas library. The user can switch freely between any of the characteristics, without compromising the quality of measurement. As confirmed in the technical measurement report compiled by test and certification company EXAM BBG Prüf- und Zertifizier GmbH, the measurement error is within the limits required by EN 50057. This also means that substitute calibration of the transmitter takes on a whole new quality. The measurement is no longer correct in just one point, but offers sufficient accuracy across the entire measurement range to allow closed-loop control.

In addition, rapid switching between substances has been made simpler with automatic remote configuration by PC. Software allows different formulation-specific system configurations to be defined which can be selected at the click of a mouse and transmitted to the transmitter when the coating process changes. Subsequent calibration is no longer necessary. It is even possible to calibrate the transmitters on one dryer to different substances if this should be necessary in a so-called multizone dryer.

Besides the measurement quality of the transmitter, however, the sensitivity distribution vis-à-vis the different solvents is also a measure of the quality of the targeted concentration control inside the continuous flow dryer. Only measurement systems with evenly distributed sensitivities can be used to set up a closed-loop control system, because otherwise deviations from the measured values will occur when solvent mixtures are used, making trouble-free operation impossible. To maintain a sufficiently even distribution of sensitivities, Dräger Safety offers the Polytron IR with different absorption wavelengths. The wavelengths of 3.34 µm and 3.44 µm which are used optimize the transmitters for specific substance groups.

To avoid confusion and incorrect calibration when using different types of the Polytron IR transmitter at the same time, the configuration software is in this case a particularly useful tool because the security prompts effectively prevent any incorrect calibration of the transmitters. Studies conducted by the EXAM BBG Prüf- und Zertifizier GmbH confirm the safe function of the software, and the technical measurement report of the transmitter has been extended to include this accessory.

Figure 3: The two-part process cuvette in the Dräger Polytron IR