Advanced Gas Sensor Technology Helps the Chemical Industry Control its Plant Emissions

The chemical industry is a major player in the global economy, with 2011 sales reported as being worth some €2800 billion with a growth rate approaching 12% as the developed and developing economies recovered from recession. Manufacturing the materials that are indispensible to today's world, the chemical industry is, quite literally, one of the foundations of modern society. Producing the raw materials that are used throughout industrial sectors, it is one of the powerhouses underpinning improvements in the living standards for millions, if not billions of people.

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Unfortunately, by their very nature, many chemicals are toxic, poisonous, flammable or explosive. As well as the intrinsically unattractive properties of the target material, the manufacturing process can also produce a wide variety of by-products, some of which have equally unpleasant attributes. Even if the chemicals are not directly harmful, some can be environmentally damaging, potentially contributing to climate change.

So, how to square the circle? On the one hand, the chemical industry's products are essential; on the other, some can be unpleasant and dangerous. The answer, well established in the developed world and becoming increasing prevalent in the emerging economies, is legislation and monitoring. Typically, strict limits and quotas are set for the emission levels of different substances, and record keeping and monitoring by the appropriate regulatory authority is put in place to ensure that the limits are observed.

The gas sensing industry plays the key role in enabling the industry to meet its obligations, with many different technologies used to monitor the emissions from the different parts of a typical chemical plant.

Gaseous Emissions Analysis

Stack emission from chemical plants is obviously the largest source of the gases produced during the process. Recognising that some gaseous emissions cannot be avoided, the quota system to manage emissions has been developed. To comply with the requirements of the emissions control quota system, Continuous Emission Monitoring Systems (CEMS), provide real-time monitoring and recording of a range of gases emitted from stacks. Typically, CEMS systems will monitor for sulphur dioxide, nitrogen monoxide, nitrogen dioxide, carbon monoxide, carbon dioxide, oxygen, hydrogen sulphide, total hydrocarbons and opacity. Additional gases are added to the core list depending on the specific process.

In addition to the main processing equipment, a chemical facility will normally contain a number of small power plants, used for a variety of purposes from space heating for on-site buildings through to pre-heating various chemicals before they are injected into the main processing plant. Depending on the availability of the different materials, the fuel source will usually be natural gas, LPG, light and heavy oils, biomass, wood pellets, coal, propane or butane.

Flue gas emissions are monitored for two main reasons, environmental and economic. Clearly, for emissions control purposes, these boiler rooms will contribute to the plant's overall emission levels. There is also an economic driver. With today's ever-increasing energy costs, keeping the combustion process operating at peak efficiency makes complete sense.

Flue gas analysers are portable / transportable instruments that are used to take spot measurements of a range of gases including oxygen, carbon monoxide, carbon dioxide, SOx and NOx in the flue gases, thereby monitoring the efficiency of the burning process and taking a reading for emission control purposes. They will normally be fitted with electrochemical sensors, which are arguably the most versatile sensors available, offering a number of benefits over alternative technologies.

The sensors are physically small, enabling the analysers themselves to be correspondingly compact. Internal filtration ensures that the readings for the target gas are immune to cross-contamination from other gases commonly present in the flue gases. The latest generation of oxygen sensors use lead-free catalytic technology derived from toxic gas sensors, improving response times, reducing current consumption and offering a quicker start up from cold. Electrochemical sensors characterised to a large number of different gases are available, enabling monitoring in specialised applications to be implemented quickly and easily.

Leak Detection

Leaks are an ever-present hazard even in the best run chemical plants. Depending on the severity of the leak and the gas involved, the effects can potentially be very serious both within and without the perimeter of the plant. An explosion or fire will damage plant and put workers at risk, while toxic gases can spread rapidly, also putting the public at risk. Even a minor small leak has an economic impact on the plant's profitability as material is being wasted and the fault has to be rectified. To monitor for leaks, fixed gas detectors are integrated into the plant at key weak points such as valves, joints and pumps. The sensors used will obviously depend on the nature of the gas to be detected. For flammable gases, pellistors are widely used. This sensor works by burning the target gas; the heat generated producing a change in the resistance of the detecting element of the sensor proportional to the gas concentration. To detect hydrocarbons, NDIR sensors are widely used.

Ultrasonic gas leak detectors measure the ultrasonic sound level, typically between 25 kHz to 10 MHz frequencies. Ultrasonic gas detectors are mainly used for outdoor environments where weather conditions can easily dissipate escaping gas before allowing it to reach gas leak detectors that require contact with the gas in order to detect it. These detectors are most useful in facilities with a lot of outdoor pipeline.

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Personnel Protection

Workers wear small gas detectors, typically a device that will detect four or five potential atmospheric hazards including oxygen, combustible and toxic gases. These units are based on electrochemical sensors, which are extremely sensitive and give fast response times when gas is detected. As well as protecting the workers themselves, personal gas detectors also act as mobile leak detectors, a useful back up to fixed leak detectors.

Electrochemical sensors are also used in portable area monitors. Often complete with wireless communications to allow for remote monitoring, local area monitors are frequently deployed after an incident to provide perimeter monitoring around the location of a leak, thereby giving first responders additional protection.

Open Area Protection - Storage Tanks

Infrared open-path gas detectors send out a beam of infrared light, detecting gas anywhere along the path of the beam, which is typically a few metres up to a few hundred metres in length.

They are increasingly used in the petrochemical industry for example in the detection of leaks from storage tanks, mainly to achieve very rapid gas leak detection for flammable gases at concentrations comparable to the lower flammable limit, typically a few percent by volume.

Conclusions

As this brief overview shows, the gas sensor industry has developed a number of different technologies, each of which has strengths and weaknesses for use in specific applications. All manufacturers share a common purpose in improving the effectiveness of life and property protection in potentially dangerous environments. Advances in sensor design are generally aimed at producing faster response, greater specificity, better stability, longer life and greater reliability. In capital-intensive industries such as the chemical sector, which produces toxic, corrosive, explosive and flammable gases as a matter of routine, plant protection rightly has a very high priority.

Add in the duty of care to the workforce, a reduction in emissions to reduce environmental damage and the need to prevent leaks that could affect the local population, the benefits from using today's gas detection advanced technology have never been more obvious.