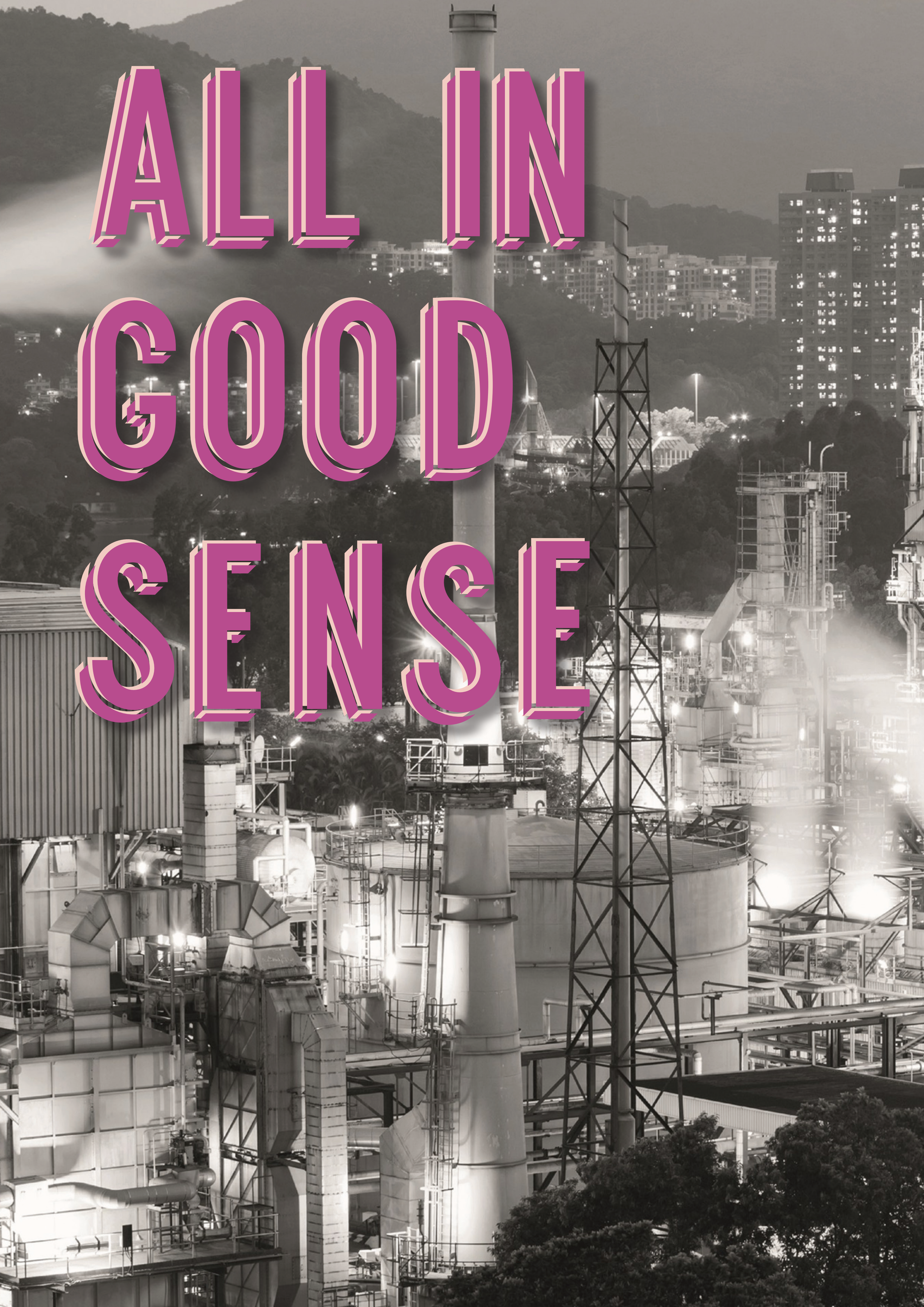
ALL IN GOOD SENSE



René Braun, Grandperspective, Germany, explains how intelligent ground-based remote sensing systems can bring both safety and environmental protection to fertilizer manufacturing.

The decision by legislators to introduce robust regulation for all methane handling infrastructure is having a major impact on the fertilizer production sector. In addition to instilling industry-leading process safety programmes, industrial plants in Europe and the USA must enforce stringent environmental protection frameworks within their facilities. In many plants, safety and environmental protection measures are intrinsically linked.

Here is a hypothetical scenario: thousands of people make their way into the dozen or so plants that produce, distribute and sell nitrogen, phosphorous and potassium based fertilizers for work.

As one of six different fertilizer manufacturing plants located on a site, one facility employs over 400 staff, who between them are responsible for producing ammonia-based fertilizer stock.

But as the workers begin their working day, unbeknownst to them, an escape of ammonia, which is toxic, begins to seep out of a loose valve on one of the six fertilizer manufacturing plants located on the industrial site. The loose valve is not located very close to

Figure 1. FTIR remote sensing technology can not only bring greater earlier detection capability and cost savings but also efficiency gains too.

Figure 2. Grandperspective's sensors are able to continuously and autonomously identify, monitor and quantify hundreds of gases – including methane, ammonia and ethylene.

Figure 3. A scanfeld sensor unit overlooking Chemelot Industrial Park in the Netherlands.

a fixed-point sensor, and there is a stiff breeze, which sends the cloud of ammonia towards housing estates and warehouses that lie to the east of the site.

However, ammonia is not the only undetected gas in the air. An invisible plume of methane, which is used to produce nitrogen-based fertilizers, billows uncontrollably. It has escaped the attention of the legacy sensors in the plant for many months now, as they do not have the capability to detect the cloud – let alone to monitor or quantify it.

With the human nose capable of detecting ammonia, it is not long before the news has made it on to social media channels and the plants are receiving calls from people living in the surrounding area. But the methane leak remains undetected and continues to increase in size and volume.

Employees from the other fertilizer manufacturing plants decide to convene an emergency meeting. But there is a problem. It quickly becomes clear that, even though each facility has a comprehensive network of fixed-point sensors covering their plants, nobody is able to pinpoint the source of the leak.

Without this key information, an evacuation plan cannot be formed, as without understanding the real-time trajectory of the ammonia cloud, it is not possible to verify that the place identified to send staff is safe. Secondly, the manager realises that they have no idea how the gas is behaving. Is the leak conforming to steady-state conditions? If it is not, then it could signal a far worse situation than first envisaged, such as a burst pipeline. The manager does not know how much of it has already been released, how long it has been there, or where exactly it has travelled.

After taking advice from the safety, health and environment (SHE) teams, the environmental monitoring division and the local fire commander, the manager agrees to a total shutdown of operations, while specialist emergency teams are drafted in to find and stop the ammonia leak. The cost of shutting down for even a day runs into tens of millions of dollars for each plant. However, with an uncontained ammonia release posing a risk to human health, the plant managers decide that it is the only option.

Meanwhile, the methane leak has become so vast it can be seen from space. However, because the plant employees cannot see it, they do not take action. With the current waste emissions charge set at US$900/t, a huge fine could leave millions of dollars in the red. With the leak so colossal and margins already extremely tight, plus the reputational cost to the plant, such a heavy sanction could lead to permanent closure.

While the picture painted is fictional and has been taken to the extreme, it has been constructed following conversations with industry insiders and is based on their real-life experiences.

It not only highlights flaws in legacy fixed point sensor systems, but emphasises a need for emission detection technology that is connected in real-time to advanced process control systems to identify, monitor and quantify leaks.

However, perhaps the most important point is to recognise the symbiotic relationship between next-generation sensor technology, process analysis systems, and data, which is the fuel that drives and accelerates visibility.

Take methane, for example. A recent study by Cornell University and the Environmental Defense Fund found that fertilizer plants in the US emitted 100 times more methane than was actually reported.[1]

Part of the issue is that methane's spectral signature occupies a much higher frequency range than gases such as ammonia and ethylene. To ensure an accurate reading, optical gas imaging cameras, which are often used in leak detection and repair (LDAR) inspections to detect methane, require experienced users to neglect effects of water vapour which is omnipresent in a typical plant and which can cause false impressions of a leak. With OGI cameras not used for day-to day monitoring, many plants still use conventional detectors and analysers. The problem is that they are often not capable of accounting for atmospheric humidity and temperature, and cannot accurately identify and quantify methane.

Specific equipment and/or trained experts may be needed to detect methane, ammonia or ethylene and even more compounds of concern for that matter.

This is why many energy and fertilizer companies are turning to emission monitoring companies for help. Grandperspective GmbH specialises in hyperspectral imaging based on fourier-transform infrared (FTIR) remote sensing technology.

The company produces remote scanfeld sensors, able to continuously and autonomously identify, monitor and quantify gases – including methane, ammonia and ethylene – at detection rates of 0.05 kg/hr or less – across a radius of 1 km^2.

In February, a series of tests demonstrated that the remote sensor technology was able to detect methane emissions at leak rates of 100 g/hr over a distance of at least 250 m in real-life conditions. The tests, which were validated by the Engler-Bunte Institute of the German Technical and Scientific Association for Gas and Water (DVGW) at the Karlsruhe Institute of Technology (KIT), were approved by a global energy corporation as part of their own efforts to drive down methane emissions.

The monitoring system could also soon be meeting the European Union's Leak Detection and Repair (LDAR type 1) 17 g/hr threshold.

Furthermore, companies have been increasingly utilising AI and advanced data analytics to map clouds in real-time. With sensors able to take multiple scans measuring the number of gas molecules present, data scientists then use 5D imaging to capture the image of a gas cloud. This enables operators to fully reveal its length, its height, its width and its depth, and most importantly, the direction in which it is heading.

The low detection thresholds that FTIR remote sensing technology brings to the table, have not only provided the sector with an effective set of tools that can help it to reduce emissions, but also the bedrock on which to put in place data driven systems which help plants to optimise their processes, systems and also reduce waste.

In continuously learning about the normal emission cycles of the plant, Grandperspective's smart scanfeld sensors, for instance, are able to differentiate between technical emissions and potentially dangerous gas leaks.

When AI, machine learning and analytics are brought into the equation, they bring with them an opportunity to explore and realise a myriad of new possibilities.

AnQore B.V., a petrochemical plant in Geleen in the Southern Netherlands, for example, produces fifteen different chemicals including, but not limited to, acrylonitrile and hydrogen cyanide.

As well as the enhanced real-time visibility, greater earlier detection capability and cost savings that the sensors bring, the plant believes that the FTIR remote sensing technology, can bring efficiency gains too.

This is perhaps best evidenced in a recent turnaround, which AnQore B.V. performs for a month every four years in order to conduct necessary inspection and maintenance work.

Previously when it came to turnarounds, AnQore's B.V.'s most experienced operators, who run the plant, were deployed by the facility to check the equipment. They were supported by a team of contractors, who carried out some of the maintenance.

In the recent turnaround, however, due to the enhanced monitoring provided, the sensors enabled the ability to monitor the working area for diffuse emissions of chemicals – some unexpected, some small, some large – without the presence of operators in the plant. This high level of real-time visibility was not only achieved at the plant, but also the neighbouring plants too. It meant that the operators could save a lot of time on monitoring and could therefore focus much more on identifying the most complex jobs. They were then able to guide and assist the contractors to perform these tasks.

Elsewhere a major integrated petrochemical company, with significant fertilizer production capability, is using remote sensing technology and analysis tools to greatly enhance its sniff testing capability, which can be a sisyphean task. When one full cycle takes around three months to complete, and it is mandatory to carry out four cycles each year, perhaps it is no surprise that the industry is looking to harness next generation technology to provide a more cost-effective, efficient and safe service.

By harnessing around-the-clock monitoring capability, the petrochemical company's technical inspection teams no longer have to manually check hundreds of thousands of points every year. Instead, they are able to oversee those points autonomously and gather continuous measurements, which is improving safety while enhancing efficiency.

But, in the future, the data drawn from ground-based remote sensing systems could also feed digital twins.

These next-generation models help plants to create a virtual representation of themselves and enable predictive analysis and optimisation. This, in turn, allows facilities to imitate real life scenarios and improve decision making, so much so that there is a real-time interaction between the virtual twin and the actual physical environment.

Figure 4. One big advantage of the scanfeld sensor units is that they operate completely independently of weather conditions.

Figure 5. Mounted at an elevated position, the scanfeld sensor unit continuously monitors large areas for dangerous emissions.

Figure 6. Scanfeld increases the safety of plant workers through 360° around the clock monitoring.

Professor Huan Nguyen, who is the Director of the London Digital Twin Research Centre at Middlesex University, says that the future is high-fidelity digital twins, which use AI and IoT to enable plants to imitate, visualise and predict the entire life-cycle of a plant to a highly accurate and complex level, often involving multiple real-time datasets from a variety of different sources simultaneously.[2]

Such digital twins, however, require a constant and rich stream of data to flourish. There are many ways that plants can gather data. Industrial facilities can install their own specialist sensors, but this can be expensive and time consuming. In the future, therefore, more and more plants may decide to lean on next-generation sensor technology to supply them with some raw data, such as Grandperspective's sensors, which use hyperspectral imaging based on FTIR remote sensing technology. So, to what extent could these smart sensors, which are capable of collecting over a million spectra per day, per sensor on over 400 different compounds, be the wellspring on which high fidelity digital twins are built?

While Professor Nguyen does not wish to advocate or endorse any specific company, product or technology, he said it depends on the use case. But if one of a plant's main objectives was to build a digital twin to drive decarbonisation, then in theory, it could utilise this real-time emission data to carry out advanced real-time predictive analysis. If the fertilizer manufacturing company operated several different plants, a high fidelity digital twin could potentially help it to transform operational efficiency and reduce waste across its network of plants.

Conclusion

With rapid advances in sensor technology, AI, machine learning and the internet of things, it may not be long before the vision of high-fidelity digital twins becomes a reality. If and when it does happen, the data-driven insights they provide could prove to be transformative. **WF**

References

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