A camera's contribution

Lenny Shaver, Advanced Energy, and Michael Li, Wonder Engineering Technologies Singapore, detail how the online deployment of infrared (IR) cameras for remote flare monitoring can lead to continuous, safe, and low-cost operations.

At present, nearly all hydrocarbon processing plants use flares to burn off waste and environmentally-harmful gases to meet safety, sustainability and legislative requirements. In the longer-term, there are goals to eliminate the practice, not least through the Zero Routine Flaring (ZRF) initiative. In the meantime, making positive changes in flaring practices in the near- and medium-term is a necessary step on the journey towards improved sustainability and better resource management.

Flare monitoring has a vital role to play in ensuring that flares are always functioning optimally. It is important that effective monitoring technologies are implemented across the industry as widely as possible. In a previous article in *Hydrocarbon Engineering*, the advantages of implementing enhanced remote flare monitoring sensors were discussed

in the context of more effective flare monitoring functionality.[1] This article will instead consider an example of where remote flare monitoring using infrared (IR) cameras was implemented as a replacement for conventional thermocouple technologies.

Processing plants typically cannot operate if a flare is not functioning properly. A key element to optimising functionality is having a continuous monitoring system that provides operators and regulators with the confidence that the flare always provides the safety and environmental protection that is both expected and required. Since plant downtime is costly, a scheduled shutdown of all or part of the plant to perform maintenance and repairs (also known as a turnaround [TA]) is very infrequent (typically every three to seven years). If the maintenance or repair of the flare monitoring system requires the flare (and plant) to be shut down, then any failure of the system between scheduled maintenance periods forces a difficult decision for plant managers. They could either operate the flare without effective monitoring, which presents risks to both the environment and the company in terms of regulatory fines, or incur a very expensive plant shutdown.

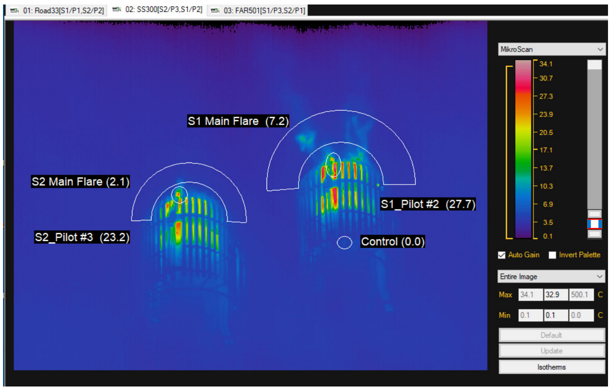

Figure 1. Software automates the monitoring of pilots and flares using thermal imaging camera streaming data, and continuously reports the status to a plant's distributed control system (DCS).

Figure 2. LCD panels showing IR flare monitoring in the plant control room.

Remote technologies reduce turnaround costs and improve operations

The safe operation of flare stacks demands that harmful gases are ignited by a pilot flame in a carefully-controlled process. The possibility of uncontrolled ignition from sources other than a pilot flame is not acceptable. Hence, a continuous method for confirming the presence of the pilot flame (or flames) is required to ensure that the flare is functioning safely and effectively. The standard method for pilot flame detection for flares is to install a thermocouple in the pilot flame. However, there are many shortcomings to this approach.

The greatest problem with thermocouples is that they fail during regular operation due to thermal shock or the corrosive flaring environment. The time between failures is unpredictable, but generally the lifetime of the thermocouple is significantly shorter than the turnaround time of the plant. This means that nearly all pilot flame thermocouples fail before the next turnaround time. Indeed, some thermocouples can fail within a year or less of operation, depending on how heavily the flare is used. Even if a site does have the opportunity to replace the thermocouples that are monitoring the pilot flames, the process of replacement can easily mount up to hundreds of thousands of dollars for a typical flare stack once all of the downtime, services and equipment are accounted for. For example, flare towers need to be taken offline and fitted with 100 m scaffolding, and a variety of expensive services for comprehensive inspection need to be deployed. As a result, while a new thermocouple may cost less than US$10 000 to buy, the cost of the services needed for a successful installation in the flare tower can be as high as US$500 000.

Because thermocouples can end up being extremely expensive consumables, there is significant motivation to find less costly, more reliable technologies for flare and pilot monitoring. Thermal imaging, which provides continuous, 24 hr/d remote monitoring of the flare and pilots, is gaining momentum as one of the best alternative approaches. It is quickly becoming the solution of choice for oil and gas companies looking to safely extend equipment uptime.

Thermal imaging-based flare monitoring systems typically consist of a high-resolution thermal imaging camera installed in explosion/weather/waterproof housing, with special optics to focus on the flare from a large distance (often up to hundreds of meters). Software running on the plant control system performs image processing and data analytics, and is configured to send out warnings, alarms and signals to reignite pilot flames if specified parameters stray outside of user-defined limits (see Figure 1).

In contrast to traditional CCTV cameras, the thermal imaging cameras can accurately and automatically monitor pilots and flame even in bright sunlight. Further, IR cameras are better able to detect the flame in fog and adverse weather conditions.

Thermal imaging-based solutions address the main issues of thermocouples in that:

- They are fundamentally more reliable.

Figure 3. Field junction box used for power and fibre optic cable communications link.

- They do not have to be installed within the harsh environment of the flare stack.
- They can be installed or repaired without shutting down the plant.
- The cost of installation is orders of magnitude less than thermocouples.
- They can monitor multiple pilot lights at the same time.
- Integration with the plant's DCS is straightforward.
- By also monitoring the flare flame, they can be used for process optimisation.
- It is possible to use the technology to monitor multiple flare stacks.

Case study: IR imaging replaces thermocouple on 120 m flare stack

This section will explore the example of an oil company's chemicals plant in Singapore that chose to replace its conventional thermocouple-based monitoring with a thermal imaging solution.

The site's original plan was to have five-year turnarounds. The operator found that thermocouples were not robust enough to survive the full five years. The project team received a proposal from a service provider to replace the thermocouples during the next turnaround, with labour and material costs estimated at around US$500 000 (excluding the cost of production loss during the shutdown period).

These factors led the team to seek a new approach and, recognising the benefits of thermal imaging technologies, they explored the possibility of a remote, optical-based monitoring solution. A critical requirement of the new technology was that it could provide all of the input to the plant's DCS that had been provided by the traditional thermocouples. This meant that any optical or remote solution needed to provide discrete status alarms/signals for each flare pilot status, but with greater reliability.

This facility had a two-flare tower with a 120 m flare stack. As each flare had three pilots, there were a total of six pilots in the tower. Working with a local engineering firm and an international flare camera manufacturer, a solution was specified that used a network of thermal imaging systems to monitor each of the six pilots discretely. In addition to this, the solution included both digital and analog connections to the plant's DCS for alarm notifications.

The complete solution comprised:

- Three IR flare cameras, each in a protective enclosure with high-resolution optics.
- Junction boxes to marshal field facilities connections to the cameras.
- Hardware and software for automation.
- Two large LCD screens for control room operator panels.
- I/O cards to provide hard-wired pilot alarms for the DCS connection.

A comprehensive site survey identified the optimum locations for the three cameras to provide the best possible view of the pilots, while ensuring that there was easy access for installation. This survey led to three mounting positions, which were roughly equally-spaced around the flare tower. Because each of the flare cameras included a high-quality, high-resolution 200 mm lens, they were able to clearly resolve the pilots and flares from these positions, even when mounted hundreds of meters from the flare stack. In line with the objective of delivering long-term, reliable operation with minimum maintenance, the final system included enclosures for the cameras to prevent dust, dirt and moisture from collecting on the window and to avoid corrosion; stainless steel, heavy-duty mounts; and hazardous area certification.

Because no access to the flare stack was required at any point, the complete implementation took place during regular plant operation. Onsite installation, cable routing, set-up, testing, commissioning, training and sign-off all took place in under four weeks. Additionally, operator training could also be completed in the shortest possible timescales thanks to the system's ease of use and the automation of flares monitoring using software that performed all image processing and provided direct reporting to the plant's DCS.

The end result is a highly-reliable monitoring system that will work for many years without degradation and without the need for expensive shutdowns for maintenance. The signal conditioning and wind compensation algorithms built into the software eliminate false alarms when flames move away from the focus area. Finally, the use of IR – as opposed to UV or CCTV video-based alternatives – ensures that the cameras can maintain a clear focus in all ambient conditions – including bright sunlight, heavy rain, and fog.

Reference

1. 'Remote flare monitoring solutions', *Hydrocarbon Engineering*, (January 2022), pp. 43 - 48.