Waste not want not

Dan Danskin, AP Sensing, UK, looks at applying DTS technology to reduce storage costs.

Distributed Temperature Sensing (DTS) systems have been used on LNG import and export terminals for decades.

Apart from the obvious technological advancements in the products themselves, this article describes new ideas for the uses of the products, which ultimately help reduce plant operating costs as well as increase plant safety.

An introduction to DTS

DTS is the distribution of temperature sensing, typically along a fibre optic sensor cable that can be several kilometres in length. There are other, very simple electrical cable systems that sense temperature based on resistance between two wires. This article, however, will discuss the highly advanced fibre optic systems.

Fibre optic DTS systems have been employed for over 30 years and have been used on LNG terminals since the 1980s. The systems use a principal known as Raman spectroscopy, whereby incident light is absorbed by a molecule and then re-emitted in different colours. One of these colours – anti-Stokes – is strongly temperature sensitive. The other – Stokes – is not. By measuring the intensity difference between the two colours (see Figure 1), it is possible to obtain a very well calibrated temperature measurement. By doing this with optical fibre, and by employing Optical Time Domain Reflectometry (OTDR) technology, one can get the highly sought after 'distributed' temperature sensing capability.

So what are the capabilities of a fibre that measures temperature along its length? Modern day fibre-based DTS systems can measure temperature at 1 m intervals and up to distances of 40+ km. They have no electronics in the field, just a single optical fibre connected to the electronics box in a control room. Furthermore, the fibre is immune to almost all environmental hazards – vibration and electromagnetic fields cause absolutely no impact on the temperature measurement. A single fibre cable can measure temperatures from -196°C to over 300°C. In fact, DTS cables are also certified to withstand +750°C for over two hours with measurement up over 1100°C for short periods.

Analysing the system capabilities for an LNG plant, it is evident that measuring extremely low temperatures is an advantage. But so is the low risk of ignition. A common misconception is that fibre-based signals are inherently safe, but this is not always true. BS EN 60079-28:2007 (IEC 60079): "Explosive atmospheres. Protection of equipment and transmission systems using optical radiation" covers just this topic.[1] All fibre systems should be tested and certified to international standards such as ATEX. Such ATEX-certified DTS systems exist even for Zone 0 environments.

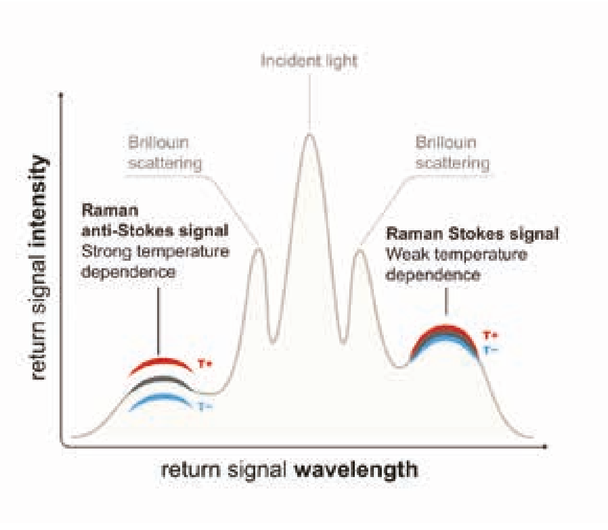

Figure 1. DTS Raman Stokes and anti-Stokes.

Figure 2. LNG storage tank in South Korea.

Typical uses for DTS systems on an LNG plant

DTS systems were first used in LNG terminals in relation to tank annulus leak detection. A fibre in a steel tube would be installed around the annulus space of a double-walled full containment tank between concrete and steel before the perlite fill. Once the tank is operational, the temperature measurement of the annulus space will indicate any leaks from the steel wall inner tank. The advantages of this technology are that the amount of gland space real-estate required on the roof of the tank is kept to an absolute minimum and the resulting solution has a very long life expectancy if the correct fibre is used. The DTS systems installed in the 1980s still use the same fibre cable, buried in the perlite.

LNG pipeline integrity is the next application of interest. Of course it is possible to detect leaks in the pipeline – a simple fibre attached under the pipe easily detects a -162°C cold spot even with arctic ambient temperatures. This solution has been implemented on a great number of sites and is almost standard now for LNG terminal FEED studies. But this can be taken further. The same cable can be used to look at the pipeline insulation integrity. It is not necessary to wait for -162°C to flag a problem, because a modern DTS system is capable of detecting small localised temperature fluctuations and hence report potential insulation failures before they become a risk to pipeline integrity.

Pipeline cooldown monitoring has been another interesting area for DTS technology and has been implemented on LNG pipelines with varying levels of success. While this is a viable and easy solution for pipelines where the insulation is to be applied at site, the application of the fibre on more popular pre-insulated pipes has had some well documented failures and remains contentious.

The ability to accurately measure LNG temperature brings with it the possibility to improve LNG processes, hence DTS instruments have found their uses in coil wound heat exchangers (CWHEs) for monitoring the temperature through the entire cooling process. While still mainly based in R&D work, this application does offer a glimpse of things to come.

Case study

DTS information can also be used to better control LNG tank pad heaters and hence reduce energy consumption and tank boil off. Kogas recently implemented such a DTS system from AP Sensing at its newly inaugurated site in Samcheok, South Korea.

DTS fibre cable has been threaded through the tank base pad alongside the heater cables, but unlike previous installations, the data from the DTS is used to directly control the heaters on an individual basis. Using the DTS information to accurately map the temperature of the pad, a feedback loop can then individually control each heater to increase or decrease certain areas of the pad temperature. No longer is the entire pad overheated just because one area may be a little colder than the rest. Now it is possible to simply heat this one area and reduce power to the rest. The result is a significant saving in heater power consumption and a reduction in boil-off gas (BOG).

At the time of writing, the tanks were in the process of being commissioned, but initial estimates from Kogas suggest a 15% reduction in heater power and an even more significant reduction in BOG. In a world where cost, waste and CO_2 emissions are intensively scrutinised, a simple change in product usage that yields such significant savings is very welcome.

Going forward, Kogas is looking to retrofit this solution to existing tanks because the process is simple and can be carried out while the tank is operational. Fibre can easily be pushed through the tubes in the base slab and configured to monitor the temperature while the existing resistance temperature detector (RTD) system is still operational. New software is brought online for the fibre system and the heater control is then switched over whilst being monitored by the RTDs. Once the fibre system is proven to be working well, the RTDs are then switched into the new software to complete the transition. Retrofit installation could be completed in a matter of weeks with full switch over shortly after.

This solution could effectively pay for the DTS implementation in a short period of time, but the same DTS may already be used for tank leak detection as part of the health, safety and environment (HSE) system. Therefore, it is possible to have an HSE system that actually saves the plant owner money. **LNG**

Reference

1. Equipment for explosive atmospheres: http://ec.europa.eu/enterprise/policies/european-standards/harmonised-standards/equipment-explosive-atmosphere/index_en.htm

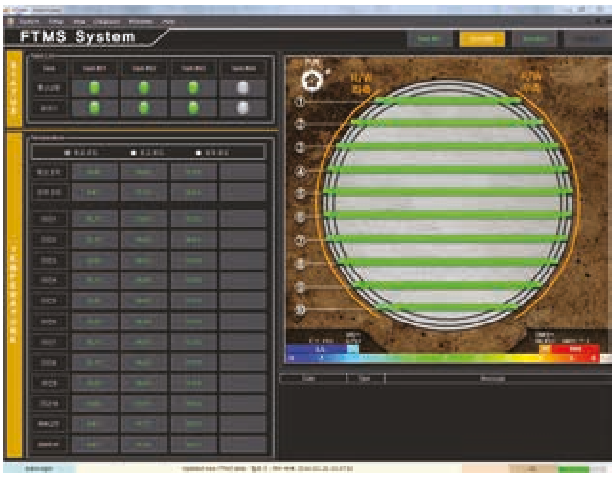

Figure 3. Base slab heater control graphical user interface (GUI).