Handheld LIBS analysers simplify carbon and carbon equivalent testing for carbon and stainless steels

Gammatec SciAps Product Specialist for non-destructive testing (NDT), Lyndon Momberg, talks about positive material identification (PMI) for measuring carbon in steels and carbon steels as part of residual element analysis (RE) in HF alkylation units. He compares the traditional technique that relied on spark OES technology and compares it to the modern much more compact and effective handheld LIBS analysers.

While still delivering the required spectral range and resolution for carbon and required transition and heavy metals, SciAps Z series LIBS analysers are much smaller because they analyse much less material.

Recommended Practice 578 (Material Verifications for New and Existing Alloy Piping, 3rd Edition) now recognises a new handheld technology, Laser-Induced Breakdown Spectroscopy (LIBS), for the measurement of carbon and other alloying elements in steels and stainless steels.

Handheld LIBS, developed by US instrumentation company SciAps, has found wide use in refining and fabricating for its ability to measure carbon content in stainless steels at suitable levels to separate low carbon (L) and high carbon (H) grades of stainless steel. Virtually every major pipeline owner/operator or its non-destructive testing (NDT) provider now uses a LIBS device for carbon content and carbon equivalent (CE) testing, most notably for determining the weldability in pipeline steels (API 5L).

A growing application for LIBS technology is residual element (RE) analysis in steels for hydrofluoric acid (HF) alkylation units, as per API 751. The most common RE formula employed is [Cr%+Ni%+Cu% < 0.15%]. In fact, this RE formula only applies to steels where the carbon content exceeds 0.18%. If carbon content is less than 0.18%, the more easily achieved RE formula [Ni%+Cu%<0.15%] may be used.

So why is the more stringent RE formula used? Historically, operators use handheld X-ray guns to perform Positive Material Identification (PMI) for HF alkylation units. Handheld X-ray cannot measure carbon content, so it is assumed that carbon exceeds 0.18% and the more conservative RE formula, including Cr content, is utilised. Despite this limitation, X-ray has been preferred because it is much easier to use and far more portable than the carbon-capable spark OES technology.

Ideally suited to scrap metal sorting, the SciAps Z can determine carbon content in steels and stainless steels and is now a proven handheld technology with nearly 600 global installations.

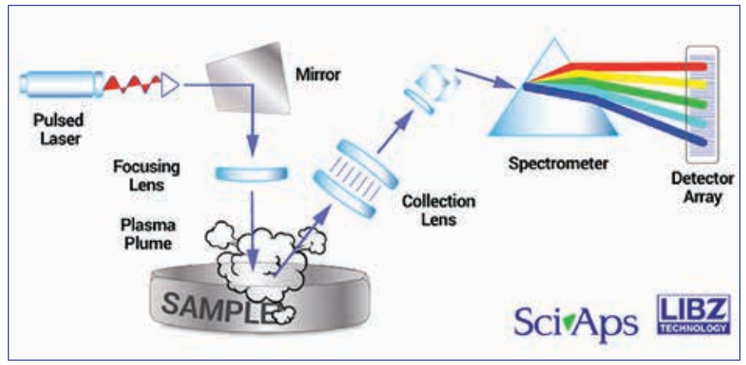
SciAps Z analysers use a tiny argon canister that fits into the handle of the device instead of a 40 lb+ argon tank.

In short, operators prefer the more conservative RE (which is tougher to meet) so they can use handheld X-ray, instead of lugging around spark OES units and the large tanks of accompanying argon gas.

LIBS technology offers a method of measuring C, Cr, Ni and Cu simultaneously using a single handheld device. If carbon is < 0.18%, then the device may use the more relaxed RE formula for only Ni and Cu. This means more incoming and in-service materials can meet the residual limit, because their Cr content can be omitted. In addition, the LIBS carbon measurement is increasingly useful because more steel product originates from recycled material than virgin iron ore, so residual levels, especially of Cr and Cu, have steadily increased over the years, making it more challenging to obtain steel product that meets the 0.15% RE requirement.

Carbon testing pre-2017

Until 2017, spark OES was the only technique for in-field carbon analysis.



LIBS is an OES method like spark, but the bulky spark source is replaced by a very small high-powered pulsed laser.

Spark OES works by generating a high frequency electric spark that heats and burns into the metal and creates an electron plasma.

Spark OES has a number of challenges. An experienced, well-trained operator is a must. Analysis requires an inert gas environment, usually argon, so spark systems are equipped with a large (40 lb +) metal container of high-pressure argon. Users have to purge the spark system before using it and, before moving to the next location, they need to turn off the argon supply then re-purge and recalibrate at the new location, slowing down throughput. Argon runs continuously during testing, thus a large tank is required. Until recently, however, Spark OES was the only option for in-field carbon work.

What is LIBS?

Many of the people who launched SciAps in 2013 were innovators in the handheld X-ray industry, having been founders and/or employees at the two leading handheld alloy analyser companies Niton and InnovX (now Thermo Fisher Scientific and Olympus). X-ray technology had become rock solid for PMI, including for testing residual transition metals such as Cr, Cu and Ni. Despite the advancements in X-ray, there remained a significant limitation to handheld X-ray: carbon. Due to the extremely low energy of carbon X-rays (and other low atomic number elements such as lithium, beryllium and boron), there is no practical way to measure carbon or similar 'light elements' with a handheld X-ray gun.

Yet carbon concentration is the critical measurement for steels and stainless steels.

So the SciAps founders got to work developing a way to analyse carbon with a handheld device. LIBS is an OES method like spark, but the bulky spark source is replaced by a very small high-powered pulsed laser. SciAps miniaturised the laser and other key components into a 4.5 lb handheld device. This breakthrough required three major innovations:

1. To replace the power-hungry high voltage sparking system with a miniature pulsed laser: The SciAps laser delivers a pulsed beam into a tiny spot (100 µm), in a very short time scale (1 ns), and can therefore be powered by an on-board battery.
2. To re-invent the purge process: The narrow laser requires a small purge volume (a few millilitres/ccs). Between tests the argon flow is also halted. The result is about a 1 000x reduction in argon consumption, allowing a tiny canister in the handle of the device to replace the 40 lb+ argon tank. One argon canister can deliver 600 burns or 600 PMI tests. The smaller canister also makes the Z-series SciAps LIBS analyser easy to carry, without having to shut off argon and re-purge.
3. To miniaturise the spectrometer: While still delivering the needed spectral range and resolution for carbon and required transition and heavy metals, the spectrometer is much smaller as it is analysing much less material.

The resulting device – the SciAps Z – now has nearly 600 installations worldwide in the petrochemical, pipeline and steel fabrication industries. It is recognised in RP 578's 3rd edition and has been evaluated favourably in comparison to spark OES systems in numerous independent studies by leading users and institutes for C and CE in pipeline steels, L-grade stainless, residuals, and even sulfidic corrosion applications.