DTS - LIOS Reactor Skin Temperature Monitoring System (RSTMS) for Gasification reactors (gasifiers)
GTC - St Augustine, FL, 02/06/2014
DTS - LIOS Reactor Skin Temperature Monitoring System (RSTMS)

- Company/DTS introduction + Gasification principle & technologies
- Reactors Hot Spot Monitoring Solutions: before and after
- Experience & References

Product information
- Optical Frequency Domain Reflectometry (“OFDR”) & Measurement principle
- RSTMS state-of-the-art DTS system
- FO cable and accessories
- Charon3 user friendly software

Conclusion: LIOS, a RSTMS turnkey solution provider?
Company/DTS introduction (I)

- Europe
- North America
- Oceania
- Asia
- Northern Europe
- Central Europe
- Eastern Europe
- China
- NKT Photonics
  - KOHERAS
  - Crystal Fibre
- LIOS Technology
- Vytran

- Parent company of an international group of industrial companies.
- Financially sound.
- Sustainable policy.

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<tbody>
<tr>
<td>Revenue</td>
<td>1,814 mEUR</td>
<td>1,850 mEUR</td>
<td>1,568 mEUR</td>
<td>1,939 mEUR</td>
<td>2,094 mEUR</td>
<td>2,047 mEUR</td>
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<tr>
<td>EBITDA</td>
<td>192 mEUR</td>
<td>163 mEUR</td>
<td>105 mEUR</td>
<td>120 mEUR</td>
<td>118 mEUR</td>
<td>139 mEUR</td>
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<tr>
<td>EBIT</td>
<td>152 mEUR</td>
<td>80 mEUR</td>
<td>38 mEUR</td>
<td>52 mEUR</td>
<td>38 mEUR</td>
<td>59 mEUR</td>
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<tr>
<td>Avg # of employees</td>
<td>7,575</td>
<td>8,610</td>
<td>7,938</td>
<td>8,589</td>
<td>9,038</td>
<td>8,867</td>
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Company/DTS introduction (II)


- LIOS Technology GmbH is a German based manufacturer of industrial Distributed Temperature Sensing (DTS) equipment, based on Optical Frequency Domain Reflectometry (“OFDR”) technology.

- Strong focus on three strategic business segments:
  - Fire detection in hazard buildings (tunnel and others);
  - Energy T&D power cable systems (U/G and O/H lines);
  - Oil and Gas exploration.

- Other applications: temperature monitoring of pipeline, industrial furnaces, LNG terminals, transformers and generators, gasifiers/reactor vessels, streams and coastal areas etc.
Company/DTS introduction (III)

- **Demand**
  - DTS to early identify potential refractory lining failure (hot spot detection) and to protect integrity of reactor/vessel surface to avoid failures/outages.
  - Gasifiers operate at very high temperatures and require thick reactor shells as well as thick refractory materials on the inside to operate more efficiently and to reduce the heat reaching the exterior reactor shell. Failure of the refractory can result in excessive shell temperatures that can lead to significant damages to the reactor (incl. reactor blow-through).

- **Reliability**
  - Designed for 24/7 operation with a **MTBF > 28 years** (according to Telcordia GR-468, reliability assurance for Optoelectronic devices).
  - Industrial production: 100% FAT, type tested.

- **SCADA integration**
  - Seamless and direct integration into the utilities existing/new simple or complex networks (SCADA infrastructures, Distributed (Process) Control System) for processing and generation of alarms… Process operators can take actions necessary to better ensure safety and reduce the potential for damage.
Gasification: principle & technologies (I)

- Simply put...

- **Gasifiers** have emerged as a tool to **extract energy from fuel** without taking the ignition phase of organic material all the way to combustion. Instead of burning materials directly, the combustion process is interrupted in its early stages through oxygen starvation. In a containment vessel (also called **the reactor** vessel), temperature and pressure are raised to thermo-chemically decompose carbonaceous matter into what is called synthesis gas (**syngas**).

- In a gasifier, carbonaceous feedstock fuels are thermo-chemically broken down at high temperatures (up to 2,800°F(*) i.e. **refractory liner in the reactor is required**) in an oxygen-starved environment where there is not enough air to burst into flames. Instead of burning, the organic structures break down and yield synthetic gas containing hydrogen (H2), carbon monoxide (CO) and carbon dioxide (CO2), plus a number of other constituents that must be captured by various means. The syngas can be burned in turbines, consumed in fuel cells, or put through other processes to form liquid fuels, industrial chemicals, and chemical precursors in bulk.

- Gasifiers can be scaled to many sizes, or capacities, tailored for their application. Their uses range from single domestic stovetop–like burners to **utility power plant units the size of spacecraft launch rockets (20-story reactor)**. Almost any organic matter can serve as fuel, ranging from any type of coal, forest products, refinery residues, subsistence farming biomass wastage, and garbage.

- The benefits gained from the use of gasifiers include **significantly improved efficiency of energy extraction (exceeding 55%)** with **Integrated Gasification and Combined Cycle - IGCC - plants** from the feedstock compared to combustion. **Harmful emissions are either not present**, in small quantities, or relatively easily captured using proven technologies. The syngas output can be re–formed and burned directly or converted to other products. The high temperatures at which gasifiers operate mean that fewer toxins can form during the process and those that do form are quickly broken down.
Gasification: principle & technologies (II)

- Gasifier System Types & Components... [link]
  - Coal to energy (CTE), Coal to liquids (CTL), Pet coke/residuals, DRI melt, Biomass to energy (BTE), Biomass to liquid (BTL), Waste to energy (WTE), Plasma.

- Feedstock (solids, liquids, gas) delivery portal + Inlet ports for steam and (95-99% pure) oxygen or air.
- Reactor chamber + Ignition mechanism.
- Sensor probes (flow, pressure, temperature etc. monitoring).
- Slag or Char catcher (at the bottom).

- Output capacity of gasifiers is often expressed in terms of the thermal energy contained in the syngas, such as megawatt-thermal (MW-th) (and kilowatt-thermal (kW-th)).

<table>
<thead>
<tr>
<th>Size</th>
<th>Output Capacity (MW-th)</th>
<th>Applications</th>
<th>Fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>20 to 400</td>
<td>Power plants, CHP, industrial chemicals, DRI melt, liquid fuels, industrial heat</td>
<td>Coal, pet coke</td>
</tr>
<tr>
<td>Medium</td>
<td>1 MW to 20 MW</td>
<td>WTE, industrial chemicals, liquids and heat, BTE, BTL, hazmat destruction, district energy, industrial power</td>
<td>Coal, pet coke, MSW, biomass, animal waste</td>
</tr>
<tr>
<td>Small</td>
<td>1 kW to &lt; 1 MW</td>
<td>Residential stoves, BTE, BTL, microindustry CHP or heat, village power</td>
<td>Coal, biomass</td>
</tr>
</tbody>
</table>

- Large scale gasifiers power plant applications are mainly based on CTE (featuring IGCC) and CTL technologies.
Before...

- Infrared thermography (LumaSense Technologies, FLIR, ICI Infrared Cameras Inc).

Continuous thermocouples (Xco)

- FTLD- 450m maximum continuous length & [-40°C; +177°C] maximum temperature range
- CT²C- 18m maximum continuous length & [-40°C; +899°C] maximum temperature range. The CT²C is a slender heat-seeking thermocouple (0.120in, 3.0mm dia.). Like all Continuous Thermocouples, CT²C is a self-generating, self-restoring, intrinsically safe thermocouple that is compatible with many standard thermocouple instruments. CT²C can measure the maximum temperature existing anywhere along its entire length, then track the increase, even if the location of the "hot spot" changes.
Reactor Hot Spot Monitoring Solutions: before and after (II)

- After…

- Distributed Reactor Skin Temperature Monitoring System (RSTMS)

- Unique Selling Points vs. “before” technologies:
  - Fully distributed temperature profile of the reactor vessel;
  - Continuous/Real-time, permanent and linear monitoring over 30km and more;
  - Installation adaptability and flexibility i.e. various methods of installation (weld-base studs, TIG welding, high-temperature magnets), different type of FO sensor cables etc.;
  - Full measurement redundancy capabilities;

- Unique Selling Points vs. “after” technologies:
  - OFDR technology;
  - Unique experience with more than 3,000 DTS installed worldwide including RSTMS installation at the World’s First IGCC state-of-the art plant using TRIG (Transport Integrated Gasification).
Reactor Hot Spot Monitoring Solutions: before and after (III)

- Project highlights on Kemper County IGCC Unit 1 project
  - Integrated Gasification Combined Cycle (IGCC) commercial electric power production facility in Kemper County, Mississippi. As part of this facility, synthesis gas (Syngas) will be produced from lignite coal using the KBR air blown Transport Integrated Gasification (TRIG™) Technology.
  - Gasification reactors (gasifiers) operate at very high temperatures and require thick reactor shells as well as thick refractory materials on the inside to operate more efficiently and to reduce the heat reaching the exterior reactor shell. Failure of the refractory will result in excessive shell temperatures that can lead to significant damage to the reactor, even to the point of reactor blow-through. Company wishes to early identify possible refractory failure conditions and alert process operators to take actions necessary to better ensure safety and reduce the potential for damage.
  - The gasification reactor external skin temperatures are expected to be approximately 275°F during normal operation with refractory in place; however, skin temperatures may range from 200°F to 400°F due to numerous external factors.
Reactor Hot Spot Monitoring Solutions: before and after (IV)
Experience & References - Unique Experience over >10-years (I)

- Unique experience, world references and track record.
- More than **3,000** DTS units installed and commissioned worldwide.
Experience & References - Unique Experience over >10-years (II)

- April 2003, Celanese I project. Gasifier temperature monitoring in EX zone “Zero” for ABB in Oberhausen, Germany.

- November 2003, Celanese II project. Gasifier temperature monitoring in EX zone “Zero” for ABB in Oberhausen, Germany.


- May 2005, Formosa project. Reactor skin temperature monitoring for BP Chemical Corp. in Mai Liao, Taiwan.

- April 2009. Industrial process measurement for SMS Siemag in Duesseldorf, Germany.


- 2013 project in process. External wall temperature monitoring of high temperatures/pressure gasification reactors at the Kemper County energy facility for Southern Company in Kemper County, MS (USA).
Principle of the Raman effect

The heating of the fiber increases the lattice vibration, which leads to a change in backscatter behavior. The Stokes and anti-Stokes scattering is called Raman scattering. While the signal of the Stokes scattering is only slightly influenced by temperature, the intensity of the anti-Stokes increases with increasing local temperature of the light waveguide clearly. The temperature can thus be determined by comparing the two signals Stoke and anti-Stoke determined.
OFDR, LIOS Technology’s approach

- Continuous wave operation.
- Backscattered signal is measured in a complex fashion as a function of the modulation frequency.

**Step 1**
- Laser light modulated by frequency.
- Controller receives # of backscattered frequency data.
- Measurement of the backscattering signal in the frequency domain.

**Step 2**
- Fourier Transformation (inverse) to time domain
- Intensity of the Stokes & Anti-Stokes signal is directly coupled to the intensity of the lattice oscillation i.e. to the local temperature.

**Step 3**
- Calculation of the temperature profile (using the internal fibre supply (around 150m) + PT100 as a reference).
Product Information- Optical Frequency Domain Reflectometry (II)

OTDR, our Competition’s approach

- Pulse echo process.
- Time delay of backscattered light indicates location.

\[ \Delta t \equiv \Delta x \]

OFDR advantages

- **No laser wear...** Designed for 24/7 operation with a **MTBF>28 years** (according Telcordia GR-468, reliability assurance for Optoelectronic devices).
- High and constant spatial resolution over long distances.
Product Information - RSTMS state-of-the-art system DTS (I)

- 100% maintenance-free (fully passive cooling, no moving parts)
- Operation temperature: -10°C to +60°C
- Up to 10cm sampling interval / 70cm spatial resolution
- Laser class1M for safe operation
- Others: exchangeable memory card, EX – devices available

Power supply (DC 24…60V, DC 110…220V, AC 100…240V)

External sensors (2x PT100, 2x 0…20mA, 2x 0…10V)

Interfaces (RS232, USB, 2x Ethernet (TCP/IP), MODBUS/DNP3/IEC etc.)

Relays (10…106 Outputs, 4…40 Inputs)

Measurement channels (1…16, [62.5 / 50 / 9]125µm). Single-ended monitoring range (0…30km MM, 10…40km SM)
Product information - RSTMS state-of-the-art DTS system (II)

Temperature resolution: 2km, 50/125µm multi-mode controller
The sensor element

- Purely passive sensor element and immune to electromagnetic interferences.
- Maintenance free (essential for inaccessible areas).
- Immune to aggressive atmospheric conditions.
- Individually adaptable to each particular application (design by LIOS Technology).
- Small volume and flexible.
- Based on a standard multimode telecom fibre.

Standard cable

- Acrylate coated fibre (GI 50/125 or GI 62.5/125) in stainless steel tube or metal free designs.
- Temperature range -30°C to +90°C.
- Halogen-free/flame retardant sheathing.
- Outer diameter 4 to 8mm.
- Cable design for explosion areas (EX Zone “Zero”).
Product information - FO cable and accessories (II)

**High temperature cable**

High Temperature (HT) Fibre In Metal Tube (FIMT) double layer (dl)...

**Permanent** Operating temperature of -40°C to +300°C i.e. -40°F to +572°F.

**Emergency** Operating temperature of +400°C i.e. 752°F.

**The fixture**

Magnetic holder with additional mesh wire solution with maximum operating temperature of 525°C i.e. 977°F.

Example of alternative fixture solutions: point welding with zinc plated carbon steel clamps.
Product Information- Charon3, user friendly software (I)

Standard & Enhanced visualization

- Quick-Start for EASY commissioning, automatic controller search and fibre check.
- Ethernet & USB access (several controllers on one PC system, connection to a virtual machine etc.).
- Visualization of backscattering curves and temperature profiles.
- Several user levels for safe operation.
Product Information- Charon3, user friendly software (II)

Standard & Enhanced visualization

Pylon
Outdoor Area & Sealing Ends
Tunnel
GIS & Sealing Ends
Tie Lines & Transformer
Advantages brought to the Utility

Technical highlights

- **Highly reliable** industrial design with key components approved by the telecom industry (tested according to Telecordia standard GR-468, with medium lifetime >28 years).
- Signal processing based on **patented Raman OFDR-Technology**.
- Flexible and direct connection to management systems such as SCADA, and real time thermal rating (RTTR) software calculation engines based on AEIC and IEEE standards.
- Maintenance free and simplified outdoor installation capability through higher allowed operating temperature range and fan-free DTS unit design.
- Sophisticated temperature surveillance at **commodity** prices.
- Turnkey solution from engineering design to installation/commissioning.
Conclusion: LIOS, a RSTMS a turnkey solution provider

Questions/Comments?

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