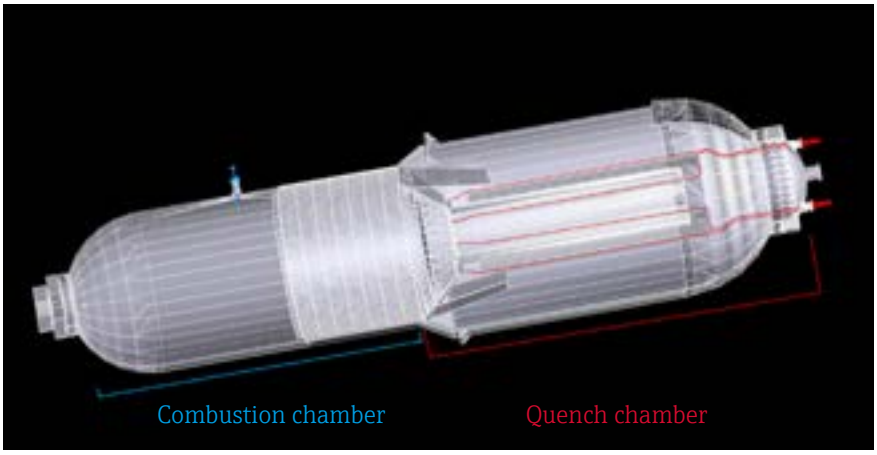
Integrated Gasification Combined Cycle (IGCC) temperature monitoring inside the combustion chamber and quench chamber

Benefits at a glance

- Process optimization
- Reliability
- Safety
- Performance monitoring & maintenance
- Environmental compliance



The customer, a major European energy company, operates a large integrated refinery and petrochemical complex, contributing to the production and supply of refined petroleum products, energy products and petrochemicals. High-temperature reactors (gasifiers) are used to produce syngas by steam reforming or partial oxidation of liquid hydrocarbons, natural gas, or coal in their plant. This application is also known as integrated gasification combined cycle (IGCC).

Asset architecture

Combustion chamber: The partial oxidation reaction of charge oil takes place with pressurized steam. The chamber has an average volume of 25 - 30 m3 and has a dome at the top with a burner in which the process fluid is preheated. Due to the high operating temperature (in the range of 1200 to 1450 °C (2192 to 2642 °F), the chamber is lined by 3 layers of refractory materials.

Quench chamber: This is where the produced syngas is cooled down. The quench chamber is connected to the combustion chamber through a internally wetted dip pipe by water flowing from a quench ring cooling the gaseous streams down to 210 °C (410 °F).

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The challenge

The biggest challenge are the extreme and harsh operating conditions that is existing within the gasifier. Several factors contribute to the difficulty of accurate temperature measurement with this setting:

- **Harsh operating conditions:** Extremely high temperatures with more than 1200 °C in some areas and high-pressure combustion at 45 bar.
- **Corrosive atmosphere:** Presence of gases like hydrogen sulfide that can decrease the performance and lifespan of temperature sensors.
- **Limited access and mounting options:** Only limited entry points into the enclosed system of a gasifier and reactor walls under high pressure.

Combustion chamber

- Operating temperature 1200 to 1450 °C (2192 to 2642 °F)
- Internal reactor surface lined by three layers of refractory with differential thermal expansion
- During operation, the refractory linings shift upwards in different ways due to thermal gradient ΔT across the 3 layers
- Thermometer loaded with high mechanical stress when passing through the bricks of each refractory layer
- Thermowell must be manufactured with different materials to ensure mechanical strength and high temperature resistance

Quench chamber

- Short transition zone from combustion to quench with quick temperature change (around 900 °C (1652 °F))
- Big thermal gradient in only 50 - 80 cm (19 - 31 in)
- Temperature measurement of four representative bolts of the quench ring
- Difficult installation as the transition zone must be reached from the bottom of the chamber
- Long inserts required for the long path from the nozzles to the bolts
- Installation along the internal surface of the dip pipe, where strongest vibrations occur due to the mixture of gas and water under high temperature changes and pressure creating intense turbolences

Our solution

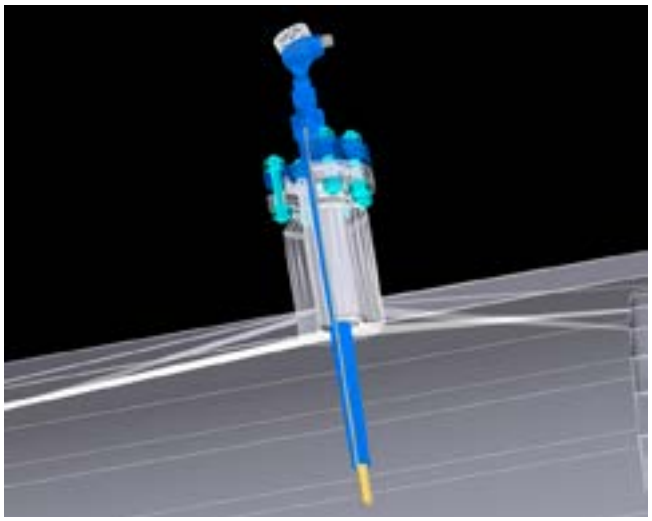
To address the customer's challenges, specialized temperature measurement techniques and sensors, designed to withstand high temperatures and harsh environments, were developed by Endress+Hauser. Those so-called Temperature Engineered Solutions (TES) are based on standard products, adapted to specific customer requirements. Both assemblies are highly modular for easy maintenance through spares planning and include replaceable sensor inserts.

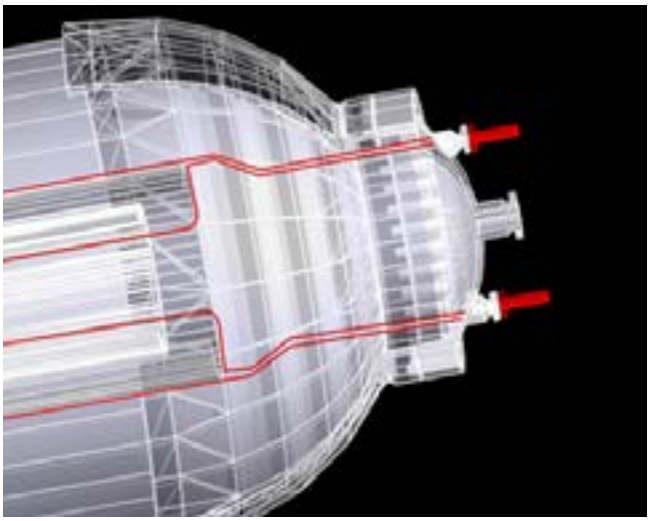
Combustion chamber: TAF16

- Thermowell made of advanced materials and multiple sealing sheaths
- Thermowell made by multiple sealing sheaths in advanced, non-porous ceramic Alumina, like type C799, combined with internal protecting metal thermowell in Tantalum for nearly no Hydrogen diffusion
- Thermowell externally reinforced by sleeve produced with Nickel-Chrome alloy to withstand mechanical stress due to the thermal expansion of refractory lining
- H2 leak detection via Dual Seal function integrated into the process connection for device monitoring
- Sealing barrier at high pressure (60 bar) and high temperature (270 °C (518 °F))

Quench chamber: iTHERM MultiSens Flex TMS02

- Continuious and reliable multipoint temperature measurement during the average time between two reactor maintenance cycles (12 - 16 months)
- Each thermometer has four measuring points (two active sensors and two backup sensors)
- Long immersion length: 8.2 m (3228.35 in)
- Measuring inserts with increased wall thickness
- High corrosion and vibration resistant sheath material (Incoloy 825)
- Leak detection via diagnostic chamber equipped with valves
- Measuring inserts tips to be matched/inserted into specific representive bolts machined as thermowells





Benefits at a glance

- **Process optimization:** Accurate temperature measurements in the combustion chamber allow optimized preheating of the feedstocks and uniform thermal behavior when reacting at the desired temperature. **The optimization is achieved when the detected temperature is reached close to the nominal temperature of the reaction with the minimum burners fuel consumption.**
- **Reliability:** The accurate temperature measurement allows **monitoring of the operating temperature of the internal refractory layers** which are progressively consumed by possible hot process zones. A high rate of refractory material consumption may lead **to heating of the metal shell of the combustion chamber over its maximum allowable design temperature,** affecting the mechanical and corrosion resistance of the alloys.
- **Safety:** Dual Seal leak detection through the diagnostic chamber feature increases the level of safety, allowing the instrument to **operate even with hydrogen diffusion** through the wetted components.
- **Performance monitoring & maintenance:** Accurate and very local temperature measurements allow thermal-gradient calculation through specific gasifier's zones along the quench ring (e.g. through the passage between the combustion and quench chamber). Furthermore, **detection of discontinued gradients around the quench ring** gives information of the residual life of the connecting bolts (or refractory layers) that must be replaced during plant shutdown.
- **Environmental compliance:** Instruments dual seal protection and leak detection capabilities ensure the gasifier stays in compliance regarding **emissions of toxic fluids and extends the life of the refractory materials that otherwise shall be replaced.**

Mounting of iTHERM MultiSens Flex TMS02

Services

For both products, the customized development of the standard products has been carried out in close cooperation with the customer's process engineering team to achieve the best possible product integration into the gasifier. This consultative approach resulted in Endress+Hauser also offering and supplying the detailed design of new connection bolts of the quench ring and new cross-sections of the instrument insertion zone through the refractory layers.

- Thermal modeling of the products
- Inserts routing and fixing inside the quench chamber
- Internal reactor modeling
- Supervision of the installation

Result

The continuous temperature detection inside the combustion chamber with Endress+Hauser devices and their long operating life of 12 - 16 months ensures minimum maintenance downtime and optimized fuel consumption of the process burners. Through steady temperature monitoring the overheating of the vessel's metal walls is avoided. The robust thermometer ensures the performance of the refractory lining giving also indicating the consumption rate by detecting fast temperature changes to ensure full product tightness towards the dangerous process media in case of unforeseen refractory brick detachments in the installation zone of the instrument.

In the quench chamber precise monitoring of the thermal behavior of the internal refractory layer is performed to detect the maximum temperature of the internal cone's surface where the key system quench ring for water injection is connected. Monitoring the operating temperature of the bolts connecting the quench ring to the dip tube ensures the integrity of the whole set of bolts for a long time, reducing the mean time between two inspections.

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