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Application Note

HYGROPHIL F 5673

Process Trace Moisture Analyzer for Recycle Gas of Catalytic Reformer

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APPLICATION NOTE

A key process of the gasoline production is the catalytic reforming of heavy naphtha.

The main purpose of catalytic reforming is the transformation of low octane hydrocarbons to high octane hydrocarbons.
A high octane number is desired in fuels for gasoline engines with high compression rates. During the normal Otto cycle the gasoline-air mixture is compressed and ignited. When heat and pressure increases, low-octane fuels tend to self-ignite too early. This unwanted detonation (known as “knocking”) also produces additional heat and pressure which can damage the entire engine. A gasoline with a high octane number offers a greater compressability which also reduces knocking.

The most wanted fuel for combution engines are C7 to C10 isoparaffinic and aromatic hydrocarbons. Depending on the source of crude oil, the content of the desired hydrocarbons may vary in a wide range from 10% to 70%.
The feedstock for the catalytic refomer is usually a straight-run naphta cut with an IBP (initial boiling point) greater than 82 °C (180 °F) to minimize the benzene content. Subsequently the naphtha passes a hydrotreater unit for removal of impurities like sulfur and nitrogen.

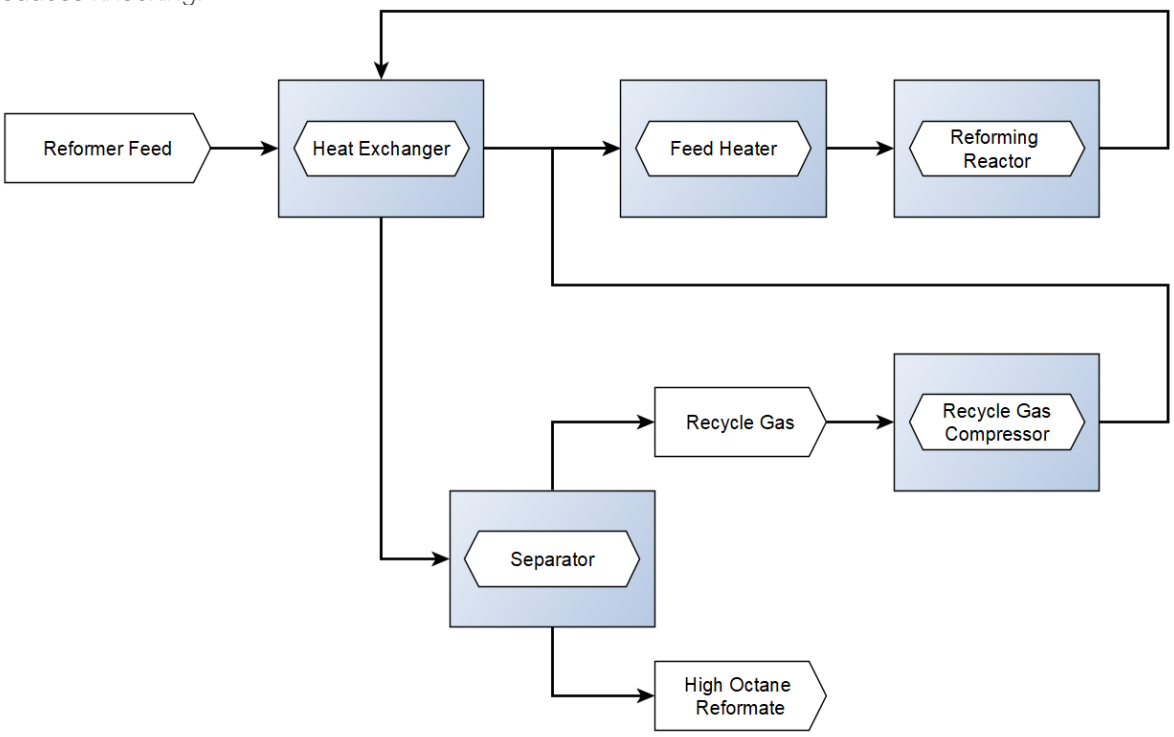

Figure 1: Simplified process flow diagram of a catalytic reformer

The reformer feed passes a heat exchanger to the fired feed heater where the temperature increases up to about 480 °C (900 °F). The reforming reactor is usually filled with and high-purity alumina catalyst which is impregnated with platium.
Within the reforming reactor, several chemical reactions take place. Naphtenic hydrocarbons are dehydrogenated to form aromatics and hydrogen in an endothermic process.

Paraffins are dehydrocyclisated to aromatics hydrocarbons and also hydrogen. Paraffins are isomerized to isoparaffins. Long chained hydrocarbons are cracked to much shorter molecules during hydrocracking.
The outlet stream of the reactor is passing the heat exanger and additional coolers to decrease the temperature.
At the separator, the hydrogen rich gas is seperated from the liquid reformate and returned to the feed stream.

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APPLICATION NOTE

Take care of the catalyst by measuring the trace moisture in the recycle gas

The moisture content of the recycle gas is an important indicator to of the process. The typical moisture content is about 25 ppm_v. A moisture content above 50 ppm_v strips chloride from the catalyst which reduces the performance of hydrocracking and isomerization reactions. The formation of hydrogen chloride decreases the yeald and lead to corrosion of the entire unit. Depeding on the type of the catalytic reformer, a decoking of the catalyst is required on a frequent basis. Air is used to burn off the coke. This procedure also enteres a great deal of moisture from the ambient to the process.
Some units are equiped with additional dryers of the recycle gas to reduce the dry-out time during startup significantly which is important. Long-term exposure of the catalyst with moisture lead to a total deactivation of the catalyst which may also require an expensive replacement.

Typical Recycle Gas Process Conditions:

Composition:	70 to 90 Mole % Hydrogen 10 to 30 Mole % C1 to C4 traces of water and hydrogen chloride
Temperature:	30 to 50 °C (86 to 122 °F)
Pressure:	150 to 300 kPa_g 14.5 to 43 psig
Moisture:	5 to 30 ppm_v (normal) up to 1000 ppm_v (startup)

Long-term reliability and and very low maintenance requirements. That matters!

Specifications of catalytic reformer units are typically rely on moisture analyzers based on capacitive impedance or quartz crystal microbalance moisture analyzers which are well known for its wide measurement range and response time. Both principles are demanding a sample handling system and frequent recalibration or costly maintenance, especially when HCl levels are high or catalyst dust is present in the recycle gas stream.
The HYGROPHIL F trace moisture analyzer is equiped with an extremely robust moisture sensor which is suitable for inline installations by using a sensor rectration tool or a simple T-fitting for integration into an existing sample conditioning system.
The robust sensor construction is resistant to HCl traces and a periodical recalibration is not needed. A yearly check is recommended but limitied to simple cleaning of the moisture sensitive layer. The sensor retraction armature makes that maintenance task very simple – without interrupting the process.

Figure 2: Moisture Sensor L1661 installed in an sensor retraction armature

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The HYGROPHIL F is designed for the needs of the oil and gas industry.

The core element of the moisture sensor is an optical thin film element made of silicon dioxide and zirconium dioxide. The microporous stack of alternating high and low refracting optical layers is forming a Fabry-Pérot Interferometer with a distinctive and reliably detectable reflection minimum in the spectral range around 820 nm.
Selective to water, molecules can diffuse into the porous Fabry-Pérot element, which then performs a shift of the reflection minimum in proportion to the actual water vapour pressure. The spectral shift is detected and evaluated with a compact high-resolution polychromator, which is located in the evaluation unit together with the light emitting diode. The interconnecting fiber optic cable can be up to 800 m long because of the detection of an optical minimum instead of an intensity change.
The evaluation unit processes and calculates the present dew point temperature as well as other units such as water vapour pressure, parts per million, mg/m³ and further more. It offers the indication of the dew point temperature at current line pressure as well as to different defined reference pressure. Optionally the calculation from dew point temperature to mg/m³ can be done in conformity to DIN EN ISO 18453, which takes respect of the entered gas composition.

Several analog outputs, MODBUS, PROFIBUS RTU and via TCP/IP as well as relay contacts are equipped as standard for interconnection to the control system.

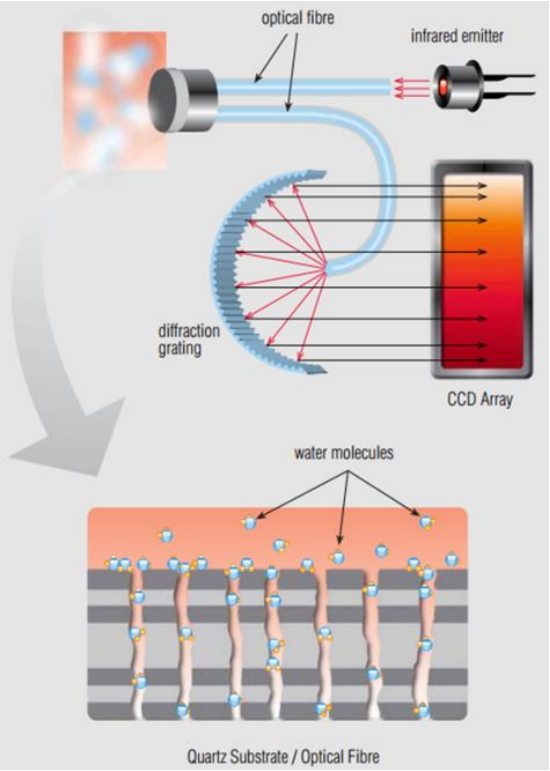

Figure 3: Schematic of the Measurement Principle

Thousands of installations worldwide prove the advantages of this measurement principle:

- Robust sensor construction for outstanding long-term stability
- Sensor validation at process conditions by accredited and independent laboratory on request
- Easy sensor cleaning and almost no maintenance required
- In-line installation with sensor retraction armature possible (fast response and emission-free)
- Flexible on-line solutions with customized sample conditioning systems
- Certified for safe operation in hazardous area (ATEX, IECEx, CSA, TR CU)

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