Use of Process Analytics in clean biofuel production

Gas analyzers and gas chromatographs monitor synthetic biodiesel production

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Second generation biofuels

Declining crude oil resources and increasing demand for more and cleaner fuels promote intensive development work in the production of alternative fuels. This is the scenario where biofuels are getting increasingly attention: according to an EU (European Union) vision, biofuels should cover about 20 % of the Market in 2030. Very similar expectations and targets exist in other countries including the US.

A first generation of biofuels is already available, but raw materials are expensive and compete with food production. Therefore, these biofuels are going to be replaced by a second generation biofuels which is characterized by a much higher grade of land efficiency by using whole plants.

Advanced technologies

Advanced technologies are required to convert biomass into second generation biofuels. Two approaches currently exist: The first approach is biofuels, namely ethanol, produced by enzyme hydrolysis of lignocellulosic biomass, and biodiesel, produced by transesterification of vegetable oil.

The second approach is the "Biomass-To-Liquid (BTL) process" which first gasifies the biomass into syngas and then uses established Fischer-Tropsch (FT) synthesis to produce liquid fuels of excellent quality. However, unlike the well-known Gas-To-Liquid (GTL) approach, where syngas is produced from natural gas, there is currently no industrial grade technology available for biomass gasification.

The world’s first commercial BTL plant has been constructed by CHOREN in Freiberg, Germany, based on the CHOREN owned and patented Carbo-V® Process for the gasification of biomass.

Siemens continuous gas analyzers and process gas chromatographs monitor and control this demanding process. The measured data are delivered to a SIMATIC PCS 7 control system.
Different Synthetic Fuel production routes

High-quality synthetic automotive fuels can be obtained from a synthesis gas (called Syngas) which is produced through different routes (fig. 1) from either Natural Gas (GTL, Gas-To-Liquid, route 1), Coal (CTL, route 2) or Biomass (BTL, route 3). All routes use similar but partly different processing steps:

- Formation of syngas from the feed material through processes such as coking, steam reforming or gasification
- Conversion of syngas to short-chain hydrocarbons resp. synthetic fuels through the well-established FT (Fischer-Tropsch) synthesis reaction
- Final upgrading of the FT hydrocarbons (waxes) through hydrocracking techniques

CHOREN’s BTL process

CHOREN, located in Freiberg, Germany (fig. 5) is one of the world’s leading gasification technology companies for solid biomass feedstock. CHOREN (Carbon, Hydrogen and Oxygen that is converted into RENewable energy) has developed and internationally patented the Carbo-V® gasification process. This 3-stage gasification process converts solid biomass into highly pure, tar-free, low-methane syngas, prevailing a mixture of carbon monoxide and hydrogen.

The following FT process, together with the final upgrading, produces the synthetic bio fuel (fig. 2).

The processing steps are:

- **Low-temperature gasification**
  The dried and shredded biomass is reduced at 400 to 500 °C into a smouldering gas containing tar-rich volatiles and solid char.
- **High-temperature gasification**
  In the patented Carbo-V® gasifier the volatiles are partially oxidized with oxygen and steam. Due to the high temperature above 1 400 °C the ash particles melt and long-chain hydrocarbons are broken into CO and H₂ resulting in a tar-free gas.
- **Endothermic gasification**
  The milled and pulverized char is blown into the hot gases beneath the combustion chamber where it is gasified endothermically. This causes an almost instantaneous drop in temperature to 800 °C (quenching) to produce a raw gas with a high heating value.
- **Gas treatment**
  The tar-free gas is cooled (yielding in steam), cleaned from ash particles and char, passes a CO conversion reactor and a fine cleaning stage before entering the FT reactors.
- **FT (Fischer-Tropsch) reaction**
  Long chain hydrocarbons are formed from carbon and hydrogen with the help of a catalyst.
- **Upgrading**
  High quality fuels and other products are formed from FT-hydrocarbons using hydrocracking techniques.

CHOREN’S BTL fuel features a number of positive properties:

- It is renewable and largely CO₂ neutral because the volume of CO₂ released during the manufacture and combustion is only that which was drawn from the atmosphere previously by the plants.
- It has a high cetane number and therefore provides much better ignition performance than conventional diesel fuel.
- It has no aromatics or sulfur and significantly reduces pollutants from exhaust emissions (by 30 to 50 percent less soot compared to fossil fuels) and it can be used without any adjustment to existing infrastructure or engine systems.
- It is produced from nonfood biomass consisting of agricultural waste products, scrap wood, and low-quality forest wood (branches, treetops).
Siemens Process Analyzers at CHOREN’s BtL plant

Process analytics is an essential part of the plant’s instrumentation to monitor and optimize all process steps and to ensure safe plant operation. Siemens gas analyzers have already been operating successfully for years in CHOREN’s first pilot plant and have proven their worth during the demanding trial runs and experiments. This positive experience and the excellent technical consulting favored the company’s decision to use Siemens analytical technology and competence also in the commercial plant.

Safety control
Areas relevant to safety of personnel, plant equipment and environment are monitored for CO and O2 concentration by the low-maintenance ULTRAMAT 23 and the OXYMAT 6.

Process control
Several Series 6 gas analyzers such as ULTRAMAT 6, CALOMAT 6 and OXYMAT 6 are used for control and monitoring tasks in the syngas production and conditioning processes at different locations. In the synthesis area (FT process) process gas chromatographs (MAXUM Ed. II) are used. The analyzers and chromatographs are installed either on site, mainly however in an analyzer house, fig. 3.

Utilities
Plant utilities such as catalyst regeneration or pressure swing adsorption are also monitored by Siemens continuous analyzers and process chromatographs.

<table>
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<th>Segment / Process steps</th>
<th>Typically used analyzer</th>
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<td>ULTRAMAT 23</td>
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<td>2</td>
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<td>3 Gas cleaning and synthesis</td>
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Tab. 1: Typical analyzer used in the process segments

Quality of final product
The final product is controlled for its purity by using laboratory analysis equipment, fig. 4.

As usual in engineering and construction of large plants, various vendors have been involved in the construction of the CHOREN plant. They delivered turnkey subsystems to the plant, including process analytical equipment. All of the vendors decided to use Siemens analyzers as well in their subsystem.

Process control system
The plant is controlled by an industry-proved Siemens control system. All measured analyzer values are directly transmitted to the system, where they are available to the plant operator. And with Totally Integrated Automation (TIA), a perfect solution is available to integrate process analytical data into a higher level automation system.

Competence in BTL process analytics
Process analytical measuring tasks in the CHOREN plant are quite typical for BTL processes making this installation a kind of standard for similar plants.

Siemens Process Analytics has proved competence and experiences in handling this project. Leading technology in analyzers and chromatographs, worldwide presence, turnkey system engineering competence and outstanding application knowledge in GTL and BTL processes make Siemens a very strong partner for delivery of process analytics to BTL plants world wide.
Siemens Process Analytics is a leading provider of process analyzers and process analysis systems. We offer our global customers the best solutions for their applications based on innovative analysis technologies, customized system engineering, sound knowledge of customer applications and professional support. And with Totally Integrated Automation (TIA). Siemens Process Analytics is your qualified partner for efficient solutions that integrate process analysers into automations systems in the process industry.

From demanding analysis tasks in the chemical, oil and gas and petrochemical industry to combustion control in power plants to emission monitoring at waste incineration plants, the highly accurate and reliable Siemens gas chromatographs and continuous analysers will always do the job.

Siemens process Analytics offers a wide and innovative portfolio designed to meet all user requirements for comprehensive products and solutions.

Our Products

The product line of Siemens Process Analytics comprises

- extractive and in-situ continuous gas analyzers (fig. 6-8)
- process gas chromatographs (fig. 9-11)
- sampling systems
- auxiliary equipment

Analyzers and chromatographs are available in different versions for rack or field mounting, explosion protection, corrosion resistant etc.

A flexible networking concept allows interfacing to DCS and maintenance stations via 4-20 mA, PROFIBUS, OPC, Modbus or industrial ethernet.

Analytical Application Sets

Siemens Process Analytics offers also standardized system solutions developed around our products for a wide range of industry sector applications. Such turnkey systems include:

- Set FLK Continuous sampling of flue gas in cement kilns
- Set GGA Continuous monitoring of H2-cooled generators
- Set CV Determining the natural gas quality
- Set CEM Continuous monitoring of emission components in flue gases
- Set ASM Manage, monitor and validate a wide range of different type of analyzers (Analyzer System Manager)
Extractive Continuous Gas Analyzers (CGA)

**ULTRAMAT 23**
The ULTRAMAT 23 is a cost-effective multicomponent analyser for the measurement of up to 3 infrared sensitive gases (NDIR principle) plus oxygen (electrochemical cell). The ULTRAMAT 23 is suitable for a wide range of standard applications. Calibration using ambient air eliminates the need of expensive calibration gases.

**CALOMAT 6/62**
The CALOMAT 6 uses the thermal conductivity detection (TCD) method to measure the concentration of certain process gases, preferably hydrogen. The TCD method as well and is specially designed for use in application with corrosive gases such as chlorine.

**OXYMAT 6/61/64**
The OXYMAT 6 uses the paramagnetic measuring method and can be used in applications for process control, emission monitoring and quality assurance. Due to its ultrafast response, the OXYMAT 6 is perfect for monitoring safety-relevant plants. The corrosion-proof design allows analysis in the presence of highly corrosive gases. The OXYMAT 61 is a low-cost oxygen analyser for standard applications. The OXYMAT 64 is a gas analyzer based on ZrO$_2$ technology to measure smallest oxygen concentrations in pure gas applications.

**FIDAMAT 6**
The FIDAMAT 6 measures the total hydrocarbon content in air or even in highboiling gas mixtures. It covers nearly all requirements, from trace hydrocarbon detection in pure gases to measurement of high hydrocarbon concentrations, even in the presence of corrosive gases.

ULTRAMAT 6
The ULTRAMAT 6 uses the NDIR measuring principle and can be used in all applications from emission monitoring to process control even in the presence of highly corrosive gases. ULTRAMAT 6 is able to measure up to 4 infrared sensitive components in a single unit.

**ULTRAMAT 6 / OXYMAT 6**
Both analyzer benches can be combined in one housing to form a multi-component device for measuring up to two IR components and oxygen.

In-situ Continuous Gas Analyzers (CGA)

**LDS 6**
LDS 6 is a high-performance in-situ process gas analyser. The measurement (through the sensor) occurs directly in the process stream, no extractive sample line is required. The central unit is separated from the sensor by using fiber optics. Measurements are carried out in real-time. This enables a pro-active control of dynamic processes and allows fast, cost-saving corrections.

**SITRANS SL**
SITRANS SL is a compact transmit-terlike designed gas analyzer for fast in-situ measurements of oxygen concentration in process gases. The measuring principle is based on the diode laser technology and almost free of crossinterferences. The analyzer consists of a transmitter and receiver unit which are mounted directly at the process.

**SITRANS CV**
SITRANS CV is a micro process gas chromatograph especially designed for reliable, exact and fast analysis of natural gas. The rugged and compact design makes SITRANS CV suitable for extreme areas of use, e.g. offshore exploration or direct mounting on a pipeline. The special software „CV Control” meets the requirements of the natural gas market, e.g. custody transfer.

Process Gas Chromatographs (Process GC)

**MAXUM edition II**
MAXUM edition II is very well suited to be used in rough industrial environments and performs a wide range of duties in the chemical and petrochemical industries and refineries. MAXUM II features e. g. a flexible, energy saving single or dual oven concept, valveless sampling and column switching, and parallel chromatography using multiple single trains as well as a wide range of detectors such as TCD, FID, FPD, PDHID, PDECD and PDPID.

**MicroSAM**
MicroSAM is a very compact explosionproof micro process chromatograph. Using silicon-based micromechanical components it combines miniaturization with increased performance at the same time. MicroSAM is easy to use and its rugged and small design allows mounting right at the sampling point. MicroSAM features drastically reduced cycle times, provides valveless sample injection and column switching and saves installation, maintenance, and service costs.
Analytical solutions are always driven by the customer’s requirements. We offer an integrated design covering all steps from sampling point and sample preparation up to complete analyser cabinets or for installation in analyser shelters (fig. 13). This includes also signal processing and communications to the control room and process control system.

We rely on many years of world-wide experience in process automation and engineering and a collection of specialized knowledge in key industries and industrial sectors. We provide Siemens quality from a single source with a function warranty for the entire system.

Read more in chapter „Our services“.

Fig. 13 Analyzer house (shelter)

Analyzer networking for data communication

Engineering and manufacturing of process analytical solutions increasingly comprises „networking“. It is getting a standard requirement in the process industry to connect analyzers and analyzer systems to a communication network to provide for continuous and direct data transfer from and to the analysers (fig. 12).

The two objectives are (fig. 14):

- To integrate the analyzer and analyzer systems seamlessly into the PCS / DCS system of the plant and
- To allow direct access to the analyzers or systems from a maintenance station to ensure correct and reliable operation including preventive or predictive maintenance.

Siemens Process Analytics provides networking solutions to meet the demands of both objectives.
Siemens Process Analytics is your competent and reliable partner worldwide for Service, Support and Consulting.

Our resources for that are

- **Expertise**
  As a manufacturer of a broad variety of analyzers, we are very much experienced in engineering and manufacturing of analytical systems and analyzer houses. We are familiar with communication networks, well trained in service and maintenance and familiar with many industrial processes and industries. Thus, Siemens Process Analytics owns a unique blend of overall analytical expertise and experience.

- **Global presence**
  With our strategically located centers of competence in Germany, USA, Singapore, Dubai and Shanghai, we are globally present and acquainted with all respective local and regional requirements, codes and standards. All centers are networked together.

**Service portfolio**

Our wide portfolio of services is segmented into Consulting, Support and Service. It comprises really all measures, actions and advises that may be required by our clients throughout the entire lifecycle of their plant:

- Site survey
- Installation check
- Functionality tests
- Site acceptance test
- Instruction of plant personnel on site
- Preventive maintenance
- On site repair
- Remote fault clearance
- Spare part stock evaluation
- Spare part management
- Professional training center
- Process optimisation
- Internet-based hotline
- FEED for Process Analytics
- Technical consulting

**FEED for Process Analytics**

Front End Engineering and Design (FEED for PA) is part of the planning and engineering phase of a plant construction or modification project and is done after conceptual business planning and prior to detail design. During the FEED phase, best opportunities exist for costs and time savings for the project, as during this phase most of the entire costs are defined and changes have least impact to the project. Siemens Process Analytics holds a unique blend of expertise in analytical technologies, applications and in providing complete analytical solutions to many industries.

Based on its expertise in analytical technology, application and engineering, Siemens Process Analytics offer a wide scope of FEED services focused on analysing principles, sampling technologies, application solutions as well as communication system and given standards (all related to analytics) to support our clients in maximizing performance and efficiency of their projects.

Whether you are plant operators or belong to an EPC Contractor you will benefit in various ways from FEED for Process Analytics by Siemens:

- Analytics and industry know how available, right from the beginning of the project
- Superior analyzer system performance with high availability
- Established studies, that lead to realistic investment decisions
- Fast and clear design of the analyzer system specifications, drawings and documentation
- Little project management and coordination effort, due to one responsible contact person and less time involvement
- Additional expertise on demand, without having the costs, the effort and the risks of building up the capacities
- Lowest possible Total Costs of Ownership (TCO) along the lifecycle regarding investment costs, consumptions, utilities supply and maintenance.
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