Turning straw into fuel.

Inbicon A/S in Kalundborg, Denmark, together with Siemens Technology produces bioethanol from cellulose – environmentally sound and economical.
There is considerable interest worldwide in second-generation bioethanol plants. The United States, for example, is planning the production of 16 billion gallons of second-generation bioethanol by the year 2022. That is about 10,000 times the capacity of the Inbicon plant in Kalundborg introduced here, one of the first bioethanol plants of the second generation worldwide. While ethanol is mainly produced from starch and sugar, such as sugar cane and grains, in plants of the first generation, plants of the second generation use biomass, such as straw, wood and other biological residual materials.

Fermentation turns residual materials containing cellulose, such as straw, into environmentally friendly fuel in bioethanol plants of the second generation.

The Danish company Inbicon A/S is a world leader in this innovative technology. In its refinery in Kalundborg, Denmark, designed as a demonstration plant, Inbicon turns straw into bioethanol. The company has patented this process and even developed special machines for the different processes required for processing the straw. Siemens was the most important technology partner during the planning, construction and commissioning of the plant in Kalundborg. During project implementation, especially for the selection of the optimum measurement method and design of the instruments, the Vogelbusch GmbH played an important role in addition to Inbicon. The company has been involved in the areas of planning and plant construction for biotechnology since its foundation in 1921.
A technology partner with lots of experience and expertise

The main reason for selecting Siemens was the comprehensive range of solutions and the tremendous experience in automation and electrotechnical fitting of plants for the production of biofuels. Siemens has for many years been one of the leading suppliers worldwide of automation and drives technology, industrial switching technology, industrial software and energy management for the entire production process that can also be used in bioethanol plants.

“We as system supplier offer the products as well as the process and technological expertise to meet the requirements of biofuel production of the first and, more importantly, of the second generation,” says Axel Grönn, Siemens project manager.

“When we awarded the contract, one of the decisive factors was that Siemens plays an important role in bioethanol plants of the first generation in the American market. The United States is the principal target market for our technology, so we are looking for synergies.”

Benny Mai, Vice President Scale-up and Demonstration, Inbicon A/S
Totally Integrated Automation makes for fast commissioning and efficient operation of plants

Immediately after being awarded the contract in July 2008, Siemens began with detailed planning of the power distribution, control systems and all instruments required to control and manage the plant.

The transformers were installed during the construction phase in January 2009 and integrated with the appropriate fire protection. More than 350 meters of aluminum conductor bar (4000 A) were installed from February to May 2009 to link up the two 2500 kVA GEAFOL transformers, the main switchgear and the local switchgear units. This setup ensured the power supply for a large part of the plant.

The modular design concept and the use of plug-in modules proved to be a very good choice, because changes could be made at any time and within the agreed budget. Other adjustments to the switchgear became necessary, mainly due to changes in the performance characteristics resulting from newly added or larger consumers, such as frequency converters and direct and reversible drives. Pump drives for flow control, for example, are governed with Siemens frequency converters. In distillation, motors with explosion protection are used.

“The move from SIMATIC SPS 7 and WinCC to the PCS 7 world took us into unfamiliar territory. Now one click is all it takes to connect a new motor. Once you are properly familiar with the principle, you can soon profit from the benefits.”

Peter Giversen, SCADA engineer and chief engineer at Inbicon

A total of 697 Siemens measuring instruments are used to control and manage the entire plant – as here in the straw feed.
Thousands of measuring points, control valves, analytical devices, frequency converters and drives were installed in the plant and are connected via PROFIBUS with the automation.

Precise information for greater process safety and product quality

For efficient operation of the plant – and efficiency is the main variable, especially in this environment – Inbicon requires precise information about the processes. Only then, it can be ensured that raw materials are used sparingly, that power is used optimally and that a high-quality, reproducible end product is created. This process requires continuous measurement of temperatures, flow rates, fill levels, pressure or pH and ethanol content.

The challenge during the engineering phase was to always match the field devices with their specific properties to the constantly refined process design. A total of 697 measuring instruments was required, such as SITRANS P DS III to measure the fill levels in the fermenter, SITRANS TH400 measuring transducers with sensor installed directly in the field for the highest temperature ranges, SITRANS FC to determine flow rates, alcohol content and concentration as well as SITRANS FM for flow rate measurements. Pointek fill level measuring devices were used for min./max. control as well as SIPART PS2 position controllers to control the inflows and outflows. Ultrasound and radar fill level measuring devices, SIWAREX weighing systems and a number of analytical devices complete the portfolio. The preconfigured measuring and control devices, coordinated with PROFIBUS, helped to save valuable time during installation and commissioning of the devices.
All processes always under control with SIMATIC PCS 7

The production processes are complex and their automation is rather challenging. Inbicon did not have any previous experience with the SIMATIC PCS 7 process control system from Siemens, but did not want to leave programming of the core technology to someone else. Inbicon was able to program the core processes independently due to the very close coordination with and support from Siemens. All programmers underwent training at the start of the project and were constantly coached. The Factory Acceptance Test (FAT) took place as scheduled in June 2009.

SIMATIC PCS 7 Version 7.0 SP1 with the standard library is used. The configuration consists of two engineering stations, four operating stations with six S7-400 controllers for automation of the subsections, seven switchboards, 697 measuring instruments and as many valves. Communication takes place via a redundant bus and server system, a web server as well as a central archiving server. Integration of the field devices takes place via ET 200M, ET 200isp in the distillation (Ex area) and PROFIBUS PA.

“The move from SIMATIC SPS 7 and WinCC to the PCS 7 world took us into unfamiliar territory. We were no longer operating at the bits and bytes level but had to hand over the reins,” recalls Peter Giversen, SCADA engineer and chief engineer at Inbicon, who actually became familiar with the SIMATIC PCS 7 world rather quickly. “Now one click is all it takes to connect a new motor. Once you are properly familiar with the principle, you can soon profit from the benefits,” states a content Peter Giversen.
An innovative process with great potential

About 4,300 tons of fuel are produced from around 30,000 tons of straw in the bioethanol plant of the second generation in Kalundborg each year.

Inbicon A/S – the name stands for Integrated Biomass Conversion – was founded in 2007 as an independent subsidiary of DONG Energy, Denmark’s largest energy provider. It is the goal of the company to become the global market leader in the development of sustainable biomass refineries that are characterized by technologies for pretreatment and systems for energy integration.

There was enormous pressure to build the demonstration plant in Kalundborg on time. The plant was to provide the fuel for the VIP and shuttle vehicles used during the UN world climate summit in Copenhagen in December 2009. Thanks to the good cooperation, it was possible to implement the project in 18 months and meet all deadlines. In August 2010, the plant reached the scheduled production quantities of ethanol, C5 molasses and lignin pellets for the first time.

Inbicon’s strength lies in its treatment of the raw materials and the efficient handling of all resources. Unlike the competitors, who use substances like ammonia in their production process, Inbicon only works with water, enzymes and yeast. This process is much more efficient because it eliminates the cleaning process and prevents waste materials.

Straw is cut for the production process, then heated under pressure and broken down by enzymes. The molecular lignin melts during the heat treatment. This step lets enzymes from Danisco Genencor and Novozymes transform the cellulose fibers of the straw into sugar. The next process step takes place after cooling: Ethanol is produced by adding yeast. The ethyl alcohol produced is isolated by distillation. The last process step is dehydration. Water is removed from the alcohol in this step so that it can be used as fuel. The result is bioethanol with a purity level of more than 99 percent. This process turns four tons of straw into 17,000 liters of bioethanol per hour in the Kalundborg plant every day.

All residual materials created in the production further increase profitability of the plant. Each year, more than 11,000 tons of cattle feed are produced from the C5 molasses and about 13,000 tons of pellets, which are used as combustible, are produced from the lignin. Another contribution to improving the energy balance of the plant.
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