

FOUNDATION™ TECHNOLOGY: AUTOMATION INFRASTRUCTURE FOR OPERATIONAL EXCELLENCE

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ABSTRACT

Brunner Mond (UK), a major producer of sodium carbonate (soda ash) for the European market, decided to replace the outdated control system at its Northwich East plant in Cheshire, England, with the latest process automation technology. Brunner Mond sought a modern control system that would improve its operational efficiency, reduce plant maintenance costs, increase safety, and minimize unplanned shutdowns due to equipment failure.

After considering various competitive approaches, Brunner Mond installed a FOUNDATION™ digital automation infrastructure. During the first phase of the DCS replacement, fieldbus technology was employed on two Solvay towers used to carbonate ammoniated brine to form sodium bicarbonate crystals. This project proved to be successful, and set the stage for implementation of additional fieldbus controls on Brunner Mond's Northwich production operation.

INTRODUCTION

The Brunner Mond Group is a leading global manufacturer of alkaline chemicals with production facilities in Cheshire, UK; Delfzijl, The Netherlands; Magadi, Kenya; and Durban, South Africa. The company is the largest producer of sodium carbonate in the UK, and the second largest soda ash manufacturer in Europe. It is also the world's third largest producer of refined sodium bicarbonate.

Brunner Mond produces two varieties of soda ash, heavy and light. The former is a vital raw material for making glass, and the latter for making detergents. Both are used in the manufacture of industrial chemicals. Refined sodium bicarbonate is a key ingredient in pharmaceuticals and toothpaste, while other grades are used for bakery products and deodorants.



Fig. 1. Brunner Mond produces both heavy and light soda ash.

BACKGROUND

Before the advent of industrial manufacturing processes, sodium carbonate came from natural sources, either vegetable or mineral. Soda made from ashes of certain plants or seaweed has been known since antiquity.

In 1861, Ernest Solvay perfected a soda ash production technique based on common salt (NaCl), limestone (CaCO₃) and ammonia. The Solvay process involves saturating a concentrated brine solution with ammonia to form ammonium salts, and then with carbon dioxide (made by burning lime). This produces ammonium bicarbonate, which reacts with the brine to form ammonium chloride and sodium carbonate. This material, in the presence of excess carbon dioxide, is converted to sodium bicarbonate, which precipitates out of the solution and can easily be decomposed to soda ash by heating. The resulting carbon dioxide can be recycled, and the ammonium chloride treated to recover reusable ammonia.

The Solvay process produces light soda ash with a specific weight or pouring density of about 500 kg/m³. The light ash is transformed by recrystallization, first to sodium carbonate monohydrate, and finally to heavy soda ash after drying (dehydration). Heavy soda ash has a pouring density of about 1000 kg/m³.

PROCESS OVERVIEW

Brunner Mond's Northwich, Cheshire, facility, constructed in the early 1870s, consists of two manufacturing plants with a production capacity of approximately 900,000 tonnes per annum (tpa). Together, the plants form one of Europe's largest manufacturing operations for alkaline-related products.



Fig. 2. Brunner Mond's Northwich West production plant.

The Northwich East plant includes 23 identical, cast iron Solvay towers, used to carbonate ammoniated brine to produce sodium bicarbonate crystals in ammonium chloride liquor. The carbon dioxide is produced in kilns where limestone is burnt using coke. At the top, a concentrated solution of sodium chloride and ammonia enters the tower. As the saturated solution moves from the top of the tower downward, it reacts exothermically with the carbon dioxide to form sodium bicarbonate crystals and is cooled. These crystals are



Fig. 4. FOUNDATION digital automation infrastructure.

Using asset management software, the new, fieldbus-based control system extracts information contained in measurement devices and shares this Process Variable (PV) data across the plant enterprise. The system uses the OPC standard to ensure configuration, calibration, status, performance, and health of devices are accessible plant-wide.

Predictive maintenance capabilities, improved process control, and increased dissemination of information are benefits not found in a conventional DCS system.

For Brunner Mond, the choice of a FOUNDATION automation infrastructure made good business sense. The technology (which is included in the IEC 61158-2 international standard) has a rapidly expanding global user base; increasingly, it is the solution of choice for large Greenfield projects—as well as many retrofit projects. FOUNDATION technology eliminates the built-in obsolescence of traditional I/O, and meets the need for an open, tightly integrated automation platform enabling plants to realize Capital Expense (CAPEX) and Operating Expense (OPEX) savings.

More than a fieldbus protocol, FOUNDATION technology removes the constraints of outdated, proprietary control systems by allowing end users to “mix and match” field instruments from different suppliers, and integrate networks, sub-systems and devices across the plant enterprise. All registered, FOUNDATION-compliant instruments are tested to a known specification and verified as interoperable with other registered devices.

FOUNDATION technology is intended primarily for process control, field-level interface, and device integration. Running at 31.25 kbit/s, the H1 fieldbus interconnects devices such as transmitters, valves and actuators on a field network. Where appropriate, the FOUNDATION solution also provides a High Speed Ethernet (HSE) implementation, running at speeds of 100 Mbit/s or higher, for use as a control backbone.

FOUNDATION-compliant instruments comprise a function block application, act as a publisher and subscriber of PVs, transmit alarms and trends, and provide server functionality for host access and management functions. Devices can

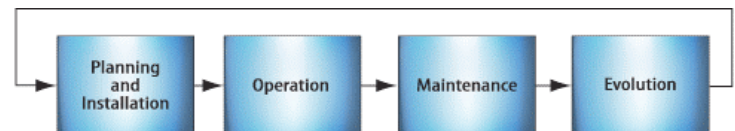
function as a scheduler and time master for regulating communication on a fieldbus segment. They can also be used for bus interfaces in process control systems or in linking devices.

The FOUNDATION automation infrastructure makes the highest possible use of “smart” instrumentation and advanced diagnostics. The technology offers a robust platform for automating continuous processes, and provides a field network for measurement and control in which each device has its' own intelligence and communicates via an all-digital, serial, two-way communications system. Modern fieldbus instruments can transmit multiple variables, helping to minimize process variability, as well as device identification information. This enables collection and transmission of instrument diagnostics, thus reducing unnecessary shutdowns and improving safety and regulatory compliance.

The FOUNDATION solution also reduces complexity by offering a standard engineering toolbox, standard Device Descriptions (DDs), and a standard Graphic User Interface (GUI) approach to configuration for all devices and vendors.

For plants with mission-critical control applications, FOUNDATION technology offers the advantage of deterministic, peer-to-peer communications. Users can choose either control in the field or control in the host, with the most complex automation tasks easily accommodated. A fieldbus control strategy restores single loop integrity to the process—improving loop reliability and increasing availability.

FOUNDATION technology also reduces Central Processing Unit (CPU) loading, and provides a “lean” system architecture with fewer wires running from junction boxes to marshalling panels and I/O terminations than a traditional control system. Fewer wires and more I/O channels decrease control room footprint and panel space. As such, loop and wiring diagrams, panel drawings and cable schedules are greatly simplified. Installation is easier than with a traditional system since several devices can be multi-dropped on a single pair of wires.



- Reduced number of wires and marshaling panels
- Reduced number of intrinsic safety barriers
- Reduced number of input/output converters
- Reduced number of power supplies and cabinets
- Reduced size of equipment rooms
- Remote configuration of devices
- More information available for operations
- Increased accuracy of measurements
- Easier evolution due to standardized function blocks
- Increased sophistication and flexibility of instrumentation
- Increased uptime due to less equipment, better self diagnostics, and remote diagnostics

Fig. 5. H1 fieldbus benefits.

SYSTEM DESIGN

During the first phase of Brunner Mond's DCS replacement project, FOUNDATION-based controls were installed on two of the Solvay towers, which carbonate ammoniated brine produced in the facility's absorber plant. Each tower operates on two separate fieldbus segments using redundant interfaces. The upgrade also included installation of digital instrumentation, including Temperature Transmitters (TT), Vortex Flow Meters (VFM), Electromagnetic Flow Meters (EFM) and Control Valves (CV) for controlling and monitoring process conditions.

Fieldbus device locations on the towers include:

- 7th level – 1 EFM, 2 CVs
- 6th level – 1 TT
- 5th level – 1 CV
- 4th level – 1 VFM, 1 CV
- 3rd level – 1 VFM, 2 CVs, 1 TT
- 2nd level – 1 CV
- Ground – 1 TT

The H1 fieldbus topology utilizes a "Crow's Foot" trunk (~150 m) and spurs (<25 m). The device network incorporates one junction box per tower at the 7th level (plus terminators), with two segments per junction box. The segments interconnect a maximum of seven devices (including four valves) each, and support deterministic communications with publisher/subscriber and VCR functions. Standard FOUNDATION function blocks are used throughout all devices.

The fieldbus system enables operators to execute hybrid control on the Solvay tower process, with PID algorithms and sequences located in the host. Using this approach, an Analog Input (AI) executes in a fieldbus transmitter, a PID block runs in a host controller, and an Analog Output (AO) block executes in a digital valve controller. Both the AI block and the AO block publish data to the H1 card, and the H1 card publishes data to the AO block. The H1 card contains the Link Active Scheduler (LAS) and transfers the published data per the LAS schedule. The timing of the controller execution rate, I/O scan rate, and macrocycle scan rate is asynchronous. In this case, the macrocycle execution rate is held at 1.0 second. Module execution cycles at 2.0 seconds and sequence module execution cycles at 5.0 seconds.

Thanks to the flexibility of the fieldbus topology, project engineers were able to situate field instruments in the most advantageous locations across the unit operations. Unlike the old control system, for example, flow meters are now installed in straight, unobstructed pipe runs to improve their measurement accuracy, and temperature transmitters are placed at the correct process points.

USER CONSIDERATIONS

During the evaluation of its DCS replacement project, Brunner Mond identified key system engineering, operations, maintenance and installation considerations for users of FOUNDATION technology. For example, even though a fieldbus

control system results in faster system I/O and panel design, easier configuration and less documentation (in this instance, two segment sheets vs. six loop sheets), it requires additional upfront detailed design. Users must also identify their fundamental control strategy and system topology earlier in the project planning.

From an operational standpoint, FOUNDATION technology helps plant personnel have greater trust in the accuracy and reliability of control instrumentation. Consequently, they are free to concentrate on other important production tasks. Fieldbus-based controls are proven to reduce unplanned downtime, false alarms, and process variability. Users can achieve higher quality measurements—including increased valve positioning accuracy—as well as tighter control with increased stability.

Plant maintenance departments are greatly impacted by a fieldbus strategy—for example, technicians may face additional training requirements in the initial stages of a project. With a fieldbus control system, however, there are fewer hardware components to service, fewer troubleshooting trips into the field, and a shorter Mean Time To Repair (MTTR). Plus, fieldbus-based asset management solutions support predictive maintenance programs that reduce the need for unscheduled equipment repair and downtime.

Last, but not least, end users should understand the changes in construction and installation brought about by FOUNDATION technology. A fieldbus control system generally contains "less of everything," including field wiring, marshalling panels, and instrument connections. Although off-site pre-commissioning activities may take somewhat longer with fieldbus, the on-site installation, commissioning and start-up phases of a project are often much shorter.

RESULTS & BENEFITS

The Brunner Mond project team, including a group of sub-contractors, successfully installed a FOUNDATION automation infrastructure as part of a controlled test. Based on the success of this effort, the size of the fieldbus control system has multiplied. Digital automation is now in place on 14 of the 23 Solvay towers, with the remaining towers scheduled for completion during the coming year. All of the project objectives have been met, with the added benefit of a higher than expected plant yield.

The new, intelligent, digital control system enables plant personnel to create and maintain the ideal conditions for production of soda ash crystals. It also allows advanced sequencing of the Solvay towers to ensure optimum product quality in the shortest possible time. Operators now have a greater understanding of the process, and are controlling carbonating and crystallization sequences more efficiently than they have been controlled before.

Best of all, the control system upgrade resulted in process efficiency gains enabling Brunner Mond to increase its throughput without added raw material or energy

consumption. This discovery of “free” product will provide economic payback on technology investments in fewer than 24 months, with the benefits going straight to the company’s bottom-line.

To date, operational cost savings have increased the profitability of the Northwich East plant by at least 2 percent.

CONCLUSION

FOUNDATION technology “changes the playing field” for process manufacturers like Brunner Mond. It enables an automation infrastructure for operational excellence, unifying open, scalable integration; distributed control; process integrity; and business intelligence—and delivering bottom-line performance benefits.

Today, a growing community of fieldbus end users is achieving lower operating costs, improved safety, higher reliability and increased maintainability.

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ABOUT THE AUTHOR

Phil Stoor has 37 years of experience in control and instrumentation from a wide range of client and vendor industries. He is a chartered engineer currently working as a Senior Project Engineer for Brunner Mond leading control system and infrastructure upgrade projects at their Northwich East and West plants. He has also lectured on aspects of Instrumentation and Commissioning at courses run by the University Leeds for over 20 years. Mr. Stoor’s main professional area of interest is the upgrading of measurement and control systems for chemical manufacturing processes. He has experience in aerospace, nuclear, and bulk chemical industries.