

PRACTICE — M A K E S — PERFECT

**Dieter Krenz, Linde, Germany,
Manel Serra, Inprocess, Spain, and
Theron Strange, Simplot Phosphates,
USA,** discuss dynamic process simulation
in an ammonia plant startup.

Process simulation is a technology used in many areas and project phases. Its usage ranges from the design stage of a plant (initial concept and front-end engineering [FEED]) to assistance in daily plant operations, including planning, optimisation and monitoring. To a certain extent, the simulation lifecycle is similar to the lifecycle of a process plant, bringing support and value to multiple stages in the lifetime of a process plant.

Using Simplot Phosphates' ammonia process plant in Rock Springs, Wyoming, US, where dynamic process simulation has been used, as an example, this article focuses on the implementation and benefits of an operator training system (OTS) for the plant. It will explain this specific use of the OTS, and will outline some experiences and results from the point of view of the three parties involved in the project:





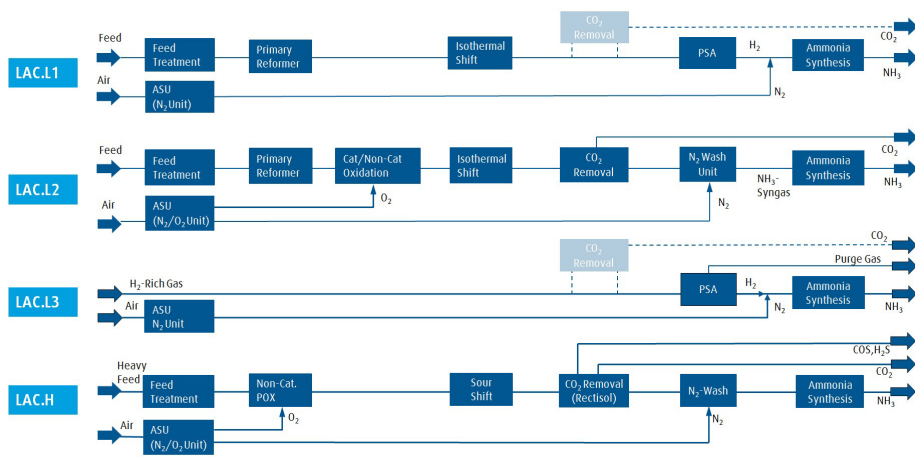


Figure 1. Linde's four ammonia concepts.

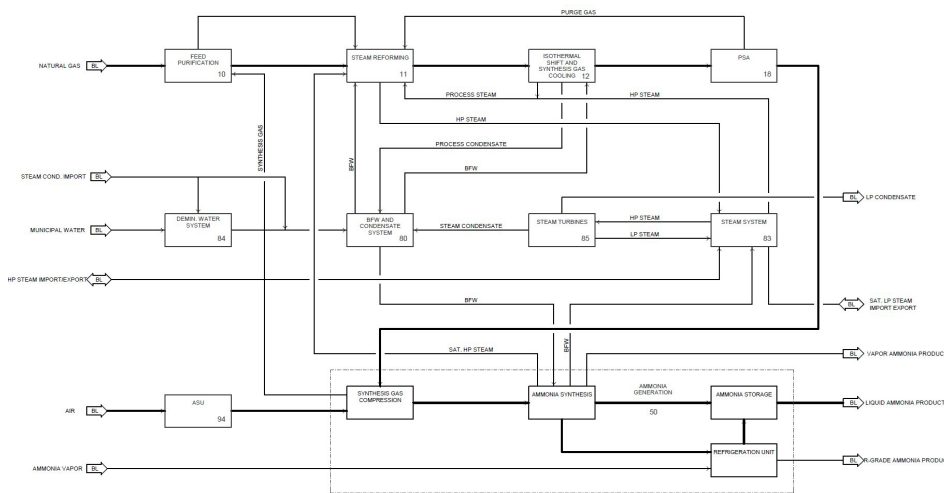


Figure 2. A block diagram of the simulated ammonia plant.

the licensor and engineering company in charge of the construction, Linde; the plant owner and operator, Simplot Phosphates; and the simulation services provider in charge of developing and deploying the OTS, Inprocess Technology and Consulting Group, S.L.

Ammonia plant training

After Simplot Phosphates decided to construct a new ammonia plant to supply its Rock Springs site, the company also saw the need to provide appropriate training to those who would eventually operate the plant. There were several reasons for looking carefully into training, including that the ammonia plant would introduce a new process that the current site operators were not familiar with and there would be a significant number of people hired to operate the plant with limited experience in the environment.

In addition, because Simplot Phosphates sought high operational performance, it also wanted to both gain an in-depth understanding of the process and push the limits of its plants to increase efficiency and throughput. Quality training and excellence in operation crystallised into the OTS project that was co-ordinated and supported by Linde, delivered by Inprocess, and powered by a rigorous dynamic simulation engine. Operator training using the system was delivered by Linde.

The scope of the OTS

To provide some context to this case, its scope involved a new Simplot Phosphates ammonia plant project in Rock Springs that was designed according to Linde's LAC.L1 concept, using a natural gas feedstock. This is one of four of Linde's ammonia concepts, all of which are shown in Figure 1. With the LAC.L1 concept:

- An inert-free ammonia synthesis gas in the right H₂ to N₂ ratio is generated.
- A steam reforming based H₂ plant with an isothermal shift reactor is used.
- Pure hydrogen and pure nitrogen (from an air separation unit) are directly available from the process streams.
- The ammonia plant remains energy efficient.

The basic LAC.L1 diagram in Figure 1 became the actual design used at the Rock Springs plant, as shown in Figure 2. With the exception of the demin water system, all of the major units are part of the scope of the OTS and were modelled in the dynamic process simulator.

Simulation lifecycle

The primary objective of an OTS is to provide a plant specific simulation environment for both initial and refresher training of those who operate the control room or other plant equipment operators. Hence, as well as the importance of the distributed control system (DCS) and safety instrumented system (SIS) emulation, another key point to consider is the simulation model that will support the OTS. The virtual plant must be high in fidelity and have a wide scope for better training. It must also run quickly, be robust and support a range of operating conditions, from cold startup up to maximum throughput.

High fidelity, customised dynamic process models built around software such as AspenTech's HYSYS®, Honeywell's UniSim® or VMG's VMGSim® and derived from the detailed design of the real plant process units, are powerful predictive tools. They can extrapolate process conditions far from nominal conditions, which extends the benefits that an OTS can provide beyond the training objectives. Figure 3 summarises this extended OTS usage.

The OTS model can be re-used for holistic evaluation of project functionality throughout an entire project. The simulation project will, in turn, benefit different project phases, including concept, FEED (pre-engineering), detail engineering, commissioning, startup, and operation of the plant. The complexity of the simulation model increases

during the execution of a project in order to fulfil specific engineering requirements. The right level of detail is needed to predict realistic behaviour without having to collect and use vast amounts of plant and design data.

Using the same process model as a base for the engineering studies, along with operational support and operator training systems, reduces the cost of developing and maintaining tools. It also maximises return on the OTS investment.

While lifecycle simulation projects are clearly suited to grassroots plants, brownfield plants can still experience the benefits of using high fidelity dynamic simulation models.

If developed and implemented correctly, the use of high fidelity models throughout a plant's lifecycle will contribute to significant learning time reduction and greatly increase operators' skills in terms of control. They can also substantially boost confidence in operating procedures while offering the possibility of testing new strategies for optimal, safe and energy-efficient operation, without influencing the actual operation.

OTS and dynamic simulation models

The hydrocarbon process industries have used OTSs with a key focus on accident prevention since the mid-1970s. An OTS is often viewed as an important, if not critical, training tool for grassroots plants and process units that are being revamped or re-instrumented.

OTSs are suitable platforms to practice on because they provide an accurate representation of the plant, which allows trainees to perform unfamiliar process and control tasks in a safe environment. Any mistake or error can be converted into a lesson learnt without any real life consequences. It is key to keep practicing the procedures regularly, particularly when a modification is implemented in the plant or control/safety system.

When thinking of an OTS, the usual expectation is that the system delivers an accurate replica, containing the following components of the processing plants:

- The process, represented by individual pieces of equipment (such as columns, compressors, heat exchangers and their connections).
- Field instrumentation (such as manual valves, level gauges).
- DCS or programmable logic controllers (PLC) for governing the plant and its equipment.
- Sequential logic and emergency shutdown (ESD) systems.
- Control room operator consoles.

The current trend in operator training simulators is to connect a dynamic simulation model (Figure 4) to a copy of the actual plant DCS and a copy of the human machine interface (HMI). Depending on how these copies are

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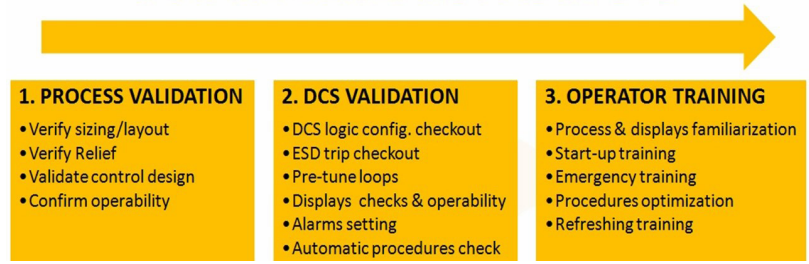


Figure 3. A simulation lifecycle and the benefits of the OTS.

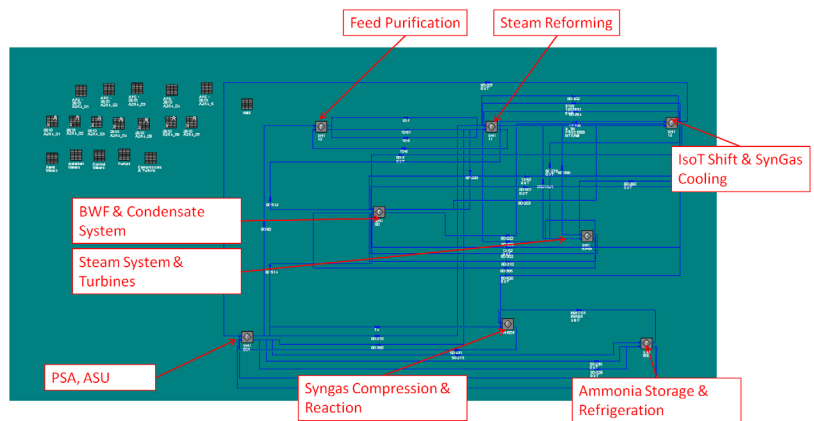


Figure 4. A dynamic simulation model.

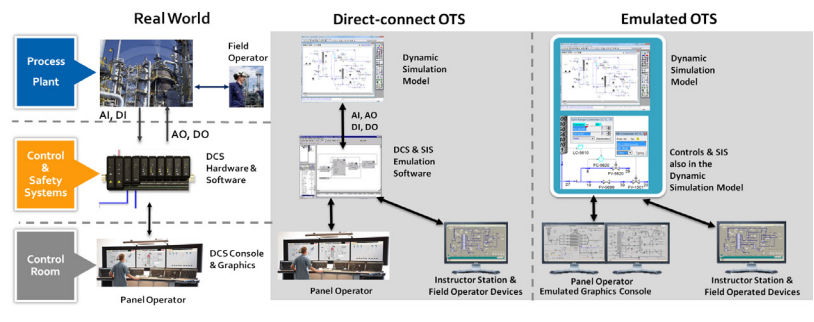


Figure 5. The OTS types and elements compared to a real plant.

developed and implemented, different commercial solutions are offered.

The DCS can be reproduced in the same dynamic simulation model, with the controllers available in the process simulation platform. Alternatively, a DCS emulation software can be used for these purposes.

Similarly, the operator console HMI can be emulated by a specific graphical and programmable software. An alternative is to replicate the operator console using the DCS HMI software or in DCS vendor consoles.

The OTS for Rock Springs involves a stimulated or direct connect OTS, as shown in Figure 5.

A direct connect option is characterised by the fact that dynamic process models and controls are separate applications. Dynamic process models are generally simulated by a high fidelity process simulator, while the controls (including ESD, FGS and PLCs) are simulated through proprietary DCS vendor software (and/or hardware, if required), reproducing the actual DCS controllers' behaviour.



Figure 6. Simplot Phosphates' Rock Springs OTS training room during the OTS commissioning.

Hence, the DCS-implemented logic for the simulator and the plant is the same.

Consequently, standard OTS architecture allows for communication between the replica DCS controller computer(s) and the process models computer(s), before sending the signal to the user (instructor or operator) on their screens, which, for a direct-connect OTS, are also an exact replica of the actual plant's control panels.

Although a stimulated solution may have a greater initial investment, it is an effective solution in terms of its fidelity to the plant's actual control and safety, and in terms of ease of maintenance. Also, the dependency of this type of OTS on the availability of the DCS database requires careful management of schedules and a flexible project execution methodology (supporting concepts such as a staggered delivery approach) in greenfield projects.

The OTS virtually emulates the plant in detail. This includes all of the DCS points, interlock logic, process controls and overall plant operation, such that the trainee sees minimal differences between the simulator and the actual plant. All operator-related activities that are performed in the real life main control room can be conducted using the OTS.

The trainee uses the plant user interface to control the simulated process via the stimulated DCS. The instructor can set malfunctions and other controls in the simulation, while accessing the trainee's station screen to see their actions. The instructor also tends to undertake field actions, as requested by the operator.

Uses and benefits of an OTS

As mentioned previously, OTSs are primarily used to train control room operators on various aspects of plants. An OTS can give trainees the equivalent of about six years of on-the-job training. Periodic training using the system, especially on critical emergency scenarios, brings operator skill levels as high as possible. Real time dynamic allows trainees to experience every type of operating condition in a 'hands-on manner', virtually. Types of scenarios include: normal operation, unusual operating scenarios, startup from cold conditions, restart from tripped conditions, shutdowns, equipment malfunctions, emergency conditions and process upsets, as well as communication with field operators.

Instructors have tools to develop standard exercises for testing and evaluating each student's performance, as well as

documenting the results of the training session. Training sessions can be repeated to monitor and prove trainee improvements.

Training using an OTS is cost-effective as it allows trainees to experience more operating situations in a relatively short period of time, while also under supervision. This helps reduce personnel errors and maximise plant availability, in turn increasing overall safety with reduced risk of expensive equipment damage. Using an OTS also provides knowledge of dynamic processes, which allows for anticipation of the unexpected.

Although the primary use of OTSs is operator training, they also allow control strategy tests to be performed, and operating procedures to be developed, verified and compared.

It can also debug and verify DCS configuration in a dynamic 'near plant' environment, which results in less interrupted commissioning. With these uses in mind, the following benefits can be achieved using an OTS:

- Minimisation of startup time and achieving steady production more rapidly.
- Achievement of an easier, stable and ongoing production.
- Reduction or prevention of operating incidents, unnecessary trips and emergencies, which leads to an increased on-stream production rate and a reduced risk of equipment damage.
- Increased operator confidence, which allows plants to be operated closer to product specifications and process constraints.

OTS use in Rock Springs

In the Rock Springs case, the OTS was delivered before the plant's startup to accommodate the training requirements with the availability of the DCS database. This allowed the operator training to be undertaken in time, following a pace to match that of the startup of the different areas of the plant.

During a three month training programme, Simplot Phosphates' trainees were familiarised with the plant's startup procedures, DCS functionality (HMI, control logic, etc.) and how to communicate with field operators.

Although many trainees were not familiar with a DCS and the ammonia plant process, the training gave them sufficient confidence to startup the plant and recognise unstable conditions early on. This led to faster and more effective response times, as well as less lost time.

When implementing the OTS, bugs in the DCS database were detected and eliminated. Running the startup procedure allowed for an extensive evaluation of written procedures, pointing to the need for clarifications, and the potential for changes and optimisation, which were later realised during the actual commissioning of the plant.

OTSs give operators refreshment on the specifics of the plant, with the simulator being continuously used to maintain and test operators' skills. **WF**