SUSTAINING OPERATIONAL EXCELLENCE

Martin Skarle, Preem, Sweden, with Manel Serra, Jesús Gil Vilda, and Josep-Anton Feliu, Inprocess, Spain, examine modern training methods for operators and how these have been successfully rolled out.

For more than a decade, refinery panel operators at Preemraff have been coached on safety and operation excellence by hands-on training with an operator training simulator (OTS). The fluidised catalytic cracker (FCC) at the Lysekil Refinery was the first refinery unit for which an OTS was built (Figure 1). In 2016, it was decided to extend the use of such a training tool to two other existing units: the hydrogen production unit (HPU) and the Isocracker unit (ICR). Furthermore, the existing FCC OTS had to be updated with recent plant changes.

Inprocess Technology and Consulting Group's OTS software and services enabled the original investment in the FCC OTS to be preserved, while building the new OTS. Inprocess Instructor Station (IIS) is an open OTS platform that can embed most of the commercially available dynamic process simulators and connect with all the major distributed control systems (DCS). This way, the end user can connect their simulator of choice with the native DCS emulation and operator console software, Emerson's DeltaV in this case.

For the three existing units, the main drivers to use OTS were demographics and training effectiveness. According to several studies, the learning retention rates are much higher when the student is involved in the use of realistic simulators. Such learning retention rates grow up to 78% with an OTS compared to 20% when using audio-visual supporting material or down to 5% in conventional lectures.

When the three OTS on existing units were almost completed, by mid-2017, the OTS project was extended to include a new vacuum distillation unit (VDU) that was being constructed at that time in the refinery. This new OTS was built in a way that it uses the same software and hardware architecture as the three previous ones and it was delivered 10 months before

Figure 1. Lysekil Refinery, Sweden.

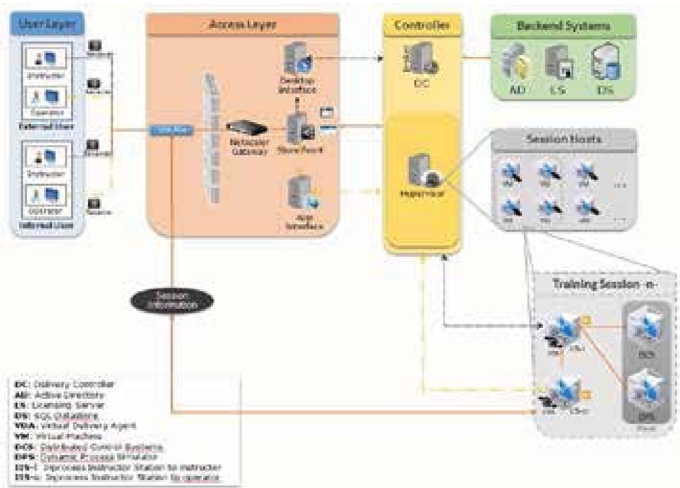

Figure 2. Architecture of a web-based virtualised OTS.

plant start-up, providing enough time to train operators on the new unit and to test and tune the DCS.

Furthermore, as an additional Preem request, the four OTS are currently running in a virtualised environment, maximising the hardware and software return on investment and providing significant flexibility to instructors, students and maintenance personnel, as will be explained in this article.

Dynamic process models

HPU

Two areas in the modelling of an HPU are of special interest. The first is the modelling of the steam circuit. Although in most cases steam circuits (generation, headers, deaeration) are considered 'utilities' and are not included in the scope of a unit OTS, in an HPU the usage of the steam as part of the process (as a reactant) and the connection of its generation to the actual operating condition of the process makes it necessary to be part of any effective training for panel operators. Modelling steam systems and, in general, pure-component systems with changing states in simulation software presents additional complexities and requires special tuning (e.g. internal recycle efficiencies), as well as artefacts to represent non-standard blocks in the simulator (e.g. desuperheaters or steam traps).

The second is the mechanism used to represent the reformer reactor in order to properly capture the interactions between the heat generation side (using either fuel gas or purge gas from the PSA unit) and the reaction in the process side, along with the thermal inertia of the large mass in the reactor and the heat recovery for pre-heating and steam generation.

ICR

Modelling of an Isocracker unit presents a few areas of interest, such as the special tuning of the amine treating section or the detailed representation of the fired heater, with all the complexities of its burner management system (also found in the HPU reformer).

But the area that requires the most attention is the modelling of the reactor itself, and the management of the component lists.

The number of components is critical for a proper representation of fluid properties, but at the same time has an impact in the simulation performance. In that sense, finding good strategies for lumping and de-lumping components is a worthy effort (i.e. less components at reaction and separation, more components at the fractionation).

VDU

A VDU also has some modelling challenges. Some of these challenges have already been mentioned for the models of the other units, but there is one that was not present in the previous two models: a vacuum system. Not only does a VDU have a vacuum system in place, but it is also part of the column condenser. Apart from the challenges of pure-component, state change modelling, mentioned earlier on, typical and fundamental pieces of equipment in a vacuum system are not standard in simulation software, such as ejectors or liquid ring pumps, requiring the construction of artefacts to properly represent the dynamic behaviour of this critical part of the unit. The piping and layout of these vacuum systems also requires special attention in order to properly represent the static and hydraulic seals in place to make the system work and act under all conditions, from start-up to emergency conditions, including its normal operation.

Web-based virtualised OTS

The solution adopted to integrate the existing OTS with the new units being developed in the same training tool was a virtualised architecture in which the different groups of virtual machines needed for each of the units could be launched on demand. The OTS infrastructure was built in a separate subnet.

Such an OTS solution takes advantage of a software architecture which increases and distributes the availability of the training facility, enabling its access to control room operators from other company sites, and even from other time zones (if that was the case), and from outside the company premises.

Essentially, the distributed OTS platform utilised is a virtualisation software-based solution that allows access to the individual applications of the system, on a shared server through individual user devices.

The installation for remote training platform contains several elements that relate to each other and the users that access it, as depicted in Figure 2.

The benefits obtained from a virtualised solution include the following:

Availability

One of the key advantages of the deployed OTS is the new possibilities in terms of who can use them and when. With the traditional approach, the OTS usage is limited to the people who can physically sit in the OTS room. By enabling the remote use, this was no longer a limitation: any person who is granted access to the system could be trained in the OTS from anywhere. And while the option enables employees from any of the company's sites to benefit from this training, it does so without incurring additional travelling time or without planning complex schedules. In addition, taking advantage of time shifts, the same software licensing and hardware infrastructure can support more than one single full training session in a given day, optimising the use of the resources. There is also the option to create an internet gateway for secured, external access

Flexibility

This deployment enables internal or external users to connect to the system, either from the workplace or when home-based; it supports both classroom training and self-training. The system is light enough to be able to fit in a portable computer. It allows cross-platform usage of the training tools: as the final front end to the user becomes a type of web interface, with no actual need for high-end supporting hardware, users may connect to the system using many different devices, including high resolution tablets.

Scalability

By basing the system in a set of virtual machines, these were easily and quickly replicated, allowing for multiple instances (replicas) of a training session to be run in parallel (as many as the licensing or the available hardware allows for). With this technology, operator stations can be created on demand based on the number of students per class, along with a simple infrastructure that allows multiple training sessions to be activated quickly (i.e. different processes, or the same process at different conditions) in a common classroom.

Maintainability and security

Using well-established software tools, especially virtualisation, streamlines the maintenance of the system from the IT point of view, as backups, software updates and other maintenance tasks were accomplished in an efficient and well-established manner. Hardware and software resources were also more efficiently consumed. Preem investment in training was secured by providing a framework under which all simulation-based trainings were hosted and managed. However, all of the advantages listed above would fall short in light of today's security risks. That is why the architecture proposed relied on the highest level of security, using authentication, encryption in all transactions and building on top of the elements that Preem uses and that trusted IT providers recommend. The finished system was as open and as secure as Preem requested it to be.

Training program

The training facility is just next to the control room of the refinery and operators are encouraged to use the OTS whenever their normal job duties allow them to. For each unit and shift there is at least one operator who has a deeper knowledge of the system. He or she may assist other operators to set up a session or work as an instructor during training. Up to 10 experienced operators could work as OTS instructors.

Operators have a minimum of 16 mandatory hours of yearly simulator training to ensure confidence in difficult, important and infrequent situations like plant start-up/shutdown or emergencies. 60 – 80 sessions per year resulted in 70 – 75 operators trained.

Prior to the start-up of the new VDU at the refinery, all DCS operators practiced several simulator exercises including a full start-up according to plant procedures. The well trained and prepared operators contributed to an unusually smooth plant commissioning in spring 2019.

Conclusions

An existing training tool was modernised and updated with additional refinery units in a corporate effort to achieve and sustain operational excellence for operators in the control room of one of the group refineries. The tool, an operator training system, not only trained operators in the existing units but also during the commissioning and start-up of a new one that was built during the OTS project development.

Thanks to the web-based virtualised architecture, operators can access the training content not only from the ad-hoc training room but from any corporate location.

The training program that was implemented has helped a large number of operators to train in uncommon operating situations. Difficult and important operating procedures can also be retrained in order to ensure operators are ready to react to them.