Introduction

Process Control deals with change. If our raw materials, production rate, catalyst, equipment performance, utilities and weather conditions were constant we would not need very sophisticated control structures. Fortunately for Process Control Engineers, the change is a constant in our daily operation, and the ability of the plant to adapt itself to these changes is the key to our profits.

The understanding of the process is the first step in the design of a control strategy. Before prescribing any solution, the Process Control Engineer needs to identify the root of the problem analyzing deeply all causes and units interactions. First-principle models will help us understanding the process dynamics and its interactions, and they will allow us to evaluate and tune our improvements before they are implemented.

Process Engineers are the traditional users of first-principle simulation, Steady-State mainly, since their objective is to design plants at nominal conditions. On the other hand, the Process Control Engineers are focused on maintaining these nominal conditions stable and operable. We can generically split the Process Engineering and Process Control roles:

Myth 1: Lack of mature products. Aspen HYSYS Dynamics (v 1.0) was released in 1996. Since then, it has been continuously improved and extensively used for dynamic studies, control and operability studies and Virtual Plant Simulators used for Operator Training. Aspen Hysys Dynamics is a mature and well-proven technology.

Myth 2: Used only by 'gurus'. Aspen HYSYS Dynamics is conceived to be used by Control Engineers who do not necessarily need to have a deep thermodynamic or chemical background. It is intuitive and user-friendly, requiring short training periods.
**Myth 3: Not oriented for control.** Aspen HYSYS Dynamics includes in the standard object palette a complete set of control oriented objects shown below:

![Control Oriented Objects](image)

**Myth 4: Excessive time for modeling.** Aspen HYSYS Dynamics allows a non-expert user to easily create accurate models in record time. For example, having ready all design and plant data, a tuned dynamic model of a depropanizer can be developed in two days.

**Myth 5: Dynamic models run slow and require big computers.** Aspen HYSYS Dynamics, running on a standard PC, can run relatively big models several times faster than real-time. For example, a Crude and Vacuum unit with preheat train on a Pentium IV 2.0Ghz and 0.5s step size runs at 10 times real-time.

**Aspen DMCplus Integration in Aspen HYSYS**

Apart from the traditional use of Aspen HYSYS Dynamics in Basic Control studies, one of the key aspects that makes Aspen HYSYS the ideal tool for the Process Control Engineer is the integration of the Aspen DMCplus multivariable controller within the Aspen HYSYS flowsheet. This new Aspen DMCplus controller object is available in the standard object palette.

The Aspen DMCplus controller is used in two different modes within Aspen HYSYS:

1. **Generate Step-Test data:** The controller object in Aspen HYSYS automatically moves the selected Manipulated Variables (MVs) and Disturbance Variables (DV's or FFs) to perturb the process model. The user specifies the type of signal (PRBS or STEP), amplitude, sampling time and testing time. Aspen HYSYS records all the moves and responses in a formatted ‘.clc’ file. This file is later used by the Aspen DMCplus Model application to generate the model of the controller (.mdl file) and by the Aspen DMCplus Build application to generate the configuration file of the controller (.ccf file). There is the option to generate the model (.mdl) directly from Aspen HYSYS. See Figure 1.

**Figure 1. Aspen HYSYS Generating Step-Test Data**
2. **Online with the real Aspen DMCplus controller:** Aspen HYSYS is acting like the real plant, connected online with the launched Aspen DMCplus Online Controller through the Aspen CIM-I0 interface. All the Aspen DMCplus Online software and the DMC user interface is exactly the same as used with the real plant. All the links and interfaces between Aspen HYSYS and the Aspen DMCplus Online Controllers are automatically done by Aspen HYSYS by pressing a button. *See Figure 2a and 2b.*

![Figure 2a. Aspen HYSYS Controlled from DMCplus GUI](image1)

![Figure 2b. Aspen HYSYS Acting like the Real Plant](image2)

The Aspen DMCplus controller can be quickly configured within the HYSYS flowsheet selecting the CVs, Mvs, and FFs from any stream or equipment, being able to perform any kind of transformation to linearize any variable.
Use in APC projects

The use of Aspen HYSYS models (steady-state and dynamics) in certain APC projects can speed up the implementation and minimize the impact on the plant. The figure 3 shows, depending on the APC project phase, where it can be used:

The first step is to develop a Steady-State model of the unit where an APC is envisioned, which in most of the cases is available in the Process Design department. Then, it is calibrated to reflect the real plant conditions and then, after adding all dynamic data (volumes, sizes, controllers, etc) and set-up the right pressure-flow relations, it can be simulated in dynamic mode using the steady-state data as initialization. The models are then used in each phase:

1. **PRE-TEST:** The Steady-State model can be used to identify new instrumentation needs, to check the feasibility of the inferentials and to estimate the potential benefits. It can also be used to detect ill-conditioning of the selected APC variables. The Dynamic model can be used to check the basic regulatory control system, evaluate different control schemes, determine the optimum amplitude of the moves during the plant test.

2. **PLANT TEST:** Some Step-Tests are applied to the real plant and to Aspen HYSYS Dynamic models. The identified Aspen DMCplus models are then compared and verified, determining where more real Step-Tests are needed. On some units, the Step-Tests can be entirely performed on the Aspen HYSYS models, and subsequently the identified Aspen DMCplus models can be used with Aspen SmartStep to fine tune the controller models after a few days of operation. Figures 4, 5 and 6 show Step-Testing on Aspen HYSYS for a CDU unit and the comparison of the identified models with models based on real plant step testing.

3. **DETAILED DESIGN:** Instead of using the Aspen DMCplus inverted model to tune and simulate the controller with Aspen DMCplus simulate with limited model mismatch, we can now use the Aspen HYSYS dynamic model that will be able to reproduce all non-linearities and dead times of the process when changing the process conditions or introducing perturbations.

4. **COMMISSIONING:** The Aspen HYSYS dynamic model provides a much richer model to test the controller in all regimes of operation. It also provides a rich and risk-free environment to train operators and engineers, being able to reproduce quickly any kind of scenario. This is especially interesting for long settling time processes.
Benefits and Limitations

The use of first-principles models has been always on the mind of the Control Engineer, but due to historical reasons or the explained myths, it has not been widely used. Now, for the first time, Aspen HYSYS and Aspen DMCplus, two leading and mature technologies in their respective fields, are integrated to bring new combined benefits to the APC projects:

- Minimize or eliminate the impact of Step-Test in the production plant and personnel
- Determine the models that will not require more real testing
- Step-test results are not contaminated by unmeasured disturbances
- Clean models due to absence of instrumentation noise and valve cycles
- Better models of FeedForwards, since moves can be imposed
- Controller tested in a wider range of operation.
- Project execution is not delayed by plant turnarounds, missing or faulty instrumentation
- Re-use of models for re-testing (revamps or operating conditions change)
- In some cases, total APC project implementation time, including Aspen HYSYS modeling, can be reduced (depends on number MV's, TSS and process nature)
- Further Control analysis or improvements can be quickly studied (add variables, change process design, relocate sensors, etc.)

The time to develop the first-principle dynamic models has been always the main issue for acceptance of this new methodology. The time invested in the development of the first-principle models has to be compensated by the benefits; otherwise it is nice, but not worthwhile.

The criteria to decide whether it is practical to use Aspen HYSYS are determined by the nature of the process, the nature of disturbances and the skills of the modeler.

The units that show long settling times are the most wanted units to apply this new methodology. Fortunately, most of these units are based on separation columns, which are quickly and easily modelable in Aspen HYSYS. On the other hand, reactors are more complex and makes them less attractive for modeling.

Some processes experience atmospheric disturbances or raw material variations that are difficult to identify in the real plant because they cannot be manipulated and historical data is drowned by other process changes. These variables can be independently manipulated within Aspen HYSYS.
aspenONE™ unifies all of AspenTech’s products and capabilities into a single cohesive system that allows users in each process industry vertical to safely and predictably manage and improve the performance of their enterprise operations.

aspenONE has impressive capabilities including the ability to:

• Use consistent models to design, run and improve your plant operations
• Design and debottleneck plants and processes for maximum performance
• Gain control of plants and processes from a business perspective
• Look ahead to capitalize on opportunities and identify problems before they occur