THE USE OF SIMULATION TECHNOLOGY FOR PRODUCT DEVELOPMENT AND VERIFICATION

In the past simulation technology has been applied to such diverse applications as engineering analysis, verification and validation of control systems, and the development of training simulators. The verification and validation of controls systems has long been a significant benefit in the justification of purchasing a training simulator by the end-user. Although this benefit is greatly appreciated by the end-users it has not been widely accepted by the DCS vendors. One explanation is that the scope of a DCS system is normally so expansive and varied that even partial standardization of the simulation model is not practical, thereby increasing the cost associated with simulation. However, if the application of a particular control system is partially standardized, such as in the case of turbine controls or burner management systems, the cost associated with simulation can be amortized over a larger number of units resulting in significant, tangible, and cost effective benefits. As an example, an OEM might support a limited line of combustion turbines and can develop standard simulation test beds to verify and validate controls systems associated with the line of turbines. The purpose of this paper is to discuss the application of simulation verification and validation techniques by such equipment manufacturers to better and more efficiently meet their customer's expectations and requirements.

With the ever-increasing flexibility that modern controls technology allows, it is becoming more and more difficult to fully utilize the equipment's capabilities without a mechanism to efficiently test the various control algorithms. In addition to supporting such generic development efforts, simulation technology can provide vital assistance in providing the final control scheme configuration and tuning for a specific customer's order. In general the following benefits are achievable through the appropriate application of simulation technology:

- Reduced costs for the evaluation of new control algorithms
- Reduced schedule for the delivery of new products
- Improved quality of the delivered product, especially the control software
- Technology can be "packaged" for resale to support customer's training needs

The successful installation and operation of plant equipment requires that it work properly in the customer's facility, not just on the test stand in a stand-alone condition. Providing a mockup of the actual plant installation is usually impractical and cost prohibitive, hence only open loop testing and evaluation can be done prior to shipment. This limited testing can result in longer and higher cost field checkout and startup testing, higher risk of unsatisfactory field operation, and unnecessary warranty costs if some remedial action is required because of customer dissatisfaction.

Even if today's testing methods are producing satisfactory results, there is still room for vast improvements. In a typical scenario where an equipment vendor produces a hardware/software package for shipment, the software component, the control logic, is generally completed separately from the hardware component. However, this control logic is not thoroughly tested until it is interfaced with the hardware on the test stand. Once on the test stand the hardware/software package is tested and the process is normally delayed while the software component is "debugged." This delay increases the time and the cost associated with production, and decreases the throughput of the process.

Simulation verification and validation techniques provide a mechanism whereby the control logic is debugged in parallel with the hardware manufacture and configuration. The control logic is "bullet-proofed" so that the integration and testing of the entire package proceeds smoothly and efficiently on the test stand. Furthermore, simulation technology can reduce the risks of development and startup by permitting a higher quality equipment and system checkout prior to shipment when corrective actions are much easier and more cost effective to accommodate.

The simulation verification and validation technique simulates the control and operator interface functions of the DCS and its interaction with the plant systems in order to dynamically verify the control logic and tuning parameters. This technique, utilizing high fidelity, first-principles, dynamic simulation of the plant, ensures compatibility of the controls with the process and interfacing control systems, actuators, and/or control loops.

Figure 1 depicts the basic workings of a simulation application for control system verification. The Process Model refers to the simulation of the plant interfaced with the hardware device, such as a governor or burners. The Process Model may include any plant systems and related controls outside of the scope of supply, but should be limited to that necessary to support the specific application. For example, to validate a governor and its logic the Process Model would model the particular turbine and provide simulated boundary conditions to duplicate the proper response of the turbine. The Control Model represents the control logic associated with the scope of supply and may include both the controls as well as the associated hardware if a fully integrated checkout is desired. The Simulation_Master block is the software that coordinates the process and controls models. It provides the user interfaces to stop and start the simulation and provides other features to simplify the user's use of the simulation, such as using Graph_Master for trending plots of key parameters.

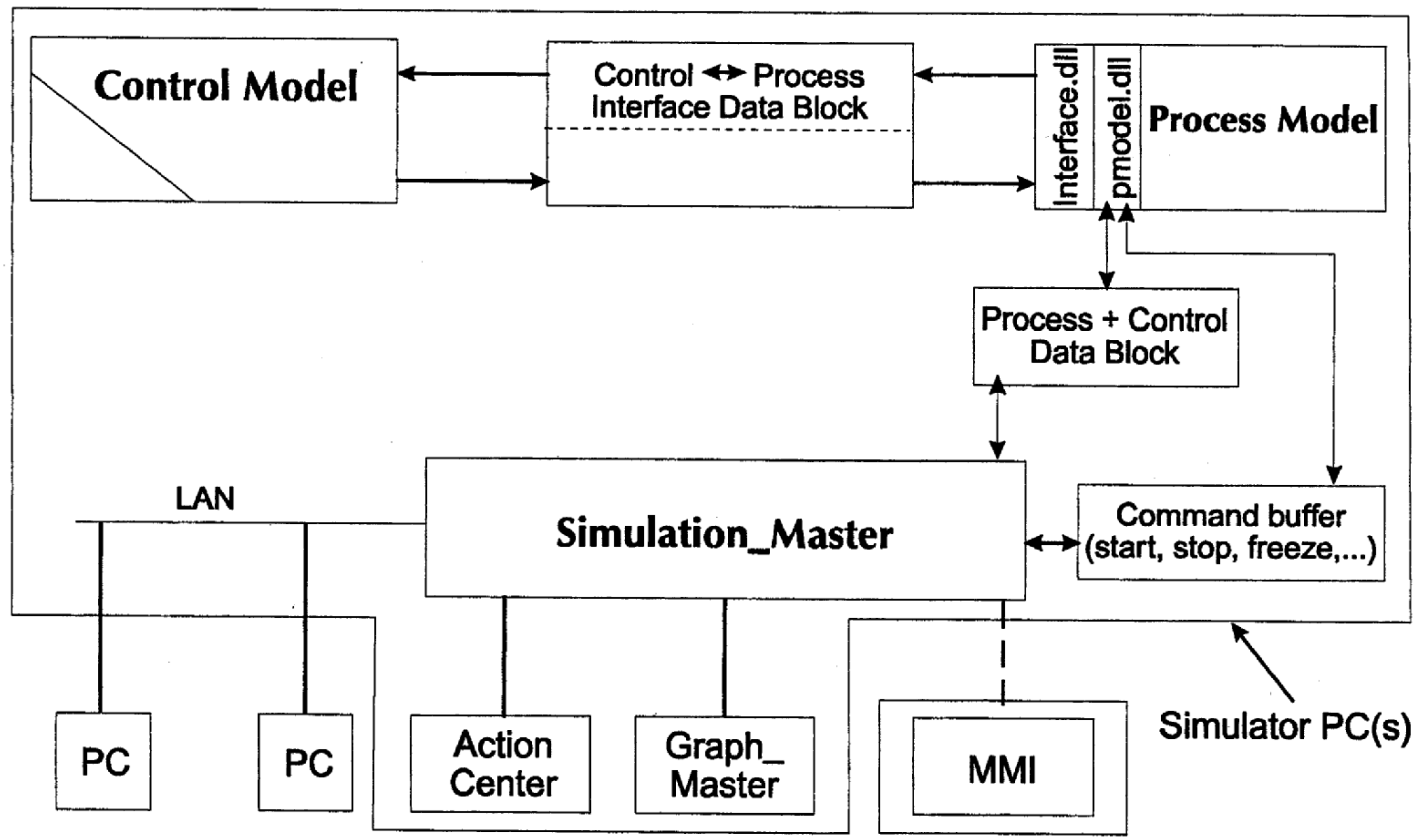
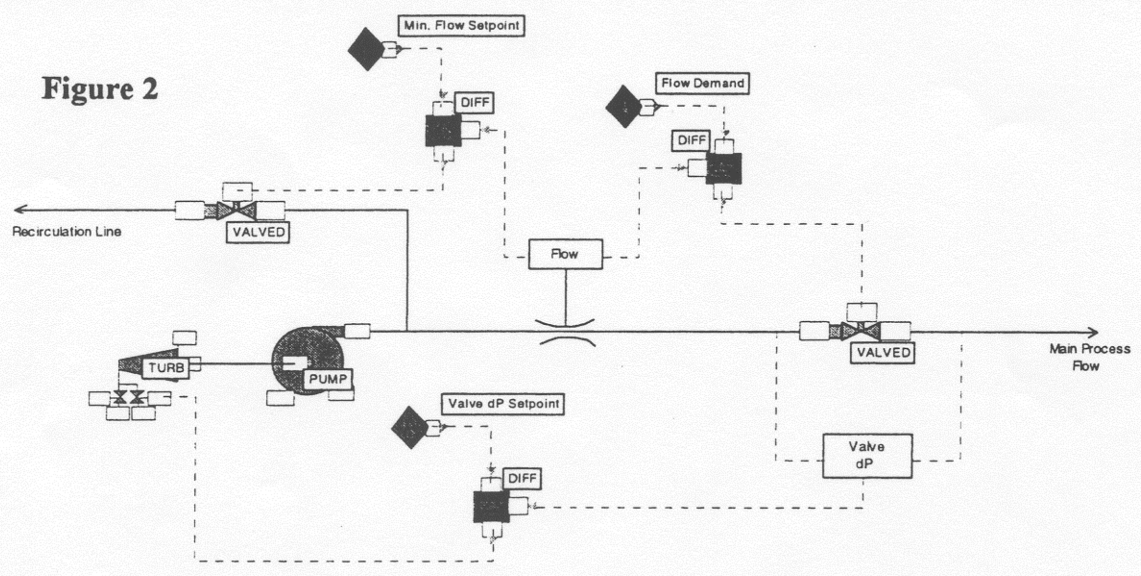


Figure 1. Simulator Configuration

Example Application

This example will assume the testing of a variable speed centrifugal pump-turbine combination with attendant controls, including the recirculation valve for the pump's protection. The pump has minimum NPSH requirements that are provided by an upstream pump. The following figure depicts part of a representative system interfaced to the pump. The flow control valve downstream of the pump is regulated by a process flow demand that the pump-turbine combination must satisfy. The recirculation valve control system must work in concert with the main flow controller and the pump speed control system to satisfy overall system demand while protecting the pump from inadequate NPSH and runout during system transients and upsets. The control system setup in conjunction with the equipment characteristics will determine how smooth the system will function during key system operational evolutions and upsets.

Figure 2



The upstream and downstream components and controllers are simulated in addition to the pump turbine combination and are interfaced to the control system. Through the use of appropriate boundary conditions, the system can be exercised through the full range of startup to full power conditions as well as put through a variety of upsets such as step increases in flow demand, failure of the recirculation valve, or failure of an upstream flow supply device. The control interactions between the recirculation valve and the main flow control valve can be examined and the controllers tuned for optimum performance. Operating margins for the full range of upset conditions can be established to determine operating limits for the equipment and to help with the development of operating procedures. This whole validation process can occur while the pump, motor, or other components are in production. Final integration of the control logic with the pump-turbine hardware will proceed smoothly, and the final testing on the test stand will really focus on the hardware since the control logic has already been verified.

The key to making the system work is the ease of use and flexibility of the simulation tools. The simulation tools have to be relatively easy to apply so that a trained engineer or technician can develop the appropriate simulation models and can integrate the technologies efficiently. Therefore, the tools should utilize graphical user interfaces, be well documented, and support standardization. Flexibility is achieved by open access to the simulation tools and a well-supported operating system, which is easy to manipulate and is compatible with other systems and software.

nHance Technologies has a complete set of simulation tools, which offer such functionality. The Modular Modeling System (MMS) is dynamic simulation software that features a graphic-based Model Builder to facilitate development of the process model. With a comprehensive library of pre-defined components and a graphical user interface to assist in model building, a trained engineer or technician can methodically develop the process model given access to the plant data.   The Simulation_Master interfaces directly to the MMS model and to your control emulation or hardware through standard protocols. Since both the MMS and Simulation_ Master utilize the Microsoft Windows NT operating system and the Simulation_Master is OLE-enabled, flexibility and compatibility are ensured. Additionally, MMS CompGen™ allows for the development and seamless integration of user defined modules, which supports the need for standardization and protects the OEM proprietary technology.

Summary

The thoughtful application of appropriate simulation technology can provide tangible benefits in terms of cost savings, throughput, and product quality. These benefits are even more pronounced when a user can take advantage of the standardization associated with their technology and its applications. Utilizing advanced state-of-the art simulation verification and validation technology makes sense from a competitive position and better serves the ultimate customer by providing the best product value.