

Using Simulation to Optimize Results of Automation Projects

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Keywords

Automation Checkout, MiMiC, Operator Training Simulator, Simulation

Summary

The use of simulation for automation projects and automation lifecycle management provides numerous benefits for companies in the process industries. These benefits are achieved by using simulation to checkout and validate Process Automation Systems, perform software acceptance tests, and by applying simulation to operator training.

The use of a simulation system for testing and training reduces time-to-market and increases business results of process automation projects. The same system can be utilized in automation lifecycle management to reduce operational costs and improve product quality. MiMiC Simulation Software from MYNAH Technologies delivers results for both applications.

A recent ARC survey indicates that the business benefits of using simulation systems for this type of investment are significant. Benefits include faster project startups and time-to-market, improved product quality, reduced plant incidents, and improved operator proficiency. In ARC's opinion, MiMiC Simulation Software from MY-

NAH Technologies meets or exceeds all the requirements for a simulation system that performs automation system checkout, software acceptance, as well as those requirements needed for a robust operator training simulator.

Applications of Simulation Systems

There are several types of process simulation systems, classified according to their application, including **Process Automation Testing, Training Simulators**, and **Engineering Simulators**. In each case, the purpose of the simulation system is to replicate the response of the process. One of the major differences among the types of simulation systems is the degree of accuracy or fidelity required for the particular application, which largely determines costs. The higher the fidelity of the simulator, the greater the cost will be.



In general, a simulator platform for **Process Automation Testing** connects to the control system via communication interfaces. The simulator accepts all the control system outputs and returns the appropriate response as if it were the real process. In this way, testing of the Process Automation System occurs in a safe environment without disrupting manufacturing operations. Although the fidelity of simulator used for Process Automation Testing is relatively low, its value is relatively high.

Operator training simulators permit carefully conducted supervised training exercises and instruction on how to run a plant in a safe, reliable, and more efficient manner while reducing the risk of operator error, equipment

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failure or damage, and process downtime. Operator Training Simulators enable operators to learn the functionality of the process automation system without the pressure of controlling the actual plant. Both normal and abnormal situation training is possible without jeopardizing the plant, environment, or health of plant personnel. The fidelity of training simulators is relatively high compared to

simulations used for testing process automation systems. In addition, the response must accurately replicate the response of the real process to reinforce positive training behavior.

Simulation used for **engineering design**, process optimization, and controllability studies are different than simulation systems used for process automation testing and operator training. Steady state and dynamic models used for plant design are valuable for designing processing plants, developing economic models of process units, and implementing good process engineering practices. The fidelity of engineering simulators is very high in order to generate valid results over a wide range of operating conditions. Generally, however, engineering simulators are not well suited for process automation testing, training, and automation lifecycle management, which is the major focus of this paper.

In some instances, the demarcation between categories is not clear. Additionally, there are varying degrees of complexity within each category. Nonetheless, each of these categories of simulation systems plays a significant role in increasing overall efficiency and effectiveness of automation projects. To achieve the greatest benefits, however, users must leverage simulation efforts across the entire lifecycle of an asset including process automation testing, operator training, and automation lifecycle management. In fact, it is possible and often preferable to use the same simulation

system for process automation testing, operator training, and lifecycle management.

Using Simulation for Automation Projects Improves Benefits of Capital Expenditures

The cost of a typical project is relative to the amount of time it takes to complete. In other words, the longer it takes, the more it costs. In the pursuit of time reduction, it is essential to integrate simulation into the automation project lifecycle at an early stage. Whenever possible, companies must leverage simulation for concurrent testing, factory acceptance, and commissioning to shorten project implementation.

Companies use a lower fidelity simulation system for the testing phase of Process Automation Systems. This offers numerous opportunities and benefits for companies. It permits offline testing of newly developed software applications with a simulated IO system and process models. The testing of software includes advanced process control, Manufacturing Execution Systems (MES), Electronic Batch Records (EBR) systems, and other business applications. Furthermore, with the right simulation system, it is also possible to use it for training operations staff on the use of the process automation platform and application software.

Supporting Operational Excellence with Simulation for Automation System Lifecycle Management

Many companies are implementing Operational Excellence and continuous improvement programs throughout their entire organization. These programs require companies to analyze and improve their work processes and supporting applications on an ongoing basis. Unfortunately, many process



ARC's Operational Excellence Process Model

facilities hesitate to make the necessary changes because they do not have the ability to test or validate application upgrades before installation. A simulation system is an effective tool for testing control system modifications, upgrades, and enhancements in a controlled, offline environment.

Plant operations staff and new operators use a training simulator to qualify on new enhancements and obtain certification on

the existing operations. The engineering and control groups use the simulation system to try out new control strategies, build new product recipes, and design new interlock strategies before proposing the changes to production management.

The controls group for the plant can use the simulation system as a test bed to try new control strategies, build new product recipes, and design new interlocks strategies before proposing the changes to production management. The simulation system is also an effective tool to mitigate risk to the process or operations staff by providing a means to conduct extensive failure testing in an offline and safe environment.

Simulation Offers Substantial Business Benefits and ROI

Quantifying the benefits associated with a process simulator in terms of financial gain is often quite difficult. In many instances, it is easier to quantify the losses of not having one. The losses relate to design quality, operator competency, production throughput, unscheduled downtime, and project startup times. Preventing losses and reducing risk is chief among the benefits provided by simulation.

In this context, the return on investment for a simulation system is substantial across all process industries from batch to continuous processes. Significant savings also accrue from identifying and correcting automation system errors in a low-cost offline environment prior to system startup and commissioning, and by identifying dormant errors or inadequacies in the automation system application software.

Early Identification and Correction of Errors Saves Money

The cost of fixing software errors increases rapidly for each stage of development that an error survives. In fact, the cost of fixing errors in successive stages of development increases by ten to one-hundred times. An error introduced in the design phase can cost hundreds of times more to fix in testing or operational phase than it would if fixed soon after its introduction.

Identifying and correcting automation system errors in an offline simulation system allows rapid testing and correction without interfering with plant operations, disrupting operations support staff, or jeopardizing safety. Identification and correction of errors in the off-line simulation environment costs 10-100 times less than in the online plant environment.

The investment of simulation for this purpose is marginal (office space, hardware and software licenses, and engineering costs) compared to the infrastructure cost associated with a process facility.

Simulation Reduces Risk and Startup Times

One of the greatest risks of automating a process facility is to ensure that the quality of the automation system application software meets the production requirements of the organization. Without using a simulation system, the user has no ability to test the application software thoroughly before actual start-up and production. By testing the automation system with a simulation system for normal, abnormal, and upset conditions, the user can verify that the application software functionality meets the need of the process and is suitable for use.

Manufacturers in many different industries have a fundamental need to get product to market as fast as possible to achieve a competitive edge. Achieving significant reductions in startup times can make the difference from the winners and losers. In addition to lowering the cost and risk associated with factory acceptance tests, simulation results in faster commissioning of automation systems.

Companies are rapidly losing their most valuable asset: people and intellectual capital. The approaching exodus of retiring workers will severely erode the knowledge base of many companies and compromise productivity if left unabated.

Enhancing Human Performance through Training

The reduction of skilled workers and the loss of knowledge reduce an organization's ability to deliver automation projects on time and budget. It also diminishes a company's ability to identify production and quality-related problems and hinders their capability to take corrective actions that mitigates any detrimental affects. Solutions that automate and simplify the commissioning and use of automation and production equipment support the changing working demographics by capturing and reusing knowledge. The reuse of knowledge embedded in simulation-based tools improves efficiency in both automation engineering and production.

The need for well-trained operators keeps increasing. A good knowledge management program must incorporate shared learning and an effective training program. The goal is to produce well-trained highly proficient operators. Human errors are costly not only in terms of waste and equipment failure, but also in terms of worker safety. Operator training simulators remain one of the best ways to transfer knowledge to production personnel

so that they can be more effective in managing operations, improving efficiencies, reducing cost, and preventing unscheduled downtime.

Selective Benefits of an Offline Simulation System		
Benefit	Description	Amount*
Time-to-Market	Faster Time-to-Market: Using a simulation system reduces commissioning and validation time of automation system application software	\$100-\$500K/day
Product Quality	Extensive testing of application software reduces off spec product	\$0.5-\$1M/run
Operating Costs	Training plant operations staff with simulation reduces operations-induced unscheduled downtime	\$5-\$100K/hour
Mitigate Risks	Simulation systems identify and reduce dormant errors in automation systems	\$50K-\$1M/incident

* **Source: MYNAH Technologies**

Offline simulation is the preferred method to train and certify operations staff prior to plant startup and production. Training operators prior to startup accelerates the learning curve on the new process and automation system. In addition, operators can be trained on upset or emergency conditions that they would normally not encounter during day-to-day operations of the plant. This early, off-line training reduces operator errors in responding to normal and upset process conditions.

Considerations for Simulation Systems

In order to improve return on investments from simulation systems, users are adopting best practices and continuous improvement programs for implementing automation system testing and training. Below are some factors to consider for automation projects.

Consider Non-Intrusive Simulation Interfaces

Control system configuration testing is a nontrivial task that is critical to the success of a project. Process simulation technology greatly improves the quality and thoroughness of software applications and control system configuration testing.

For testing automation software applications and configuration, non-intrusive simulation interfaces have several advantages over other methods. Non-intrusive simulation interfaces provide a means to test the

control configuration without needing any changes to the configuration database. A non-intrusive simulation interface uses a virtual IO interface to allow the unmodified application software to run in a normal mode during testing so that the test application software is identical to the production application software. After testing and making all the necessary configuration corrections, the updated control system configuration is downloaded to the live system without requiring any additional modifications and re-testing.

Establish Comprehensive Testing and Training Program

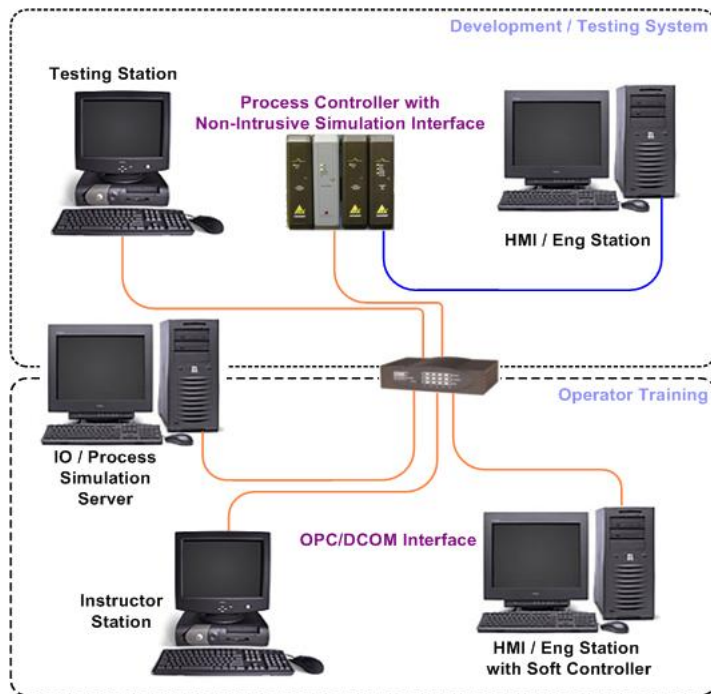
The faster a plant is up and running, the faster it generates revenue and improves the return on investment (ROI). To reduce commissioning time and cost, the development of simulation models, testing, and training must be part of the overall automation project lifecycle management strategy. Simulation model development, testing, and training is not a one shot deal, but an incremental approach, tightly integrated with the automation project lifecycle. This “ground up” testing facilitates identification and elimination of errors early in the project cycle before being propagated throughout the system. Catching errors early reduces the overall cost of the project and brings a plant online faster. In addition, ground up testing allows plant personnel to gain familiarity with the automation system throughout the entire project instead of at the just the final acceptance testing.

Best practices require tight integration between simulation model development, testing, and training throughout the automation project. Simulation model development must be comprehensive to include all the elements of the real process.

Control Modules are the fundamental elements of the process automation system. These elements include motors, valves, analog loops, and monitoring points. A highly effective way of testing these elements is with simple tieback simulations and automated test scripts. Training operators on these elements promotes acceptance of the automation system and provides feedback on the usability of its features.

Equipment Modules are the next level of automation systems and generally refer to simple continuous unit operations such as charging paths, valve manifolds, and package equipment. A highly effective way of testing these elements is with simple tieback simulations and with limited process dynamics.

The next level of the automation system is sequence, batch controls, and continuous advance controls. Effective testing at this level typically entails a higher level of sophistication by incorporating mass balance simulations



with temperature and pressure dynamic models. Operator training at this level is essential to impart proper understanding of the controls and user interface for the safe and reliable operations of the plant.

The final layer of most automation systems is the Manufacturing Execution System (MES) applications and Business System Integration. Effective testing at this level requires mass and energy balance models. At this level, opportunities exist to leverage training beyond operators to include quality assurance, information technology and other stakeholders.

For a comprehensive test program, it is also necessary to test the display elements from each layer of the automation system. For instance, best practices include testing Control Module faceplates with Control Module elements and batch help screens with Batch Controls.

System Configuration Makes a Difference

There are several benefits to using the actual automation system controllers or equivalent soft controllers and application software with a simulation companion system. This configuration allows effective testing and training on HMI use, display access familiarity, process and emergency procedures, response to process upsets, and control system dynamics. This approach builds automation system confidence in operations staff, resulting in more effective use of the automation system for improved performance and greater profitability.

Satisfying Unique Requirements of Validated Industries

Manufacturers in the validated industries have unique regulatory compliance issues associated with the production of their products. Automation

system users and integrators must consider the ramifications of the GAMP4 Guidelines when applying simulation systems to their automation projects. The GAMP4 Guidelines permit the use of simulation systems for automation system testing with several requirements. The guideline requires that the application software be "frozen" prior to Software Integration and System Acceptance Testing. It also requires the removal of dead code prior to testing. These requirements are satisfied with the use of non-intrusive simulation interfaces.

The GAMP4 Guidelines stipulates that suppliers of simulation systems must have a documented quality and software development program in line with industry best practices. The simulation software should be specifically for process control system testing and operator training. The product used should also be a commercial off-the-self (COTS) tool, delivered in validated, tested object code.

Conclusions

- To reduce the time and cost of automation projects, the development of simulation models, testing, and training must become an integrated part of the overall automation project.
- A comprehensive testing and training plan that uses an incremental approach achieves the best results. An incremental approach is required to fine-tune models and simulation at different times throughout the automation project. A comprehensive testing and training program must target all levels of automation. A comprehensive testing and training plan pays multiple dividends in timesavings during commissioning and provides significant benefits in operational performance.
- In ARC's opinion, MiMiC Simulation Software from MYNAH Technologies meets or exceeds all the requirements for a simulation system that performs automation system checkout, software acceptance, as well as those requirements needed for a robust operator training simulator. MiMiC is suitable to build a comprehensive testing and training program for automation projects.

This paper was written by ARC Advisory Group on behalf of MYNAH Technologies. The opinions and observations stated in the paper are ARC's. For further information or to provide feedback on this paper, please contact the author.