DYNAMIC SIMULATION: A MATURING TECHNOLOGY GENERATING REAL BENEFITS

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ABSTRACT

Dynamic simulation when correctly applied is a technology gaining a history of established results. Knowing where to apply the technology is a matter of determining the limitations of the software in relation to the requirements of the simulation. IDEAS is intended to be used from process design concept through to operations management. One of the distinguishing strengths of IDEAS however, is a solution engine which can simulate hydraulically and thermo-dynamically coupled systems to design level accuracy.

1.0 INTRODUCTION

Where a simulation product is best applied is a function of where the original intent of the market focus was, and the technical decisions made to implement that vision. IDEAS was intended to be an object oriented tool kit of parts, running on the engineer's desktop computer to create a virtual operating plant. In order to fulfill that vision the software had to do and be certain things:

• Run on a standard PC
• Run in faster than real time
• Be easily understood by engineers
• Be priced reasonably
• Be robust enough for everyday use

Ease of use and faster than real time performance were two features that the team considered of primary importance. The ease of use constraint led to the decision to employ an object based solution method. The constraint to keep performance fast while still running on a desktop computer meant that considerable thought had to be put into the solution methods. The numeric methods chosen take advantage of object oriented techniques as well as matrix solution methods. The result is a hybrid solution to a pressure flow network that provides a basis for solving an arbitrarily complex piping network.

IDEAS performs mass, energy and momentum balances, and offers pressure/flow solutions for complex piping networks. It can track over 60 components in solid, liquid and gaseous phases. One significant feature of IDEAS is that it allows interactive operation, therefore modification, analysis and optimization while the model is running.

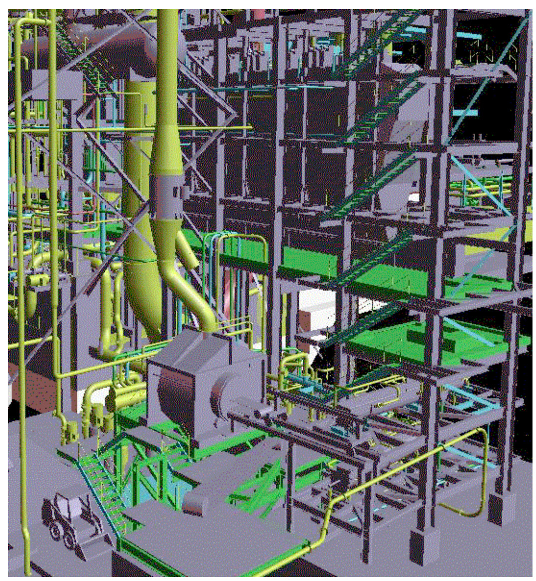

Figure 1
KIVCET Lead Smelter, Trail, BC

IDEAS can be used as a single modeling platform for process design[1,2], advanced control design/testing[3], DCS configuration checking, operator training and process optimization[4]. In the KIVCET simulation project completed for Cominco at their lead smelter operations, a simulator was designed and used to stage the ABB control system in Trail, BC In addition the IDEAS simulator was used to train the operators prior to plant start-up (see Figure 1).

2.0 TYPES OF SIMULATORS

Steady-State - Simulators have been most extensively used in the process industries to perform steady-state material and energy balances to assist in the design of process plants. Steady- state simulators are not focused on the accumulation of volumes in tanks or the control logic associated with equipment, but on the instantaneous state of the process. This is because steady-state simulators by definition do not include time as a simulation variable. Steady-state simulators provide a quick and powerful method of determining flows and temperatures for selecting equipment during process design.

Discrete - Discrete simulators have been used to design such things as port facilities, bottling plants and telephone systems. Discrete simulators are event driven, whereas dynamic simulators are driven from a integration-based solution method that references the previous thermodynamic state of the process. To a discrete simulator an event would be the arrival of a case of bottles. The simulator would decide where and how to sort the bottles.

Dynamic - A dynamic simulator calculates the pressure, flow and momentum that couples a hydraulic and thermodynamic system together. Dynamic simulators include time as a system variable and therefore can be used to simulate control logic (both analog and discrete). Dynamic simulators have the advantage of being able to provide controller tuning constants, logic checkout, and tank sizing (or any vessel that accumulates volume) because or their ability to calculate the state of all process variables against time. A batch simulation is in fact a dynamic simulation controlled in a batch way, not a discrete simulation. Batch simulation must still account for time, thermodynamics and accumulation.

IDEAS can perform steady-state, discrete and dynamic simulation.

3.0 IDEAS APPLIED

Discrete Simulation: IDEAS in discrete mode has been used to simulate the downtown Vancouver telephone network, to simulate the commercial distribution of the Liquor Distribution Branch, the Chips Ahoy! cookie production and the Royal Cup coffee process, to name a few applications.

Steady State Simulation: In steady-state mode IDEAS is used daily by operating companies to determine the optimum use of capital expenditure, and by engineering companies in process design. Autoclaves have been simulated (see Figure 2), by entering the steady state equilibrium equations as a function of pressure and temperature. Future enhancements to the aqueous solution solving capabilities within IDEAS will make this type of simulation even easier (see Section 4.0).

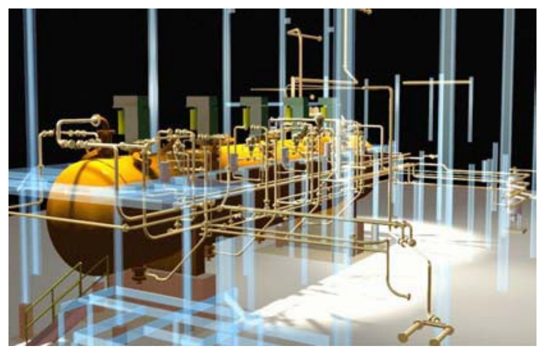

Figure 2 : Autoclave

Below is an example of a mineral processing plant that has been simulated in steady-state using IDEAS, including the underground conveying, pumping and innovative process design. McArthur River is a Cameco uranium mining/milling project in northern Saskatchewan, which is presently being developed, and will start production of uranium ore by 1999.

Ore will be transported to Key Lake in special containers for milling into yellowcake, which will be shipped to Blind River and Port Hope for further refining to UO_2 or UF_6. The annual production is anticipated at approximately 18,000,000 lbs U_3O_8 per year. There are a number of reasons to simulate this particular mining system prior to actual production:

- The ore averages 15% U_3O_8, which has to be mined as safely as possible. Simulation could be useful in monitoring radiation levels, particularly underground and in the ore bin handling area.

- The water balance is crucial for the underground mining technique. The amount of water required, as well as the primary and secondary treatment needed in important.

Initial particle sizes, and the comminution effects of the crushing and grinding have been studied with IDEAS prior to actual operation of the equipment.

Dynamic Simulation: It is however in the dynamic mode that IDEAS fully distinguishes itself as a unique tool. The ability to simulate friction loss in pipes, valve and pump sizes, elevation and momentum provides a framework from which to accurately predict not only the flowrates and temperatures in a process, but the pressures and response times associated with the chosen equipment. Knowing the hydraulic and thermodynamic behavior allows the control designer to implement and test the control strategy for the process during the design phase. Having a momentum balance inherent in the simulation means that accurate tuning constants can be determined prior to process startup saving time and reducing the risk of equipment damage.

Control System Staging: IDEAS has the ability to communicate to control system hardware (DCSs / PLCs) to allow the control logic embedded in plant control equipment to be de-bugged and modified against a dynamic model of the actual process. This process is referred to as model based control system staging. The control system using the actual controls used to operate the real plant is connected to an IDEAS model of the process. The process is then started up and any deficient logic is corrected prior to startup.

Operations Training: This same real time connection to the control system has been used as an operator training system. Operators train from the same interface, using the same graphics and control algorithms that will control the real process. A dynamic model of the process is then connected through a communication driver to the control system. Instructors can introduce process upsets to the system and log operator actions. This training system can be used to help certify operators in the safe start up, shut down and normal operation of the process [5].

Advanced Control Testing: In addition, the system can also be used to test advanced control strategies envisioned by mill personnel on an ongoing basis. As new operating strategies are formulated by operations, they can be entered into the training system and tested against the dynamic model of the process for effectiveness. This provides a risk-free environment to formulate and test new operating strategies that will have operating quality and throughput implications for the mill. A control analysis and loop tuning library allows automatic conversion of first principles models into time and frequency domain equivalents for use by control engineers in optimization and tuning of control loop performance. Even complex processes with interacting continuous loops and discrete event processes can be easily analyzed [6].

IDEAS Simulation Inc. was contracted by Cominco Ltd. Trail Operations to develop a dynamic model of the KIVCET lead smelter to assist in staging of the ABB control system and in the training of process operators.

The model of the KIVCET lead smelter began with existing IDEAS furnace and boiler objects which were modified to suit the Cominco process. Inclusion of Gibbs Free Energy was a fundamental modification as well as the solution of over 50 stoichiometric, equilibrium and phase equilibria equations which would accurately characterize the process. Results of the dynamic model were within 3% of all values predicted by Cominco research. This accuracy gave Cominco confidence in the changes proposed to the control strategy indicated by comparison against the model. The dynamic model will be used in future as a testing place for future modifications to the control of the smelter.

The IDEAS technology was successful on the project due to the excellent teamwork between the IDEAS modeling team and the Cominco team. The Cominco team included Cory Engel the process control engineer on the project, Dr. Greg Richards of Cominco Research, and Russ Babcock, the superintendent of furnaces at the lead operations. The IDEAS team included Raluca Constantinescu, John Ulinder, Chris Calef and Mark Watson.

Cory Engel summarized the use of the IDEAS model during the recent KIVCET Lead Smelter design and start-up in the following way *:*

"IDEAS also allowed engineering personnel to 'pre-commission' the DCS control logic long before installation in the actual plant. A number of deficiencies were corrected and improvements made which translates into significant cost savings for Cominco."

"The IDEAS dynamic simulator provided an excellent means of training inexperienced operators on the operation of Cominco's new KIVCET lead smelter and new ABB open control system."

"The models generated with IDEAS are easily understood by our technical people, in sharp contrast to other modeling packages we have evaluated."

4.0 FUTURE DIRECTIONS

Training: A trend within the industry is for a new generation, integrated training simulator, complete with DCS configuration checking, training manuals, and embedded employee evaluation system.

In a project now underway, IDEAS Simulation Inc., Vicom Multimedia Inc., and TransTech Interactive Training Inc. are producing a process simulator, complete with embedded training manuals, evaluation procedures, multimedia presentations, and dynamic simulation.

This package includes software links between the Vicom and IDEAS software, as well as an interface to WonderWare, and the operator control room screens. Trainees can launch simulations from the training software and be evaluated while operating the simulated plant. In addition, using the PASCE 3D design data, actual equipment layouts, process schematics and other design information can be sent to the multimedia database and animated or rotated for the benefit of the trainee. P&IDs are accessible and brought before the trainee for his clarification on the details of the process. Audio and video segments can be launched whether automatically or by the trainee to assist in learning. If a paper copy is required, then the system will print out the desired sections. Using computer based training (CBT) the trainee is free to learn at his own pace and follow the path that brings him the most knowledge out of the system, not simply following a pattern set out in fixed paper-based systems.

Aqueous Solutions Solver: Prediction of what different compounds are formed when placed into solution is an ability IDEAS will have in place in the near future. Using the technology developed by OLI Systems Inc. of Morris Plains, New Jersey, IDEAS will have the ability to more accurately predict the speciation and equilibria of aqueous solutions. This means more accurate simulation of many of the mining and metallurgical applications within IDEAS. For example prediction of crystallization will allow engineers to predict the proper temperature, pressures and related sizes of reactors prior to equipment selection. Unlike traditional interfaces to aqueous thermodynamic packages, IDEAS will have this technology seamlessly embedded for maximum ease of use.

5.0 SUMMARY

Dynamic simulation is a technology that has developed to the point where when used in a cooperative team environment on a large project, can generate significant benefits. Control logic that has been tested against a dynamic process model can provide a method of risk management for new or existing process installations. Operators given process experience on a simulator are more confident at the proper operation of the process.

Integration with other technologies such as computer based training and aqueous solution solvers allow users to experience more of the benefits of dynamic simulation without having to master multiple computer programs.

Knowing where and how to correctly apply dynamic simulation is a skill vital to the success of any simulation project. Assembling a team that includes simulation, process and management expertise will maximize the potential of the benefits of the technology. A standard part of IDEAS' approach on simulation is to have a teaming session that plans in advance all aspects of the work. This process provides clarification on not only what the tasks are, but the information requirements, the resources needed and the schedule.

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