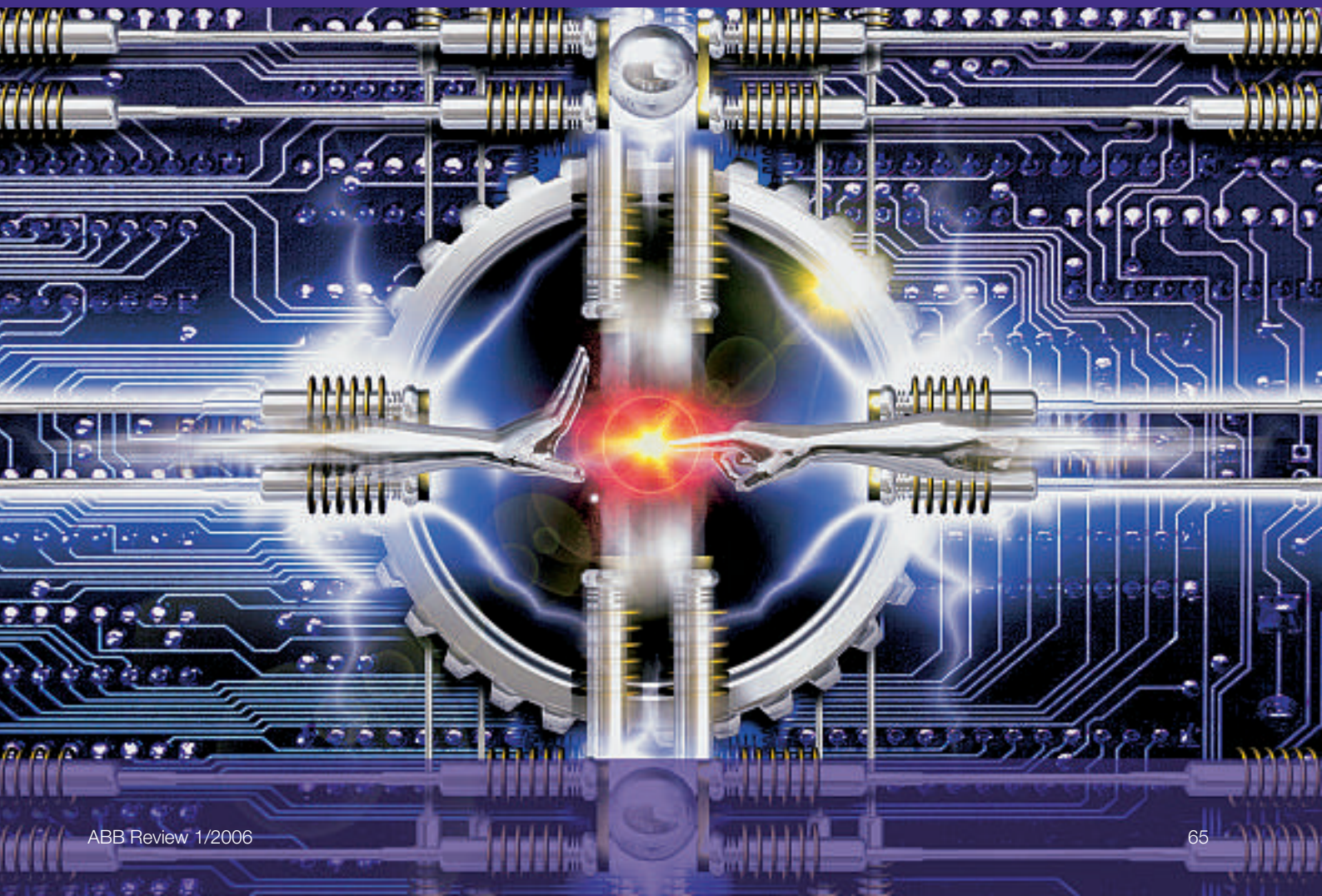
Simulating success

Simulation of manufacturing processes at ABB

Jukka Torvinen, Gerald Lee

Consider the risk involved when deciding to build a new factory or the purchase of capital equipment. Many questions need to be answered before a final decision can be made. Is the facility too large? Will it supply customer demand? Does it meet cost targets? Will the equipment work within the existing factory? These are answers every ABB engineer should know as early as possible on a project, long before any contract is signed, and with a high probability of success.

Process simulation has become an increasingly important and integral tool as businesses look for ways to strip nonvalue-adding steps from their processes and maximize human and equipment effectiveness. Simulation allows the user to model and test multiple scenarios and learn from them. Process Simulation is a tool that has been used successfully by ABB's Corporate Research Centers to answer these questions. This article looks at the simulation process, simulation packages, and examples of simulation in use at ABB factories.



Companies are always looking for more efficient ways to run their business, improve work flow, and increase profits. To achieve these objectives, they increasingly turn to practices such as lean manufacturing. It can be said that lean manufacturing and process simulation go hand in hand: lean manufacturing is a highly productive way of manufacturing, and process simulation allows methodology to be tried and tested without any capital investments being made.

Process simulation involves the modeling of physical processes with the aim of studying their performance. Computer software models are good at examining interactions between systems that are too complex for people to comprehend or predict unless time-consuming and costly real life experimentation is used 1. There are many examples of processes being simulated in both manufacturing and everyday life: weather forecasting is used to understand the interactions between weather systems; and products are often modeled during their service life to foresee the effects of thermal cycling and load cycling for example.

Manufacturing processes are simulated to understand how they effect the composition, shape stresses and material properties of the products being made. The results are often used to reduce the variability in the manufacturing process and this helps increase process quality.

ABB is a leader in the implementation of advanced production systems in its facilities. These systems demand continuous improvement of delivery times, operating costs, capacities, material utilization and information flow. Simulation is a widely used tool by the company because of its unparalleled ability to accurately predict these performance metrics for any scenario. Companies such as ABB apply it in areas such as: investment planning; planning of a new factory; conceptual design; factory layouts; process analysis and optimization 2; 3D Visualization; ergonomics; testing new production control methods and principles; education and training; and marketing.

The risk in building reliable models highly depends on the availability of data against which to validate the model. In many cases, input data may be available from the customer's production system or collected by conducting time studies.

The simulation process

Steps involved in a typical simulation based analysis are:

- Determining the goals
- Data collection
- Modeling the (current) process
- Verifying and validating the model with the existing data
- Simulation runs
- Analyzing the results of the simulation
- Iterations (modelling-simulation-results)
- Selecting the most suitable solution
- Implementation
- Follow-up

Data required for a typical simulation analysis include: product mix; schedule, variations; process maps; labor allocation; inter-arrival times; set-up times; cycle times; planned/non-planned down times; and layout and batch sizes. The risk in building reliable models highly depends on the availability of data against which to validate the model. In many cases, input data may be available from the customer's production system or collected by conducting time studies.

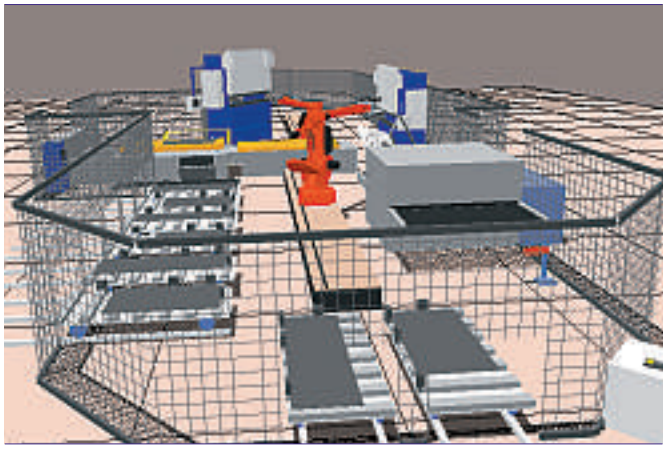
Some of the key results from the simulation runs are capacity, resource utilization, and throughput times. Optimization of these parameters leads to improved productivity, reduction in through-put time and delivery time.

Two simulation packages used by ABB are "Quest" and "Extend" and these are briefly described below.

Quest is a flexible object-based discrete event simulation tool to efficiently model, experiment and analyze facility layout and process flow.

1 Simulating a manufacturing process

From concept



To implementation

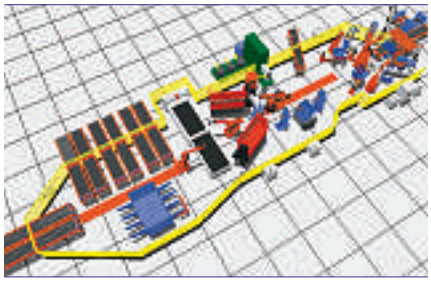
Both 2D schematic and 3D physical models are quickly created through pushbutton interfaces, dialog boxes and extensive libraries. Real-time interaction enables modification of model variables and viewing parameters during runs.

For manufacturing industries, computational efficiency and model building time are critical issues, as they determine the number of possible design iterations and experiments that can be achieved.

Extend is a 2D simulation tool that can quickly create simulation models as easily as one would create a spreadsheet. Extend uses libraries of typical user functions and reports, that can be easily modified if required. Both discrete and continuous simulation is possible. Extend also has a number of models closely approximating many functions so that it is possible to run multiple scenarios in a matter of minutes.

2 Automated and flexible processes

3 "Lights out" manufacturing



Simulation in practice

The first example of simulation in practice is a World Class Breaker project which was executed at ABB's circuit breaker factory in Ludvika, Sweden between 2001 and 2002. The project involved the design and validation of new production systems for breaker manufacturing, of which simulation played a major role.

Simulation was applied in the following areas:

- Testing the various production control principles and validating the selected one.
- Verifying the impact of limited work in progress (WIP) using a specific CONWIP (Constant WIP) methodology.
- Defining and visualizing the related layout changes.
- Verifying the capacity for the modified production lines.
- Definition and validation of the scheduling principle for component production.
- Verification of the production Through-Put-Time (TPT) reduction.
- Thorough analysis of the implemented production process that can be used for further development.
- Validation of the production process using real life schedule file.

Very good technical and business results were achieved including:

- A reduction of 60 percent in the production TPT.
- WIP was reduced by more than 50 percent.

A constant WIP ensures a more constant TPT, and this makes planning more accurate.

The second example uses simulation in ABB's "Focused Factory" for distribution transformers. This factory is a highly automated "factory of the future" for the production of pad-mounted distribution transformers for the North-American market.

The project was executed in Athens, Georgia, and combined an Internet capable quotation and order entry system, a fully automated tank manufacturing cell, new automated coil winding equipment, and a fast assembly line to make significant reductions in material and labor costs, and cycle times. Simulation was used extensively for:

- Defining new production processes.
- Layout design for the production line (more than 30 iterations analysed).
- Modelling the new production line and processes.
- Line balancing to maximize the capacity.

Significant achievements in this project were:

- "Lights out" manufacturing with optimized layout and production processes 3.
- Flexible, one-of-a-kind manufacturing with high capacity.
- No set-up required between different product configurations.
- Minimized WIP because cell buffers were eliminated.
- Quick implementation and ramp-up.

These achievements resulted in labor savings of 50 percent, cycle time reductions of 90 percent, and a 60 percent reduction in floor space. Ultimately, this project helped demonstrate the value of focused factories, a concept which is currently being implemented in many ABB businesses.

The value of simulation can never be emphasized enough. For manufacturing industries, computational efficiency and model building time are critical issues, as they determine the number of possible design iterations and experiments that can be achieved. Developments are occurring in hardware and software that continue to accelerate the speed at which these activities can be carried out. These improvements continue to make simulation software an excellent tool for enhancing lean manufacturing.

Jukka Torvinen
ABB Corporate Research
Vaasa, Finland
jukka.torvinen@fi.abb.com

Gerald Lee
ABB Corporate Research
Raleigh, NC, USA
gerald.lee@us.abb.com