Tecnomatix Plant Simulation Validation of Plant Performance and Plant Control
Dr. Georg Piepenbrock, Siemens Industry Software
Digital Enterprise is our portfolio of solutions for the digital transformation – in both discrete and process industries.

Digital Enterprise

**Process Industries**
- Product design
- Process and plant design
- Engineering
- Operation
- Services

**Discrete Industries**
- Product design
- Production planning
- Production engineering
- Production execution
- Services

**Industrial Software and Automation for process industries**
- Industrial Communication
- Industrial Security
- Industrial Services

**Industrial Software and Automation for discrete industries**

Digital Enterprise Suite
Our customers have essential requirements – throughout the manufacturing industry

- Speed
- Flexibility
- Quality
- Efficiency
- Security
Product Design
Production Planning & Validation

Design and simulate the product
NX CAD/CAE/CAM

Simulate working conditions for humans
Tecnomatix
Process Simulate

Simulate work processes for robots
Tecnomatix
Process Simulate

Simulate and optimize your production processes
Tecnomatix
Plant Simulation
Digital Twin of the product

Digital Twin of the production

Digital Twin of the performance

MindSphere

feed back insights to continuously optimize product and production
Digital Twin Factory Model in Tecnomatix Plant Simulation
Factory 51 – Department Pictures
Digital Twin
Introduction

Video

Digitalization changes everything

It changes the way products are developed

and become a game changer

with the Digital Enterprise Suite

Tecnomatic Plant Simulation
What makes a Digital Twin on Factory Level?

❖ Shop floor layout, machines, conveyors, buffers,…
❖ Processing times, availability => real world processes
❖ Material: storage, commissioning, transportation, logistics
❖ Shift systems / staffing
❖ Production orders / sequences, schedules
❖ Plant control
❖ Energy consumption and control

➔ PLANT PERFORMANCE

- Show & Optimize with the Digital Twin
- Get KPI values and throughput numbers
- Evaluate statistics and many more….
A typical Plant Simulation Example: Storage, Transportation, Personnel, Product Variants,… Everything connected as in real Life

In case the production throughput is low:

Is it better to invest into a faster HBW or into a faster monorail system? Or is both necessary?
Increase Throughput by improved Intra Logistic and Transportation

The Material handling systems is a bottleneck and prevents better results.

Simulation Result:
Higher driving speed for EOM shuttle system and Warehouse RSU double manufacturing performance
Principles of Discrete Event Simulation

Real System / Plan

Simulation Model

Simulation Result

Production System Modeling

Production System Analysis

Production System Optimization
Production Optimization – in a Digital Factory

Where are the bottlenecks?

Can I produce more with less?

What are the process interdependencies?

Can I handle more products and variants?

What is the optimal batch size?

Do I really need that much space / inventory / equipment?

How can I evaluate new control strategies without disrupting production?

Can I handle more products and variants?

How can I be more responsive to changing customer demands?

Is the “gut feeling” of my planners optimal?
Factory 51 – Revisited & Evaluated
KPI Review and Statistics Graphs

Simulation Results
Improved Core Functionality
Ease-of-Use for Material Handling
Assembly Station:
Operator carrying Parts from Store to Assembly

- You can activate the store object’s exit strategy “Carry part away” and configure an operator for carrying the side parts to the assembly station
- The store attribute “MU target” can be used to define whereto the operator shall deliver the part
- The complete configuration is done through dialog settings
- Demo…
Pick & Place Robot: 
Motion Path Definition for enhanced Visualization

- Interactive definition of intermediate points for motion paths between objects
- By interactive positioning of these points, orange markers, you can e.g.
  - Define advanced motion paths
  - avoid collisions
  - define part insertion into a machine
Pick&Place Robot:
Enhancements for Material Handling

- The new pick&place robot can now pick and drop material from somewhere in the middle of attached lines.
- Pick and drop positions are defined just by dragging the robot object onto the lines and selecting the material handling type.
- Material handling types are:
  - Pick part, container or vehicle from a line/track.
  - Unload part from arriving container or vehicle on a line/track.
  - Drop part, container or vehicle on a line/track.
  - Load part to a container or vehicle on the target line/track.
- Definition of handling times for:
  - Pick/unload and drop/load.
Stacking for Parts and Container

Stacking for parts, container and boxes is possible now. You can e.g. build piles of plates or boxes in a floor storage area.

You can use the Pick&Place robot for part and container stacking without any additional configuration or coding.

The robot automatically calculates pick and drop positions according to the boundaries of affected objects.
Live Chart as part of 3D Scenes

- You can visualize live charts and plots on graphical chart boards, that are part of your 3D scene
- Graphical chart boards can be scaled and positioned in the 3D scene similar to all other graphical objects
HBW Library
Ease-of-Use, 3D Appearance

- Easy-to-use HBW objects
- Configuration drag&drop and dialogs
- Simple Standard in/out strategy predefined
- Custom logic for HBW content administration and HBW logic can be added through SimTalk
Crane Library: Gantry Loader
Extended for Machine Feeding

- Using the portal crane as base for machine feeding extension
- Several gantry loader per crane instance
- Loader types \textit{I-loader, H-loader}:
  - Optional: double gripper for I-Loader:
    - load capacity: 2
    - replace finished part with new part in one move
PLM Platform: Layout & Simulation
Teamcenter Example: Plant and Process Structure Trees
A simple but typical Planning Environment

Plant Line Station …

Operations, linked to resources, tools, …

Layout, can be created in Teamcenter MPP or Line Designer
Teamcenter Active Workspace

- Saving/loading simulation models and HTML reports through AWS
- Access to planning data in TC dedicated for use in Plant Simulation (CC, AI)
- Navigating for information purposes in Teamcenter project and data structures
- Working with and use of workflows in Teamcenter
Teamcenter Interface
Active Workspace: Navigation in TC, Model Selection,…
### PLM Interfacing

NX & Line Designer Interface – revisited

- Re-use Manufacturing Layout designed in NX Line Designer for Material Flow Simulation in Tecnomatix Plant Simulation
- Map Plant Simulation functionality to line and station objects in LD library
- Define material flow sequence and attributes (Availability, MTTR, …)
- Enrich the Line Designer layout to a full material flow simulation
- Publish simulation report and recommendations back to Teamcenter
Customer's Voice
WP Performance Systems
Case Study: Radiator Production

Business challenges:
• Increase production of radiators
• Offer great model diversity
• Reduce cycle times
• Remove material flow bottlenecks
• Reduce process steps

Keys to success:
• Increase production of radiators
• Offer great model diversity
• Reduce cycle times
• Remove material flow bottlenecks
• Reduce process steps

Revenue: > $250 Million
Industry: Automotive & Transportation
Company Description: Leading supplier of performance-defining components for motorcycles and automobiles
PLM Software: Teamcenter, Tecnomatix
Country: Austria

"With SimTalk's advanced simulation programming language in Plant Simulation, it is easy to add and modify special features as needed."

Fabian Steinbacher, Project Manager
WP Performance Systems
Case Study: Radiator Production

Keys to success cont’d:
• Implement a batch production strategy
• Simulate production cycles

Business results:
• Doubled daily output
• Decreased overtime costs by 85 percent
• Reduced net processing time by up to 23 percent
• Reduced work-in-process by 60 percent

Using a digital twin helps WP secure the company’s future as a leading supplier of radiators for motorcycles and cars

“The most important effect, however, is the reduction of overtime work by 85 percent or the equivalent of 5.2 full-time workers.”

Harald Edlinger, Industrial Engineering Manager
“It is, however, a good feeling that it is based on reliable simulation results so that all the optimizations and fine-tuning have been done before installation and not during operation.”

Harald Edlinger
Industrial Engineering Manager
WP Performance Systems
Using Core Functionality in Higher Level Apps and Libraries
Industry 4.0 in Logistics – Agent Based Vehicle Control
Demo to show concept & capabilities

Simulation Model
- Logistics network according to Industry 4.0
- Product owns Information about production process and operation sequence (RFID, barcode, …)

Content
- Control Logic
- Network of traffic lanes
- Vehicles, products and process information
- Scalable with production machines, storage, …

Target
- Development and test of driving strategies
- Find optimal vehicle numbers, traffic lane layout, positioning for loading stations,…
Industry 4.0 in Logistics – Agent Based Vehicle Control

Steps for a Transport Order

1. **Red parts** need a transport to the red target

2. A red part sends a request-for-transportation broadcast to all vehicles, using SimTalk: callEvery()

3. All available vehicles send their proposal when they can deliver the part at its destination

4. The “requesting part” allocates the vehicle with the best proposal and waits for being picked up

5. The allocated vehicle executes the transportation order

Broadcast: Send Proposal

\[
\text{minTimeTo Deliver} = 1:04.7046
\]

\[
\text{selectedTpag} = *.\text{TransportAgent.TPAG:1}
\]
Some examples for simulation results...

<table>
<thead>
<tr>
<th>Fahrstrategie 1</th>
<th>Fahrstrategie 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teil</td>
<td>Warten</td>
</tr>
<tr>
<td>A</td>
<td>43.07%</td>
</tr>
<tr>
<td>B</td>
<td>42.97%</td>
</tr>
<tr>
<td>C</td>
<td>39.23%</td>
</tr>
</tbody>
</table>

You see the waiting and transportation statistics

Too many vehicles increase the probability for blocking situations.

You do not need more than 7 vehicles. No additional throughput with 8 or 9 vehicles.
Evaluate Logistics Concepts by Simulation:
Test Milk-Run Strategies without disturbing Production
Virtual Commissioning
Validating real Plant Controls
Shop Floor Connectivity: Simplified OPC UA Support

Connecting Plant Simulation to PLC controls is now possible through the enhanced OPC UA (unified architecture) Server / Client infrastructure, a communication technology offered through the OPC Foundation. The OPC UA Client interface is part of the Plant Simulation Interface Package.

Due to the OPC UA standardization you can connect
- Siemens PLC (S7-1200, S7-1500,…)
- Any other PLC brand supporting OPC UA
- MES and shop floor software with OPC UA interface

The OPC UA interface is independent from the Microsoft COM/DCOM protocol. It is easier to configure / implement in a network. The OPC server can resided on IT components that are not running a Microsoft operating system, e.g. a Siemens PLC or PLCSIM Advanced.
Plant Simulation, TIA Portal V14 and the virtual PLCSIM Advanced
The PLCSIM Advanced interface object connects Plant Simulation models with a PLC program running in a virtual PLCSIM Advanced.

- PLC-Out signals are copied to Plant Simulation variables and simulation object attributes.
- Plant Simulation writes PLC-In signals that are send to and used by the PLC program running in PLCSIM Advanced.
- Time synchronization between PLCSIM Advanced and Plant Simulation supports aligned time progress on both sides.
- Real time mode and time scaling with factors between 0.01 and 100 are supported (not always possible/achievable).
The Import Button imports data items that are defined through the PLC program to Plant Simulation.

More convenient signal grouping in the item table of the interface dialog is possible by creating new groups and copying items between the groups.

A live view table of the configured items shows the current data item values in case a connection to a running virtual PLC is active.
Tecnomatix Plant Simulation
Virtual EOM + Virtual PLC Control as Digital Twin
Embedded in a Laser Scan Point Cloud

- Tecnomatix Plant Simulation Model
- The simulation model is connected to a real or a virtual control S7-1516F
  Currently though (OPC / UA)
- Direct PLCSIM Advanced interface is available with Plant Simulation 14.0
- EOM vehicle communicate with the PLC and get their driving information from the PLC
- User interface is done through standard HMI
  (Part of the TIA-Portal engineering project)
  - Automatic mode
  - Manual mode
  - …
VC Workflow: Video
Closing Remark
Thank You!
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