Co-Simulation scenarios in industrial production plants

Two use cases from the manufacturing domain and the process industry

Andrés Botero, Tim Schenk, Jan C. Wehrstedt

Public © Siemens AG 2019
Some challenges for modular production plants during the lifecycle

### Manufacturing plants

**Task**
Arrange and parameterize plant out of available components to
- avoid bottlenecks
- maximize total load capability
- assure quality

**Challenge**
Setup of comprehensive plant simulations by considering impact of all hierarchical levels:
- Material flow
- 3D kinematic in each cell
- First principle simulation of components

### Process Plants

**Task**
Verify the engineered plant automation virtually before the plant is commissioned in reality

**Challenge**
Conventional approach is not applicable as
- inner module behavior (automation & process) is unknown to plant commissioner and
- modules probably have different automation systems and thus require multi-vendor SW environment.

Source: Siemens
➢ Engineering of Manufacturing plants
➢ Virtual commissioning of process plants
Comprehensive simulation of modular manufacturing plants has to be executed by using different tools.

<table>
<thead>
<tr>
<th>Plant Simulation</th>
<th>Process Simulate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>Material flow</td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td>Event-based</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Logistics, material flow, dimensioning,...</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Calculation of plant KPIs</td>
</tr>
<tr>
<td><strong>Modeling aspects</strong></td>
<td>Cells are modelled as time-delay blocks</td>
</tr>
</tbody>
</table>

- **Type**: Material flow
- **Timing**: Event-based
- **Scope**: Logistics, material flow, dimensioning,...
- **Purpose**: Calculation of plant KPIs
- **Modeling aspects**: Cells are modelled as time-delay blocks

**Material flow simulation**

**3D kinematic simulation**

**First principle simulation for component behavior**

Source: Siemens

**Manufacturing plants**
A Co-Simulation approach accounting for different time evaluation strategies of the clients is required

Use Cases for such a coupling

- Validation of detailed cell behavior in the whole plant context (different cell configs, different component vendors)
- Accurate plant simulation by detailed cell behavior

Example Setup

Realization by a master-slave co-simulation environment

- Establish communication between Plant Simulation and Process Simulate
- Co-Sim Master coordinates event-based, time-discrete and continuous simulators
Demo of interplay between Plant Simulation and Process Simulate
➢ Engineering of Manufacturing plants
➢ Virtual commissioning of process plants
Modular process plants are a new approach to reduce engineering effort, reduce downtimes and be much more flexible

- **Process Equipment Assembly (PEA)**
  Module with integrated control (e.g. automation)

- **Module Type Package (MTP)**
  Description used for integration into higher level plant automation
  - Module services (utilized in state-based process control)
  - Communication variables
  - Communication technology
  - HMI description
  - Open to further aspects

- Connection of PEAs results in process
  1. Import of MTPs
  2. Orchestration of the services

Source: J. Bernshausen & A. Haller, Namur HS 2017
Virtual commissioning of a process plant has to test the engineered automation against different virtual realizations of the plant.

**Conventional Plant**
- **Real plant**
  - AT-Konfiguration
  - HMI
  - Automation / Control
  - Communication
  - Sensors
  - Actors
  - Plant / Process

- **Virtual commissioning**
  - Software-in-the-Loop (SIL)
  - HMI
  - Emulated

- **Simulated / omitted**
  - Simulated
  - Signal test
  - Field device test
  - Process simulation

**Modular Plant**
- **Process Orchestration Layer (POL)**

Source: VDI/VDE 3693
Demo of proprietary modular VIBN with Siemens tool SIMIT
Virtual PEA (modules) can solve the problem of setting up a comprehensive simulation model of the whole plant.

**“Model-Cuts”**
- Single model containing automation & process
- Separate models for AT & process (+ coupling)

**Operator-specific parameterization**
- Material databases
- Behavior models (e.g. reaction kinetics)

**Continuous process ports**
- Automation / field device parameter
- Process parameter

**Virtual PEA**
- Failure state (local)
- Validation state (local)

**Model wrappings**
- Process: FMUs
- Automation: Vendor specific virtual controller (via OPC UA, VM or FMU)

**Model wrappings**
- Process: FMUs
- Automation: Vendor specific virtual controller (via OPC UA, VM or FMU)

**Different levels of process models** for specific VC tests

**Today no FMU export for VCs**
Co-Simulation realizations can be set up by either vendor specific tools or a generic co-simulation environment.

**System Structure Package (SSP)**
- Plant engineering
- Process recipe
- Operator databases & models

**Virtual PEAs as CoSim-FMUs**
- (from different vendors)

**Operator Modul-Garage**

**Modular Co-Simulation VIBN environment**
- SIMIT (Siemens VIBN tool)
- Process Plants
- POL
- Modular Co-Simulation VIBN environment
- Process Orchestration Layer (POL)
- Failure injection and validation

**SS Definition**
**SS Mappings**
**SS Values**
Co-Simulation together with utilization of standards like FMI and the new SSP speed up different use cases in the production industry

Summary & Outlook

➢ As production plants get more modular and thus multi-vendor plants, simulations cannot be set up with a single simulation environment anymore.

➢ The modularity enables a new flexibility of the plants, which allow fast plant changes. To not loose this advantage by conservative (long-lasting) verifications of the new setup, the (simulation-based) validations have to be as flexible.

➢ Co-Simulation is actually the appropriate choice of exchange as most of the commercial simulation tools in the production industry support only one specific solver type.

➢ The engineering of production plants results already in a topology model. Export into a standard like SSP enables an easy setup of system simulations independent of the specific simulation environment.

➢ Virtual commissioning tools should be able to import Co-Simulation FMUs (Siemens SIMIT plans to release this feature in next version). Virtual controller should be able to export FMUs.
Contact information

❑ Andrés Botero
CT RDA SDT MST-DE
Otto-Hahn-Ring 6
81739 Munich
andres.botero@siemens.com

❑ Tim Schenk
CT RDA SDT MST-DE
Otto-Hahn-Ring 6
81739 Munich
tim.schenk@siemens.com

❑ Dr. Jan Christoph Wehrstedt
CT RDA SDT MST-DE
Otto-Hahn-Ring 6
81739 Munich
janchristoph.wehrsted@siemens.com