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From a 3D Plant Model to a Forge-Based OPC UA Connected Virtual Twin for Simulation

Reiner Meyer-Roessl
Global Business Development Process Plant
Autodesk

Gerardo Santillán
Customer Manager
Semantum Oy

Learning Objectives

- Learn about automatically creating a simulation model from a 3D plant model.
- Learning about Forge usage in the process plant industry.
- Learn how to capitalize on the Open Ontology-based Simulation Integration Platform “Simantics”.
- Learn real-life use cases capitalizing on the industry-standard OPC AU technology.

Description

In this session, we will present a powerful service for automatic generation of process simulation models from 3D plant models (for example, AutoCAD Plant 3D software). The simulation service is based on the Open Ontology-based Integration Platform “Simantics.” Information of a 3D plant model is extracted to generate and configure a dynamic simulation model and to calculate head-loss coefficients and other important parameters of the pipeline network. After its integration with the plant through Autodesk Forge, the simulation model is the core of a simulation-based digital twin. This application can be used for process and control design, control system testing, operator training, and process optimization and troubleshooting. The generated simulation-based virtual twin can be connected automatically to the Forge platform, capitalizing on the OPC UA standard, and simulation data can be visualized in Forge. We will also show how one can interface measurement data to the same system and do comparison between simulated and measured data, enabling fault diagnostic and troubleshooting services in Forge. We will demonstrate a case example using a laboratory process.

Speakers

Reiner Meyer-Roessl is the process plant industry lead in the Global AEC Sales Development Group at Autodesk, Inc. He joined Autodesk in 2007 with the acquisition of ACPlant technology, which is the base for the Autodesk plant flagship product AutoCAD Plant 3D software. He is responsible for strategic partnerships and projects, managing the Process Plant Industry Eco System (technical partners), and is working on different initiatives such as the Plant Vision and the Autodesk iRING/ISO15926 initiative. He represents Autodesk in various industry groups like DEXPI or Fiatech. Prior to Autodesk, he was owner and managing director of ACPlant Austria, board member of AC Rosa AG, Germany, and chairman of Flow Logic International in Baton Rouge, Louisiana.

reiner.meyer-roessl@autodesk.com

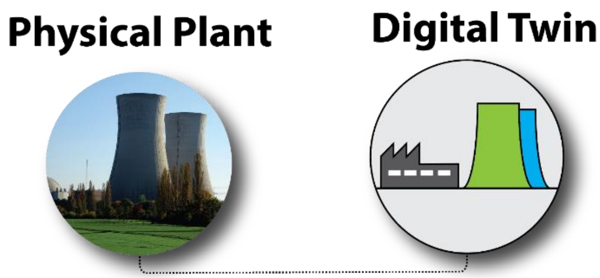
Gerardo Santillán is a Customer Manager at Semantum Oy. Semantum is a software development company specialized on engineering automation and on the development of simulation-based digital twins for production plants. Gerardo has over four years of experience on research focused on the application of simulation throughout the entire production plant lifecycle. Recently, his main work has been targeted on the application of engineering automation techniques for rapid and efficient development of digital twins.

gerardo.santillan@semantum.fi

Introduction

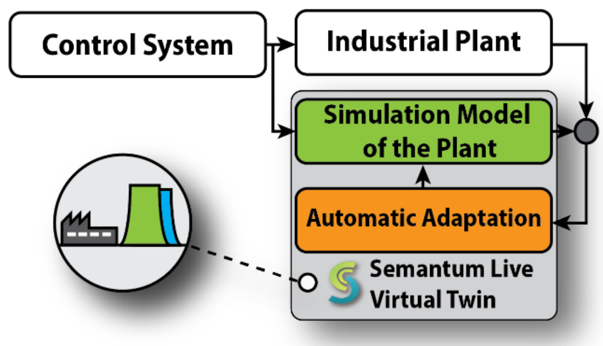
Digital Twins

A digital twin, also known as Virtual Twin, is a digital replica of the physical assets of an industrial plant which contains, the structure and the dynamics of how the devices or process operate. Virtual Twins are a promising application for decision support of modern plants and they are becoming highly popular in industry.

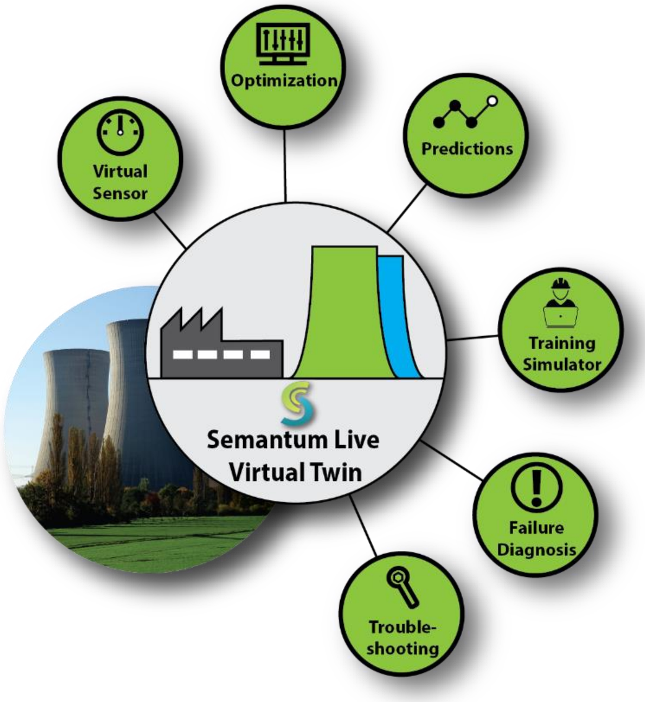


Semantum Live Virtual Twin

In a digital twin, structure information can be obtained from CAD material of the plant. While dynamics of the process could be obtained from data-driven methods based on capturing data of the plant, this approach has different disadvantages. These drawbacks range from high data dependability to limited prediction capabilities. In contrast, Semantum Live Virtual Twin is a Digital twin based on first-principles simulation models of the plant. First-principles models are those relying on engineering, physics or chemical descriptions to represent the behavior of the plant. In our Live Virtual Twin, a simulation model runs together with the plant while various automatic model adaptation techniques keep the simulation results in the same state as the targeted device or process.



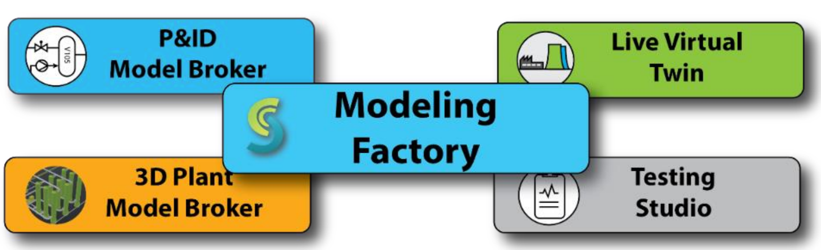
As a result, the Live Virtual Twin becomes a virtual sensor from which non-measured information of the current state of the plant can be obtained. The underlying simulation model can be used to obtain high-fidelity predictions, including production forecasts of operating regions from which there are not any measurement data available. Our Live Virtual Twin can be used for developing operator training simulation systems, for troubleshooting, or for production optimization and failure diagnoses. The simulation-based Live Virtual Twin is a holistic and powerful application for plant operation support of modern industrial plants.



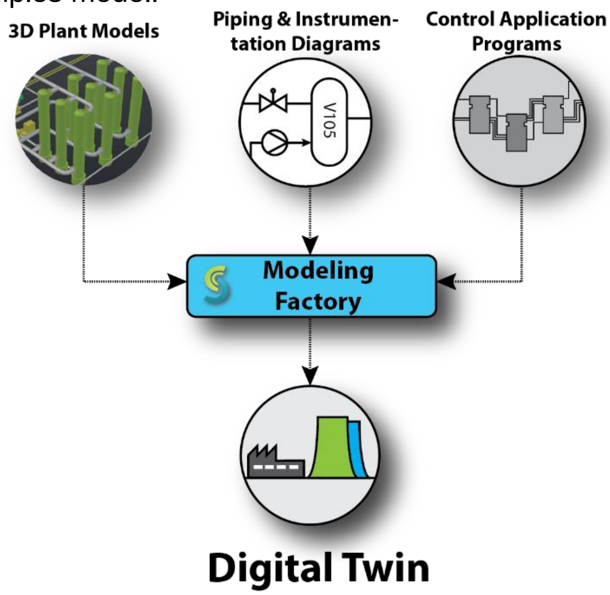
Creating a simulation model from a 3D plant model

One of the biggest challenges for implementing a Digital twin based on simulation models of the plant is laborious model generation. To tackle this, our Live Virtual Twin leverages on the use of Semantum Modeling Factory. Modeling Factory is a cloud-based service for managing creation and utilization of engineering assets throughout the plant lifecycle. It is based on different Modeling Factory Workrooms, which can be used e.g. to:

- Automatically generate simulation models from engineering data sources.
- Configure and use Digital twins.
- Manage and automate collaborative multi-simulation for testing.



In particular, the model brokering workrooms provide services to automatically generate simulation models from data aggregation of different engineering and design sources such as pipping and instrumentation diagrams (P&ID), control application software and 3D plant models. Automatic generation of simulation models significantly increases the Live Virtual Plant implementation cost-efficiency and dramatically reduces development and maintenance time of the underlying first-principles model.



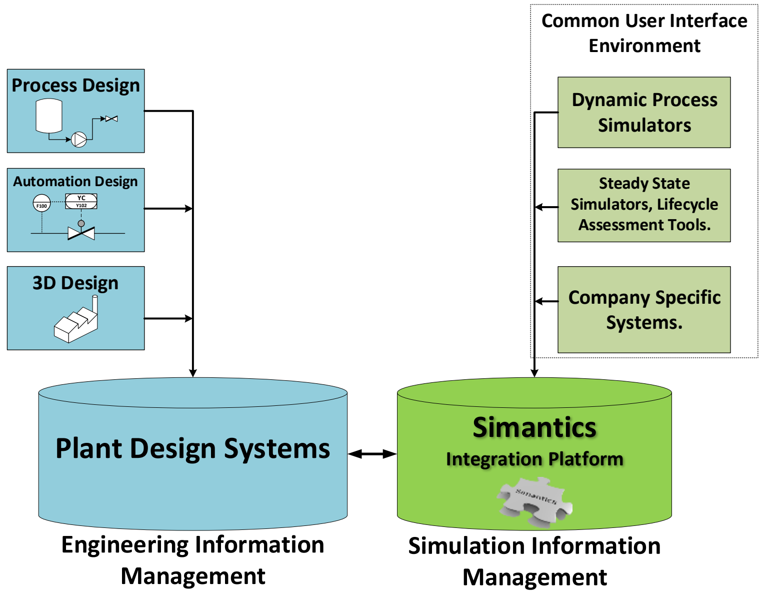
Forge usage in the process plant industry.

Simantics: Open Ontology-based Integration Platform for Modeling and Simulation.

Simantics is an open, high/level application platform on which different computational tools can be easily integrated to form a common environment for modelling and simulation. Simantic's ontology-based information modelling allows arbitrary mapping of data. The platform includes several modelling tools and editors, such as 2D graph-like hierarchical model composition and semantic graph browsing.
Arbitrary information mapping enables, e.g.:

- Efficient mapping of simulation and measurement data to the simulation model configuration and its visualization interface.

- Arbitrary information brokering between different purpose tools and applications.



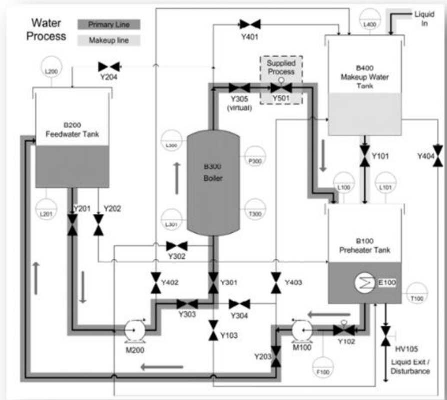
OPC Unified Architecture

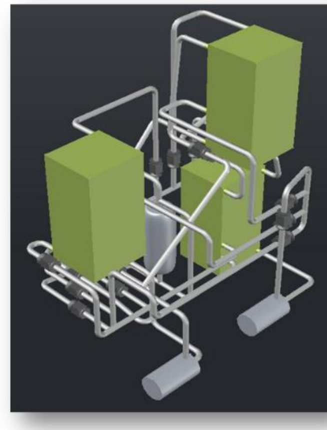
OPC UA is an industrial interoperability standard that enables transport of information between heterogeneous systems. It is a platform independent standard widely adopted for vertical and horizontal integration in many industrial domains. OPC UA provides a set of specifications for systematically retrieving exchanging data between control devices, monitoring systems as well as MES and ERP systems. OPC UA has been selected as the only standard for the communication layer in the Reference Architecture Model for Industry 4.0 RAMI, which will further consolidate its relevance in the future.

From 3D plant model to a Forge-based Digital Twin: Implementation example

The HPP process

The proposed methodology was implemented and tested using a laboratory-scale heat production plant (HPP) process. The HPP process is simpler than real power plants but has been designed together with automation professionals to ensure that it includes key automation functionalities of such processes. The process, its P&ID and its 3D model (developed in AutoCAD Plant 3D) are shown in the following figures.





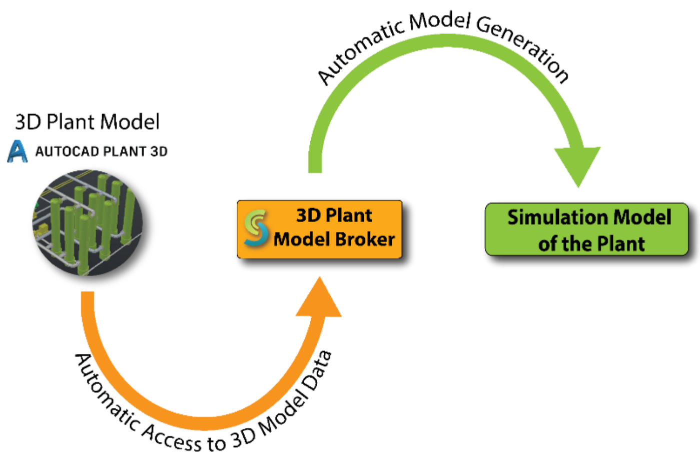
Apros simulation tool

Apros® is the targeted simulation tool for generating the simulation model of the HPP process. Apros® is a tool for modelling and dynamic simulation of thermal-hydraulic processes that has been used to simulate various industrial systems such as combined heat and power plants, nuclear power plants, renewable energy production system, as well as pulp and paper mills. Apros® provides simulation libraries with simulation components of common process equipment, which can be connected through pipes and thermal-hydraulic points to simulate process sub-systems or entire plants. This tool also provides functionalities to develop a model of the process automation system for independently controlling the simulation model. Apros® is integrated to Simantics platform.

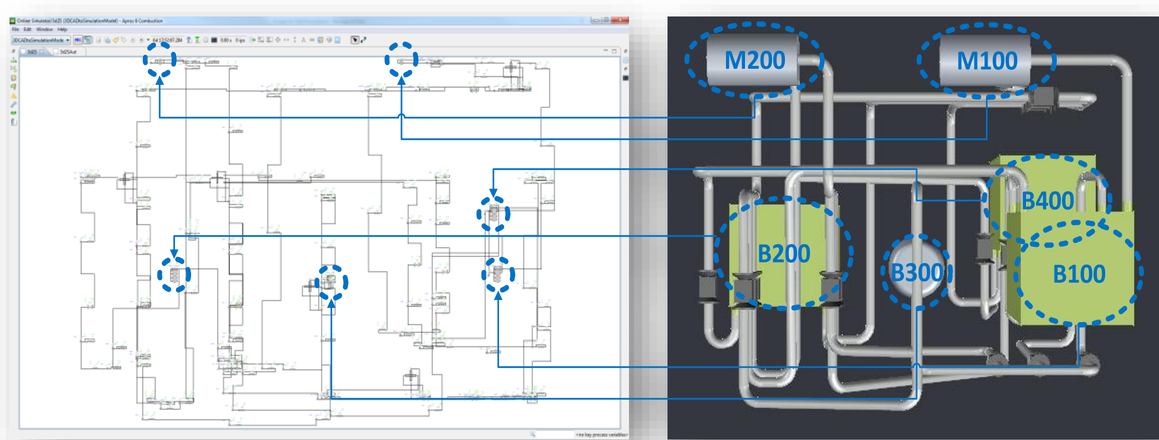
® Apros is a registered trademark of Fortum and VTT.

Automatic simulation model generation from 3D plant model

Automatic model generation is carried out utilizing the Semantum 3D Plant Model Broker, a workroom currently under development of the Semantum Modeling Factory. The automatic generation method thereof first retrieves 3D plant information from the 3D plant model. Next, it automatically generates and configures process components.

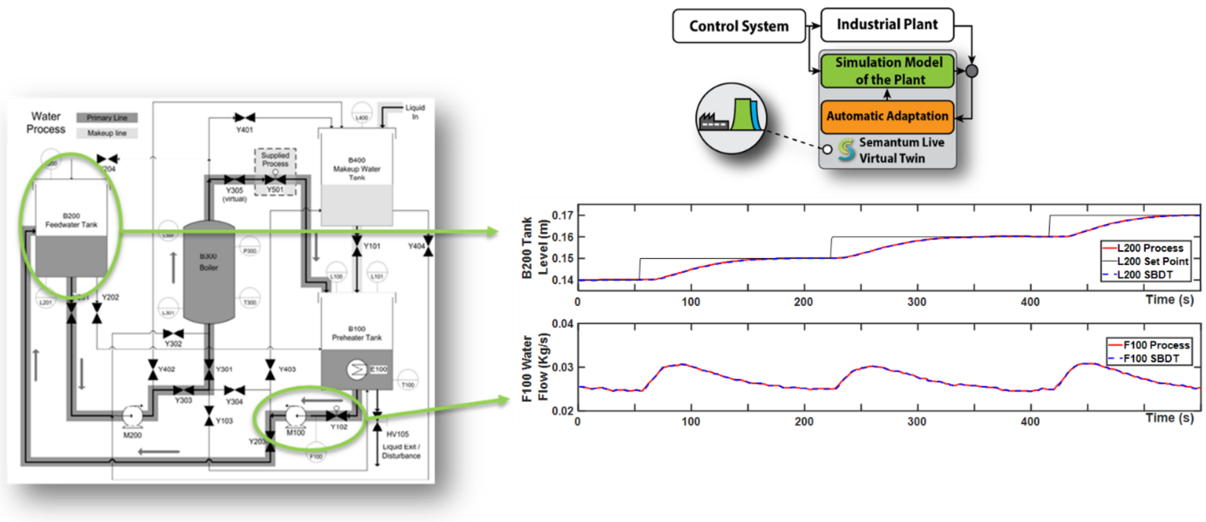


The resulting simulation model is configured with detailed information of the process equipment and its pipeline network. This information includes equipment location and elevations as well as pipelines lengths, diameters and elevations. The automatic generation method also calculates and configures head loss coefficients of the pipeline network. These coefficients represent pressure losses due to abrupt changes on the pipeline directions. They are highly important for obtaining high-fidelity simulation results required to implement simulation-based digital twins. The resulting model and its comparison with the lower isometric view of the HPP 3D model is shown in the following picture.



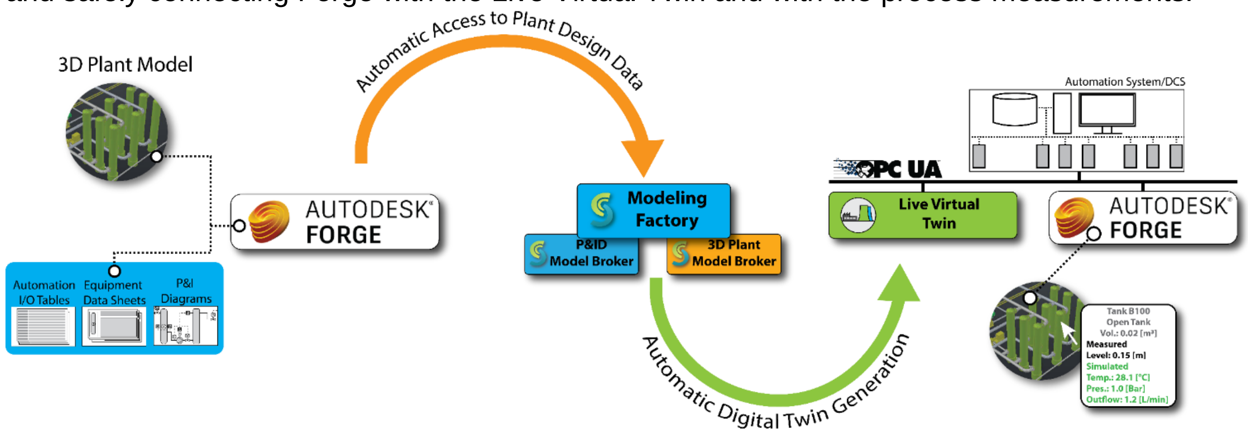
Implementing a Live Virtual Twin

The automatically generated model is connected to the HPP process and to the model adaptation methods for achieving permanent state synchronization of the simulation model with the plant measurements. Automatic adaptation adjusts model parameters after comparing process measurements in order to drive the simulation results to the same value as the process. The following figure shows results of the simulation-based digital twin and its comparison with the process outputs. As it can be seen, the digital twin achieves synchronization with the process measurements. At this point, the model becomes a Live Virtual Twin that can be used to obtain non-measured process information, to perform production forecasts or to carry out system optimization.

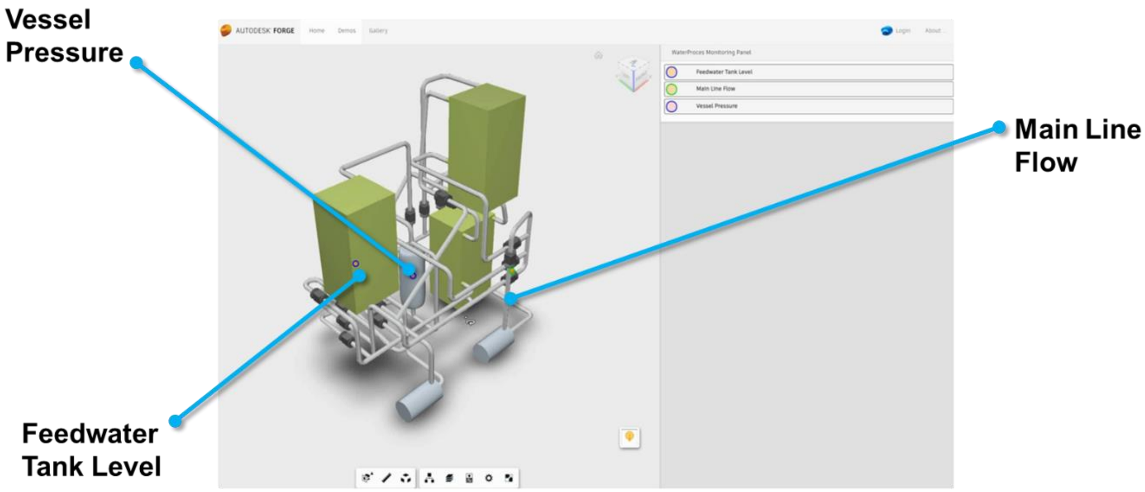


Visualization of the digital twin through Autodesk Forge

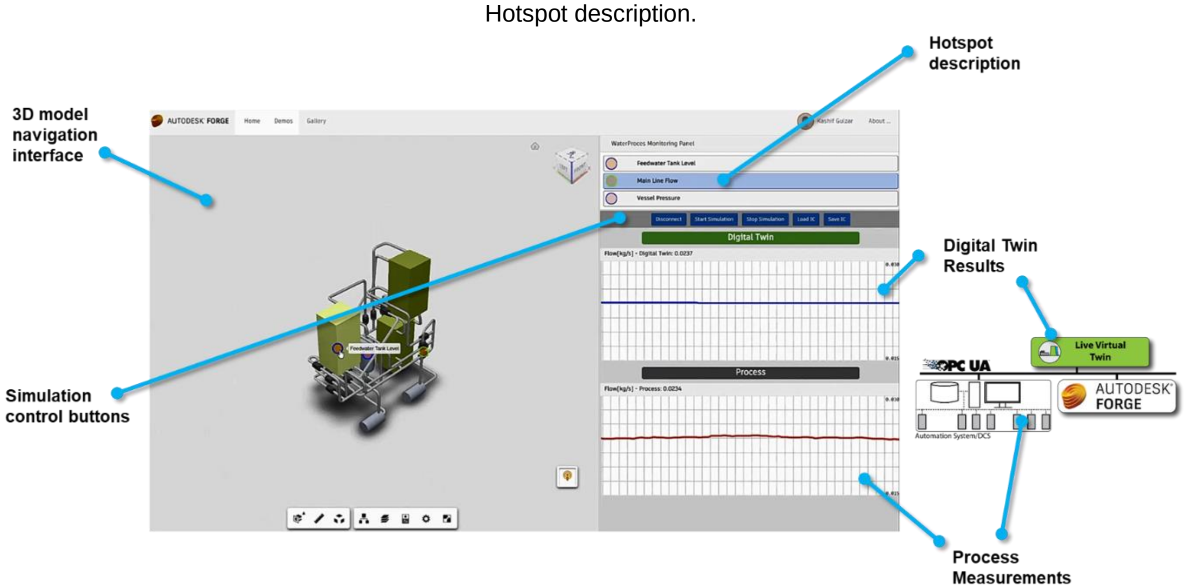
The Live Virtual Twin of the HPP plant is integrated with Autodesk Forge for enabling intuitive visualization through its 3D plant model. Firstly, the HPP 3D plant model was imported into the Forge visualization interface. Next, newly developed OPC UA interfaces were used for seamlessly and safely connecting Forge with the Live Virtual Twin and with the process measurements.



The resulting application is a web-based user interface where the 3D plant model gives context to the information coming from the real plant and from the Live Virtual Twin. In order to ease navigation for the system operator, 3 hotspots of the process are placed into the interface. These hotspots are process variables that are controlled by the control application of the plant and that are of high interest for achieving efficient and safe plant operation.



Hotspot description.



Process measurements and Live Virtual Twin results can be visualized on the Forge-enabled UI.

Application case: Transient predictions

Production transients are caused by changes on the plant states due to:

- External disturbances
- System malfunctions
- Production set point changes

Predicting the plant's transient response is critical for ensuring that:

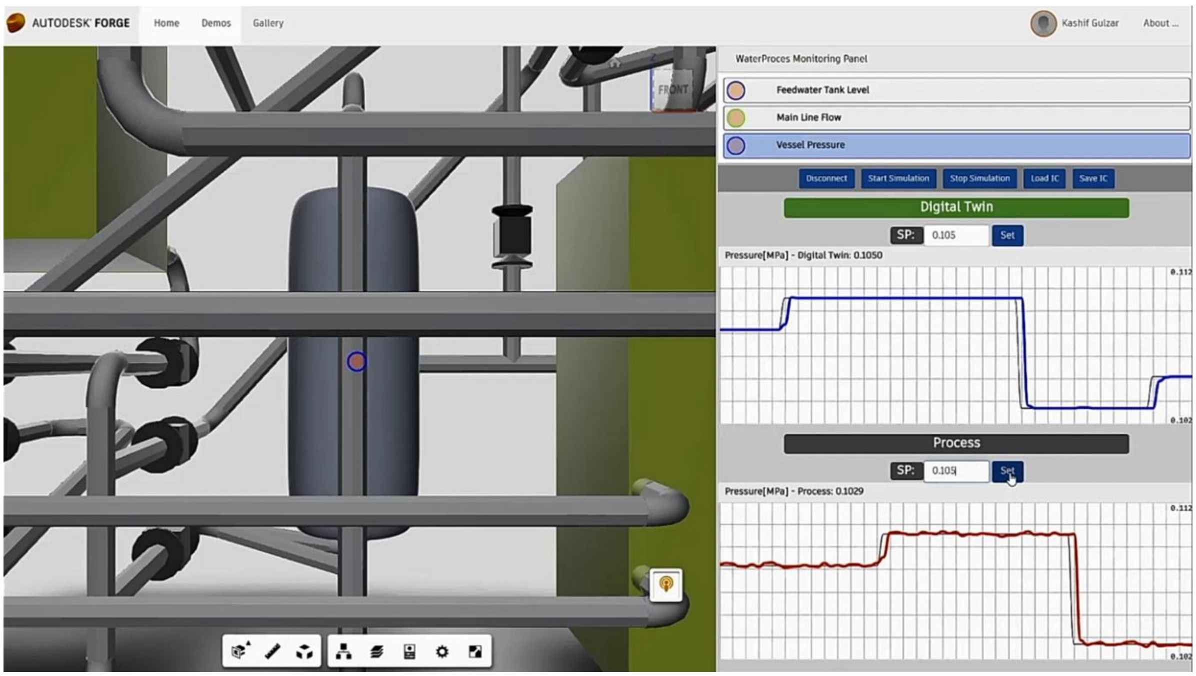
- the changes are safe (e.g. system stability)
- the production remains efficient

Reliable transient prediction can only be achieved through dynamic simulation!!

The developed digital twin is ideal for this application as the predictions obtained with this system have two main advantages:

- They are based on a model state that is in the the exact current state of the physical process.
- They are based on a model that has been adapted to provide results very close to the process measurements.

In the developed system, predictions transients are run by changing production transients on the Live Virtual Twin to ensure that the production remains efficient and safe. Once this is verified by the simulation results, the setpoint changes are implemented in the real process plant.



Conclusions

Digital twins of process plants are digital replicas of the physical assets of the plant which provide information of the process structure and its dynamics. The system presented in this session provides information of the process structure utilizing the 3D plant model, developed in AutoCAD Plant 3D. Furthermore, it relies on a first-principles simulation model to provide information of the process dynamics. Knowing that model development is laborious and expensive, in the proposed system, Semantum 3D Plant Model Broker is applied for automatically generating the simulation model of the plant. Then, Semantum Live Virtual Twin is utilized for synchronizing the simulation model results with the process measurements. Finally, Autodesk Forge is connected to the Live Virtual Twin through a newly developed OPC UA interfaces. This integration is applied to build a web-based user interface for the digital twin.

Simulation-based digital twins, such as the one presented in this session, are a holistic application that can be used for several important applications during process operation and maintenance. The information available from these systems can be used to support process monitoring, to forecast future plant states or to diagnose failures. The adjusted model can be used for obtaining non-measured data of the process, for model-based testing of the control application, for implementing training simulator or for plant troubleshooting. Tracking simulators enable a holistic set of applications and through which current and future plant data are made available for operation decision support. The methods and tool-sets presented in this session are targeted to enable a rapid and more efficient development of digital twins based on simulation.

Helpful References

Semantum Live Virtual Twin
https://www.semantum.fi/solutions/semantumlivevirtualtwin/

Automatic Generation of simulation models from 3D plant models
https://ieeexplore.ieee.org/document/8434288

Autodesk Forge
https://forge.autodesk.com/

Apros simulation tool
http://www.apros.fi/en/