DIGIBatch

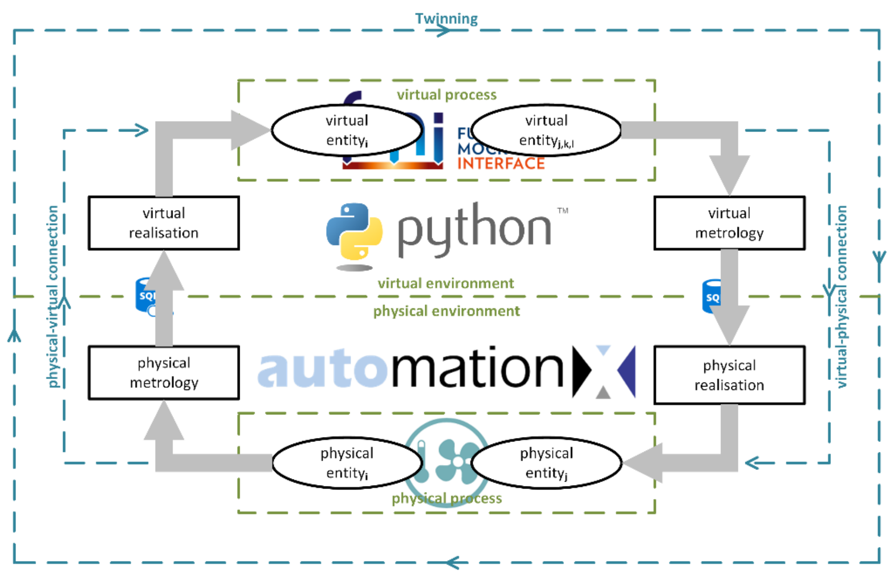

Figure 1: Visualisation of the Twinning cycle and digital twin environment

Summary of project

The research project DIGIBatch focuses on performance optimization of batch processes with the help of digital twins. As an example of a batch process, the heat pump during performance tests. A virtual representation of heat pump on a test rig was created to facilitate heat pump testing. With each stable operating point during heat pump testing – according to standard – the relevant mass flows and temperatures are measured and transferred to the virtual representation. This enables model parameterization and simulation of the next optimal operating point. Therefore, allowing the operator to avoid time and energy intensive iterations.

Motivation

During heat pump testing at certain lower part load conditions, or by design, heat pumps go in an on/off-mode. Operating points specified by the standard then can only be achieved via virtual mixing temperatures. As the actual heating capacity is dependent on the temperatures and vice versa these points can only be reached iteratively. This is time and therefore energy consuming. The digital twin application provides the operator with these temperatures obtained through simulation. Due to the low number of overall operating points, there is a strong emphasis on good parameter identification for model calibration.

Approach

A physical model of the heat pump was developed in Modelica and simplified to the lowest feasible number of parameters. Still an overparameterized model, with each operating point a subset of those parameters is selected adaptively through regression analysis and support vector decomposition. This subset then is fitted and used in the prediction model. The digital twin of the heat pump was realized by integration the model as a *functional mock-up unit* (FMU) in a commercial cloud application facilitating the integration with the test rig SCADA system.

Results

It was possible to show that the adaptive parameter selection method reliably finds (locally) optimal parameters. Therefore, it was possible to predict the correct temperatures for the next virtual operating points starting from only two provided operating points. Avoiding iterations and reordering the operating points by temperatures the overall testing procedure could be speed up and save time and energy. Furthermore, a parametrized model of the heat pump, suitable for the prediction of thermal performance, is obtained during testing that can be reused in the later stages of the heat pump product life cycle.

Learnings

- There is no generic heat pump model. Development and/or adaptation of heat pump models for the use as digital twins needs consideration of thermodynamics of refrigerants, specific components, circuits, operating conditions. Complexity of models is restricted by available measurements.
- Robustness of the twinning framework critically depends on the balancing between available data, complexity of models and operation conditions

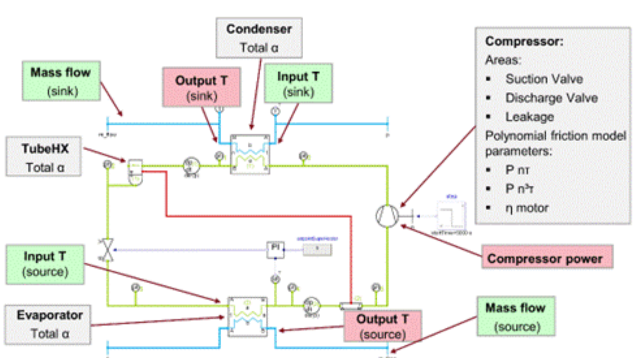

Figure 2 Visualisation of the Dymola model and parameters identification

FACTS ABOUT THE PROJECT

IoT Category: Optimize HP operation

Goal: lower costs and emissions

Beneficiary: User, component manufacturer

Data required: Sink and source temperatures, sink and source massflows

Analysis method: Digital twin, simulation, demonstration

Modelling requirements: Reduced physical model, parameter identification methods

Quality-of-Service: On demand, near real-time

Project participants: AIT Austrian Institute of Technology, AutomationX GmbH

Time schedule: 2018-2020

Technology availability : 5

Link to webpage:
https://projekte.ffg.at/projekt/2917872

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