Training Simulator for Molten Salt Parabolic Trough Test Plant

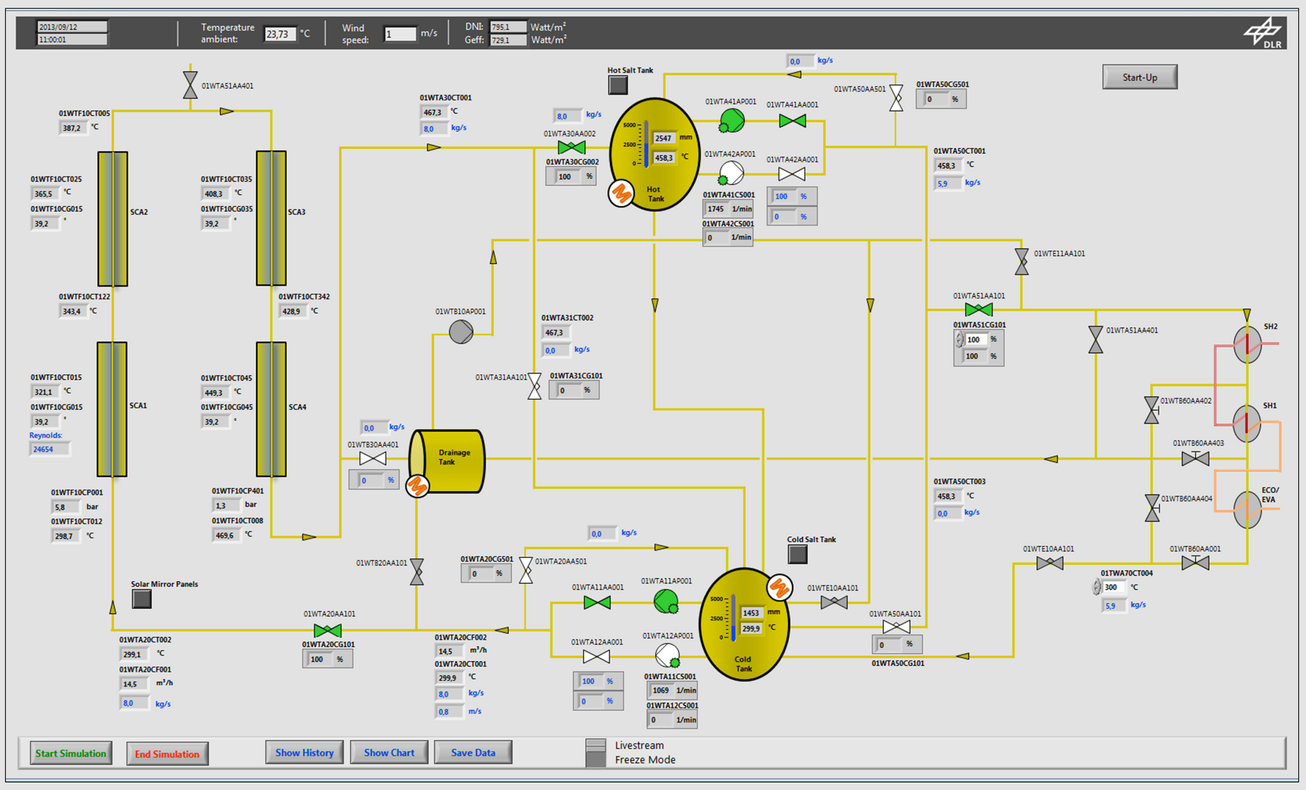

Fig 1: Screenshot of the Training Simulator with the four collectors of the solar field (left), hot and cold molten salt tank (center), drainage tank, and heat steam generator (right). Situation at 11:00.

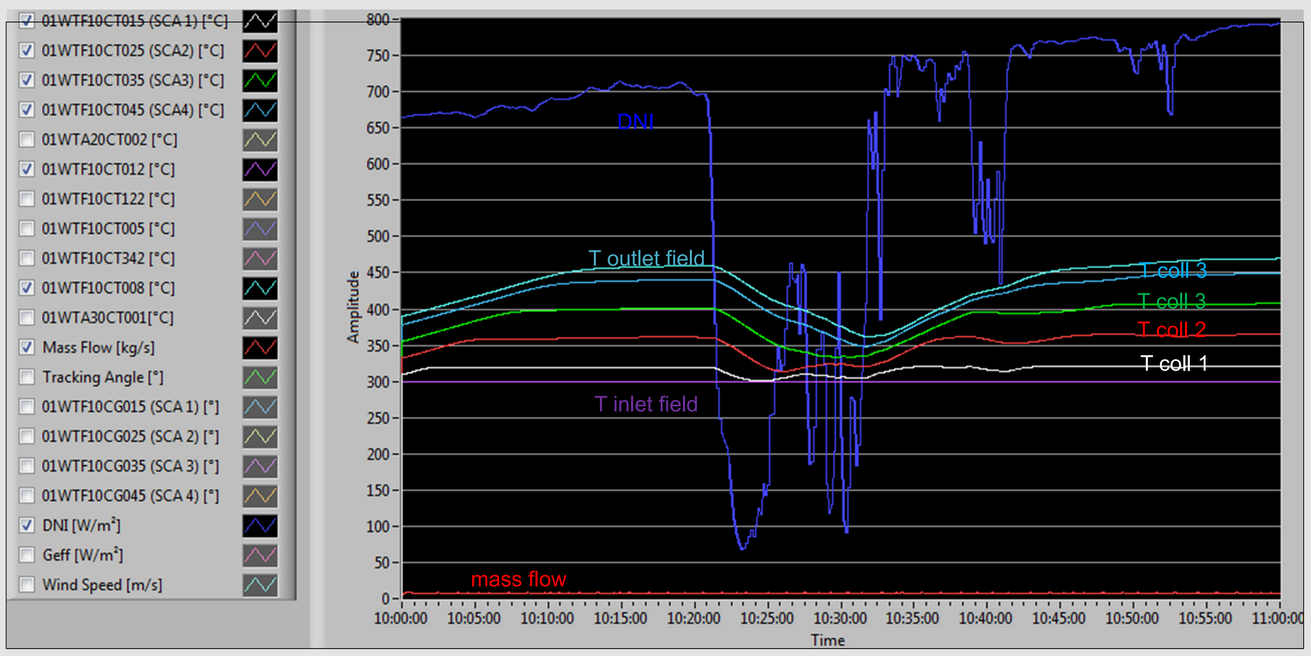

Fig 2: Screenshot of result display

Motivation

Operators of a solar-thermal facility bear a high responsibility. They are in charge of the plant integrity, the safety of staff, and the optimal performance. At the same time, the complexity of the plants is very high. Thus, competent operators who understand what they do and, especially, know how to react in non-standard plant conditions, are needed. Regarding the operation of test facilities, five additional hurdles exist:

- The plant's layout and procedures can be unique, as it is built without established standards yet;
- The plant layout and control system can change regularly, when innovative components, tests, or algorithms are introduced;
- The operators may come from different backgrounds or varying project partners and, thus, have different requirements when becoming acquainted with the plant;
- Various transitions during operation might require manual actions, as a complete automatization is often too expensive for test plants;
- The plant safety control system might not reflect all possible emergency scenarios, since the complete behavior might not yet be known or shall be explored. This is especially relevant for commissioning of test plants.

To take care of qualification of the operators, DLR is currently developing a training simulator for the new molten salt test loop in Évora, Portugal. The test loop is erected within the HPS2 project [1] with various research and industry partners. Together with the co-operation partner University of Évora, the project serves as initiation of the Évora Molten Salt Platform (EMSP).

Implementation

Various possibilities to design and implement a training simulator exist. Highly detailed control room duplications with models of even small components serve for education of staff for large nuclear or coal-fired power stations. Operators work with a plant model running in the background and a trainer who can impose disturbances to the plant model. The effort for such complex training simulators is very high and not suited for test plants.

The design of the training simulator is thus driven by different boundary conditions:

- Detailed simulation model of the solar field shall be integrated;
- Main operation modes and control system behavior of solar field shall be reflected;
- Layout of the human machine interface (HMI) similar to real plant;
- Simulator shall serve for testing of process control procedures;
- Simulator shall be able to integrate other models of other plant sections in the future;
- Simulator framework shall be usable for other test plants in the future.

The software LabVIEW was chosen as the main simulator management platform. DLR's Virtual Solar Field (VSF) model [2] for detailed transient simulation of single-phase fluids is used for the solar field simulation. VSF is implemented in C++ and a TCP/IP connection is used for communication with LabVIEW. The simulation management, control system, and HMI are directly implemented in LabVIEW. Connection with other simulation tools are feasible by standard connection interfaces, e.g. with Matlab/Simulink and Modelica/Dymola, or can be connected via an OPC interface.

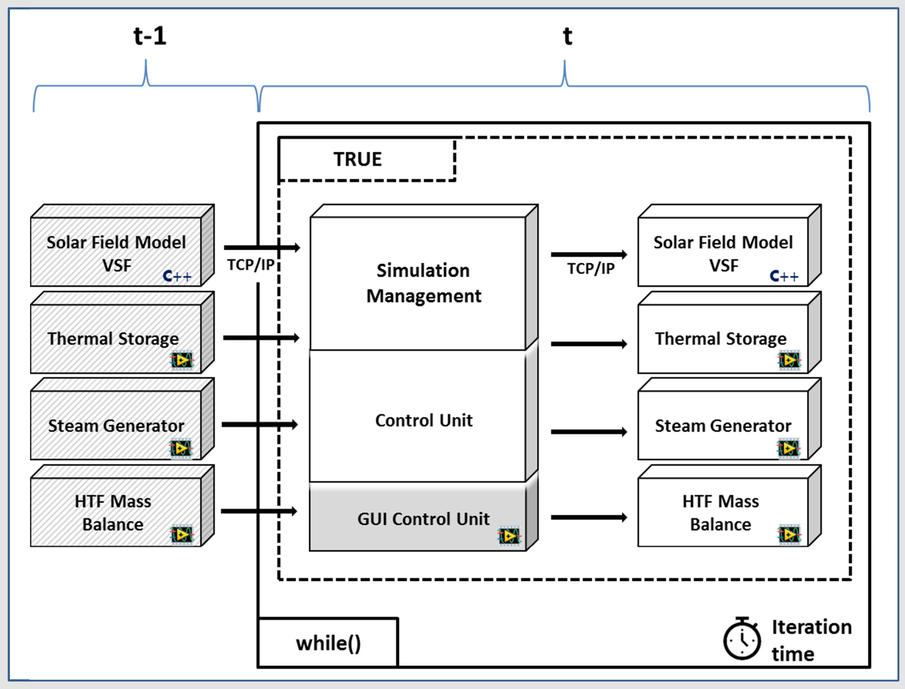

Fig. 3: Simulator software architecture and time step handling

[1] Hennecke, Klaus; Wittmann, Michael: HPS2 - High Performance Solar 2 - Evora Molten Salts Plattform, Presentation at 3rd IPES Symposium on Solar Energy - Solar Concentration and the future, Feb. 1-2, Évora, Portugal (2016), available at http://elib.dlr.de/108981/

[2] Noureldin, Kareem und Hirsch, Tobias und Pitz-Paal, Robert (2017) : *Virtual Solar Field - Validation of a detailed transient simulation tool for line focus STE fields with single phase heat transfer fluid.* Solar Energy (146), Pages 131-140.

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