Project: Development of fast regulating heat pumps using dynamic models

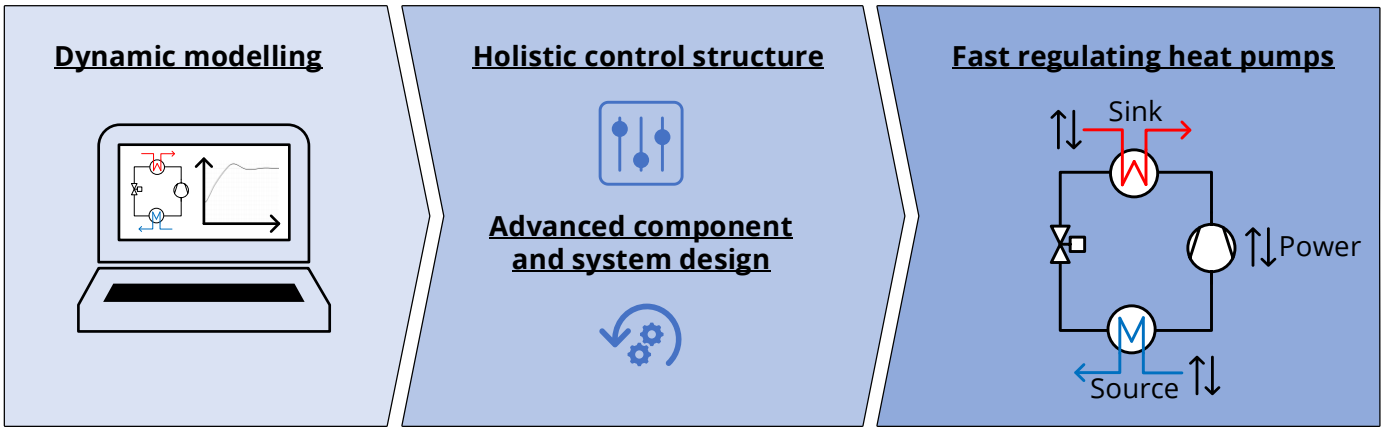

Figure 1: Concept of development of fast regulating heat pumps based on dynamic modelling.

Summary of project

The project develops software tools that enhance the flexibility of large-scale heat pumps operating in integrated systems with varying operating conditions. This is approached by the development of a holistic control structure and a design procedure that is considering dynamic aspects, yielding higher overall performances and lower operating cost. Hence, digitalization is included and used actively in the development of heat pumps system.

In order to use large-scale heat pump systems most effectively and exploit their potential with regards to sector coupling, a sophisticated integration into the given boundary conditions is paramount. The increasingly flexible integration of large-scale heat pumps does, however, imply certain challenges for the equipment, as short reaction times are required.

This project provides an advantage when designing and operating heat pumps, which are to be integrated in the energy system. The platform for modeling the transient operation enables Johnson Controls to create a digital representation of their systems to perform troubleshooting for site and plant specific interactions.

Furthermore, the dynamic modelling platform will provide the basis for integrating digital modelling approaches more thoroughly in the design process of Johnson Controls heat pumps, which is expected to imply significant advantages compared to the conventional design procedures.

Johnson Controls is the overall project manager and leads the application and demonstration activities. Danish Technological Institute leads the development, implementation and validation of component and system models, which will serve as the basis for the development of advanced design procedures and a holistic control structure, which is led by the Technical University of Denmark (DTU Construct, Section of Thermal Energy).

Figure 2: Johnson Controls Heat pumps with UniSAB III controller.

Learnings and results

Dynamic models of various heat pump systems are developed in Dymola (Modelica) and visualized in DaVE, where the results are compared and validated with operating data from a reference plant, see Figure 3.

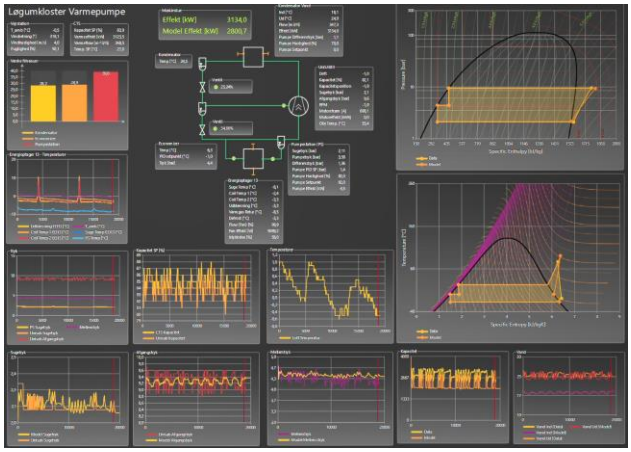

Figure 3: Initial comparison of operating data and simulation data.

One of next steps in the project is to simulate various scenarios during fast changing operating conditions, e.g., a sudden change in temperature on the sink side of the heat pump, where different control strategies then will be tested for accommodating this.

Demonstration of the developed control strategies is planned for the reference plant in the final phase of the project.

FACTS ABOUT THE PROJECT

IoT Catagory: Optimize heat pump operation and installation error analysis

Goal: Support development of large-scale heat pump systems for faster response time and hence e.g. exploit their potential with regards to sector coupling

Beneficiary: Manufacturer and operator

Data required: Operating data and datasheets for heat pumps components

Analysis method Visualization and analysis of modelling results for heat pump operation during dynamic changing operating conditions. Simulation model first requires validation based on real time operating data

Modelling requirements: Dynamic model made in Dymola (Modelica) using the TIL library from TLK as starting point. Models includes data-driven submodels.

Quality-of-Service: Real-time

Project participants: Johnson Controls, DTU Construct, Section of Thermal Energy, and Danish Technological Institute

Time schedule: 2020-2023

Technology availability: TRL 6-7

Link to webpages:

https://www.johnsoncontrols.com/en_sg/industrial-refrigeration/chillers-and-heat-pumps

https://www.dti.dk/dynamic-modelling/42634

https://construct.dtu.dk/Sections/thermal-energy

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