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EnEffReg

Energy Efficiency Control
for Supply Systems in industrial Production

OPTIMIZATION OF ENERGY USAGE: FROM MONITORING TO CONTROL

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Efficiency optimization as a current challenge

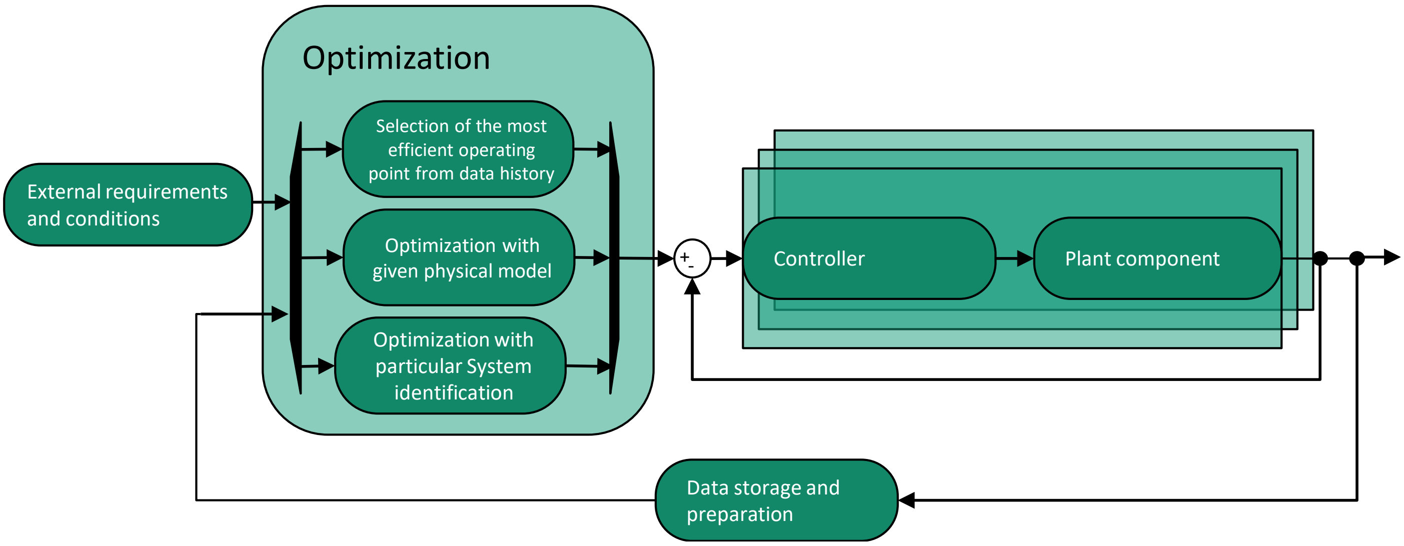
Energy saving is of central importance from both an ecological and an economic point of view. As the backbone of production, process supply technology plays a major role in electrical energy consumption. In Germany, refrigeration systems alone account for about 14 % of total electrical energy consumption. The project EnEffReg aims at operating these plants as energy-efficiently as possible. At Fraunhofer IPK, we developed a framework that enables testing and evaluating different optimization algorithms on either simulations or real plants. Our latest work focuses on new approaches for set-point-optimization strategies.

Efficient control of existing systems

In common industrial plants, energy efficiency is considered in the planning process. As a result, new plants are equipped with modern machines, sophisticated layouts and the latest control systems. However, once installed, replacing the existing supply structures evokes considerable financial and energy expenditure. In order to improve sustainability, we need both: efficiency-oriented design of new systems as well as long life of existing facilities with improved operation. The latter can be achieved by orchestrating all individual components in their reference set-points towards a common optimum. Within the EnEffReg project, we design and evaluate different models for such orchestration.

From monitoring to intervention

Presently, monitoring sensor data – especially regarding energy consumption – is common in many industrial plants. The possibilities of energy-related evaluation of measurement data were already explored in the EnEffCo project that preceded EnEffReg. In our current



research, we advance these groundworks towards energetically optimal control of plants. A methodology based on energy indicators developed by our cooperation-partner ÖKOTEC interprets the measured variables in their respective roles as cost, benefit or influencing factor of every component. This allows for a universal declaration of energy-efficiency in industrial structures. Based upon this theoretic work, the EnEffReg-team at Fraunhofer IPK develops different optimization algorithms, partially including automatic system identification.

From individual components to a complex topology

Energy-efficiency optimization is a promising research topic, especially regarding interconnected systems. Adjusting each individual subsystem in such a way that it consumes little energy does not necessarily result in best efficiency of the overall composition. Many years of personal experience show that in some cases a less efficient operation-point of a single component is necessary in order to operate the composition of all involved components economically.

An example of an optimization task is operating a cooling tower in combination with a chiller via water circulation. The particular efficiency of the cooling tower is predetermined by the ratio of dissipated heat and electrical energy needed for ventilation. The target temperature of the output provides a certain degree of freedom for this component. Depending on external circumstances, it may be better to run the cooling tower in a non-optimal operation point to ease the operation of the chiller. For this decision, information about the cooling tower and the chiller has to be combined. An experienced operator has gained intuition about these properties over many years.

EnEffReg is now intending to systematize this knowledge. Using available measurement data, every single component is modeled regarding its dynamic behavior. A critical issue for the composition of these models is establishing a common representation format. The fusion of all partial models allows to solve the overall optimization problem in a straightforward way. This allows us to determine efficient set-points for all components. The framework is not limited to energy-related optimization but is a basis for manifold data-driven or model-based applications.

Optimization in practical comparison

As a research project, the goal of EnEffReg is to evaluate different optimization approaches. In order to compare established methods with the latest developments, we have developed a modular framework, which allows flexible comparisons of different algorithms (Figure above).

We developed a benchmark algorithm, which serves as a reference for optimization procedures. This algorithm determines situations of similar requirements from the past and selects the most energy-efficient operating point. This simple search procedure gives the lower limit for optimization quality. For first tests, a realistic simulation of a refrigeration circuit was built up with MATLAB® / Simscape™. Thanks to our close cooperation with our project partners from industry, experiments with real facilities are intended to reach transferability. The presented framework is the basis for further development as well as a comparative analysis of efficiency enhancement techniques.

Image: *The diagram shows how the EnEffReg system works with a plant. The set-point (reference value) for the existing control loop, which contains the components and its controllers, can now be calculated using data preparation.*

Project partners

- ÖKOTEC Energiemanagement GmbH
- ThyssenKrupp Steel Europe AG
- Daimler AG
- Bayer Pharma AG

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