Production Planning for Distributed District Heating Networks with JModelica.org

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Production planning for district heating networks aims at finding the most profitable scheduling of the production units of the system. This task is typically handled as an optimization problem. The standard approach for solving this problem is to create a highly simplified model of the system, so that the optimization problem can be solved using linear methods. In this paper an alternative method, previously implemented in (Velut et al, 2013), is presented, in the context of distributed networks.

The production planning problem is solved in two steps by integrating physics-based models into the standard approach. The first optimization step solves for the discrete variables of the unit commitment problem (UCP) using mixed integer linear models and standard mixed-integer solvers. The second step, the economic dispatch problem (EDP), considers dynamic optimization using physics-based non-linear models that utilize the unit statuses from the first step. For this purpose the nonlinear optimization features of JModelica.org (Modelon AB, 2015) is used. All optimizations aim at maximizing production profit using fuel, electricity and heat prices as well as maintenance and start-up/stop costs as variables. The physics-based modeling in the EDP means that important physical variables such as supply temperature, supply flow rate, pump speeds and condenser pressures are included in the formulation. This makes it possible to formulate constraints on these variables corresponding to the limitations of the physical system, which will be utilized in the optimization.

The modeling has focused on distributed consumption and production. The goal has been to represent the most important production units and network distribution of the Uppsala district heating network in Sweden. The district heating network has been modelled using physics-based pipes, including mass flow dependent delays and temperature dependent (district heating water and outdoor temperature) heat losses. The total heat demand is divided between several customers. Comparisons between optimizations with and without distribution network models have been performed, showing that more detailed modeling of the net impacts the production planning in several ways. Most notable is the reduction of costly production peaks which is achieved by considering the different transportation times to different customers. Experiments show that costly unit start-ups can be delayed when this effect is considered. Other results of the distribution model include production compensation for heat losses and time delays and usage of the net for heat storage (accumulation). The optimizations also result in production plans where supply temperature and flow rate is minimized and maximized, respectively, and there is a balance between heat production and heat consumption.

References

S. Velut, P.-O. Larsson, J. Windahl, K. Boman, and L. Saarinen. Non-linear and Dynamic Optimization for Short-term Production Planning. *Värmeforsk*, 2013.

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