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**Modelowanie i zaawansowane algorytmy sterowania  
procesami dystrybucji i wymiany ciepła**

**Rozprawa doktorska**

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# **Modelling and advanced control algorithms of heat exchange and heat distribution processes**

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## **Abstract**

Increasing the energy efficiency of heat exchange and heat distribution processes is one of the most common subjects of current research. In the presented thesis, evaluation of possible improvement of this efficiency by the use of advanced control algorithms and different control loop structures of heating substation is being examined.

In the thesis, modelling of elements that compose laboratory heat exchange and distribution pilot plant are presented. Those elements include: electric flow heater (EFH) being the source of heat, plate heat exchanger (PHE), which is the sink of heat, two control valves with actuators working in separate flow control loops and piping that connects all the elements. The models are based on physical phenomena equations and tuned to fit the realistic experimental measurement data. For the EFH model it was needed to extend the model by adding the second order plus dead time (SOPDT) model, the parameters of which were calculated using reverse-modelling technique. Tuning of the PHE model was done with the use of an innovative method where two PI controllers were applied to minimize modelling error by adjusting the substitutive heat exchange coefficient values. Each model was validated separately and all together they were validated as a single plant simulator.

The presented heat source (EFH) and sink (PHE) models, after simplifications, were used to prepare dedicated advanced control algorithms strategies. From among the advanced control algorithms of process control, the following were taken into consideration: Balance-Based Adaptive Control (B-BAC) methodology, Internal Model Control (IMC) methodology and Dynamic Contraction Method (DCM) methodology. For the purpose of comparison, the well-tuned classic PID controller was used, with extensions such as gain scheduling or feedforward correction to the known and measurable disturbance. The control methodologies mentioned were verified with the use of prepared plant simulator, for the purpose of EFH control and for the three structures of PHE control loops. Results achieved by using the simulation experiment were validated on real hardware setup (pilot plant).

Summarising, the achieved results show that one, universal control algorithm, which provides the best control quality in every case, does not exist. Thus, the control algorithms should be always selected by taking into consideration the technological requirements. Using an accurate simulator reduces the amount of time needed for this selection. Simultaneously, having appropriate models of the processes simplifies formulation of control rules for advanced control algorithms. Those algorithms often offer better control quality than typical, most commonly used PID controller.