

Abstract

Due to the tightening UE environmental regulations related to the reduction of greenhouse gases, the modernization measures in the Polish heating sector are required. One of the alternatives is to use of biomass-fired cogeneration systems. The concept fits perfectly into the current trend of sustainable development in terms of improve energy efficiency and the use of renewable energy sources. This dissertation presents comprehensive research on a biomass CHP plant based on Organic Rankine Cycle (ORC) technology.

The first part of the dissertation presents a description and analysis of two real municipal CHP plants based on the ORC technology. The operating experience of the facilities allowed to identify key decision variables in terms of the structure and operating parameters that affect energy, ecological and economic efficiency. Then, based on the collected historical measurements of CHP Krosno, a reference mathematical model was developed. Simulation models of the CHP plant were also developed, taking into account the different architecture of the ORC module and different type of the working fluid which could be applied in the system.

The last part of the work presents optimization section. The study examines the influence of boundary conditions on the optimal design characteristics of the ORC CHP system within heating plant backfitting project for Polish conditions. The developed optimization algorithm allows for multiple calculations (simulation of the object's operation) in order to obtain the optimum value for the adopted objective functions. It examines influence of such decision variables as ORC system rated electric power output, architecture and working fluid or taking into account the legal aspects of support mechanisms.

The results of this study prove that biomass cogeneration based on the ORC module can be a good alternative in terms of decarbonisation process in the case of small and medium-sized heating plants. However, the profitability of implementing such a technology depends on many decision variables, presented in the dissertation. The motivation to take up the subject of the doctoral dissertation was the need to prepare feasibility studies and acquire knowledge supporting the decision-making process and design of ORC CHP plants for use in municipal heating plants.