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Exergy analysis for district heating network

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Abstract

An exergy factor analysis of the Ludza city district heating system (DHS) in Latvia is performed in the research paper. Calculated results of exergy factor are analysed in order to understand which parameters of district heating mostly affect exergy factor. The algorithm of the exergy analysis for district heating network is elaborated and evaluated. From calculations, it can be concluded that in case of decreasing of ambient temperature, the supply temperature rises and it leads to increasing of exergy factor. The results of the analysis are compared with similar heating system parameters in other countries.

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Keywords: second law of thermodynamics; energy efficiency; energy management; heating system

1. Introduction

Exergy analysis nowadays is an effective method to perform an objective evaluation of energy conversion processes in heating systems. Comparing the energy balance composition, based on the first law of thermodynamics, during exergy analysis the first as well as the second law of thermodynamics are used [1, 2]. Exergy analysis is used to define the energy loss types and causes on the base of determined value of energy loses in the thermal and chemical processes. Thereby it is possible to understand objectively the thermodynamic processes of district heating operation efficiency, and choose an optimum district heating mode or the optimum way to improve the energy conversion process of the already selected heating process [3]. Energy balance is a traditional approach to evaluate various energy conversion

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processes in which forms of energy are changing: mechanical energy, internal energy, electromagnetic energy, chemical energy, nuclear energy, etc. [4].

There are also a number of energy analysis methods known, such as statistical analysis, input-output flow analysis and process analysis [5]. Energy balance allows to calculate heat losses, but does not provide information on how to optimally transform energy. This can be done by exergy analysis, because the second law of thermodynamics determines that all the entire energy input of system can not be converted to useful work [6, 7]. In order to determine how much useful work in a given system is obtained through a variety of energy sources, it is necessary to determine exergy factor parameters and evaluate them. The above mentioned provides the basis for determining the parameters that contribute to the maximum amount of the assessment or evaluation of the achievement of the work within the given system with a variety of energy sources. From the thermodynamics point of view exergy is useful work, which the system is able to perform [8].

2. Methodology

Exergy analysis method is a new instrument which can be used to improve energy production and conversion. Exergy is defined as the maximum amount of work to be able to take by system in relation to the ambient temperature [8]. Exergy was used in order to determine the maximum amount of work in the particular system. Exergy factor defined as the ratio of energy and exergy E / Q, where E is the exergy of heat energy and Q – heat energy. Exergy factor of a heating system is calculated by the following Eq. (1) [10]:

$$\frac{E}{Q} = 1 - \frac{T_0}{T_S - T_r} \cdot \ln \frac{T_S}{T_r} \tag{1}$$

where

E exergy of heat energy, MWh;
Q heat energy, MWh;
T_0 outdoor temperature, K;
T_s supply temperature, K;
T_r return temperature, K.

The algorithm of the exergy analysis for district heating network is depicted in Fig. 1.

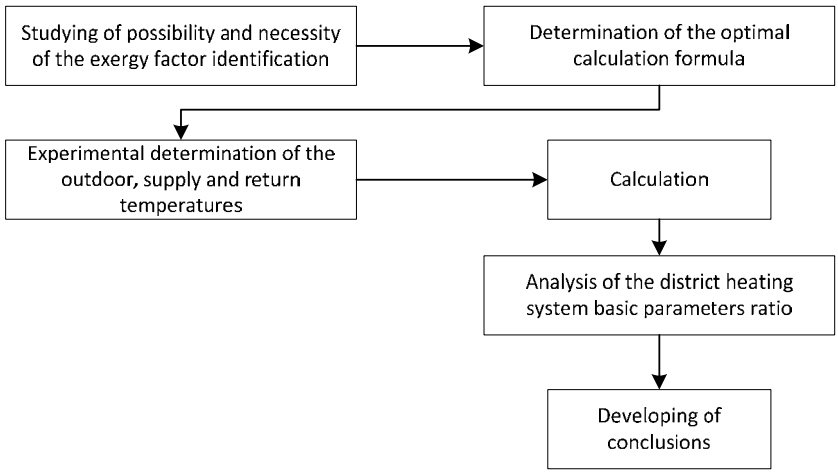

Fig. 1. Algorithm of the exergy analysis for district heating network.