Selection of the optimal type of thermal insulation structure based on the neural network modelling

Irina Akhmetova [1,*], *Elena* Balzamova[1], *Veronika* Bronskaya[2], *Denis* Balzamov[1], *Konstantin* Lapin[3] and *Olga* Kharitonova[2]

[1] Kazan State Power Engineering University, 420066, 51 Krasnoselskaya Street, Kazan, Russian Federation
[2] Kazan National Research Technological University, 420015, 68 Karl Marx Street, Kazan, Russian Federation
[3] JSC «Tatenergo», Kazan, Russian Federation

Abstract. A software package with the user interface for calculating, analyzing and predicting the parameters of cogeneration-based district heating based on the neural network modelling is presented in order to optimize and ensure the reliability of heat networks. The package is the basis for a web-application that allows to calculate the characteristics of the heat network in accordance with the model, keep a query log and provide the possibility of administration.

1 Introduction

When designing a thermal insulation structure, the question came up about the range of applicability of various sealing materials depending on the curvature of the surface on which they are installed, so it is important:
- to select the optimal thermal insulation materials
- to calculate the thickness of the thermal insulation layer to ensure acceptable heat loss;
- to select the standard sizes of thermal insulation materials[1-6]

2 Package of control and forecast of optimal thickness of thermal insulation

In order to create a complex for monitoring and predicting the optimal thermal insulation, a neural network model of the selection of thermal insulation material and a Windows Forms application were created.

The multi-layer direct distribution network is used in the course of the work. The training procedure requires typing the input and output data from the process. During training, weights and offsets are iteratively adjusted to minimize the objective function. The learning algorithm (backpropagation) transfers the network parameters in the direction of a negative gradient. The activation function is sigmoid with a coefficient equal to 1.

Initially, it is important to define the input and output variables. Based on the goals and objectives, the input and output data are presented in table 1.

Table 1. Input and output parameters of the neural network

Input	Output
Thermal conductivity coefficient	The thickness of the thermal insulation
Density	

Then the architecture of the artificial neural network should be selected. Figure 1 shows the neural network diagram.

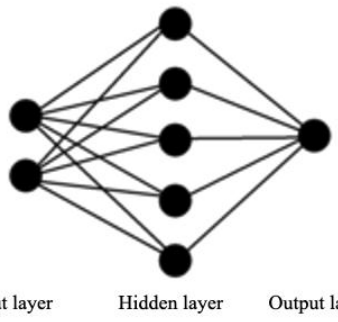

Fig. 1. The topology of the neural network.

In the course of this work, a Windows Forms application was created. A user can independently maintain a database of insulation materials: to add new materials to it and edit the parameters of existing ones, such as insulation structures and products made of mineral wool, K-Flex, Rockwool, Foam-GLAS[7,8] .

The main task of the developed system is to calculate the thickness of the thermal insulation based on the entered coefficient of thermal conductivity and density. Thus, the program will provide a forecast of the thickness of the thermal insulation, taking into account the minimization of heat losses.

* Corresponding author: e.balzamova@mail.ru

The system is the web-application that allows to calculate the characteristics in accordance with the neural network model and keep the query log of users.

The main stages of the software package operation:

1. After authorization, the user opens the main page of the program.
2. After clicking on the "Calculate values" button, the system checks the correctness of data entry directly on the client side and, if successful, transmits the data to the server.
3. After successful calculation, the output characteristics of the synthesis are displayed in the results window in the formatted form.
4. If it is important to vary one or more output characteristics, the user changes the input data and requires the recalculation. It is important to note that if a user sets up the input parameters that they or another user typed earlier, the calculation will occur almost without time delays since in this case the query results are already stored in the system.
5. A special request log is kept for each user of the system. In this section, the user can see their latest queries with the date and time and their results.

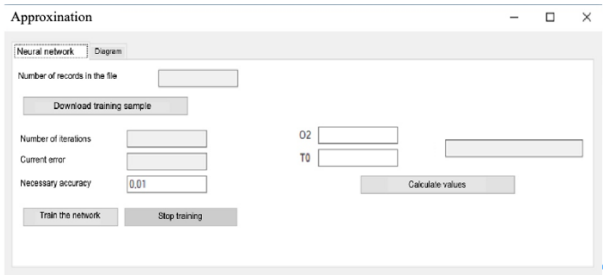

Fig. 2. The application interface for working with the neural network.

Loading input data from a file for training the neural network was implemented. The CSV format was chosen for files for ease of writing and reading.

The adequacy test was performed using the coefficient of determination. According to the values of R2 when checking the network for adequacy, the value of the determination coefficient in the case of training (0.99811) and testing (0.99222) samples are close on average and there is no network retraining.

3 Conclution

The web-application has been developed for predicting optimal thermal insulation using the artificial neural network. Training and test samples of the network were created based on the experimental data and responses from the neural network were obtained. Thus, a neuromodel of the relationship between technological factors and optimal thermal insulation is built as the basis of the web-application using multi-layer neural networks.

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