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Neural Network Model of Energy Saving of Combined Drum Dryer

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Abstract: This article is devoted to the construction of a neural network model for predicting the electricity consumption of a combined dryer. The neural network model was carried out in the Neural Networks Toolbox package in Matlab. The adequacy of the built model was determined and compared with the experimental results.

Keywords: combined drum dryer, neural network model, grain dryer, drying process.

Introduction

As we know, there are many types of grain dryers. They can be distinguished from each other by their construction, drying technology and various other features. Grain dryers and drying methods are detailed in [1]. The requirements for drying devices are increasing. One such requirement is that dryers are energy efficient. According to this demand, changes are being made to the design of grain dryers, combined dryers are being developed. In addition, mathematical modeling is performed in order to increase productivity and reduce energy consumption by effectively controlling the drying process. It is presented in [2-4].

As a result of studying dryers and drying methods, we have developed a new combined and energy-efficient drum dryer [5, 6]. The energy efficiency of the developed dryer was studied and a mathematical model was developed [7].

Many calculations were required to develop the mathematical models presented above and compiled by us. Currently, modeling of the drying process through neural networks is developing and differs from traditional modeling methods in that it is fast and easy to model. The prediction of energy consumption in grain processing plants using a neural network model is discussed in [8, 9]. As a result of our analysis, we did not find neural network models for the energy consumption of dryers. Experiments were conducted on the power consumption of our developed combined drum dryer. In this article, we will consider the neural network model of our dryer based on the experimental results.

Materials and methods

The combined drum dryer for drying seeds and grains was built and experiments were carried out for energy saving research (Figure 1). In addition to electricity, the dryer can also use the solar thermal energy to dry the product. The dryer consumes a maximum of 4500W of electricity per hour. Electricity is saved due to the additional use of solar thermal energy. Changing the speed of the drying agent has a significant effect on the electricity consumption of the dryer. Also, power consumption changes as drying temperatures change. Therefore, the electricity consumption of the dryer is influenced by the activity of the sun, the value of the drying temperature and the speed of the drying agent.

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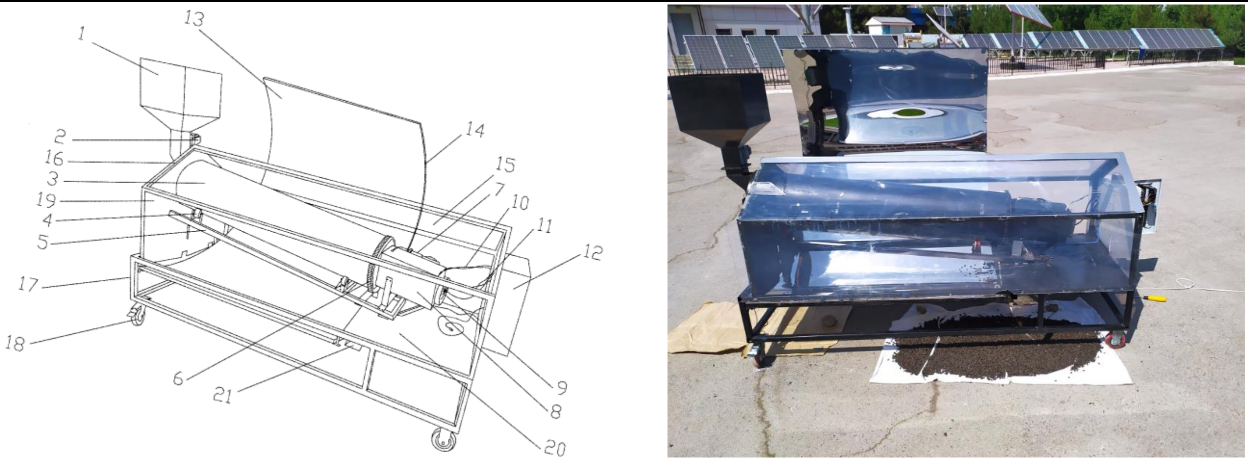

Figure 1. Scheme of combined energy-saving experimental drum dryer: 1-loading hopper, 2-stepper motor for adjusting grain consumption, 3-drying drum, 4-rotating rollers, 5-rotating rollers hardened support, 6-gear wheel fixed on drum, 7-drum rotating motor , 8-electric heater, 9-fan, 10- electric furnace power supply conductor,
11- sensor cables that transmit information about temperatures, 12-control cabinet, 13-parabolic tube reflector,
14-reflector fixed metal profile, 15-solar collector, 16-the metal frame of the solar collector, 17- the lower support part of the dryer, 18-wheels that move the dryer, 19-metal panel blocking the solar collector from the front,
20-metal panel blocking the solar collector from the bottom side, 21-unloading hopper.

We take as input factors the factors affecting the change in the electricity consumption of the dryer:

1) drying agent temperature, °C;
2) air temperature in the solar collector, °C;
3) drying agent speed, м/s.

Experimental results obtained based on changes in the values of the input parameters

Table 1

№	Drying agent temperature, °C	Air temperature in the solar collector, °C.	Drying agent speed, м/s	Electric energy consumption of the dryer, kWh
1	80	55	0,5	2410
2	100	55	0,5	2893
3	80	65	0,5	2285
4	100	65	0,5	2685
5	80	55	1,5	2655
6	100	55	1,5	3244
7	80	65	1,5	2520
8	100	65	1,5	2971

9	80	60	0	2305
10	80	60	0,5	2341
11	80	60	1	2425
12	80	60	1,5	2545
13	90	60	0	2365
14	90	60	0,5	2491
15	90	60	1	2653
16	90	60	1,5	2918
17	100	60	0	2520
18	100	60	0,5	2620
19	100	60	1	2829
20	100	60	1,5	3138
21	80	65	0	2241
22	90	65	0	2365
23	100	65	0	2574
24	80	65	1	2379
25	90	65	1	2540
26	100	65	1	2826

Based on the experimental results presented in Table 1, we build a neural network model of the drying process in the Matlab Neural Networks Toolbox package. The structure of the one-layer neural network model based on the Levenberg-Marquardt algorithm of the software package is shown in Fig. 2. The number of neurons in the hidden layer was taken as 20.

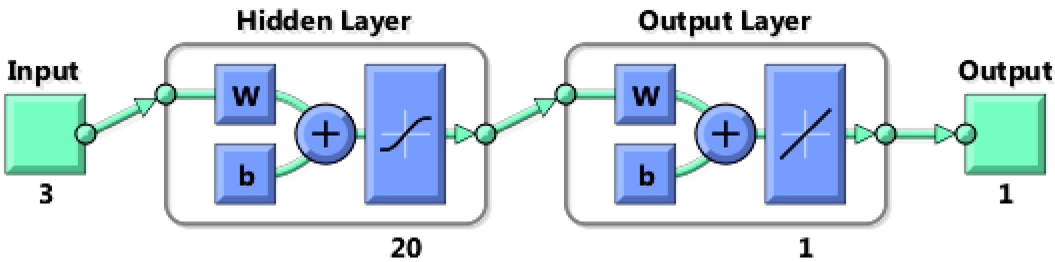

Figure 2. Neural network architecture.

A gradient descent method is used to minimize the nonlinear learning error function in MATLAB. This method allows to adjust the weights in the neurons to the gradient value with high efficiency after each training period. The quality of the learning process of the best neural network is illustrated by graphs of changes in the gradient value of the error function (Fig. 3).

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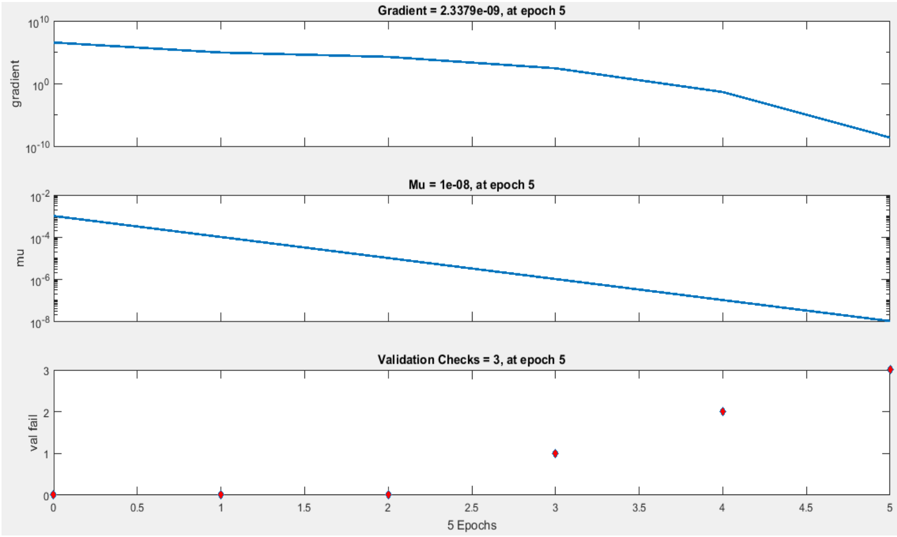

Figure 3. Assessing the adequacy of the neural network model.

Results and discussion

Based on the constructed neural network model, we calculate (predict) the electric energy consumption of the combined dryer (Fig. 4).

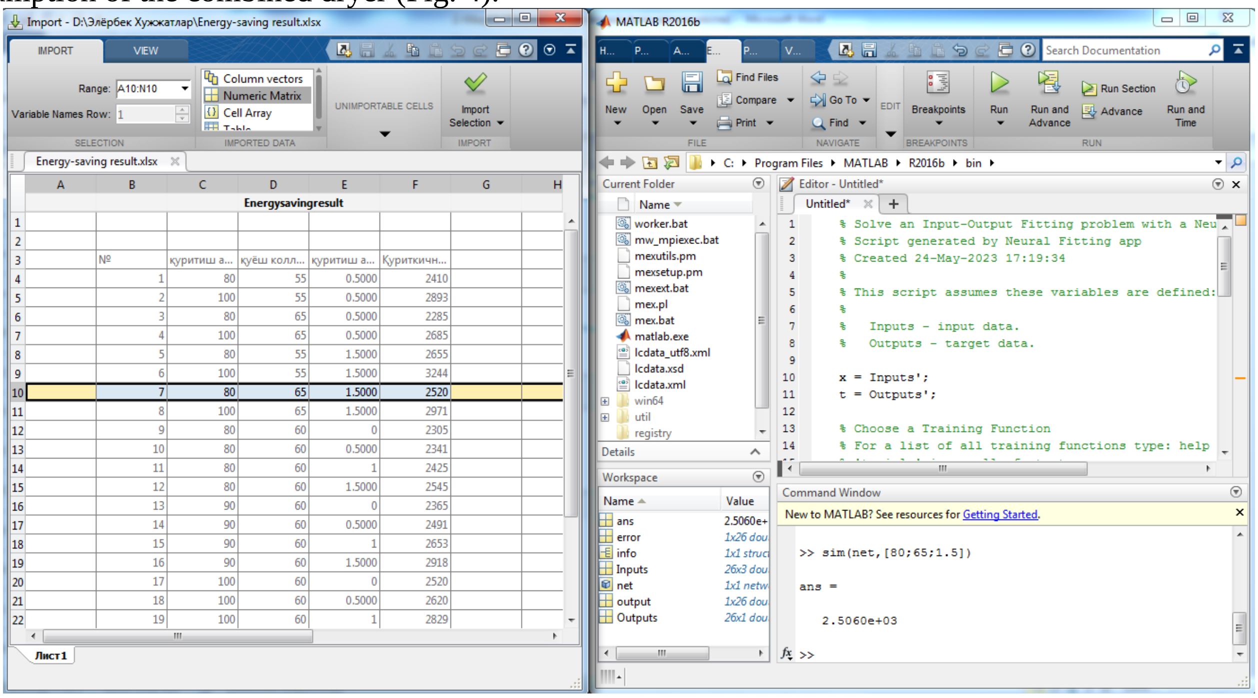

Figure 4. Calculation of the output parameter using the constructed model.

Figure 4 shows that the difference between the experimental value and the model-predicted value is small. The difference between the values found on the basis of the experiment and the model was calculated, and the adequacy of the constructed model to the experimental values was determined. The adequacy of the values calculated by the model and found in the experiment can also be seen from the comparison graph in Figure 5.

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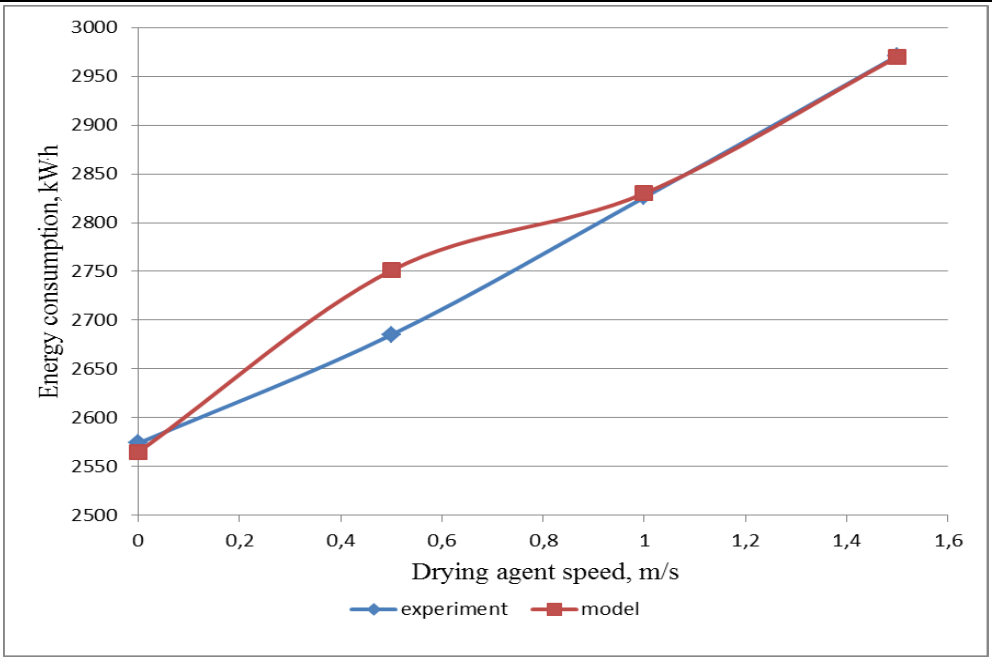

Figure 5. Adequacy graph of experiment and model values.

The figure shows the graph of the change in the electricity consumption of the dryer based on the change in the speed of the drying agent. As the speed of the drying agent increases, the electricity consumption of the dryer also increases.

The neural network model was easily implemented based on the results of the experiment. This built model also provides the required accuracy. The model can predict values that are very close to the experimental values. By increasing the number of experiments, it is possible to increase the level of accuracy of the neural network model.

Conclusion

The neural network model of the electric energy consumption of the experimental dryer in the Matlab system was built based on the obtained experimental results. Neural network modeling of processes is built on the basis of typical algorithms and can be modeled quickly and easily. It was found that the built model is adequate to the experimental values, the adequacy of the model can also be seen graphically. We believe that it is appropriate to use neural network modeling in the Matlab system when building a model for predicting the electrical energy consumed in drying processes.

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