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ANN MODELLING FOR THE ANALYSIS OF THE GREEN MOULDING SANDS PROPERTIES

ANALIZA WŁAŚCIWOŚCI SYNTETYCZNYCH MAS FORMIERSKICH Z ZASTOSOWANIEM SZTUCZNYCH SIECI NEURONOWYCH

Application of modern technological solutions, as well as the economic and ecological solutions, is for foundries one of the main aspects of the competitiveness on the market for castings. IT solutions can significantly support technological processes. This article presents neural networks with different structures that have been used to determine the moisture content of the moulding sand based on the moulding sand selected properties research results. Neural networks were built using Matlab software. Moulding sand properties chosen for quality control processes were selected based on wide previous results.

For the proposed moulding sand properties, neural networks can be a useful tool for predicting moisture content. The structure of artificial neural network do not have a significant influence on the obtained results. In subsequent studies on the use of neural networks as an application to support the green moulding sand rebonding process, it must be determined how factors such as environmental humidity and moulding sand temperature will affect the accuracy of data obtained with the use of artificial neural networks.

Keywords: data mining, artificial neural networks, green moulding sands

Zastosowanie nowoczesnych rozwiązań technologicznych, a także ekonomicznych i ekologicznych stanowi dla odlewni jeden z głównych aspektów konkurencyjności na rynku produktów odlewów. Doskonałym wsparciem dla procesów technologicznych są rozwiązania informatyczne. W artykule zaprezentowano sieci neuronowych o różnej strukturze, które zostały użyte do określania wilgotności masy formierskiej na podstawie wyników badania wybranych właściwości masy. Sieci neuronowe zbudowano z wykorzystaniem oprogramowania Matlab. Właściwości mas wybrane do procesów sterowania jakością zostały dobrane w oparciu o wcześniejsze wyniki badań.

Dla zaproponowanych właściwości syntetycznych mas formierskich sztuczne sieci neuronowe mogą być użytecznym narzędziem do przewidywania wilgotności masy. Ilość warstw ukrytych w strukturze sieci nie ma wpływu na otrzymywane rezultaty. W kolejnych badaniach nad wykorzystaniem sieci neuronowych jako aplikacji wspierającej procesy odświeżania syntetycznych mas formierskich, należy określić, w jaki sposób czynniki takie jak wilgotność otoczenia, czy temperatura masy wpłyną na dokładność danych uzyskanych z wykorzystaniem sztucznych sieci neuronowych.

1. Introduction

Large number of data which is generated in industry is usually not directly measured and recorded. However, even the data which is measured and stored is not used for the optimisation and computer aided quality management. An access to a larger amount of possible data requires purchasing of the proper measuring equipment and employing new staff [1].

On the other hand, the improvement of the production quality may be achieved by just using the knowledge of casting processes, their computer modelling and forecasting of the casting quality, applied statistic methods and neuron networks. Unfortunately in many cases it is not enough to assess properly the production anomalies and to prevent them, since there is a lack of the reliable, continuously updated data.

Large foundry plants are implementing expensive IT systems (e.g. SAP R/3), with an expanded structure, but they are mainly used (according to the list of modules the most often implemented in companies) in finance, production planning, sales and distribution, purchasing, materials management.

Some interesting solutions on application of data analysis and artificial intelligence to support the technological processes are presented in the work of Kusiak [3], Perzyk [4, 5] and Kluska-Nawarecka [6, 7] and Durmuş [8]. Study of using artificial neural networks to determine the properties of green moulding sand was presented by Parappagoudar, Pratihar and Datta [9]. Artificial neural networks are instrument to assist decision making at different stages of production, can also be useful in the process of rebonding of moulding sand.

The main purpose of this study was to determine the effect of the ANN structure on accuracy prediction of moulding sand moisture by measuring selected properties of moulding sand.

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2. Investigation methods

Neural networks are modern self-training systems. The values of constants determining the significance of input data (network weights) are determined on the basis of experimental results (training examples) and by means of successive corrections, in such a way as to have the output data nearing the actual values. Neural networks can realise several types of tasks depending on the kind of the problem, which is to be solved.

Network training is being done by solving the problem of optimisation of several variables function. From the mathematical point of view, we are aiming to find such weight values to get the smallest root-mean square error from all network outputs in relation to the experimental observations.

Matlab software version 2012 was used to build an artificial neural network model. It is an extensive mathematical instrument supporting many fields of science, used also in foundries for example to test mathematical model of vacuum-assisted compaction processes[10, 11].

In this study neural networks are used for data analysis. Earlier publications of the authors [12,13] indicate, that there is a possibility to use neural networks to predict some properties of moulding sands, using previously collected data (for example, to predict moulding sand moisture on the basis of the other moulding sands properties). It has been proved that good results of the predictions are obtained while using the parameters of compactibility, permeability and friability and that they can be achieved in a short time. Those results were obtained using Statistica program. It is an application that allows to build a neural network, without interfering the number of hidden layers. Analysis described below use Matlab software that allows to specify the structure of the network.

The data set contains 490 values for each parameter. Exemplary distribution of experimental data for one of the parameters selected for training neural networks as a moisture function is shown on Figure 1.

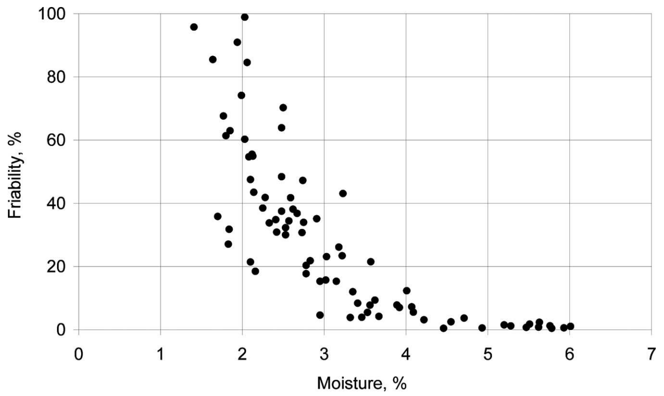

Fig. 1. Experimental data of chosen parameter (friability) for training neural networks

3. Results

Previous studies [13] indicated that the best results are obtained for the RBF 3-37-1 network structure. That structure was assumed as the starting point for further analysis. Permeability, friability and compactibility were used as the input data, and moisture content is the output value.

TABLE 1 shows the distribution of the training and validation data of previously assumed network structure. The quality of mapping is slightly lower than in the case of the results of Statistica. A network tendency to overfitting can effect it, especially in the case of RBF network. The next step was to determine the influence of the number of hidden layers on the accuracy of neural networks to the set data. A series of simulations were made using hidden layers in the range of 2 to 10 in the network structure.

TABLE 1

Mapping accuracy for a set of training verifying and test data depending on the number of hidden layers

Number of hidden layers	Mapping accuracy		
	Training data	Validation data	Test data
1	0,80318	0,73273	0,79789
2	0,8656	0,87443	0,86018
3	0,94792	0,94112	0,95869
4	0,82703	0,81609	0,77886
RBF 3-37-1	0,78653	0,86144	0,78499

There were 10 neurons in each hidden layer in each particular case. The results revealed that the expansion of neural network structure, by increasing the number of hidden layers of the attached data set, does not increase the quality of the network. Examples of results are also shown in TABLE 1.

Quality improvement of the network can be achieved by reducing the input data. Due to the nature of dependences between friability, permeability, compactibility and moisture, data reduction to applied moisture range will affect the accuracy of the results. However, such reduction can lead to overfitting models and high sensitivity to measurement errors.

In the next stage of the research, analysis of influence of neurons number in the hidden layer on the quality of the network mapping were made. The study was conducted in the range of 10 to 37 neurons. The examples of the test results for the network with two hidden layers are presented bellow. Changing the number of neurons in the hidden layer, as well as changing the number of layers, can have a positive effect on the accuracy of the results (Figure 2 a and b). However, the complexity of network structure should also be taken into consideration. More complex structures will be more susceptible to changes in the input data due to independent factors. A time required for data analysis would also extend.

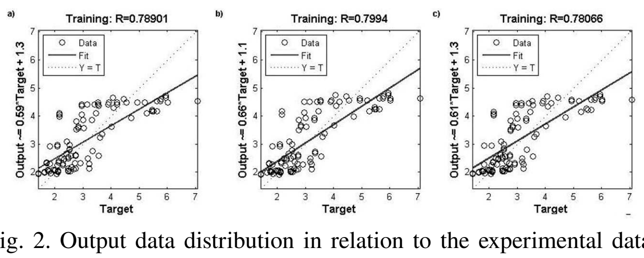

Fig. 2. Output data distribution in relation to the experimental data for networks with different numbers of neuron in hidden layers, a) 10, b) 20, c) 30

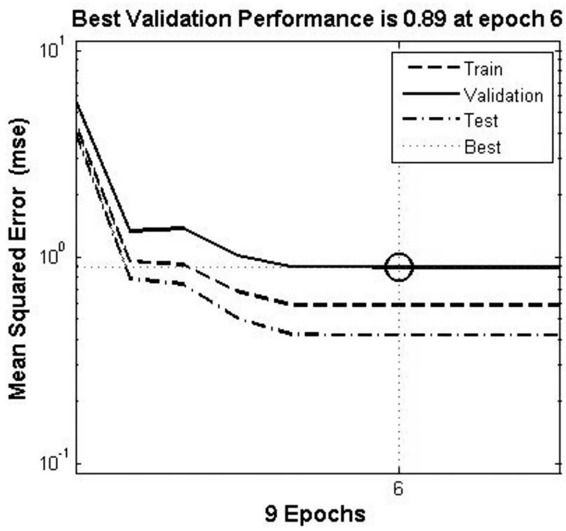

Fig. 3. An example of change of error rate for network RBF 3-37-10-1, depending on the number of repetitions

4. Conclusions

Based on the results of the conducted research, it can be concluded that, for the proposed moulding sands properties, neural networks can be a useful tool for predicting moisture content. The structure of artificial neural network do not have a significant influence on the obtained results. There was no unequivocal effect of compared factors on neural networks behavior. Thus, in the case of using artificial neural networks for support of the green moulding sands rebonding process, a neural network with a simple structure should be used. More important is a choice of the input data, which can model correctly the unknown variable, such as moisture content. In subsequent studies on the use of neural networks as an application to support the green moulding sands rebonding process, it must be determined how factors such as environmental humidity and moulding sand temperature will affect the accuracy of data obtained with the use of artificial neural networks.

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