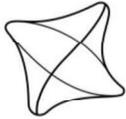
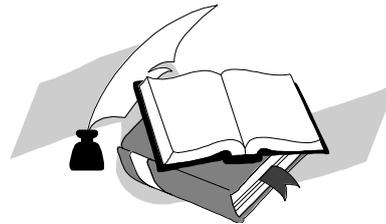


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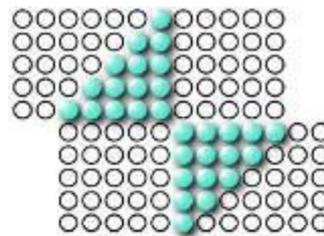


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**SEMDOK 2026**  
**29<sup>th</sup> International Seminar of Ph.D. Students**



**Western Tatras - Zuberec, Slovak Republic**  
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# SEMDOK 2026

## 29<sup>th</sup> International Seminar of Ph.D. Students

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## ARTIFICIAL NEURAL NETWORK BASED ESTIMATION OF WEAR TRACE WIDTH IN HARD-FACED STRUCTURAL COMPONENTS

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**Abstract:** In this paper is presented a study aimed at developing a predictive model for estimating the wear trace width of hard-faced and base metal samples based on their chemical composition. The research motivation arises from the need to establish a correlation between the alloying elements and tribological performance, thereby enabling early-stage evaluation of material behavior without extensive experimental testing. The dataset was formed using characteristic experimental cases obtained from block-on-disk tribological tests. The wear trace width values were measured after experimental tests, while the chemical composition data were taken from material specifications. A feed-forward ANN with Bayesian regularization was implemented in MATLAB. The proposed model demonstrated low agreement between predicted and experimental values due to small number of training data-sets.

### 1. Introduction

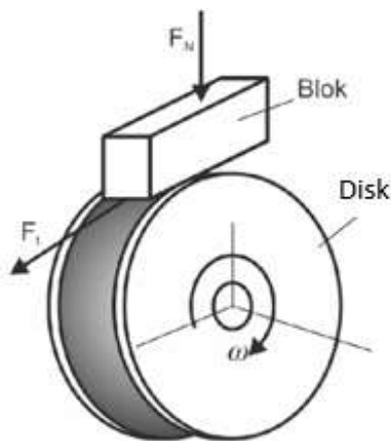
Components of construction and mining machinery are frequently exposed to severe abrasive and combined wear mechanisms, leading to rapid degradation and reduced service life. Typical examples include bucket teeth, mixer paddles, and levelling blades, operating under intensive contact with mineral aggregates (*Fig. 1*). Replacement of worn components is associated with high costs and long delivery times, making repair and production hard-facing technologies an economically justified solution. Hard-facing enables deposition of wear-resistant layers onto the new or worn components, using appropriate filler materials and welding procedures. The tribological behavior of hard-faced layers depends on a complex interaction between chemical composition, microstructure, hardness, and applied technology. Consequently, the laboratory tribological testing is widely used for preliminary evaluation and ranking of hard-facing systems. The aim of this research was to implement Artificial Neural Networks (ANN), since they have been increasingly applied in materials engineering for modelling nonlinear relationships between input parameters and material properties. When properly implemented, the ANN models can significantly reduce experimental effort by enabling early-stage prediction of material behavior. The objective of this study was to develop an ANN model for estimating wear trace width of hard-faced systems under defined tribological conditions and to validate the obtained predictions using the real exploitation data.



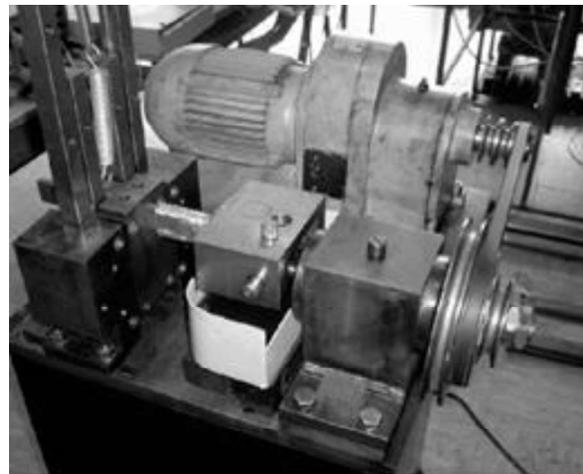
*Fig. 1 Display of some damaged structural components*

## 2. Experimental background and data sources

The training data consisted of chemical compositions of commonly used base and filler materials and data collected from experimental block-on-disk tribological tests performed under the same conditions on the same base and filler materials (*Fig. 2*) [1-2]. All the tests were conducted at a sliding speed of 1 m/s, normal load of 300 N, and duration of 60 min, using lubricated contact. Results for two base materials and three common applied filler materials were used



(a)



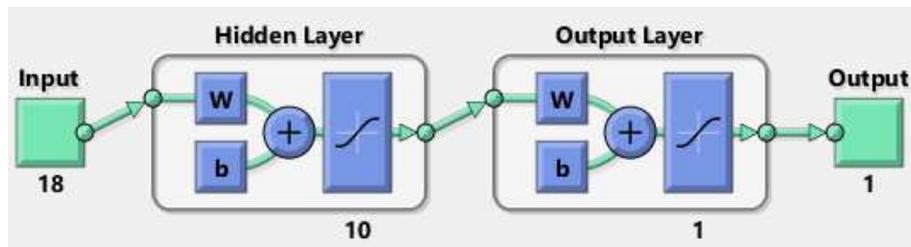
(b)

*Fig. 2 Schematic display of block on disk contact (a) and device used for investigation (b)*

For the data prediction an ANN model was designed. Material's mass fractions were used as the input data and hard-facing configuration to the resulting wear trace width. A feed-forward neural network with one hidden layer was implemented using the Bayesian regularization to ensure the stable convergence and prevent overfitting due to the limited



dataset size. Architecture of the ANN is shown in **Fig. 3**. and network parameters are presented in **Tab. 1**.



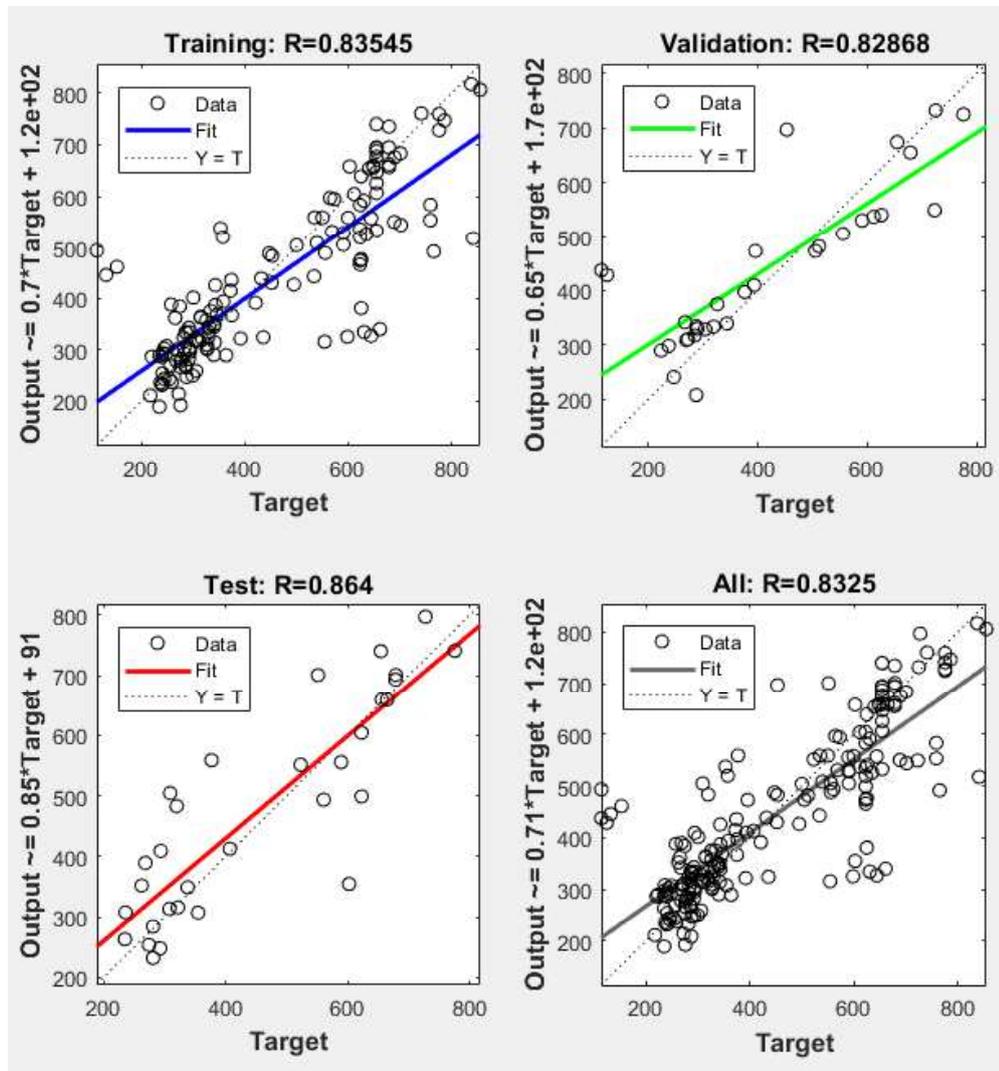
**Fig. 3** Architecture of the built ANN

**Tab. 1** Main and training parameters of prepared ANN

<i>Parameter</i>	<i>Description</i>
<i>Network type</i>	<i>Feed-forward backpropagation</i>
<i>Training algorithm</i>	<i>Bayesian regularization</i>
<i>Learning function</i>	<i>learnsgdm (gradient decent momentum)</i>
<i>Input parameters</i>	<i>18 chemical elements</i>
<i>Output parameters</i>	<i>Wear track width, mm</i>
<i>Number of hidden layers</i>	<i>1</i>
<i>Number of neurons</i>	<i>10</i>
<i>Activation functions</i>	<i>Hidden layer: tansig, Output layer: tansig</i>
<i>Training/ validation/ test ratio</i>	<i>70/15/15%</i>
<i>Momentum</i>	<i>0.005</i>
<i>Evaluation metrics</i>	<i>R</i>

### 3. Results and Discussion

Despite the intensive work on optimization of the constructed ANN, and varying training parameters the built network did not successfully capture the complex and nonlinear relationship between the chemical composition, and wear trace width obtained under controlled tribological conditions. The regression analysis between the experimentally obtained and ANN-predicted values demonstrated a low level of agreement and lack of the model's capability to generalize the material behavior due to limited size of the dataset. The regression (R) values are shown in **Fig. 4**. In all four cases, the R values were below 0.8, (approximately 0.6), which is insufficient for a network to provide the good prediction of wear trace width. Similar models of ANN were built earlier and they have provided good precision of ANN prediction [3-4], so the future work should include additional input parameters to improve the ANN's precision.



*Fig. 4 Display of R values obtained through ANN training*

#### 4. Conclusions

The wear trace width obtained from the block-on-disk tribological tests represents a useful comparative parameter for evaluating the abrasive wear resistance of the base and hard-faced materials, under controlled laboratory conditions. In this study, an artificial neural network was developed with the aim of estimating the wear trace width based solely on the chemical composition of base and filler materials.

The implemented feed-forward ANN with Bayesian regularization demonstrated limited predictive capability, as indicated by relatively low regression coefficients between the predicted and experimentally obtained values. The obtained results suggest that chemical composition alone is insufficient to fully describe the complex wear mechanisms governing the wear trace formation in hard-faced systems, particularly when the available dataset is small.



Nevertheless, the study confirms the feasibility of applying ANN-based approaches in tribological investigations and highlights their potential as supportive tools for preliminary material assessment. The results clearly indicate that the additional input parameters, such as hardness, microstructural characteristics, layer configuration, and other variables, are required to improve the model's accuracy and generalization capability.

The future research should therefore focus on expanding the experimental database and incorporating microstructural and mechanical properties into the ANN input space. Such an approach is expected to significantly enhance the prediction reliability and contribute to development of more robust data-driven models for wear resistance evaluation of hard-faced structural components.

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