



# Amperage prediction in mono-wire cutting operation using multiple regression and artificial neural network models

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## Abstract

Operational parameters such as cutting speed and peripheral speed in diamond wire cutting operation greatly affect the efficiency of the machine. The cutting machine's amperage draw measures how hard the machine must work to run, and it is an alternative way to understand the cutting performance of rocks. High amperage values in cutting indicate that the machine has difficulties in cutting process. The retreat rates of the quarry type cutting machines and downward rates for stationary diamond wire cutting machines change the cutting rates of natural stone blocks. In addition to operational parameters, rock properties such as strength, abrasivity also affect cutting performance. In this study, variations of amperage values during mono-wire cutting were investigated and the effects of cutting parameters and some rock properties on amperage values were examined. While analyzing the basic relationships between cutting parameters and amperage values, obtained experimental data were grouped depending on rock properties. In the final part of the study, amperage values were predicted using multiple regression and artificial neural network models. Produced models were compared by using  $R^2$ , RMSE, VAF and MAPE performance indices. This comparison showed that the constructed ANN model is highly acceptable for prediction of amperage.

**Keywords** Mono-wire cutting · Amperage · Uniaxial compressive strength · Böhme · Artificial neural network · Multiple linear regression

## 1 Introduction

Diamond wire cutting machines (DWCS) are widely used machines in quarries for squaring and block production and in natural stone processing plants for slab cutting, etc. In natural stone industry, depending on diamond wire cutting machine type, pull cutting or push cutting modes are used. Pull cutting mode DWCSs are generally used in natural stone quarries and construction applications (Fig. 1a). This type of cutting system generally contains one drive pulley to rotate the diamond wire and additional small guide pulleys to stabilize the wire in cutting operation. Push cutting mode (Fig. 1b) is generally used in the processing plants for block squaring and slabbing operations. Generally, two big pulleys (drive pulley and driven pulley) (and

sometimes guide pulleys) are used in this type of cutting machines. Drive pulley rotates the diamond wire while driven pulley rotates freely and tensions the wire. These types of cutting machines are generally called as stationary diamond wire cutting machines. The retreat rate of the quarry type cutting machines and downward rate for stationary diamond wire cutting machines affect the cutting performance. Cutting rate of the diamond wire is one of the performance parameters in diamond wire cutting method. It is a function of various controllable and uncontrollable parameters.

In natural stone quarries and processing plants, the aim is to manufacture products of good quality at the lowest possible cost. In cases where a high production in a short time is aimed, the machines can be operated at higher cutting speed values. In such cases, the diamond beads are forced much more than normal cutting conditions, which is an important factor in their abrasion in a shorter time. It also affects the amperage (electrical intensity) and power values. Higher amperage values in cutting indicate that the

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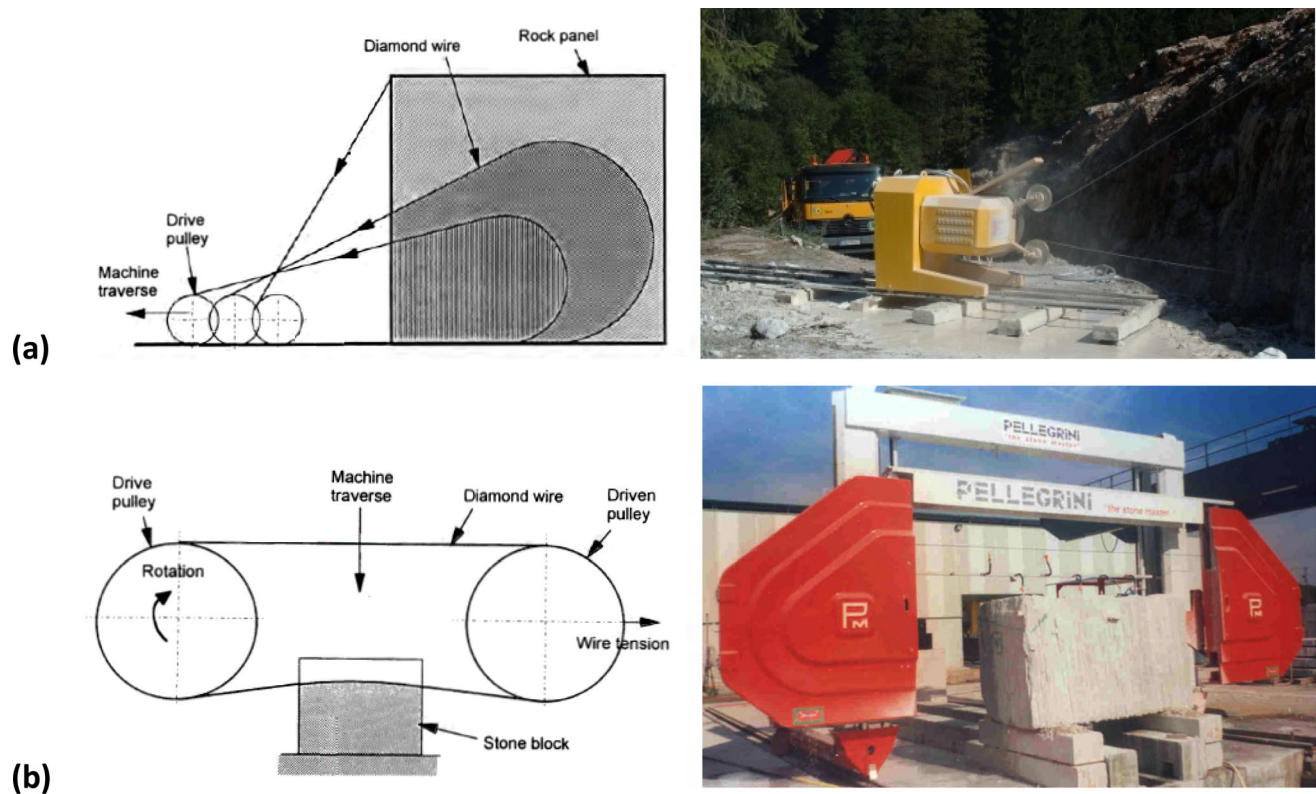


Fig. 1 Pull cutting mode (a) and push cutting mode (b) DWCMs [1–3]

machine has difficulty in cutting process. The ampere (A) is the base unit of electric current in the SI (International System of Units) System. It is the amount of electrical charge that flows through a conductor in a specific time. In simple terms, the cutting machine's amperage draw measures how hard the machine must work to run.

Most of the studies related with DWCMs in literature are about the machines using the pull cutting mode. In recent studies, researchers have studied the machine parameters in cutting bead wear, bead structure, motor power and wire velocity, physical and mechanical properties of rocks, mineralogic and petrographic properties of rocks, cutting geometry and distance, dimensions of the marble block to be cut [4–17]. Additionally, there are some studies related to amperage values in diamond wire cutting process. The literature related to amperage in cutting is presented in the following paragraphs.

Jain et al. [18] studied the effects of machine parameters on different strength rocks. Pullback amperage of the machine was studied as a part of the study. The obtained results showed that the optimum peripheral speeds of the wire were found as 29, 28 and 27 m/s for soft, medium-hard and hard dolomitic marbles, respectively.

In their study, Cardu et al. [19] characterized rocks and wire performances for pull cutting mode diamond wire

saws in Italy and India quarries. Researchers collected various parameters related to diamond wire cutting machine and diamond wire equipment to investigate the cutting efficiency. As an outcome of the study, the cutting rate was correlated as a function of machine power and amperage. Also, they found that the retreat rate of the machine varies from 1.5 to 3 mm/s, depending on the block dimensions and on the amperage value, and if the amperage is low, the greater time required for cutting process.

Almasi et al. [9] used the MSP tree algorithm to research the relationship between cutting process and some physico-mechanical properties such as strength and deformation properties, hardness of hard rock samples. The cutting rate of wire was measured at different pullback amperages in laboratory conditions. Researchers indicated that MSP tree technique has a higher performance in the cutting rate prediction than the regression methods.

Rahimdel and Bagherpour [12] studied the effects of the pullback force on cutting rate of the pull cutting mode DWCMs. Authors tried different pullback amperages for travertine cutting. As a result, they found that in the large cutting areas, there is a reverse relationship between the pullback amperage and the cutting rate. In another study, to determine the optimum wire tension for different block sizes, Almasi et al. [20] evaluated cutting surfaces under

**Table 1** Average values of physical and mechanical properties of natural stones used in the study

	UVW ( $\text{gr}/\text{cm}^3$ )	WAW (%)	AP (%)	SH	BAL ( $\text{cm}^3/50 \text{ cm}^2$ )	UCS (MPa)	TS (MPa)	FS (MPa)
Sample 1	2.71	0.05	0.15	48	38.3	50.8	7.0	13.01
Sample 2	2.72	0.06	0.08	53	11.9	98.9	8.1	14.49
Sample 3	2.70	0.17	0.43	43	32.1	65.7	4.7	15.21
Sample 4	2.72	0.09	0.24	53	13.7	88.5	8.5	14.91
Sample 5	2.65	0.50	1.38	62	23.1	62.7	4.9	9.20
Sample 6	2.72	0.16	0.42	45	34.9	76.9	7.0	12.75

UVW, unit volume weight; WAW, water absorption by weight; AP, apparent porosity; SH, shore hardness; BAL, Böhme abrasion loss; UCS, uniaxial compressive strength; TS, tensile strength; FS, flexural strength



**Fig. 2** Mono-wire cutting machine and diamond wire setting (a) and diamond wire in a rock sample, guide pulley of the cutting machine and water feed (b)

different thrust forces for travertines. Rock blocks were cut with various wire tension values on different amperage values on 45 to 65 A. Authors suggested that to obtain the optimum cutting rate, the wire tension should be high for small block sizes and low for large block sizes.

As mentioned before, most of the studies focused on evaluating the pull cutting mode DWCMs and there are very limited number of studies related to amperage values in pull cutting. However, there are no study about variation of amperage values in mono-wire cutting machines (push cutting mode) in literature. Therefore, this study aims to investigate the variation of the amperage values during mono-wire cutting of natural stone blocks having different rock properties in laboratory conditions. In the first part of the study, effects of different cutting speed and peripheral speed of wire, uniaxial compressive strength and Böhme abrasion loss of the samples on amperage were investigated. In the second part, amperage prediction models were produced using multiple regression and artificial neural network techniques.

## 2 Material and method

### 2.1 Work-piece properties

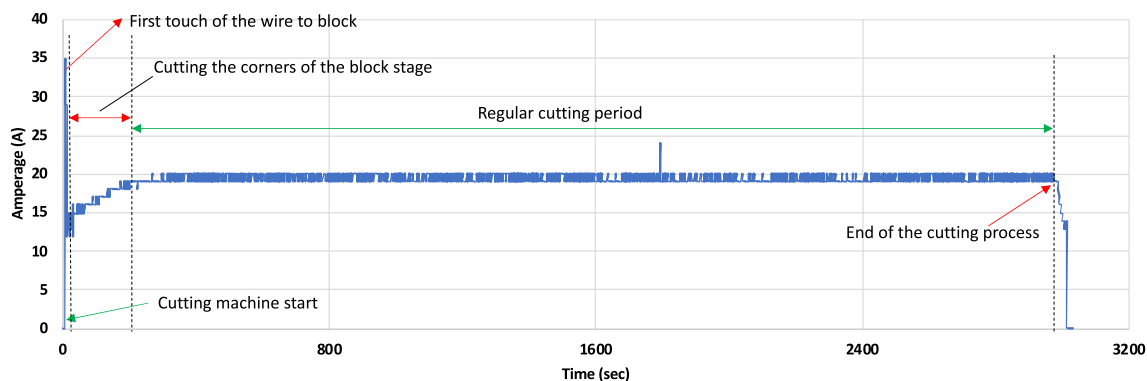
In the study, cutting experiments were done on six carbonated rock blocks having  $1 \text{ m}^2$  cutting surface area under different cutting rates using a diamond wire with 11 mm in diameter. Physical and mechanical properties of the samples used in the study were determined (Table 1) in accordance with the suggested methods adopted by the ISRM [21]. In the evaluation of data section, stones having different uniaxial compressive strength and Böhme abrasion loss properties were used to observe the effects of rock material properties on the amperage under different cutting conditions.

### 2.2 Mono-wire cutting machine

In the experimental stage, a computer-controlled mono-wire cutting machine located in the Mining Engineering Department of Hacettepe University was used (Fig. 2).

**Table 2** The operating parameters used in the study

	Cutting parameters				
	25 m/s	28 m/s	30 m/s	33 m/s	35 m/s
Peripheral speed	25 m/s	28 m/s	30 m/s	33 m/s	35 m/s
Cutting speed	10 mm/min	12 mm/min	14 mm/min	16 mm/min	

**Fig. 3** Amperage variation during a cutting experiment

Mono-wire cutting machines (a.k.a stationary diamond wire saws) can be used for block cutting and slab-cutting processes and decorative profiles for monumental and ornamental uses. The machine used in the study was equipped with sensors and can measure reactional forces, wire vibrations and water consumption, etc., during cutting process. Cutting machine has four main units namely “Mechanical,” “Hydraulic,” “Electrical and electronic” and “Automation” units [22]. Cutting experiments were performed on rock samples at 20 different cutting speed parameters. The operating parameters used in the study are given in Table 2.

During the cutting experiments, many data were collected for the investigation of the behavior of the mono-wire cutting machine, such as amperage, peripheral speed and cutting speed. After each cutting experiment, amperage values taken by computer software are investigated. An example of amperage variation during cutting process is given in Fig. 3.

### 3 Experimental results

In the study, while analyzing the relationships between cutting parameters and amperage values, obtained experimental data were grouped depending on rock strength and abrasion resistance properties. According to the intact rock strength classification proposed by Deere and Miller [23], samples used in this study are called as medium strength rocks ( $UCS = 50\text{--}100$  MPa). 75 MPa was selected as a threshold value for this study to evenly divide 50–100 MPa interval. When we investigated the abrasion values, samples used in the study called as moderate ( $7 < Böhme <$

20) and high abrasable rocks ( $Böhme > 20$ ) according to abrasion classes table given in a study by Özvan and Direk [24]. Therefore, to classify the data depending on strength and abrasion loss values, experimental data divided into groups as medium–high strength ( $75 \text{ MPa} < UCS < 100 \text{ MPa}$ ), medium–low strength ( $75 \text{ MPa} > UCS > 50 \text{ MPa}$ ), moderate abrasable ( $7 < Böhme < 20$ ) and high abrasable rock samples ( $Böhme > 20$ ).

#### 3.1 Effect of wire peripheral speed on amperage

The relationships between rotation speed of the diamond wire and amperage values are given in Fig. 4 for lower strength and higher strength samples. Relationships for moderate and high abrasable samples are given in Fig. 5.

For both type of samples, it can be seen that the amperage value tends to decrease with increasing peripheral speed of wire. The relationship between peripheral speed and amperage is statistically more significant (higher  $R^2$  values) for lower strength samples. It has been determined that the amperage values obtained in cutting of lower strength samples are closer to each other for same peripheral speed. This finding is not valid for higher strength samples. Amperage values are in a wider interval for same peripheral speed of higher strength samples.

When Fig. 5 is examined, although there is no clear relationship between amperage and peripheral speed, it can be understood that the amperage value tends to decrease as the peripheral speed increases. Amperage values obtained for the moderate abrasable samples are higher than the high abrasable samples.

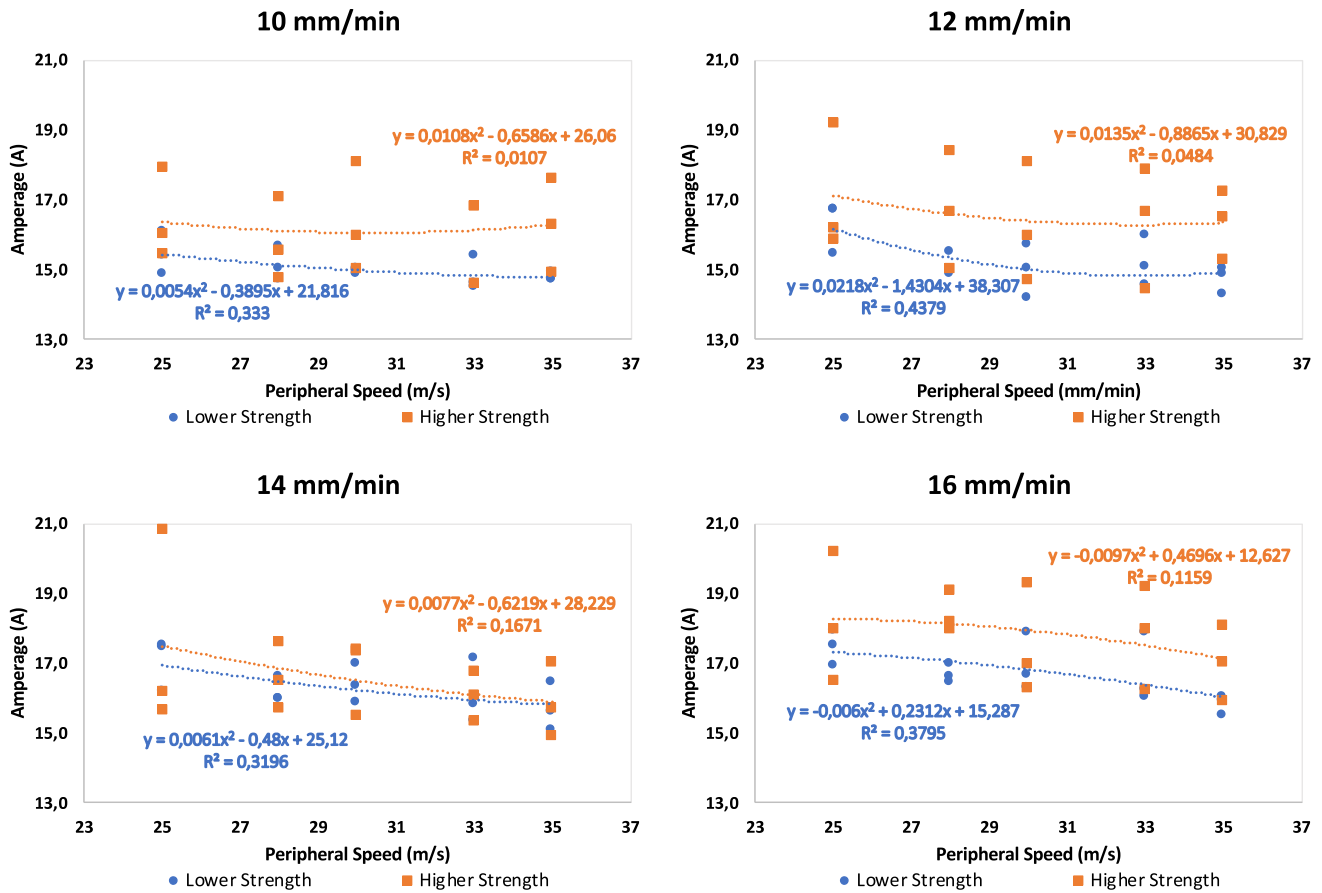


Fig. 4 Relationships between amperage and peripheral speed for different cutting speeds depending on rock strength

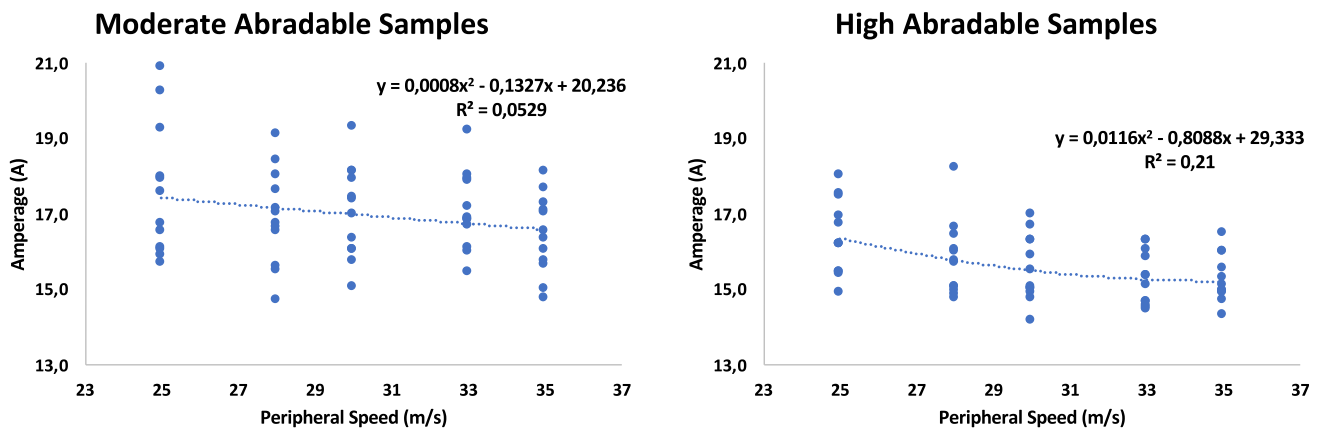
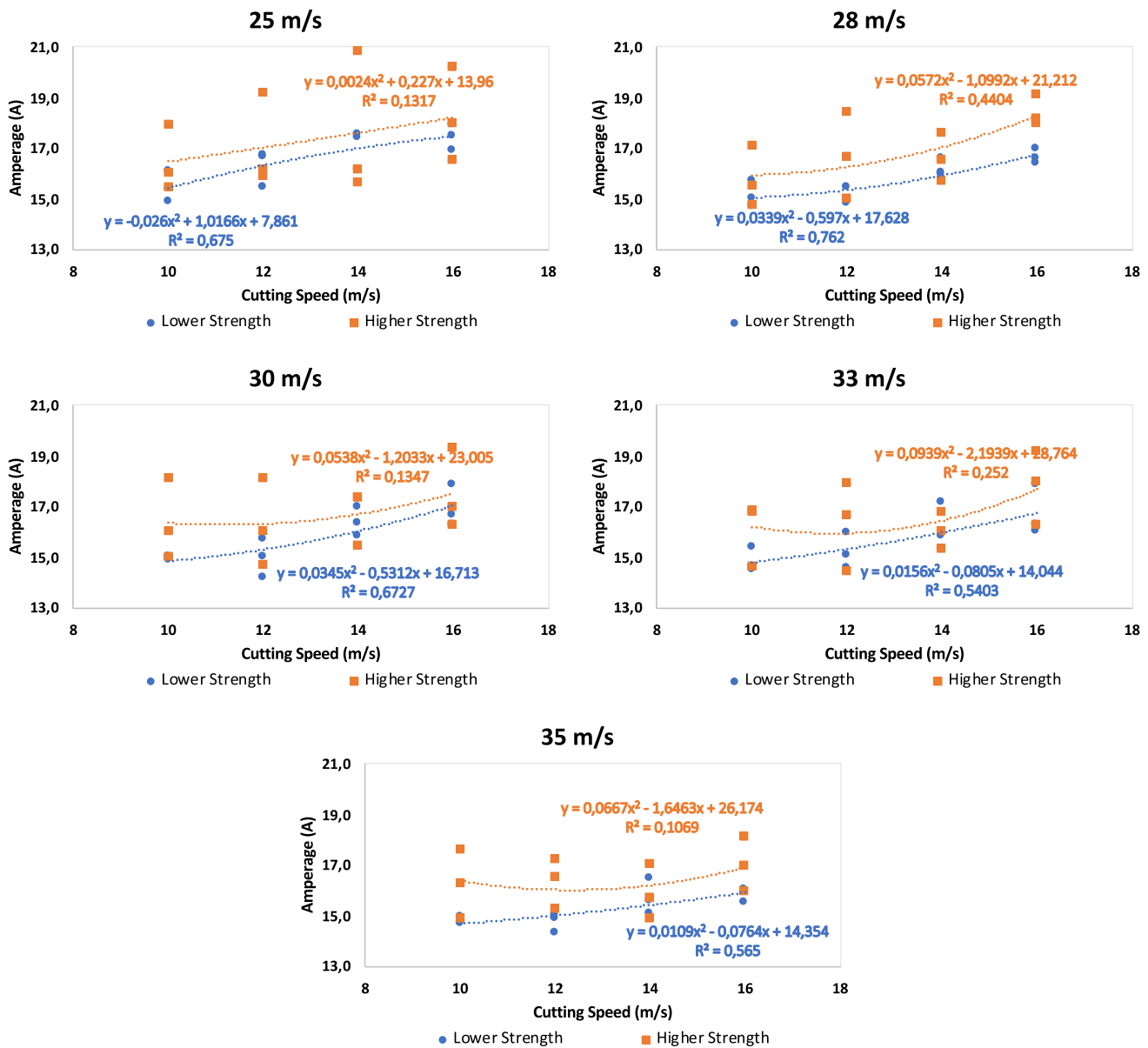


Fig. 5 Relationships between amperage and peripheral speed for different cutting speeds depending on Böhme abrasion loss of samples

### 3.2 Effect of cutting speed on amperage

The relationships between cutting speed and amperage values are given in Figs. 6 and 7 for samples having different strength and abrasion resistance properties, respectively.

It can be seen from Fig. 6 that increasing the cutting speed causes the amperage values to increase as well. The amperage values seen in rocks with higher strength are also higher. Figure 7 shows the amperage and cutting speed relationships for moderate abradable and high abradable samples. Amperage data obtained in high abradable



**Fig. 6** Relationships between amperage and cutting speed for different peripheral speeds for lower and higher strength samples

samples for same cutting speed are in a closer range. At the same time, Fig. 6 also shows that the amperage values for high abrasable samples are lower than moderate abrasable samples.

In diamond wire cutting, as a result of bead-rock interaction, diamond beads wear as they cut the rock. This abrasion controls the life of cutting tools in cutting operations. Wear life of the cutting equipment such as diamond wire often has a linear relationship with the rock abrasion. High Böhme value for a rock indicates that the wear resistance of that rock sample is low. Cutting of these rocks is easier for cutting machines than high wear resistant

rocks. The main reason is that the friction applied to the bead by a rock sample with high Böhme value is lower.

### 3.3 Effects of UCS and Böhme on amperage

The relationships between uniaxial compressive strength and amperage values are given in Figs. 8 and 9 for different cutting speeds and peripheral speeds, respectively.

According to the graphs given in Figs. 8 and 9, as the strength of the rock increases, the amperage values during the cutting process increase, too. According to Fig. 8, the highest correlation between UCS and amperage was

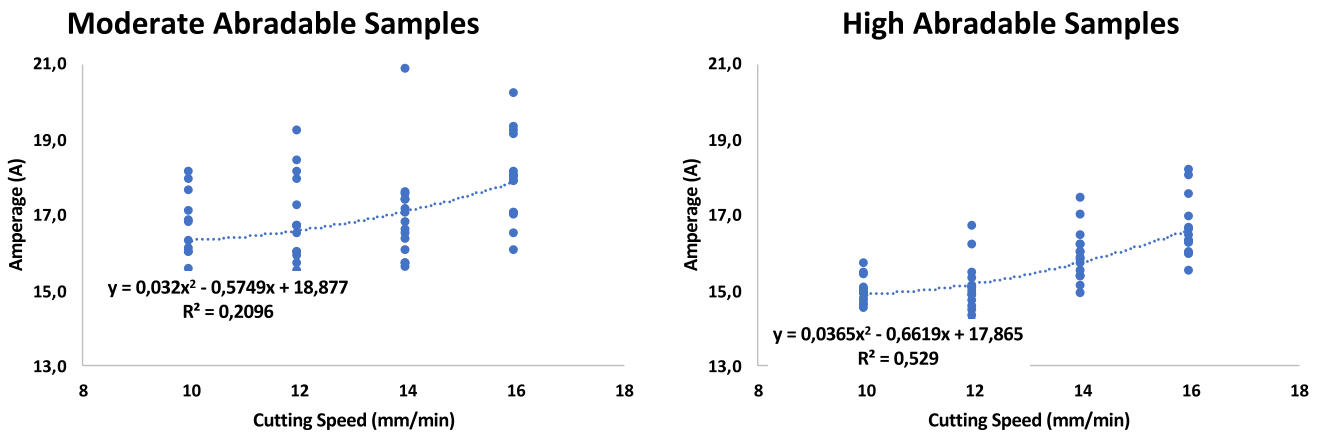


Fig. 7 Relationships between amperage and cutting speed for different peripheral speeds for moderate and high abrasable samples

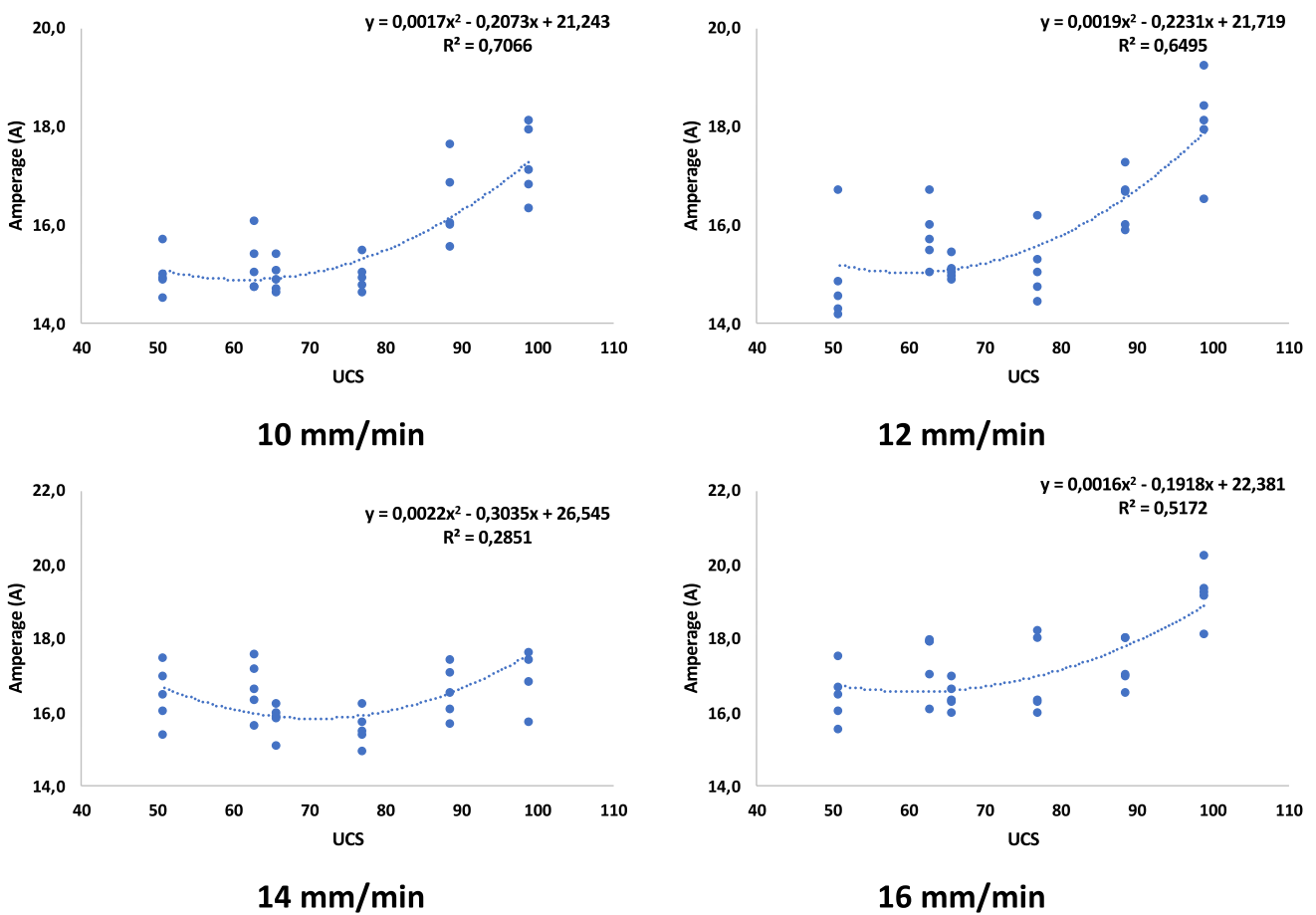


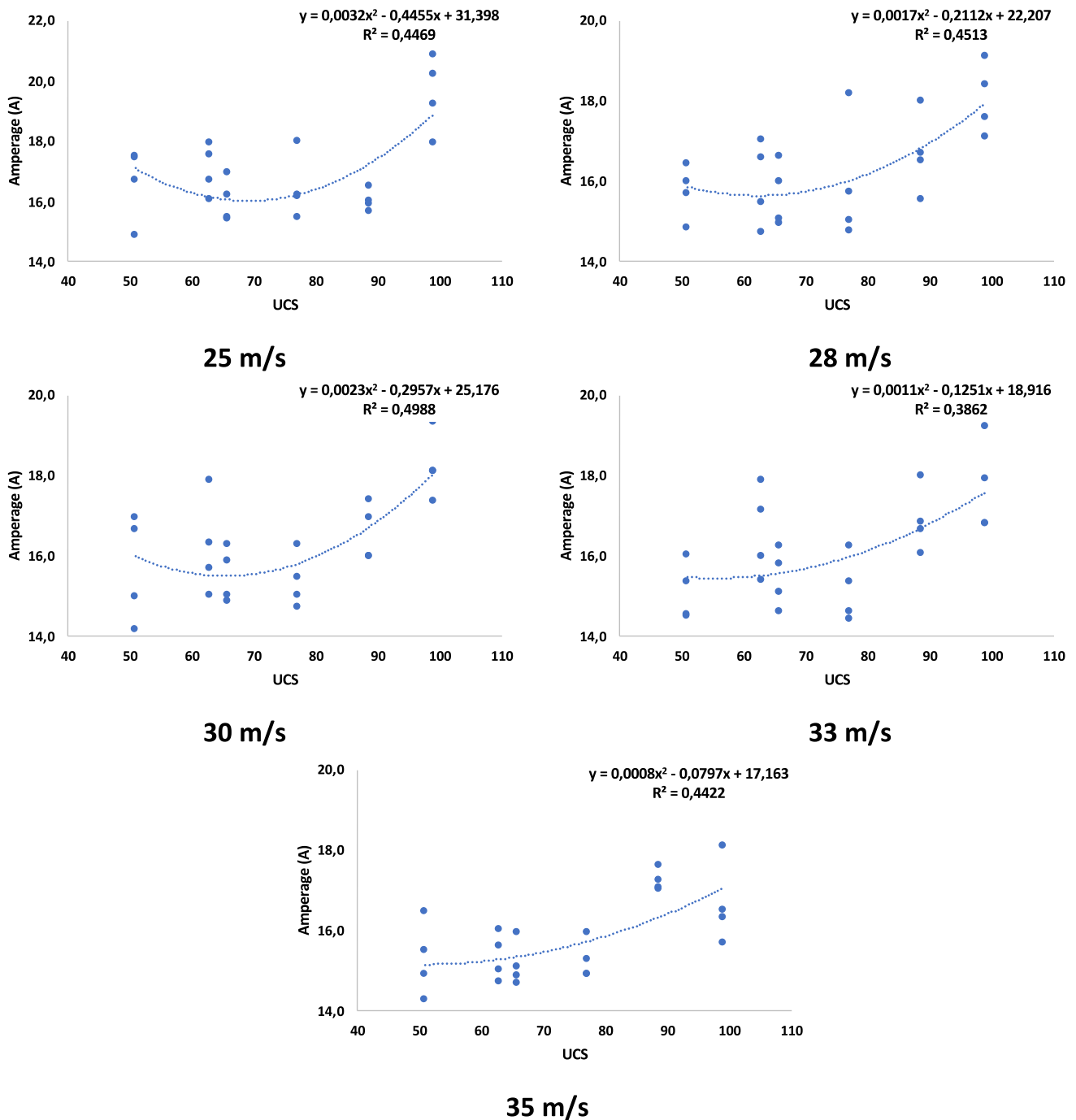
Fig. 8 Relationship between amperage and UCS for all samples for different cutting speeds

detected at the lowest cutting speed (10 mm/min) ( $R^2_{10 \text{ mm/min}} = 0.71$ ).

Figure 10 shows the relationships between Böhme abrasion loss and amperage values for different cutting speeds. For lower cutting speeds, there is high polynomial relationship between amperage and Böhme abrasion loss

when they are compared to higher cutting speeds ( $R^2_{10 \text{ mm/min}} = 0.68$ ,  $R^2_{12 \text{ mm/min}} = 0.66$ ).

Relationship between amperage and Böhme abrasion loss for different cutting speeds is given in Fig. 11. It was observed that the amperage decreased with the increase in Böhme values for moderate abrasable samples at lower



**Fig. 9** Relationship between amperage and UCS for all samples for different peripheral speeds

cutting speeds. There is no such relationship for high abrasable rocks.

### 4 Statistical Analysis

In this section, data analysis, multiple linear regression and artificial neural network (ANN) studies were carried out.

#### 4.1 Multiple regression model

It is a well-known fact that the regression-based equations are very easy to use tools for prediction. In the previous part of the study, in order to the determine the relationships among the parameters, simple regression was performed. Statistically significant correlations are showed in Figs. 4, 5, 6, 7, 8, 9, 10, and 11, and regression equations were



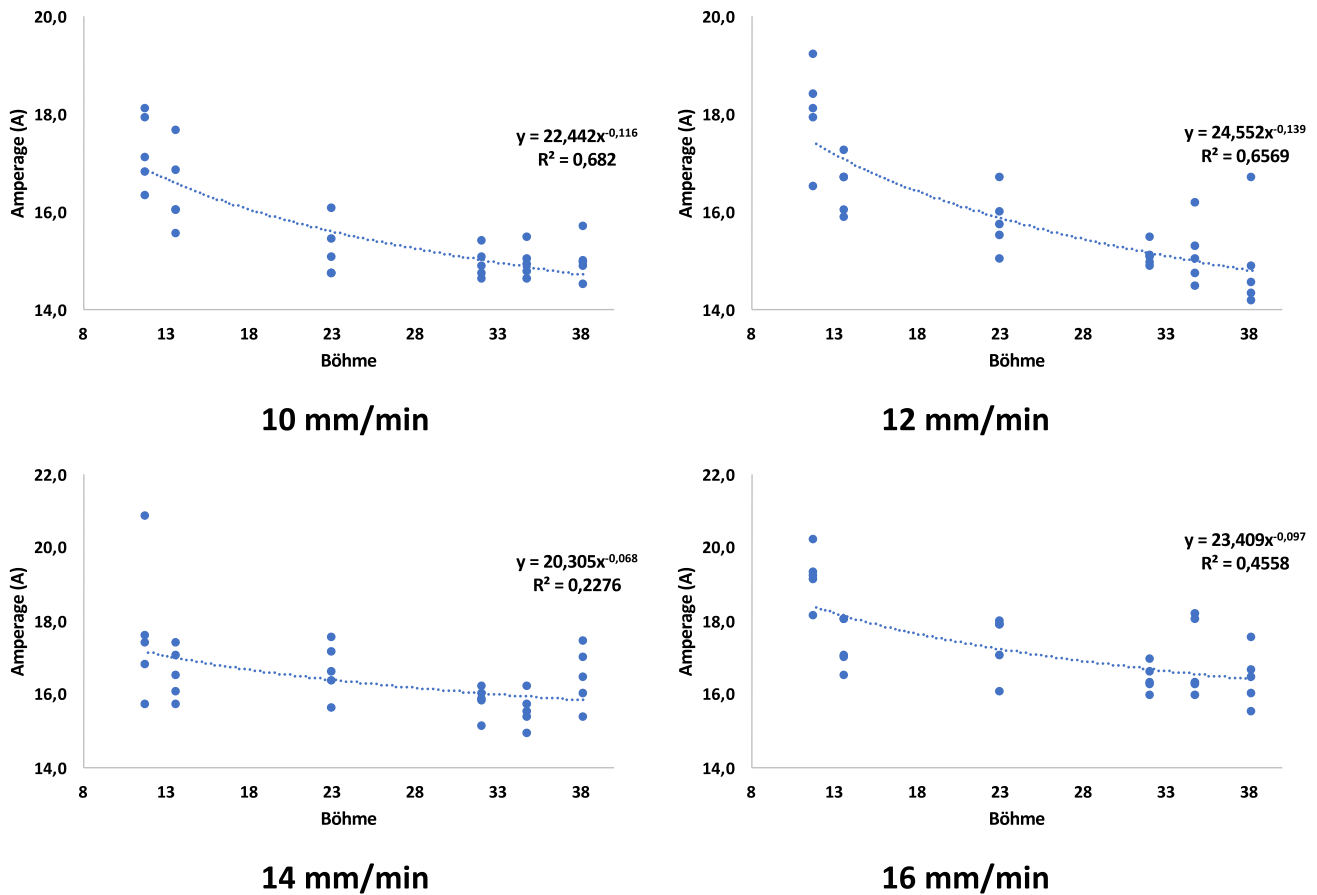


Fig. 10 Relationship between amperage and Böhme abrasion resistance for different cutting speeds

established among operational parameters and rock properties with amperage.

In this section, to produce a prediction model for amperage value, multiple regression analyze was performed. Multiple regression is one of the methods for analyzing the contribution of more than one independent variable to change in a dependent variable. This method is effective for cases where there are complicated relationships and the combination of two or more parameters affect the properties of the rock [25]. As seen from the simple regression studies given in the previous chapter, the sufficient prediction of amperage consumption during cutting process is not possible when just one input is considered in the model. Therefore, in this stage of the investigation for a better amperage prediction model, multiple linear regression analyses were performed.

Experimental datasets including amperage values for each cutting speed and peripheral speed, and physical and mechanical properties of the samples were imported in the statistical analysis software as a matrix for data analysis in IBM SPSS Statistics v.23 [26]. Additionally, instead of using only the machine parameters separately for the model, combined variables were generated using CS, PS,

UCS and BAL inputs considering their positive and negative relations with amperage. Combined parameters as CS/PS ratio and UCS/BAL ratio were added to the data table to search for a better correlation. Descriptive statistics for the parameters used in the study is given in Table 3.

While amperage was considered as output of the model, operational parameters of cutting machine and rock properties were selected as inputs of the model. The relationship between the input parameters and the measured amperage according to multivariate linear regression is given in Eq. 1.

$$A = 11.701 + 7.735 * (CS/PS) + 0.317 * (UCS/BAL) \tag{1}$$

$$R^2 = 69.2\%$$

By using statistical model given in Eq. 1, the average amperage of mono-wire cutting machine was predicted for rock samples based on rock properties and cutting parameters. In the analyses, the proportion of variation in the dependent variable (amperage) that is explained by the independent variables (rock properties and cutting parameters) is shown by  $R^2$  value (0.692).  $R^2$  value is a commonly used parameter in statistical analyses to show the

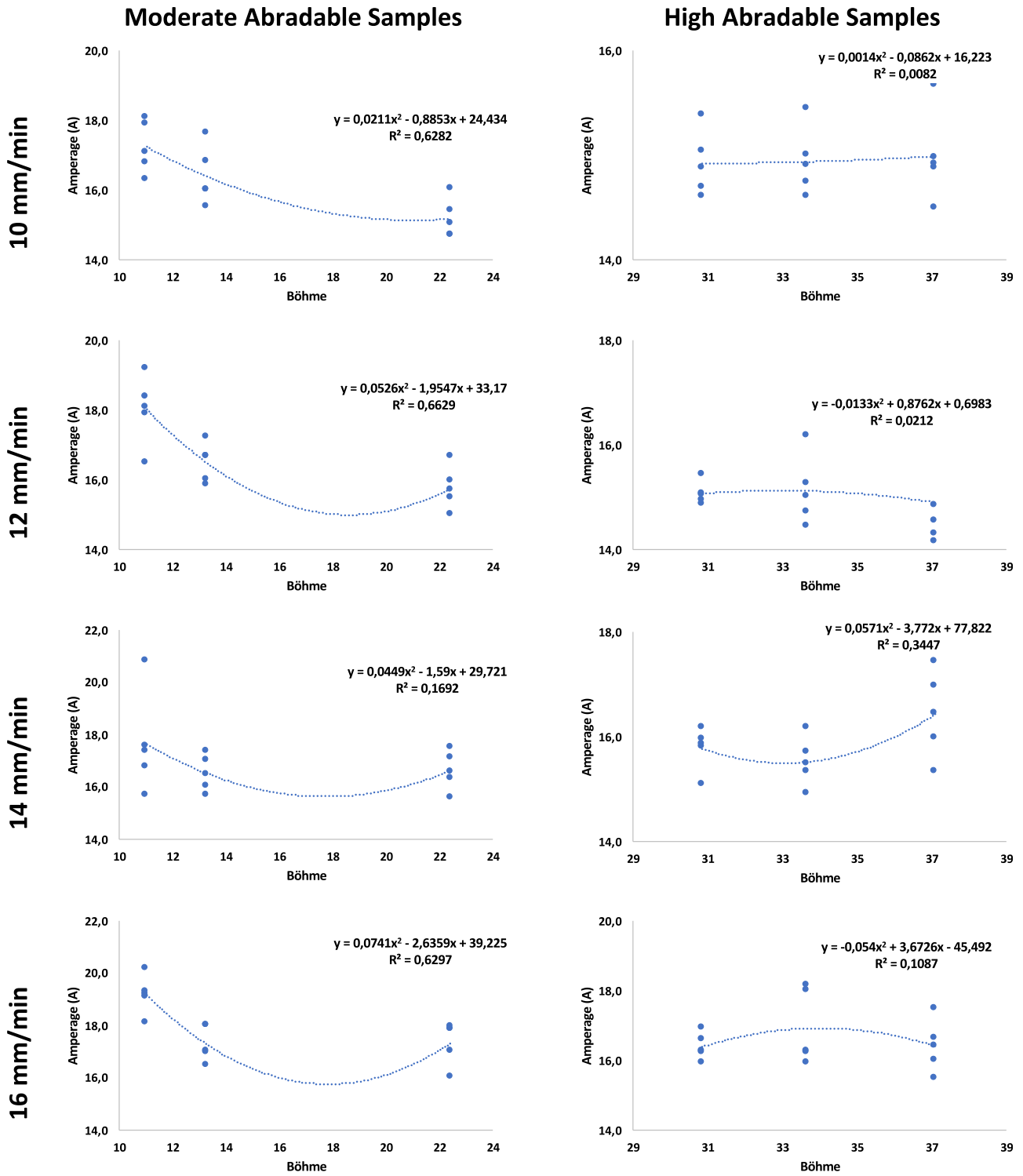


Fig. 11 Relationships between amperage and Böhme abrasion loss values for different cutting speeds

overall effect size of the independent or predictor variables on the dependent variable. The relationship between measured and predicted amperage values for the samples is given in Fig. 12. Fitted and 1:1-diagonal lines are also given in the figure. If the predicted and measured values

are equal, this means that the model is 100% successful. The relationship between predicted amperage and measured amperage in the study is close to the  $X = Y$  line which shows that the model given in Eq. 1 has sufficient validity.

**Table 3** Basic statistics of the results obtained from cutting and rock mechanics tests

	<i>N</i>	Minimum	Maximum	Mean	Std. deviation
PS	120	25	35	30.20	3.559
CS	120	10	16	13.00	2.245
AMP	120	14.20	20.80	16.2980	1.31328
UWW	120	2.65	2.72	2.7033	.02505
WAW	120	.05	.50	.1717	.15442
AP	120	.08	1.38	.4500	.43718
SH	120	43.0	62.0	50.667	6.3157
UCS	120	50.8	98.9	73.917	16.2618
TS	120	4.7	8.5	6.700	1.4564
FS	120	9.2	15.2	13.262	2.0434
BAL	120	11.90	38.30	25.6667	10.25354
CS/PS	120	.29	.64	.4366	.09248
UCS/BAL	120	1.33	8.31	3.8436	2.60357

**Table 4** Statistical results from the multiple regression model

Model	Unstandardized Coefficients		<i>t</i>	Sig.
	<i>B</i>	Std. error		
<i>Amperage</i>				
Constant	11.701	0.340	34.434	.000
CS/PS	7.735	0.728	10.622	.000
UCS/BAL	0.317	0.026	12.264	.000

samples. In the model, CS/PS ratio has the highest correlation with amperage. From the statistical results, UCS/BAL ratio for the rock samples was added to the model to predict the cutting amperage values.

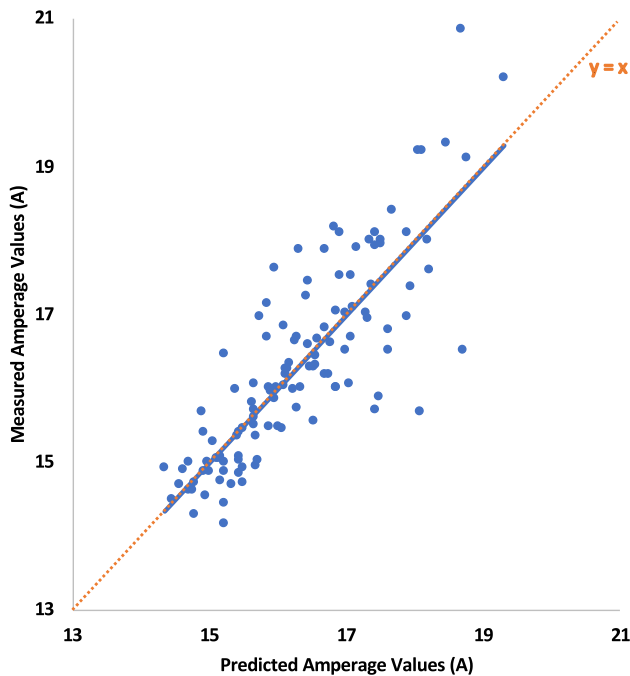
### 4.2 Artificial neural network (ANN) model

Soft computing methods are commonly used as a prediction tool in academic and non-academic studies due to their good prediction abilities. These techniques have been found to be highly efficient for prediction of the output parameters for specific engineering applications [27].

Neural networks (also called as artificial neural networks) are simple mathematical models inspired by functioning of human brain. Neurons are the fundamental processing units in ANN models. These neurons are connected and operated in layers [28].

Especially in recent decades, artificial neural network models are preferred as one of the powerful soft computing prediction tools in many studies and researches. The commonly used neural network types for engineering applications are feedforward neural networks, recurrent neural networks (RNN) and convolutional neural networks (CNN). Feedforward neural networks which were also used in this study consist of an input layer, one or a few hidden layers and an output layer. A neural network collects the inputs from the external data and combines these inputs. Then, in hidden layer or layers, it performs an operation on the result. As a final stage, output is reported.

In this study, similar to multiple regression analyze, the output of the ANN architecture was amperage. Input parameters were selected as CS/PS ratio and UCS/BAL ratio. While preparing the data for neural network analyses, input and output parameters were normalized. All data scaled between 0 and 1 by dividing each value to maximum value. Then, total data divided into three data sets as training (70% of all data), test (15% of all data) and validation (15% of all data). For an objective comparison, the combination of inputs was selected same in Multiple Regression and Artificial Neural Network Analyzes. In the ANN analyze, MATLAB 2022a [29] software was used



**Fig. 12** Cross-correlation graph between measured and predicted amperage values obtained from multiple linear regression

Table 4 present the results of the errors related to the coefficients of the developed models. The entries in Table 4 enable us to test some important hypotheses in regression and shows the rationality of the relationships based on the concepts of the *F*-test. According to these results, the obtained relationship is relatively valid.

The statistical results show that the amperage of mono-wire cutting machine has different degree of relationships with variables in the study for low and high strength

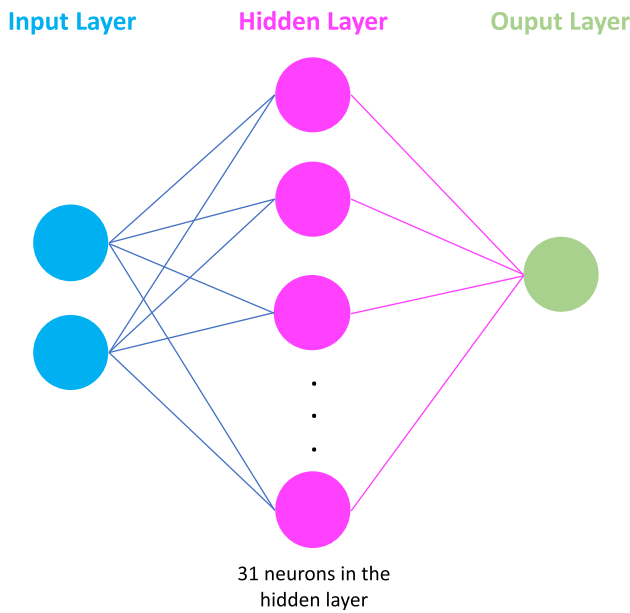


Fig. 13 ANN architecture constructed

having one input layer (2 neurons), one hidden layer (31 neurons) and one output layer. ANN architecture used in this study is shown in Fig. 13. Parameters used in the analyzing stage are given as follows: learning rate parameter: 0.01, momentum parameter: 0.9, networks training function: variable learning rate with momentum and activation (transfer) function for all layers: tansig (Tan-Sigmoid Transfer Function).

The number of neurons in the hidden layer was determined depending on Root Mean Square Error (RMSE) values. As a result of trials using different neuron numbers,

Fig. 14 Variation of the RMSE values for train, test and validation data depending on the number of neurons in the hidden layer

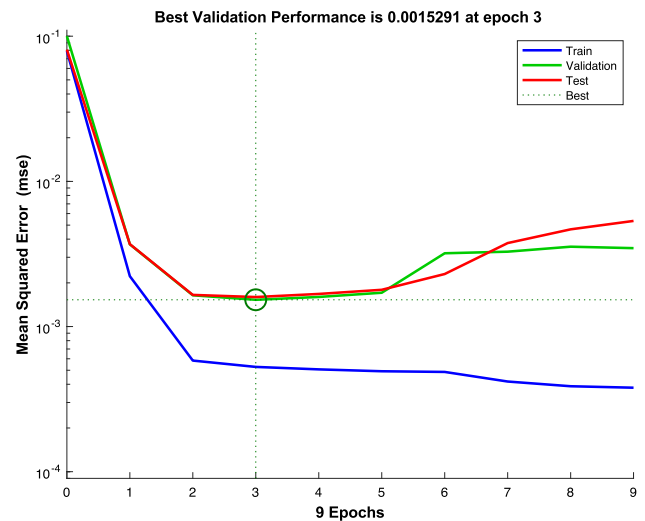
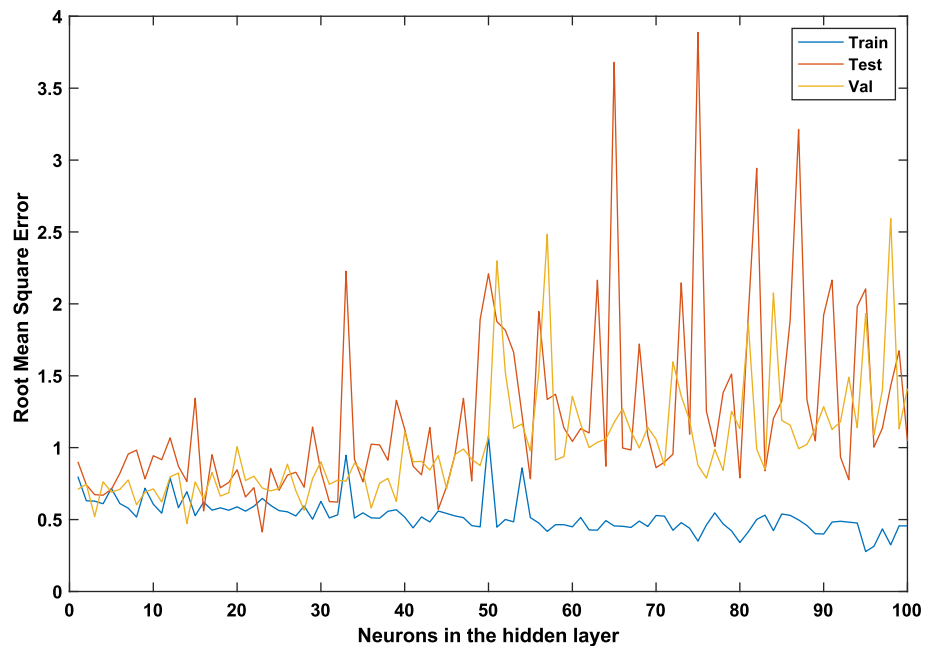


Fig. 15 Best validation performance for train, test and validation data

the number of neurons with the lowest RMSE value was determined for the hidden layer. The variation graph of the RMSE values depending on the number of neurons in the hidden layer obtained in trials is given in Fig. 14.

In the study, during the training stage, “the feed forward-back propagation” technique and “the sigmoid function” were used, which are commonly used technique and widely used function in the literature.

When train, test and validation data graphs given in Fig. 14 are evaluated together, it can be said that the optimum RMSE values for each data type were observed for 31 neurons in the hidden layer condition. Therefore, it was selected as the neuron number in hidden layer of neural network. The Levenberg and Marquardt algorithm

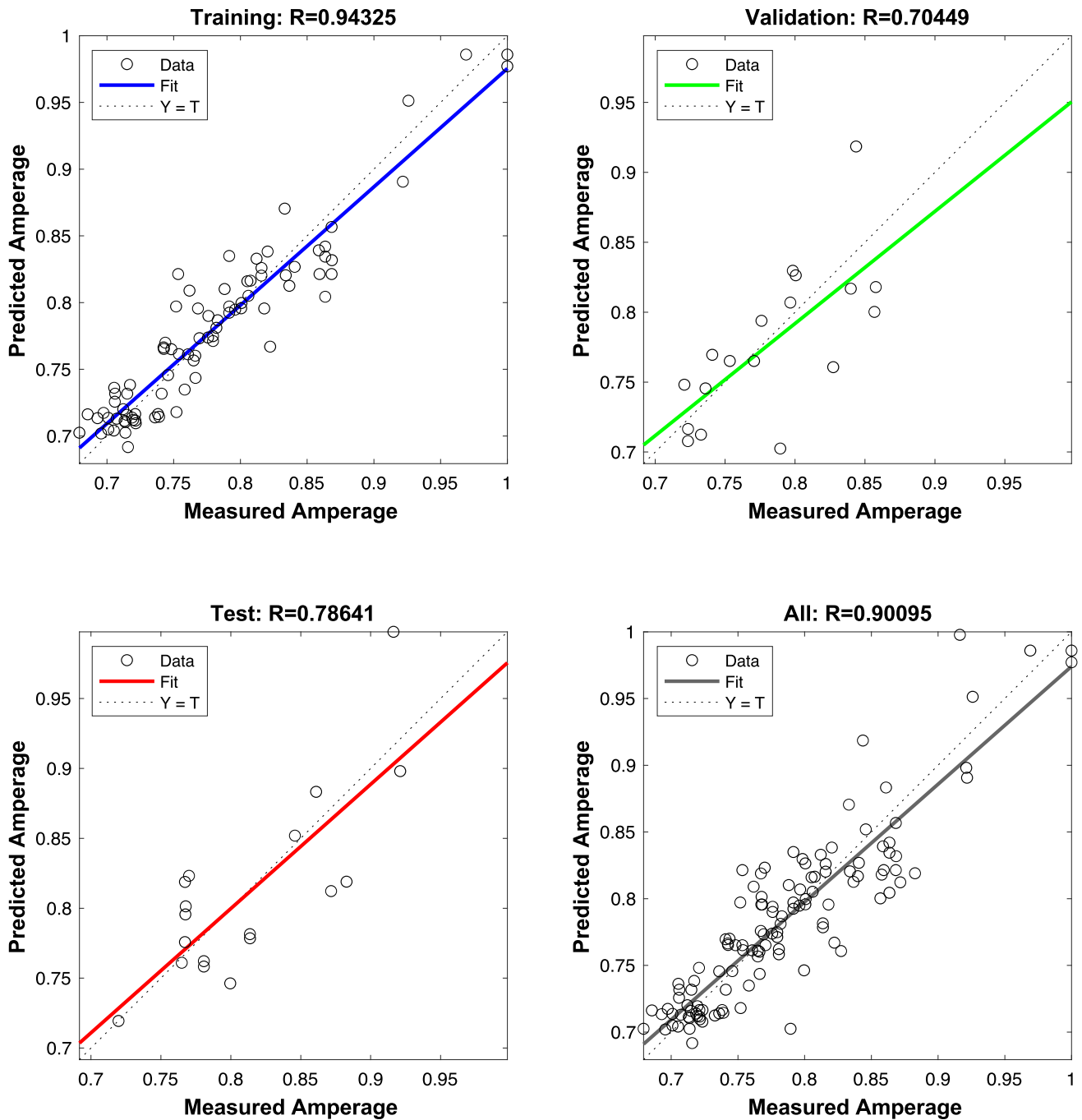


Fig. 16 Correlation coefficients for training, validation, test and all data in the optimal ANN model

was used for training of the network. The network output was compared with the desired output at each time and the error was computed. In the analysis, a mean square error (MSE) of  $10^{-4}$ , a minimum gradient of  $10^{-7}$  and maximum number of epochs of 1000 were used as limit values. If any of these three conditions were met, the training process stopped.

Figure 15 shows the variation of mean squared error using the Levenberg–Marquardt algorithm in the optimal models for amperage. The lowest values of MSE were obtained in the third epoch. The relationships and correlation coefficients (R) between measured and predicted values for training, test, validation and total data of the optimal ANN model are given in Fig. 16. Cross-correlation between predicted and measured amperage graphs showed

that the ANN model constructed for training data ( $R^2 = 0.89$ ) is highly acceptable for prediction of Amperage.

## 5 Performance of the predictive models

To determine and compare the prediction capacity of multiple linear regression and artificial neural network models, some of the widely used performance indices were used. In general meaning, all these kind of indices are different expressions of the succession of the prediction stage. In this study, coefficient of determination ( $R^2$ ), root mean square error (RMSE) (Eq. 2), variance accounted for (VAF) (Eq. 3) and MAPE (Eq. 4) were used for performance analysis.

The coefficient of determination between the actual and predicted values ( $R^2$ ) is a widely used parameter to understand the model performance. The RMSE and VAF can also be used to verify the correctness of the models, by comparing the real output with the estimated output of the models. If the actual and predicted values are the same, the VAF of these two values is 100%. If there is a difference between these values, the VAF will be lower. If the VAF is 100 and RMSE is 0, this means the model is excellent. Another index used to check the prediction performances of the models is Mean Absolute Percentage Error (MAPE). MAPE is a measure of prediction accuracy in statistics and usually expresses accuracy as a percentage:

$$\text{RMSE} = \sqrt{\frac{1}{N} \sum_{i=1}^N (y - y^t)^2} \quad (2)$$

$$\text{VAF} = \left[ 1 - \frac{\text{var}(y - y^t)}{\text{var}(y)} \right] \times 100 \quad (3)$$

$$\text{MAPE} = \frac{1}{N} \sum_{i=1}^N \left| \frac{y - y^t}{y} \right| \times 100 \quad (4)$$

where  $y$  is the measured and  $y^t$  is the predicted value.

$R^2$ , RMSE, VAF and MAPE values for the models are given in Table 5.

The obtained values of  $R^2$ , RMSE, VAF and MAPE, given in Table 5, indicated higher prediction performance for ANN model.

**Table 5** Comparison of the performance indices of the multiple regression and artificial neural network models

	$R^2$	RMSE	VAF	MAPE
MLR	0.69	0.7281	69.0	3.2367
ANN	0.89	0.5273	80.7	2.4698

## 6 Conclusions

In this study, cutting parameters of a mono-wire cutting machine and some rock properties were used to predict the amperage consumption during the cutting process of mono-wire DWCM on carbonated rock samples. To clearly investigate the effects of rock strength and abrasion properties on amperage, experimental data were divided into groups.

At the end of the cutting experiments, it was observed that the amperage value tends to decrease with increasing peripheral speed of wire. The relationship between peripheral speed and amperage is statistically more significant for lower strength samples. Similarly, increasing the cutting speed causes the amperage values to increase as well. The average amperage values in rocks with higher strength were also higher.

When it comes to relationships among UCS, Böhme and Amperage, as the compressive strength of the rock increases, the amperage values during the cutting process increase, too. The highest correlation between UCS and amperage was detected at “10 mm/min” cutting speed which was the lowest cutting rate value in the study. For lower cutting speeds, there are higher polynomial relationship between amperage and Böhme abrasion loss when they are compared to higher cutting speeds. For this reason, it can be said that there is a clearer relationship between Böhme and Amperage at low cutting speeds.

In the study, a statistical model was constructed by MLR and the average amperage of mono-wire cutting machine was predicted for rock samples based on rock properties and cutting parameters. In this model, CS/PS ratio and UCS/BAL ratio parameters were used. Then, a better correlation between input and output data was researched by ANN model. The obtained values of  $R^2$ , RMSE, VAF and MAPE indicated higher prediction performance for ANN model. Results from the analysis demonstrate that ANN model constructed is highly acceptable for amperage prediction.

Obtained results in the study showed that the cutting machine’s amperage draw shows how hard the machine must work to run and highly effected by the cutting speed, peripheral speed, rock strength and rock abrasiveness properties. This study also showed that high amperage values in cutting operations are one of the indicators of the difficulties in cutting process.

Based on the mono-wire cutting studies in the literature, it is known that changes of the operational parameters such as cutting speed or peripheral speed directly affect the cutting performance [22, 27]. Therefore, for the future prospect of regression or neural network studies, it is recommended to have at least one of the operational

parameters in models. Such operational parameters improve the prediction quality. For similar studies, in addition to the physical and mechanical properties of the rocks, petrographic properties such as average grain size or the classification of rock types (such as marble, limestone, granite) can also be used to provide higher accuracy in the modeling phase. The better correlations may be obtained if samples with similar characteristics are selected during sample selection stage. The analyzes in the first part of this study (grouping the obtained experimental data such as medium/high rock strength or moderate/high abrasible) support this fact.

This study can be extended by considering the cutting of various rock samples having various strength values. For further studies, it has also high importance to test different diamond wires which have different structural properties and diameters. It can also be recommended to increase the number of samples and the number of data to increase the estimation accuracy.

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**Data availability** Data will be made available on reasonable request.

## Declarations

**Conflict of interest** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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