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Research Paper

Determination of the Appropriate Speed for Drum Shearers Considering Coal Strength and Gas Content in Tabas Mechanized Mine

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Abstract: To increase and Join production in coal mining panels, predicting and determining the appropriate speed of these devices can greatly help the project implementation time and economics of designs. For this purpose, 1260 types of coal, cut by the coal mining machine were carried out in the E3 extraction panel of the Tabas mechanized mine. First, after recording the shearer speed of each cut, the information about gas flow was collected at three points along the total length of the panel. These three points include emitted methane gases as a percentage on sensor 88, the tailgate input sensor (TG), and the sensor embedded on the Armored face conveyor (AFC). Shearer speed was predicted with three models of linear and nonlinear multivariate regression (exponential and logarithmic). The results show that the multivariate linear regression model with a coefficient of determination R2=0.90 has a more accurate prediction than the other two methods using the linear multivariate regression model, the amount of shearer speed can be predicted with good accuracy. For this purpose, the genetic algorithm in MATLAB software has been used to optimize the speed of the shearer device. Determining the appropriate speed results show that cross diagrams based on coefficient of determination (R2), according to Equations (logarithmic, exponential and linear), linear type has a higher coefficient of determination than other equations. Therefore, the best model is selected to determine the appropriate speed. Using the linear equation in the genetic algorithm, the extraction speed of the shearer machine was estimated to be 4.79 m/min.

Keywords: Determining the appropriate speed, shearer, statistical analysis, genetic algorithm, Tabas mechanized mine.

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INTRODUCTION

The purpose of this study is to investigate how the loader shearer machine works based on the parameters affecting it and finally to optimize and evaluate loader shearer speed according to the gasification of the layers and the properties of rock resistance in Parvadeh Tabas coal mine number one. Among the innovations that can be mentioned in this research includes reviewing and studying the progress rate of the loader shearer regarding the strength properties of coal in Tabas mechanized mining number A and examining the relationship between loader shearer performance with operational parameters in the coal cutting process and also comparing the relationship between operational and non-operational parameters and coal strength characteristics and gasification of the layers [1].

METHOD

Case study area, extraction panel E3

To extract this extraction panel, it is necessary to have two upper and lower corridors named E3 main gate and E3 tailgate. As in Figure 1, the corridors are rectangular and 3*5 meters. The extraction in the E3 extraction panel is done by the loader shearer. The loader shearer is relatively narrow moves on a wall chain conveyor and usually creates a cut with a depth of 60 to 90 cm. Generally, the loader shearer is a machine with a lot of flexibility and almost cuts any type of layer and passes through faults well [2].

In Parvadeh Tabas mine No. 1, for the extraction of the Coal layer, the shearer machine puts the extracted material on the adjacent conveyor and transfers it to the main conveyor in the tunnel. In mechanized systems, transportation inside the extraction panel is done by a chain conveyor or AFC conveyor. Hydraulic jacks are used in the roof of the wall that can withstand a lot of loads. With the advance of the wall, the special conveyor of the wall and maintenance equipment move forward with a specific schedule and the roof part behind the maintenance equipment will be destroyed. The destruction decreases the pressure of layers on the equipment; so it can avoid damaging the equipment. Figure 2 shows the shearer used in Tabas mine number 1 [2].

Figure 1. The shearer used in Parvadeh Tabas mine

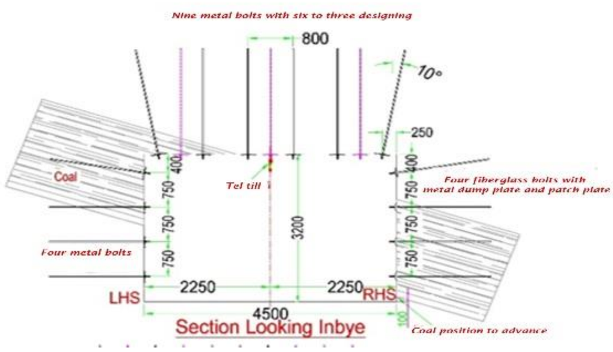

Figure 2. A view of main corridors for extraction in extraction panel E3 [3]

Investigating the performance of shearer machine speed in extraction panel E3

In order to investigate the shearer speed the first step is to establish a data bank including the properties of mass rock, machine, and emitted methane in extraction panel E3. To do so, researchers and field studies are precisely and carefully done by site visiting and controlling the shearer operation in extraction panel E3 for 1260 cuts along the whole extraction panel E3. Table 1 shows the brief results of 10 extractions. Actually, the extraction of methane gas has been conducted through sensors inside the extraction panel and the main routes. These extractions involve Coal toughness (Mpa), emitted methane in terms of percentage on sensor number 88, input tailgate (TG), sensor installed on the chain conveyor (AFC), methane gasification system, and shearer speed during extraction [2].

A speed prediction of shearer machine

The proper and successful use of shearer technology in any mining operation depicts the fact that precise estimations and evaluations should be done over the shearer speed. In order to develop the predicted models including the linear and nonlinear regression models, 70 percent of data (882) is used which is called training data. To do so, defining the measured speed of shearer as a dependent parameter and different types of linear and nonlinear multivariate regression models will be studied. To evaluate the developed models, we have used 30 percent of data (378) which is called test data. The prediction of shearer Speed is based on the training data and test data by three models linear multivariate regression, exponential multivariate regression, and logarithmic multivariate regression which will be explained next. Like the Figures 3 and 4, SPSS software is used for predicting the shearer speed by regression methods. In order to make a comparison between the three predicted models and the real average speed of the shearer (Table 2), we have used 1260 cuts of the shearer in extraction panel E3. The more the speed is, the more the power of this model will be. The real is the speed of shearer in extraction panel E3 is estimated as 3.79 m/s. The results show that the linear multivariate regression model has more precise predictions than the other two methods in a way that the training data for predicting the shearer speed in the linear multivariate regression model with a determination coefficient of 0.90, a correlation coefficient of 0.95, and root mean square error has the least number of errors. In the linear multivariate regression model, all independent variables except the methane gasification system can directly affect the shearer speed. The root mean square error (RMSE) of training data in the linear multivariate regression model with the least number of errors will be 0.29. Therefore, the linear multivariate regression model can precisely predict the shearer speed in Parvadeh Tabas coal mine number 1 [2].

Table 1. Summary of 10 extractions of shearer in extraction panel E3

Shearer speed (m/min)	Meethane gasification	Ssensor gas TG	Sensor gas AFC	Sensor gas 88%	Toughness	N umber of extraction
3.5	12	0.59	0.65	0.35	14	1
2	12	0.78	0.73	0.59	15	76
4	12	1.29	0.94	0.53	17	179
4	13	0.84	0.73	0.67	32	457
3.6	21	0.41	0.84	0.9	13.31	564
3.8	18	0.29	0.78	0.29	8.95	622
3.8	26	0.39	0.93	0.9	6.98	882
4.8	32	0.25	0.98	0.35	6.34	955
4	13	0.37	0.59	0.86	6.34	1122
3.7	18	0.47	0.73	0.63	9.35	1260

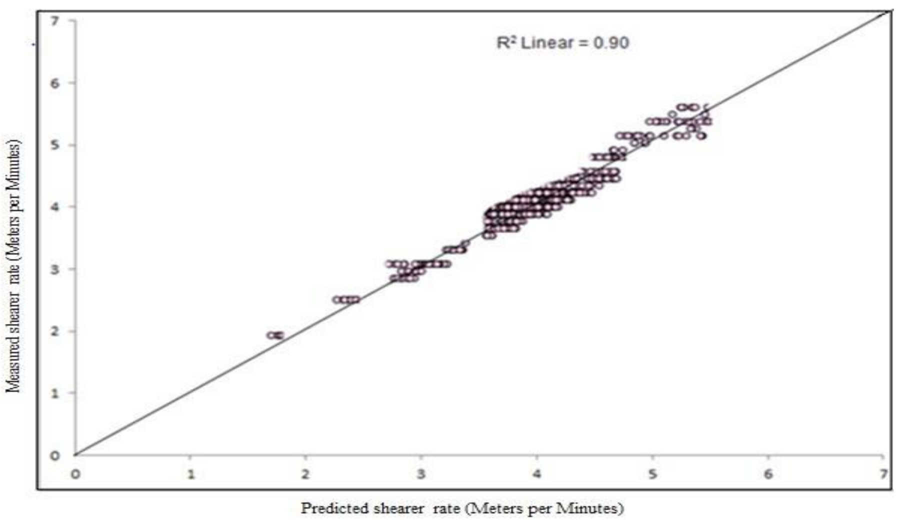

Figure 3. The relationship between the measured and predicted shearer speed in linear multivariate regression model using training data

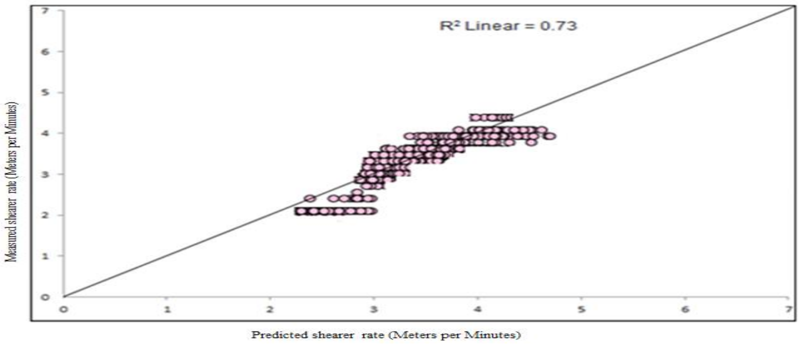

Figure 4. The relationship between the measured and predicted shearer speed in linear multivariate regression model using test data

Table 2. Comparing the predicted shearer speed using the three conducted models

Average speed (m/m)	Number	Model
3.81	1260	Linear multivariate regression
3.78	1260	Non-linear exponential multivariate regression
3.32	1260	Non-linear logarithmic multivariate regression
3.79	1260	Real shearer speed

Problem statement

In order to study the optimal performance of shearer speed, controlling the extraction operation of shearer in extraction panel E3 1260 cuts along the whole extraction panel will be accepted.

Based on Table 2, methane extraction using gas sensors inside the extraction panel and the main routes are conducted. These extractions are similar to those of previous steps for predicting the shearer speed. Objective functions are used to optimize the shearer speed. In these functions we have [4]:

ST: coal toughness in terms of mega Pascal

CH488: sensor 88 methane in terms of percentage

DRG: gasification system

The objective functions of this problem which are obtained by SPSS software are as follows:

A: objective function number one multivariate regression model

B: objective function number two non-linear multivariate regression model

C: objective function number three logarithmic nonlinear multivariate regression model [5]

Results obtained by genetic algorithm based on various equations

Table 3 represents the result of the genetic algorithm output. Besides, Figure 5 shows the Convergence graph for the linear equation. Figure 6 indicate the Convergence graph of equations used for optimizing the shearer speed. As it can be seen from the tables, convergence graphs, and optimal speed, the exponential method gives the best response comparing the other two functions. However, the optimal response time is related to the linear equation which is quite natural. Also, the rate of speed is related to the linear equation. Thus, linear equation presents the best performance with an optimal speed of 4.79 m per minute comparing the other two optimized equations [6].

The results of correlation coefficient of equations in optimizing genetic algorithm

Correlation coefficient is a statistical tool for determining the type and the relation degree of a quantitative variable with another quantitative variable. Using this coefficient, we can also draw a cross graph based on different limitations. The limitations of Table 1 are used for determining the correlation coefficient of shearer Speed. The second limitation involves 384 limitation data. That is, the answer set in the second limitation will be 384. The results obtained from the simulations of cross graphs based on the correlation are presented in Table 3. Regarding the fact that the linear equation has more regression than the other equations; therefore, it is the best model for optimization [6].

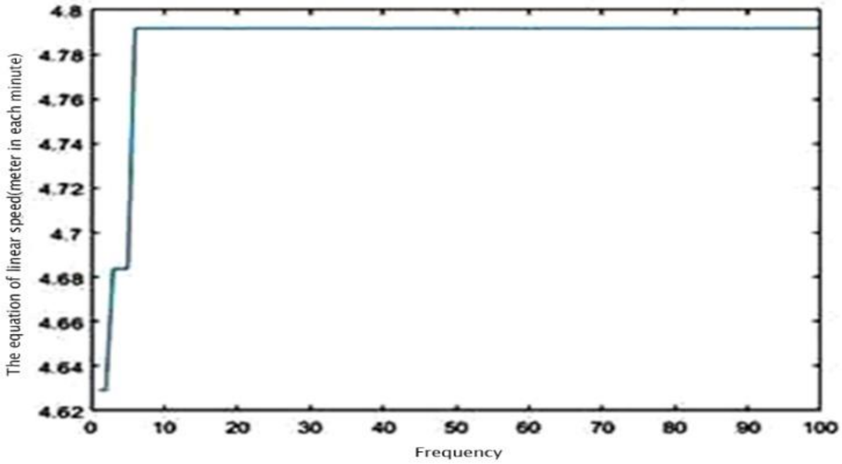

Figure 5. Convergence graph of linear equation

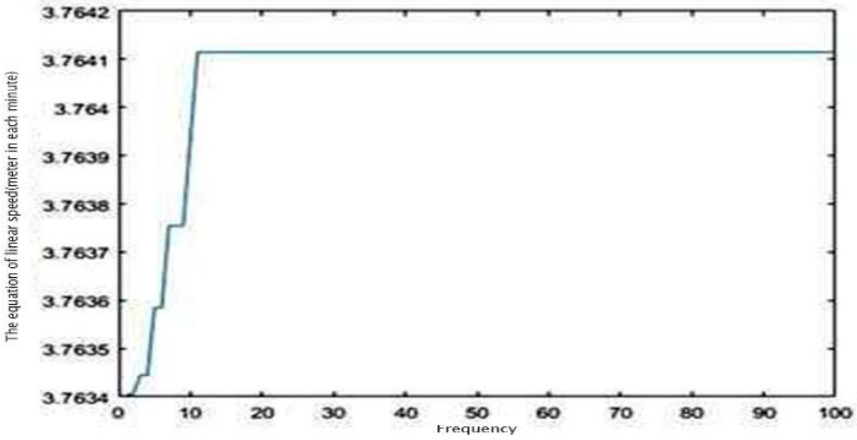

Figure 6. Convergence graph of exponential equation

Table 3. Results obtained from the simulation of cross graphs based on the correlation coefficient

Type of equation	Correlation coefficient R
linear	0.93
logarithmic	0.69
exponential	0.73

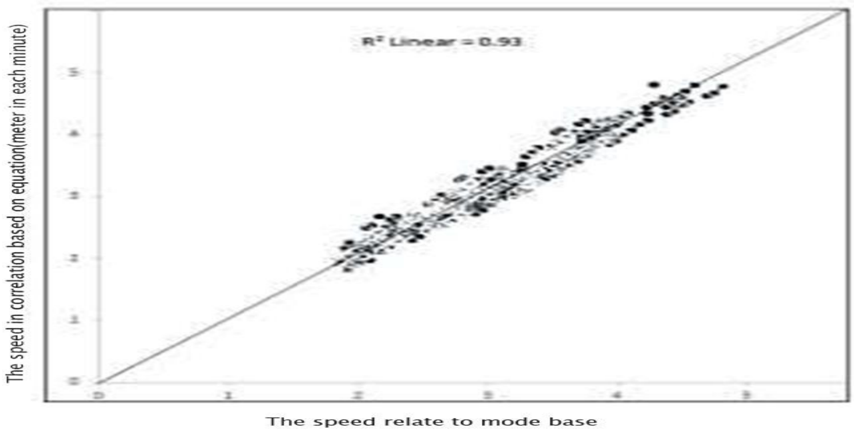

Figure 7. Cross graph in correlation mode based on the linear equation

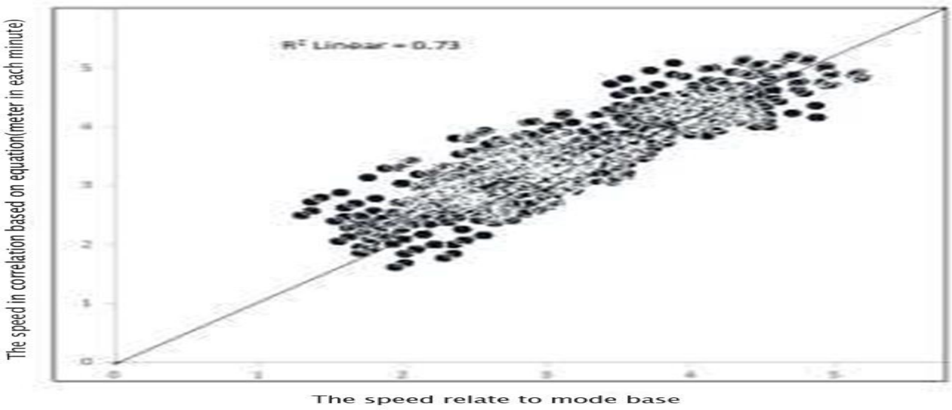

Figure 8. Cross graph in correlation mode based on the exponential equation

CONCLUSION

In this research, the relationship between shearer speed with resistance properties and coal gasification in Parvadeh Tabas mine number one is investigated by statistical studies and multivariate regression in SPSS software. To do so, 1260 types of coal cut by Shearer in extraction panel E3 in this mine are studied. The extraction operation of this mine is done using the backward long-wall method. Due to mechanization in the Parvadeh mine, the shearer is used for cutting or coal extraction in the extraction panel. The first step for investigating the shearer's performance is to establish a data bank including the properties of rock mass, machine and emitted methane. The data relating to methane is obtained using sensors installed inside the extraction panel and the main routes [7]. These extractions include coal toughness (Mpa), emitted methane in terms of percentage on sensor number 88 and tailgate sensor (TG) and the sensor installed on the chain conveyor (AFC), methane gasification system and shearer speed. Linear multivariate regression, exponential multivariate regression and logarithmic multivariate regression models are used for predicting the shearer speed based on the training and test data. In order to develop the predicted models, we have used 70 percent of data as training data (882) and 30 percent of data as test data (378). The results show that the linear multivariate regression model has more precise predictions comparing the other models in a way that training data for predicting the shearer speed in linear multivariate regression model with determination coefficient of 0.90 and correlation coefficient of 0.95 and root mean Square error has the least number of errors. In a linear multivariate regression model, all independent variables except the methane gasification system can directly affect shearer speed [8].

The first Society is all input and output files. Shearer speed is related to input and the rest of the variables include problem inputs. In order to be done better and regarding the dependency of all parameters (input variables) on output (shearer speed) in cases where one of the inputs equals 0, it will be removed from the first Society (16 societies are removed from 1260 societies); therefore the first Society will be 1244. Objective functions including linear, exponential, and logarithmic are used for optimizing the shearer speed. The results of objective functions show that the exponential method gives the best response comparing to the other two functions. However, the optimal response time is related to the linear equation which is quite natural. Also, the rate of speed is related to the linear equation. Thus, the linear equation presents the best performance with an optimal speed of 4.79 m per minute comparing the other two optimized equations.

The results obtained from the simulations of cross graphs based on the correlation show that the linear equation has more regression than the other equations; therefore, it is the best model for optimization (Table 3). It's worth mentioning that the linear equation with a correlation coefficient of .93 has had the best performance comparing the other equations.

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