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PREDICTING THE RELATIONSHIP BETWEEN SYSTEM VIBRATION WITH ROCK BRITTLENESS INDEXES IN ROCK SAWING PROCESS

PROGNOZOWANIE ZWIĄZKU POMIĘDZY DRGANIAMI URZĄDZENIA A WSPÓŁCZYNNIKIEM KRUCHOŚCI SKAŁ W TRAKCIE ICH URABIANIA

The system vibration is a very significant measure of the sawing performance, because it indicates the amount of energy required to saw the rock. The maintenance cost of system is also dependant on system vibration. A few increases in system vibration cause a huge increase in the maintenance cost of the system. In this paper, the vibration of system in terms of RMSa was investigated and models for estimation of vibration by means of rock brittleness indexes and operational specifications were designed via statistical models and multiple curvilinear regression analysis. In this study, the relationships between rock brittleness indexes and operational specifications were investigated by regression analysis in statistical package for social science (SPSS) and the results of determination coefficients have been presented. In the second part, the diagrams show that a point lying on the line indicates an exact estimation. In the plot for model, the points are scattered uniformly about the diagonal line, suggesting that the models are good. It is very useful to evaluate the vibration of system and select the suitable operational characteristics by only some mechanical properties of rock.

Keywords: system vibration, brittleness indexes, sawing process, statistical analysis

Drgania układu uważane są za miernik wydajności procesu urabiania, ponieważ pokazują ilość energii niezbędnej do urabiania skały. Od poziomu drgań zależą także koszty eksploatacji systemu. Nieznaczny nawet wzrost poziomu drgań prowadzi do znacznego zwiększenia kosztów eksploatacyjnych urządzenia. W pracy tej przeprowadzono analizę drgań (ich wartości skutecznych) i opracowano model estymacji poziomu drgań w oparciu o współczynnik kruchości skał i parametry eksploatacyjne urządzenia. W pracy wykorzystano modele statystyczne i wielokrotną analizę metodą regresji krzywoliniowej. W pracy obecnej związek pomiędzy współczynnikiem kruchości skał a parametrami eksploatacyjnymi urządzenia badano z wykorzystaniem analizy metodą regresji dostępnej w statystycznym pakiecie oprogramowania dla nauk

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społecznych (SPSS) a wyniki podano w postaci wyznaczonych współczynników. W drugiej części pracy przedstawiono wykres pokazujący, ze punkt leżący na linii oznacza dokładne oszacowanie. W wykresie wykonanym dla modelu punkty rozrzucone są równomiernie wokół linii przekątnej, co sugeruje że modele są właściwe. Określenie poziomu drgań urządzenia jest niezwykle korzystnym zabiegiem pozwalającym na dobór parametrów pracy urządzenia jedynie w oparciu o mechaniczne właściwości skał.

Słowa kluczowe: drgania urządzenia, współczynnik kruchości skał, proces urabiania skał, analiza statystyczna

1. Introduction

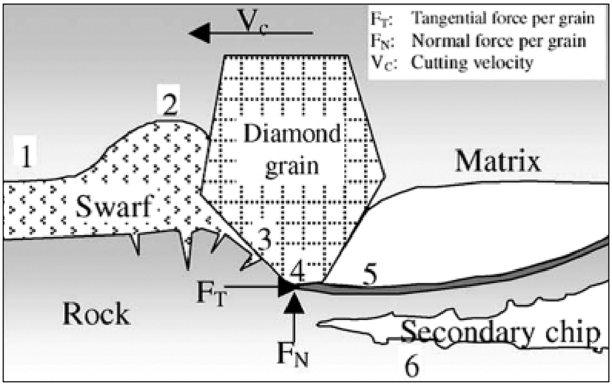
Up to now, many studies have been done on the relations between sawability and rock characteristics in stone processing (Burgess, 1978; Wright & Cassapi, 1985; Birle & Ratterman, 1986; Jennings & Wright, 1989; Clausen et al., 1996; Tonshoff et al., 2002; Eyuboglu et al., 2003; Wei et al., 2003; Ersoy & Atici, 2004; Gunaydin et al., 2004; Kahraman et al., 2004; Özçelik et al., 2004; Delgado et al., 2005; Ersoy et al., 2005; Buyuksagis & Goktan, 2005; Kahraman et al., 2006; Fener et al., 2007; Tutmez et al., 2007; Özçelik, 2007; Buyuksagis, 2007; Kahraman et al., 2007; Mikaeil et al., 2008, 2011a-c, 2012, 2013a-b; Krauze et al., 2009; Atici & Ersoy, 2009; Ataei et al., 2012).

The prediction of rock sawability is important in the cost estimation and the planning of the stone plants. The production cost of any stone factory is affected by the complex interaction of numerous factors. These factors can be classified as energy, maintenance, labour, water, diamond saw, polishing pads, filling material and packing. Among the above factors, maintenance cost is one of the most important factors in the production cost. In this paper, it was aimed to develop new statistical models for evaluating the system vibration of ornamental stone in sawing process. By these models, the system vibration was predicted from rock brittleness indexes and machining parameters. These models can be used for cost analysis and project planning as a decision making index. This paper is organized as follows; in the second section, the mechanism of sawing process is explained. In the third section, the factors influencing on rock sawability are shown. In the fourth section, after explanation of effective parameters on rock sawability, statistical models are established for predicting the system vibration. Eventually, in fifth section, results of the application are reviewed. This section concludes the paper. According to the authors' knowledge, predicting the system vibration using statistical model is a unique research.

2. Sawing mechanism

Chip formation can be defined as the destruction of a work-piece material using diamond circular saw. The process is a grinding process; however, in general, the term "sawing" is commonly used. The saw rotates about the saw centre with an angular speed cutting into the work-piece at a constant traverse rate. The diamond particles on the segment surface remove the material through scratching and cracking the work-piece surface. During these processes, a cut is formed in two mechanisms. This is given in Fig. 1.

In front of a grain that is engaged in the process, stresses are affected by tangential forces. Swarf is processed by tensile and compressive stresses. This mechanism is called primary chip formation. The swarf is forced out through proves in front and beside the grain. It is usually



1: Friction between swarf and matrix
2: Matrix erosion by swarf and chip
3: Friction between stone and grain
4: Plastic deformation
5: Elastic deformation
6: Primary chipping zone

Fig. 1. Mechanical interaction between saw and stone during sawing process (Ersoy et al., 2005)

small in size but could be abrasive. While the rock shows elastic characteristic up to its ultimate stress, it is necessary for cutting to reach a certain minimum grinding thickness. The rock cut is deformed by the compressive stress carried below the diamond. As the load is removed an elastic revision leads to critical tensile stress, which causes brittle fracture. This process affected by tensile stresses is described secondary chip formation. The swarf is removed away by the coolant fluid (Ersoy et al., 2005).

3. Factors influencing the system vibration in rock sawing process

The vibration of system in rock sawing process is a very significant measure of the sawing performance, because it indicates the amount of energy required to saw the rock. The maintenance cost of system is also dependant on system vibration. A few increases in system vibration cause a huge increase in the maintenance cost of the system. The system vibration in rock sawing process can be dependent on non-controlled parameters related to rock characteristics and controlled parameters related to machine and tools properties. In the same working conditions, the sawing process and its results are strongly affected by rock characteristics and operational parameters.

3.1. Brittleness

Brittleness is one of the most important mechanical properties of rocks. Brittleness in the Glossary of Geology and Related Sciences, is defined as a property of materials that rupture or fracture with little or no plastic flow (1960). However, a few researchers define brittleness for different purposes (Yarali & Soyer, 2011): Hetenyi (1966) define brittleness as the lack of ductility. Ramsey (1967) defined brittleness as follows: “When the internal cohesion of rocks is broken, the rocks are said to be brittle”. Obert and Duvall (1967) defined brittleness as follows: “materials such as cast iron and many rocks usually terminate by fracture at or only slightly beyond the yield stress". Brittleness is defined as a property of materials that rupture or fracture with little or no plastic flow. Some brittleness index definitions obtained from stress – strain curves were introduced and used in the literature (Baron, 1962; Coates & Parsons, 1966; Aubertin & Gill, 1988; Aubertin et al., 1994; Ribacchi, 2000; Hajiabdolmajid & Kaiser, 2003). Evans and Pomeroy (1966) theoretically showed that the impact energy of a cutter pick is inversely proportional to brittleness. Singh (1986) indicated that cuttability, penetrability, and the Protodyakonov strength index of coal strongly depend on the brittleness of coal. Singh (1987) showed that a directly proportional relationship existed between in-situ specific energy and brittleness (B_2) of three Utah coals. Goktan (1991) stated that the brittleness concept (B_2) adopted in his study might not be a representative measure of rock cutting specific energy consumption. Kahraman (2002) statistically investigated the relationships between three different brittleness definitions for both drillability and borability using the raw data obtained from the experimental works of different researchers. Altindag (2000, 2002, 2003) found significant correlations between his proposed new brittleness concept (B_3) and the penetration rate of percussive drills, the drillability index in rotary drilling, and the specific energy in rock cutting. Kahraman and Altindag (2004) correlated fracture toughness values with different brittleness values using the raw data obtained from the experimental works of two researchers. They indicated that the Altindag's (2003) brittleness concept can be used as a predictive rock property for the estimation of the fracture toughness value. Kahraman et al. (2003a, b) found a strong correlation between Los Angeles abrasion loss and the Altindag's brittleness (B_3) for 26 different rocks. Gunaydin et al. (2004) found a very strong correlation between hourly production and brittleness B_3 and they emphasized that the brittleness B_3 is the most reliable index among the brittleness indexes adopted in their study. Yarali (2007) found a power relation with correlation coefficient of 0.86 between drilling rate index (DRI) and brittleness B_3 for 14 different rocks. Yilmaz et al. (2008) stated that the grain size seems to predominantly influence their relative brittleness index values in granitic rocks. Recently, Mikaeil et al. (2011) investigate the effect of the rock brittleness indexes on the specific ampere draw of the circular diamond saws. The results show that, there is no strong correlation between the specific ampere draw values and the brittleness of B_1 and B_2 values in carbonate rocks but there is a strong correlation between specific ampere draw and B_3. While the specific ampere draw values of granite rocks are strongly correlated with all of brittleness indexes. The used brittleness indexes in this study are given below.

$$B_1 = \frac{\sigma_c}{\sigma_t} \tag{1}$$

$$B_2 = \frac{\sigma_c - \sigma_t}{\sigma_t + \sigma_c} \tag{2}$$

$$B_3 = \frac{\sigma_c \times \sigma_t}{2} \tag{3}$$

$$B_4 = (\sigma_c \times \sigma_t)^{0.72} \tag{4}$$

Where, B_1, B_2, B_3 and B_4 are brittleness, σ_c is the uniaxial compressive strength (MPa), σ_t is the Brazilian tensile strength (MPa). Eqs. (1), (2) and (3) are widely used in the literature such as

Walsh and Brace, (1964), Niwa and Kobayashi, (1974), Beron et al., (1983), Chiu and Johnston, (1983), Kim and Lade, (1984), Vardoulakis, (1984), Koulikov, (1987), Inyang and Pitt, (1990), Goktan, (1991 & 1992), Inyang, (1991), Andreev (1995), Kahraman (2002) and Atici and Ersoy (2009). A new brittleness index (B_4) which is found as a result of laboratory studies has proposed by Yarali and soyer (2011) for percussive drilling and rotary drilling.

3.2. Operational parameters

Operational parameters that affect sawing efficiency in the circular diamond saw are:

a) Feed rate
b) Depth of cut
c) Peripheral speed

3.2.1. Feed rate

Feed rate is the velocity at which the cutter is feed, that is, advanced against the workpiece. It is expressed as distance cut per unit time. Peripheral speed, together with the forces acting on saw blade determines the feed rate or cutting speed. Maximum performance of a saw blade is achieved using the right feed rate. An excessively high feed rate will cause premature wear by tearing out the diamond particles and not penetrate into the rock sufficiently (Ersoy & Atici, 2004).

3.2.2. Depth of cut

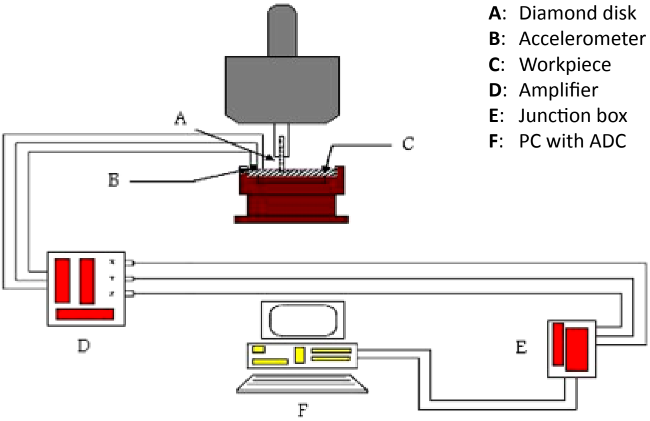
Depth of cut may be defined as the quantity of saw blade penetration into the rock. A required force for feed rate of saw blade is less than the required force for depth of cut saw blade in rocks. Depth of cut should not be increased for increasing the sawn area. Instead of this, less force can be spent with increase in the feed rate for sawing process (Ersoy & Atici, 2004).

3.2.3. Peripheral speed

The peripheral speed is the rotational frequency of the spindle of the machine, measured in revolutions per minute (rpm). Excessive spindle speed will cause premature tool wear, breakages, and can cause tool chatter, all of which can lead to potentially dangerous conditions. Using the correct spindle speed for the material and tools will greatly enhance tool life and the quality of the surface finish.

4. Predicting the system vibration

For predicting the system vibration on workpiece, experimental procedure was carried out. For this purpose, a variety of tow groups of ornamental stones contain 7 soft rocks and 5 hard rocks were saw at different feed rate (100, 200, 300 and 400 cm/min) and depth of cut (35, 30, 22 and 15 mm) using a fully-instrumented laboratory sawing rig. The rig was based on a commercially available machine and was capable of simulating realistic sawing conditions. It consists of three major sub-systems, a sawing unit, instrumentation and a personal computer. Sawing tests were performed on a small side-cutting machine, with a maximum spindle motor power of 7.5 kW. Sawing parameters such as feed rate and depth of cut were controlled in the monitoring system. The circular diamond saw blade used in the present tests had a diameter of 410 mm and a steel core of thickness 2.7 mm, 28 pieces of diamond impregnated segments (size 40×10×3 mm) were brazed to the periphery of circular steel core with a standard narrow radial slot. The grit sizes of the diamond for soft rocks were approximately 30/40 US mesh at 25 and 30 concentrations and for hard rocks were approximately 40/50 US mesh at 30 and 40 concentrations. During the sawing trials, water was used as the flushing and cooling medium. The acceleration signal was acquired along the whole cut. For monitoring the vibration in stone sawing, an adopted sensor system was designed (Fig. 2).



A: Diamond disk
B: Accelerometer
C: Workpiece
D: Amplifier
E: Junction box
F: PC with ADC

Fig. 2. A schematic diagram of the adopted sensor system

This system is made up of the data acquisition program to sample out from sensor and the judgment program to show the monitoring state on screen. An accelerometer (ADXL105-3) for measuring the acceleration of workpiece was used. This accelerometer was attached onto the sides of the workpiece to cut for monitoring the vertical direction. A monitoring strategy has been adopted based on time domain characteristics. Figure 3 shows typical time-domain signals monitored at different time interval.

After the signal is stored, a feature extraction program in Labview analyses the data. vibration feature has been extracted for the acceleration signals. The vibration value of a function $x(t)$ over an interval of T is equal to:

$$X_{rms} = \sqrt{\frac{\int_0^T x(t)^2 \, dt}{T}} \tag{5}$$

In the next step, laboratory tests were carried out. For laboratory tests, some rock blocks were collected from the studied factories. An attempt was made to collect rock samples that were big enough to obtain all of the test specimens of each rock type from the same piece. Each block sample was inspected for macroscopic defects so that it would provide test specimens free

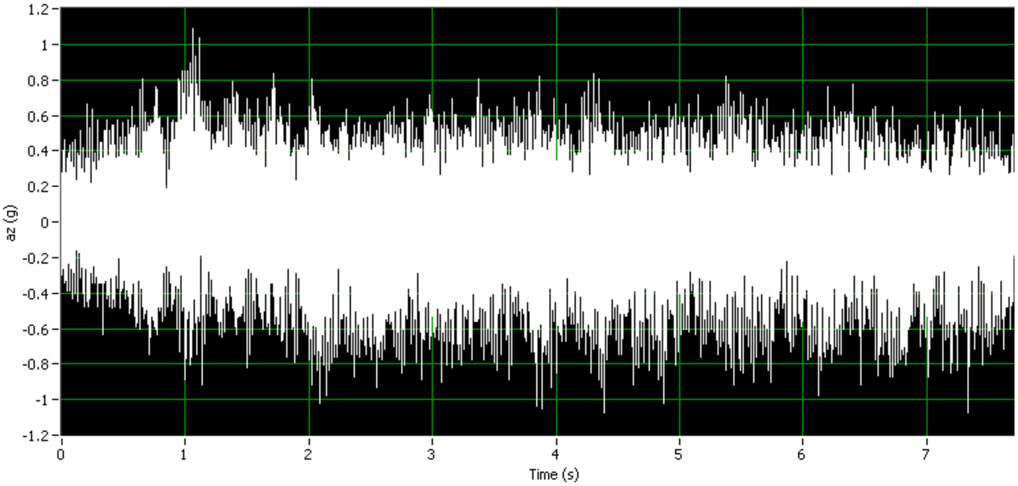


Fig. 3. Typical time-domain acceleration signals monitored at different time interval

from fractures, partings or alteration zones. Then, test samples were prepared from these block samples and standard tests have been completed to measure the rock characteristics following the suggested procedures by the ISRM standards (ISRM, 1981). The results of laboratory studies and rock sawability index are listed in table 1.

TABLE 1

The result of laboratory studies

Rock sample		UCS	BTS	B_1	B_2	B_3	B_4
		MPa	MPa				
1.	Harsin (Marble)	71.5	6.8	10.51	0.826	243.1	86.00
2.	Anarak (Marble)	74.5	7.1	10.49	0.825	264.5	91.38
3.	Ghermez (Travertine)	53	4.3	12.33	0.849	113.95	49.84
4.	Hajiabad (Travertine)	61.5	5.6	10.98	0.833	172.2	67.09
5.	Darebokhari (Travertine)	63	5.4	11.67	0.842	170.1	66.50
6.	Salsali (Marble)	68	6.3	10.79	0.830	214.2	78.51
7.	Haftoman (Marble)	74.5	7.2	10.35	0.824	268.2	92.31
8.	Chayan (Granite)	173	14.5	11.93	0.845	1254.25	280.27
9.	Ghermez Yazd (Granite)	142	8.52	16.67	0.887	604.92	165.79
10.	Sefid Nehbandan (Granite)	145	9.2	15.7	0.881	667	177.87
11.	Khoramdare (Granite)	133	8.3	16.02	0.883	551.95	155.20
12.	Morvarid Mashhad (Granite)	125	7.4	16.89	0.888	462.5	136.65

Each rock was sawn at different feed rate and depth of cut. During the sawing trials, the acceleration signal and vibration were monitored and calculated. The results of experimental procedure were used for establishing the statistical models. The input vectors of the models are divided into two parts, the first part is the rock brittleness indexes which are obtained from new classification system based on uniaxial compressive strength and Brazilian tensile strength. The second part contain the operational parameters which include depth of cut and feed rate which are very important in rock sawing process because, production rate is directly affected by these parameters. The goal of the models is to estimate the system vibration during operation in the sawing process.

4.1. Establishing the new statistical models for predicting the system vibration

The relationship between vibration and machine parameters and rock brittleness indexes is investigated by using multiple regression methods. Multiple regression methods can be divided into two types as linear and non-linear methods. In this study, the twin-logarithmic model, which is the one of the nonlinear methods, was used. The equation representing the model can be written in the following form:

$$Y = aX_1^{b_1} \times X_2^{b_2} \times \ldots \times X_n^{b_n} \tag{6}$$

where Y is the predicted value corresponding to the dependent variables, a is the intercept, X_1, X_2, X_n are the independent variables and b_1, b_2, b_n are the regression coefficients of X_1, X_2, X_n. Taking logarithms of both sides of Eq. (6) converts the model into linear form as follows:

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + \ldots + b_n \log X_n \tag{7}$$

Eq. (7) can be written as the linear regression function:

$$Y^* = c + a_1 X_1^* + a_2 X_2^* + \ldots + a_n X_n^* \tag{8}$$

Regression analysis was performed using the obtained data in experimental procedure. The vibration of system vibration was considered as the dependent variable. Operating characteristics (depth of cut and feed rate) and soft and hard rock brittleness indexes were considered as the independent variables. Regression analysis was carried out using a computing package "Statistical Package for Social Science (SPSS)". The models developed are given below.

$$V_H = \frac{D_c^{\,0.179} \times F_r^{\,0.46}}{10^{1.668} \times B_1^{\,0.215}} \qquad \text{Model (1)}$$

$$V_H = \frac{D_c^{\,0.179} \times F_r^{\,0.46}}{10^{2.004} \times B_2^{\,1.419}} \qquad \text{Model (2)}$$

$$V_H = \frac{D_c^{\,0.173} \times F_r^{\,0.464} \times B_3^{\,0.17}}{10^{2.404}} \qquad \text{Model (3)}$$

$$V_H = \frac{D_c^{\,0.173} \times F_r^{\,0.464} \times B_4^{\,0.236}}{10^{2.455}} \qquad \text{Model (4)}$$

$$V_S = \frac{D_c^{\,0.4} \times F_r^{\,0.594}}{10^{0.662} \times B_1^{\,1.891}} \qquad \text{Model (5)}$$

$$V_S = \frac{D_c^{\,0.4} \times F_r^{\,0.594}}{10^{3.455} \times B_2^{\,10.398}} \qquad \text{Model (6)}$$

$$V_S = \frac{D_c^{\,0.403} \times F_r^{\,0.597} \times B_3^{\,0.584}}{10^{3.993}} \qquad \text{Model (7)}$$

$$V_S = \frac{D_c^{\,0.403} \times F_r^{\,0.597} \times B_4^{\,0.811}}{10^{4.169}} \qquad \text{Model (8)}$$

Where V_H and V_S are the vibration value of acceleration for soft and hard rocks respectively (g), F_r is feed rate (cm/min), D_c is depth of cut (mm) and B_1, B_2, B_3, B_4 are rock brittleness indexes.

The validation of the models was carried out by considering the determination coefficient, the t-test and F-test. The statistical results of the models are given in Table 2.

TABLE 2

Statistical result of the multiple regression models

Model	**Independent variables**	**Coefficient**	**Standard error**	***t*-value**	**Tabulated *t*-value**	***F*-ratio**	**Tabulated *F*-ratio**	**Determination coefficient (*R*)**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
(1)	Constant	–1.668	0.211	–7.921	±1.65	52.170	4.61	0.8
	Dc	0.179	0.069	2.593				
	Fr	0.460	0.037	12.474				
	B1	–0.215	0.136	–1.582				
(2)	Constant	–2.004	0.153	–13.074	±1.65	52.023	4.61	0.8
	Dc	0.179	0.069	2.593				
	Fr	0.460	0.037	12.459				
	B2	–1.419	0.929	–1.528				
(3)	Constant	–2.404	0.204	–11.79	±1.65	59.062	4.61	0.81
	Dc	0.173	0.066	2.601				
	Fr	0.464	0.035	13.095				
	B3	0.170	0.530	3.216				
(4)	Constant	–2.455	0.216	–11.367	±1.65	59.062	4.61	0.81
	Dc	0.173	0.066	2.601				
	Fr	0.464	0.035	13.095				
	B4	0.236	0.073	3.219				
(5)	Constant	–0.662	0.535	–1.238	±1.65	48.000	4.61	0.8
	Dc	0.140	0.095	4.208				
	Fr	0.594	0.055	10.822				
	B1	–1.891	0.477	–3.966				

TABLE 2. Continued

1	2	3	4	5	6	7	8	9
(6)	Constant	–3.455	0.282	–12.241	±1.65	47.694	4.61	0.8
	Dc	0.140	0.095	4.195				
	Fr	0.594	0.055	10.802				
	B2	–10.398	2.657	–3.913				
(7)	Constant	–3.993	0.273	–14.650	±1.65	66.474	4.61	0.83
	Dc	0.403	0.086	4.714				
	Fr	0.597	0.049	12.093				
	B3	0.584	0.092	6.375				
(8)	Constant	–4.169	0.295	–14.155	±1.65	66.474	4.61	0.83
	Dc	0.403	0.086	4.714				
	Fr	0.597	0.049	12.093				
	B4	0.811	0.127	6.375				

The determination coefficients (R) of the models are good, but these are not necessarily identifies the valid models. The other tests must be performed. The significance of R-value can be determined by the t-test, assuming that both variables are normally distributed and the observations are chosen randomly. The test compares computed t-value with tabulated t-value using the null hypothesis. If the computed t-value is greater than tabulated t-value, the null hypothesis is rejected. This means that R is significant. If the computed t-value is less than the tabulated t-value, the null hypothesis is not rejected. In this case, R is not significant. In the models a 99% confidence level was chosen in this test, a corresponding critical t-value ±1.65 for the model was obtained. As it is seen in Table 2, the computed t-values are greater than tabulated t-value for the models, suggesting that the models are valid. To test the significance of the regressions, analysis of variance was employed. This test follows an F-distribution with degrees of freedom $v_1 = 2$ and $v_2 = 88$ and 91 for models. In this test, a 99% level of confidence was chosen. If the computed F-value is greater than the tabulated F-value, the null hypothesis is rejected that there is a real relation between dependent and independent variables. Since the computed F-value is greater than the tabulated F-value for models, the null hypothesis is rejected. Therefore, it is concluded that the models are valid. However, models 3, 4, 7 and 8 have the highest possible correlation coefficient. For practical consideration, the mentioned models were selected among all possible models. These models derived from B_3 and B_4 indexes.

To see the estimation capability of the derived models, the scatter diagrams of the observed and estimated values can be plotted. Ideally, on a plot of observed versus estimated value, the points should be scattered around the 1:1 diagonal straight line. A point lying on the line indicates an exact estimation. A systematic deviation from this line may indicate, for example, that larger errors tend to accompany larger estimations, suggesting non-linearity in one or more variables. The plots of estimated versus observed values (training and test data) for the two models (3 and 7) are shown in Figs. 4-7. In the plots for the model (7) (soft rock) the points are scattered uniformly about the diagonal line, suggesting that the model is reasonable. However, the points in the plot for model (3) (hard rock) deviate somewhat from the diagonal line, showing that there may be some doubts about the model. It is therefore concluded that the system vibration can reliably be predicted from B_3 index in soft rock sawing process (similarly, it can be shown for the B_4 index).

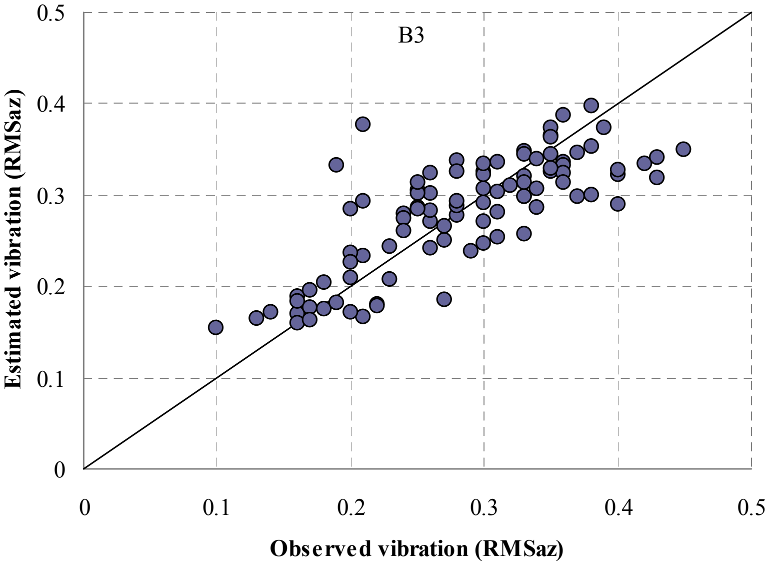


Fig. 4. Observed vibration versus estimated vibration for model 3

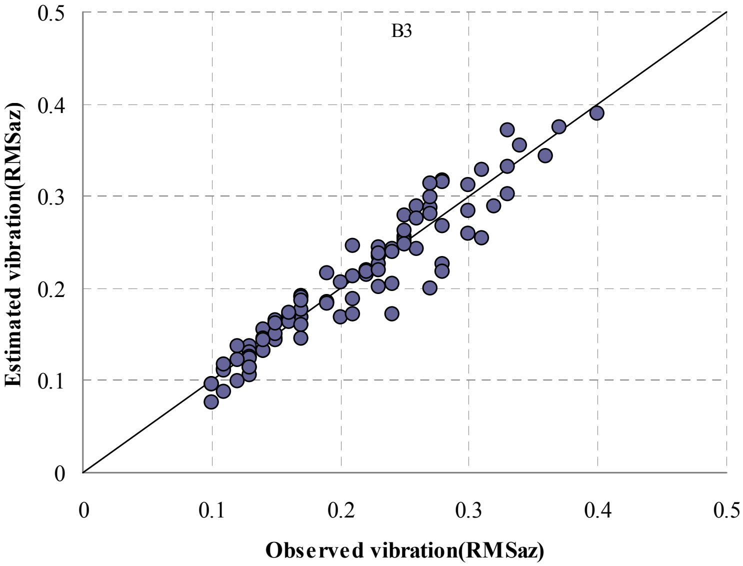


Fig. 5. Observed vibration versus estimated vibration for model 7

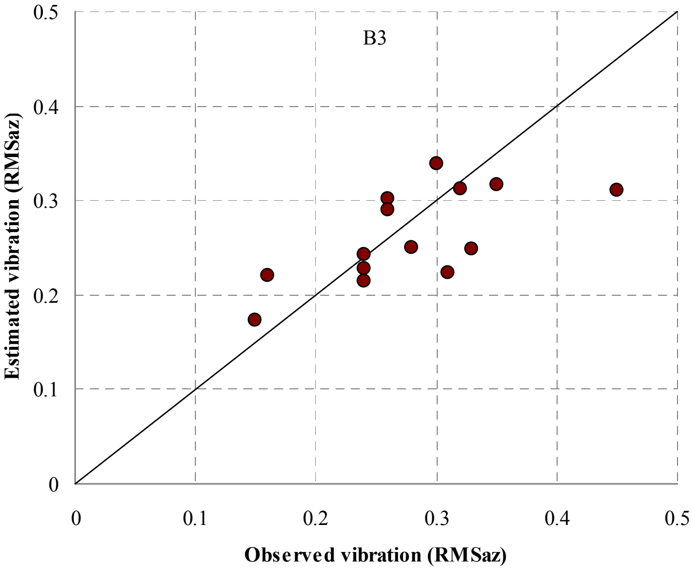


Fig. 6. Observed vibration versus estimated vibration for model 3 (test data)

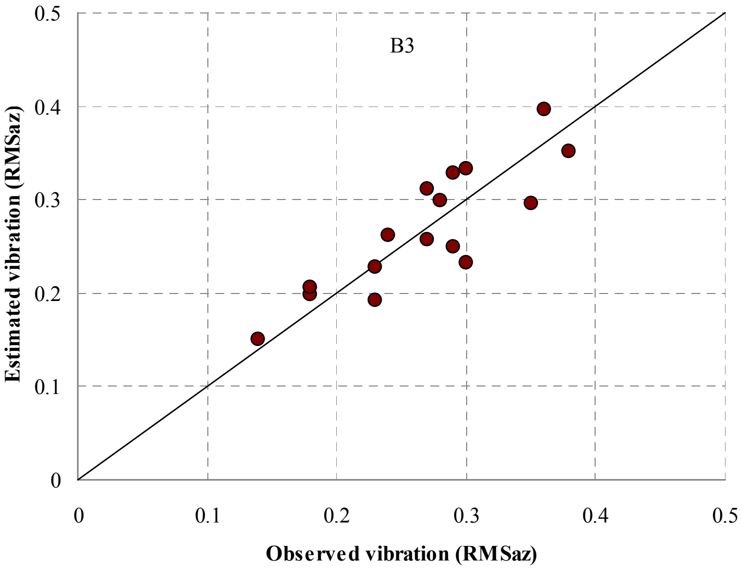


Fig. 7. Observed vibration versus estimated vibration for model 7 (test data)

5. Conclusion

In sawing process, the vibration of rocks is an important factor of sawing performance in terms of required energy and maintenance cost. The principal factors that require consideration in predicting the system vibration, particularly for stone application, is the operational parameters of the saw. In this research, it is tried to design new models for vibration of sawing machine in sawing of the hard and soft rocks via statistical models by SPSS as a general purpose linear estimator. The goal of the predicted models was to estimate the vibration of the rocks during operation in the sawing process. Vibration of the machine is a key criterion for effective life of a saw and whatever the vibration is lower the effective life of the saw will be longer. This study evaluated merits of statistical model declared by SPSS in estimation of vibration of sawing machine. Finally, four models were selected among all predicted models. Confirmation of the selected models were done by considering correlation coefficient, the F-test, the t-test and the plots of estimated versus observed values. According to simulations models could estimate the vibration with a sufficiently low error. According to the formulizing the vibration for soft and hard rocks B_3 and B_4 had the best determination coefficient. It is therefore concluded that the vibration of system can reliably be predicted from B_3 and B_4 indexes in rock sawing process.

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