17th International Mining Congress and Exhibition of Turkey- IMCET2Q01, © 2001, ISBN 975-395-417-4

Investigation into Relationship Between Cutting Depth and Vibration in Cutting Process

Y.Ozcelik, S.Kulaksiz & LC.Engin
Department of Mining Engineering, Hacettepe University, Ankara, Turkey
A.S.Eyuboglu
Department of Applied Science, University of Arkansas at Little Rock, AR, USA

ABSTRACT: Vibration occurs in disc cutter machine during the cutting process of hard rock. If the vibration frequency is high, cutting quality can decrease, the segments on disc can wear untimely, deteriorate rapidly, and energy consumption can be higher. The aim of the study is to measure the magnitude of vibration occuring in the equipment during the cutting process and to investigate the relationship between the cutting depth and vibration frequency. Experiments performed include the measurements of the components of the vertical, lateral and longitudinal particle velocity, effective frequency and highest vectorial resultant values as a function of the cutting depth. About 40 Hz average effective frequency value was measured. The only relationship was observed between the cutting depth and lateral particle velocity. Consequently, it was found that when the cutting depth increases, the lurching in the cutting machine decreases,

1 INTRODUCTION

Circular diamond saw blade used in the stone industry contains a steel core which has diamond impregnated segments brazed on the periphery (Fig. 1). The two basic functions of the segments (metal bonds) are to hold the diamond tight and to erode at a rate compatible with the diamond loss. Due to a large variety of sawing conditions many metal matrix compositions are in general use. Bonds based on copper, various bronze, compositions, cobalt, tungsten, tungsten carbide as well as combinations there of cover a wide range of stone sawing applications. Sometimes small amount of iron, nickel etc are added to aid the manufacturing process or in belief that the addition improves diamond retention or matrix wear properties; however, the complexity of compositions encountered in production practice, which in same cases comprise seven components makes a scientific approach to the total behaviour extremely difficult or even impossible (Konstanty 1991; Ozcelik et al. 2000;OzceIiketal.2001).

In general, stone cutting by circular saw blade method influenced by many factors. These factors are divided in to 3 groups (as shown in Table. 1) (Ozcelik et al. 2000; Eyuboglu, 2000; Kulaksiz et al. 2000; and Ozcelik et al. 2001).

Vibration occurs on a rock cutting machine during the cutting process of hard rock with circular blades. When the vibration frequency is high, cutting quality decreases, segments on disc can wear untimely, deteriorate rapidly, and energy consumption can be higher (Eyuboglu, 2000; Kulaksiz et al. 2000).

As seen from the Table 1, the technical properties of the working conditions such as cutting speed, peripheral speed, depth of cutting, water quantity and vibration of the machine are very important for stone cutting by circular saw blade.

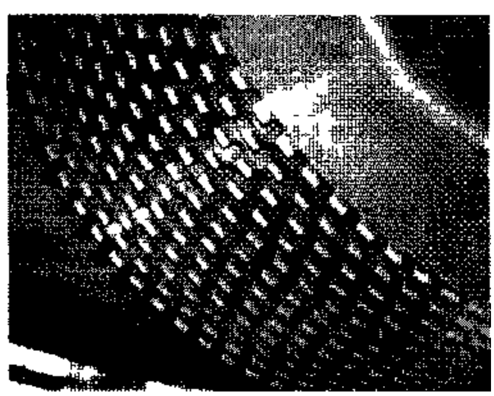

Figure I. Circular diamond saw blade

Table 1. Factors effecting the stone cutting by circular saw blade

Unchangeable Parameters

- ➤ Engineering Properties of Sawing Material
  - ⇒ Physico-Mechanical Properties
  - ⇒ Chemical Properties
  - ⇒ Mineralogical Properties
  - ⇒ Pétrographie Properties
  - ⇒ Particles Orbit and Filled Discontımıtİes
  - ⇒ Textural Properties
  - ⇒ Structural Properties
  - ⇒ Weathering Characteristics

Changeable Parameters

- ➤ Properties of Cutting Equipment
  - ⇒ Disc Diameter
  - ⇒ Blade Structure
  - ⇒ Metallurgical Structure of Matrix
  - ⇒ Tolerance Boundary
  - ⇒ Diamond Type
  - ⇒ Wear Types in Segment
  - ⇒ Peripheral Speed
- ➤ Technical Properties of Working Conditions
  - ⇒ Feeding Forces
  - ⇒ Water Quantity
  - ⇒ Cutting Speed
  - ⇒ Power of the Machine
  - ⇒ Depth of Cutting
  - ⇒ Up and Down Cutting Parameters
  - ⇒ Traverse rate
  - ⇒ Vibration of the machine

Nowadays, there are different model seismographs with and without record unit. These are small, more powerful and so they are used easily and have a high capacity for recording of vibration. Generally they have a rechargeable accumulator İn their constitution. These equipments measure the particle velocity and also give the displacement and acceleration values by calculation. When displacement and acceleration are important parameters for the study, they should be measured directly in the study. The maximum particle velocity value measured by typical seismograph is 254 mm/s and frequency interval is 2-200 Hz (Erkoc & Esen 1998).

Particle velocity is defined as the movement velocity of particle on the ground. Initial particle velocity is zero and die particle velocity decreases after reaching the maximum velocity value. Frequency shows the number of vibrations of the particle on the ground per second. Frequency is expressed by Hertz (Hz)(Kulaksizetal.2000).

The scope of this study was to determine the existence of die relationship between vibration values and cutting depth.

2 EXPERIMENTAL STUDY

The seismograph machine (Fig 2) was taken from Middle East Technical University Mining Engineering Department (Ankara, Turkey) for determining the vibration frequencies occur during the cutting of andésites.

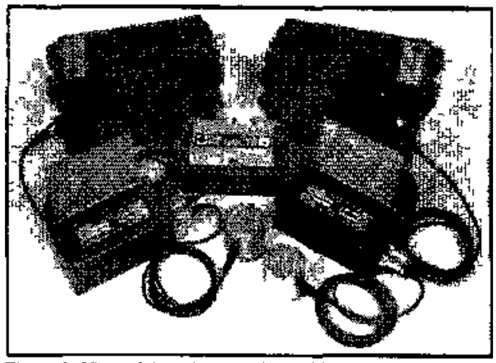

Figure 2. View of the seismograph machine.

Vibration (particle) velocity and frequency values were taken with seismograph at different cutting depth during the cutting process with disc cutter. Vertical, lateral and longitudinal velocities and highest vectorial resultant values were obtained during measurements. During the experiments, the velocity of 1200 mm in diameter circular saw blade was set at 13.1 m/rain and the cutting depth was set at 1.2 mm for forward motion and 1.1 mm for backward motion and also diamond impregnated segments in the circular saw blade were used. These constant operating parameters of this study are shown in Figure 3.

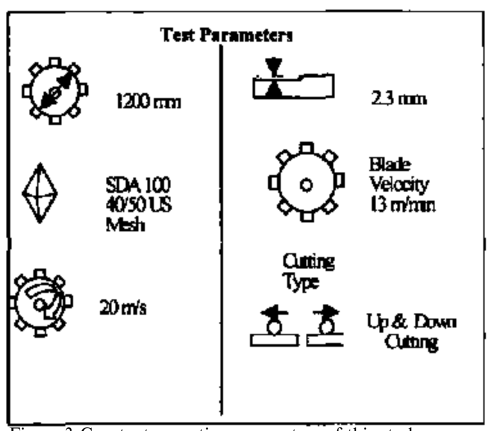

Figure 3 Constant operating parameters of this study

3 RESULTS AND DISCUSSION

Experimental values include vertical, lateral, longitudinal particle velocities (mm/s), effective frequency and highest vectorial resultant value (mm/s) as a fonction of cutting depth and results obtained were given in Table 2. Furthermore, the relationships among these properties and cutting depth were investigated and results were given in Figure 4.

When the relationship between particle velocity and cutting depth was investigated (Fig. 4), it was observed that there was no correlation between them. Lateral particle velocity varies among 0.5, 0.63 and 0.76 mm/s, vertical particle velocities were same (0.38 mm/s) except the 0.25 mm/s particle velocities at 22 cm cutting depth. Longitudinal particle velocity values vary between 0.5 and 0.63 mm/s and highest vectorial resultant value are determined among 0.63, 0.76 and 0.88 mm/s. When the relationship between lateral particle velocity and cutting depth was investigated (Fig. 4), decreasing of lurching was seen with increasing of cutting depth. Any relationship was not determined İn other figures. When the relationship between frequency values and cutting values was investigated (Fig. 4); it was determined mat lowest value of lateral effective frequency was 12.8 Hz, highest value of lateral effective frequency was 64 Hz, lowest value of vertical effective frequency was 25.6 Hz, highest value of vertical effective frequency was 51.2 Hz, lowest value of longitudinal effective frequency was 18.9 Hz, highest value of longitudinal effective frequency was 56.8. Any relationship can not be found between cutting depth and all effective frequency.

4 CONCLUSION

Many parameter affect the cutting process during sawing of rocks. These parameters are unchangeable properties related with rock, changeable and/or semi-changeable properties related with circular blade. Each variable should be controlled for economical cutting and desired capacity and it is necessary to perform the conception according to these.

During cutting process, approximately 40 Hz average effective frequency value was measured. During this process, only one relationship was determined, this was between cutting depth and lateral particle velocity. Increasing of cutting depth causes decreasing of lurching. Any relationship can not be found between other vibration values and cutting depth.

ACKNOWLEDGEMENTS

The authors would like to thank to Assoc. Prof. Aydin Bilgin and Research Assistant Sedat Esen for their kind help throughout the research.

REFERENCES

Erkoc O. Y., & Esen, S. 1998. Measurement of blast induced ground vibrations and the evaluation of the vibration recording device outputs, *3rd Drilling and Blasting Symposium,* Ankara, pp. 139-147, (in Turkish).

Eyuboglu, A. S., 2000. Investigation of segment wear on disc cutting machines in Ankara andésites, M.Sc. Thesis, Hacettepe University, Ankara, 133 p. (unpublished) (in Turkish).

ISRM, 1981. Rock Characterisation testing and monitoring; suggested methods: Oxford, 16 p.

Konstanty, J., 1991. The materials science of stone sawing, *Industrial Diamond Review,* No: 1, pp. 27-31.

Kulaksiz, S., Ozcelik, Y., Eyuboglu, A.S., Engin. I.C, Gene, Y., 2000. Statistical and microscopic investigations of diamond segment wear after sawing of hard rocks by circular disc, *Hacettepe University Research Fund,* Project No: 99 02 602 003 (unpublished).

T.S.E., 1987. Testing and examination methods of natural building stones, T.S. 669, TSE. Press, Ankara, 82 p. (in Turkish)

Ozcelik, Y., Eyuboglu, A. S., Kulaksız, S., Engin. I.C, Özgüven, A., 2000. Investigation of the affect of up and down cutting parameter on the current consumed in the process of cutting with disc in hard rocks, *V. National Rock Mechanics Symposium of Turkey,* pp. 123-128.

Table 2. Partical velocity (P.V.) and effective frequency values occurred during the rock cutting with disc cutter.

Record Number	Current (Ampere)	Recording Time	Cutting Depth (cm)	Lateral Partical Velocity, ppv, (mm/s)	Vertical Partical Velocity, ppv, (mm/s)	Longitudinal Partical Velocity, ppv, (mm/s)	Highest Vectorial Resultant Value, pvs, (mm/s)	Lateral Effective Frequency, (Hz)	Vertical Effective Frequency, (Hz)	Longitudinal Effective Frequency, (Hz)
2	124	10.57	0	0.50	0.38	0.50	0.63	64.0	39.3	36.5
3	148	10.59	1.0	0.76	0.38	0.50	0.88	17.0	36.5	20.4
4	148	10.59	1.3	0.63	0.38	0.50	0.63	18.9	36.5	18.9
5	152	11.00	1.5	0.63	0.38	0.63	0.76	17.6	30.1	30.1
6	152	11.02	2.0	0.76	0.38	0.63	0.88	18.2	34.1	19.6
8	154	11.10	5.0	0.63	0.38	0.63	0.76	25.6	46.5	30.1
9	154	11.10	5.0	0.63	0.38	0.63	0.63	26.9	39.3	26.9
10	157	11.21	10.0	0.50	0.38	0.63	0.63	19.6	32.0	34.1
11	157	11.21	10.5	0.63	0.38	0.63	0.63	12.8	36.5	34.1
12	158	11.32	15.0	0.50	0.38	0.50	0.63	28.4	34.1	30.1
13	158	11.39	18.0	0.50	0.38	0.50	0.63	23.2	36.5	32.0
14	158	11.43	20.0	0.50	0.38	0.63	0.63	32.0	25.6	56.8
15	160	11.45	21.0	0.63	0.38	0.63	0.76	21.3	34.1	32.0
16	161	11.47	22.0	0.50	0.25	0.50	0.63	64.0	51.2	32.0
20	161	11.50	23.0	0.63	0.38	0.50	0.63	23.2	34.1	34.1

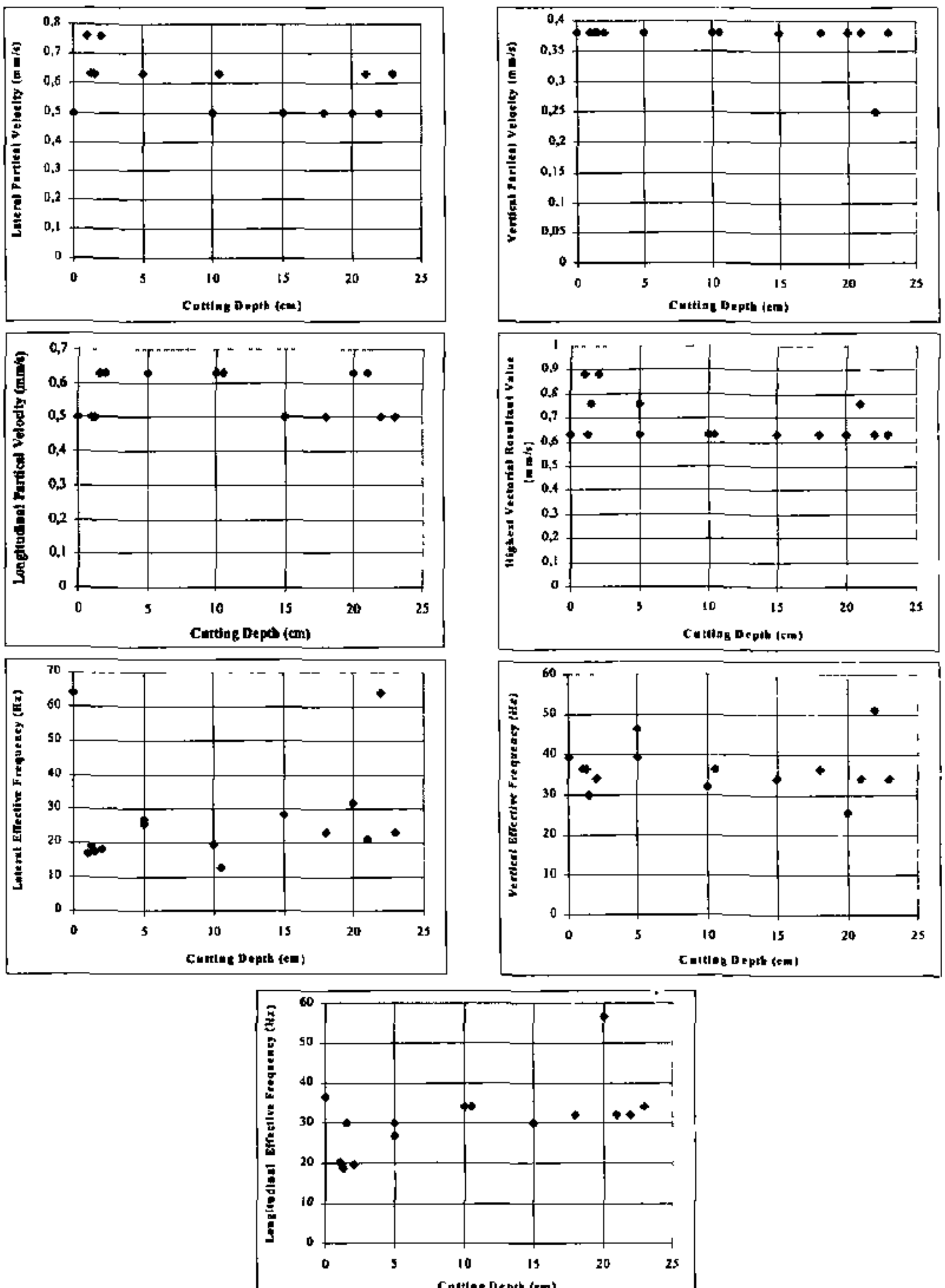

Figure 4 Relationships between particle velocity, effective frequency and cutting depth.