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MINIMIZATION OF BLASTING-INDUCES VIBRATIONS IN A METAL MINE USING SURFACE WAVE MITIGATION

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Abstract

In rock excavations using blasting, the effects of seismic waves propagating into the environment are very important. Severe seismic vibrations can cause damage to nearby structures, buildings and even open pit slopes within the quarry, as well as to the leach fields, if any. Vibrations can affect structural integrity and lead to cracks. In this study, a different approach from conventional methods is adopted to reduce blasting-induced vibrations. The new method is based on the principle of surface wave mitigation and aims to minimize vibrations by considering the interaction of seismic waves with each other. Within the scope of the study, two group blasts were carried out in a metal mine in Turkey using an electronic ignition system to compare the traditional method with the innovative, novel method, and a pilot blast was carried out to be used in the developed method. Since the seismic signal obtained from the pilot blast contains geological information throughout the area it passes through, no geological data is needed for group blasting modeling. When the recorded data is analyzed, the positive contribution of the method based on the principle of surface wave mitigation to the environmental impact and blasting efficiency of the detonation whose delays are determined by the method based on the principle of surface wave mitigation is clearly evident.

Key words

Electronic initiation system, seismic waves, blasting, vibration,fly rock

1 Introduction

Crushing rock masses by blasting is one of the most powerful and economical methods in mining, quarrying, road, tunnel, dam, construction and infrastructure works. However, increasing competition, environmental protection requirements and safety measures have necessitated the development of new blasting techniques. Along with these developments, environmental impacts caused by blasting such as stone blasting, air shock, dust emission and vibrations have also come to the fore. Among these impacts, vibrations caused by blasting cause the most complaints. This is because while stone blasting and air shock are effective in areas close to the blasting point, blasting vibrations can be felt even at much greater distances. For this reason, conscious and sensitive enterprises should carry out or have the necessary measurement and evaluation studies carried out to minimize the negative effects of blasting and to prevent damage to the environment.

As it is known, electronic detonation systems have been used in the world for more than 30 years. These systems enable the design and implementation of highly successful blasts in mines to prevent ore contamination, ensure slope stability, obtain the desired fragment size, minimize vibration and air shock problems. In this study, it is aimed to see the application of electronic firing systems in the field and to compare the results with similar blasting with a non-hand firing system. As known from the literature,

electronic igniters provide more accurate timing than conventional pyrotechnic igniters based on the burning rate of a pyrotechnic composition. (Cardu, 2013).
In this study, delay values that aim to minimize vibrations by taking into account the principle of surface wave attenuation and the interaction of seismic waves with each other are used against the conventional delays in blasting using an electronic firing system. The aim is to compare these delay values with the vibrations that occur as a result of blasting. In this context, the mentioned delay values, which aim to minimize vibrations by taking into account the principle of surface wave attenuation and the interaction of seismic waves with each other, were processed into our patented software Seisblast Promax with the signal received from a single hole blasted representing the group one day before the group blasts and the delays were determined.

Electronic capsules, which have been used globally for more than 30 years, have not yet achieved widespread use in our country except for special applications. One of the main reasons for this is the lack of sufficient studies on this subject. For this reason, it is aimed to shed light on the subject by researching and revealing the advantages of electronic ignition systems in order to popularize the use of electronic ignition systems by enterprises and to raise our country to the level of global technology in the field of mining.

2 Methods

As part of an experimental study, 1 pilot blast and 2 group blasts were conducted in a metal mine. In order to determine the electronic delays in the 30-hole group blast, a single-hole pilot blast was first performed. Seismic data from the pilot blast were subjected to signal analysis with the Seisblast Promax program and electronic delays were determined. A total of 3 blasts were conducted, one group of 30 holes in which the delays determined as a result of seismic wave analysis from the pilot blast were applied and another group of 30 holes in which the delays were given classically. The aim here is to use the delays determined using Seisblast Promax software and compare the results with similar blasting with conventional (17-25 ms) delays using electronic firing system.

Group blasting locations and seismograph locations are given in Figure 1.

Figure 1. Group blasting locations and seismograph locations (Seismographs: micro,14465,12269,13638,12270)

Seismic waves from the pilot blasting were recorded with 4 seismographs and seismic waves from the group blasting were recorded with 5 seismographs. Thus, it was possible to analyze and analyze the seismic waves generated by the blasts with electronic capsule and to compare them with the results of previous blasts in the same area with conventional delays (17-25 ms) and seismic recordings made by us using Seisblast Promax software. For group blasts, the nearest seismograph (micro) was placed 60 m away from the blasting location and the farthest seismograph (12270) was placed 182 m away.

The delays were determined using Seisblast Promax software using micro-coded seismograph data located 51 m from the blast location in the pilot blast.

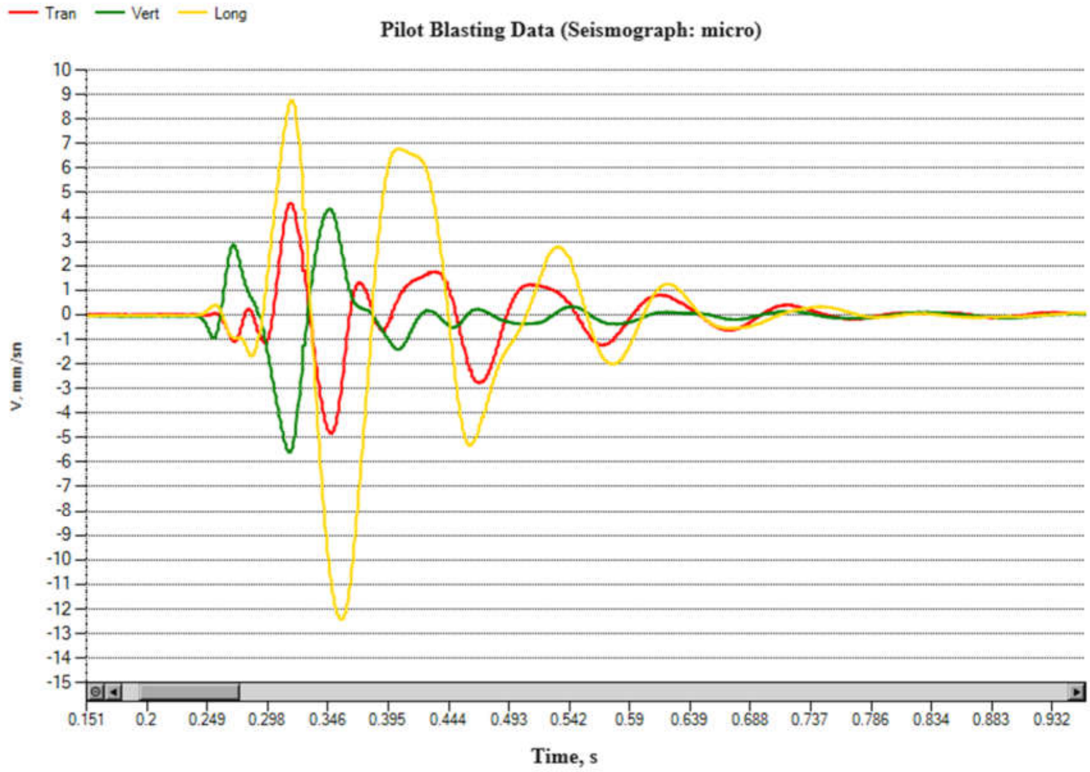

Figure 2. Pilot blasting data recorded from seismograph micro

Electronic capsule delays were determined by us, uploaded to the logger and defined to the capsules in the field (Figure 3).

Figure 3. An image from the field application of electronic capsules

Information on the blast geometry of the group and pilot blast holes is given in Table 1.

Table 1. Information on the blast geometry of the group and pilot blast holes

Blasting Location	Hole Diameter, mm	Average Hole Length, m	Blasting Geometry	Explosive Quantity, kg	Detonating Element	Number of Holes
Pilot	102	5.5	-	Emulsion: 10 Anfo: 12.5 Dynamite: 0.5	Nonel Capsule	1
Group-1 (17-25ms) Classical Delays Applied	102	5.5	Burden: 3.1 Spacing: 3.6	Emulsion: 10 Anfo: 12.5 Dynamite: 0.5	Electronic Capsule	30
Group-2 SeisBlast Promax Delays Applied	102	5.5	Burden: 3.1 Spacing: 3.6	Emulsion: 10 Anfo: 12.5 Dynamite: 0.5	Electronic Capsule	30

Group blast holes are shown in figure 4.

Figure 14. Group blast holes

Figure 5 shows the delays applied to the holes for conventional blasting and Figure 6 shows the delays applied to the holes using Seisblast Promax software, respectively.

Figure 5. Delays applied to the holes for conventional blasting system

Figure 6. Delays applied to the holes using Seisblast Promax software

The reason for choosing these delays is to minimize the effects of blasting-induced seismic waves on the slopes and the surrounding residential areas. With the data obtained from the pilot blasting, the designs were made through SeisBlast_Plus software, and in this way, it was aimed to control and minimize the vibration values at the specified distances. The number of holes, hole geometry and seismograph locations are the same for both electronic capsule group blasts.

3 Results

Table 2 presents the results of measurements using different seismograph instruments (Micro, 14465, 12269, 13638, 12270). For each seismograph, pilot and two separate groups (Group 1 and Group 2) data are included. These data show particle velocity readings and dominant frequencies in the lateral (T), vertical (V), longitudinal (L) and peak particle velocity (PPV) components of the seismic waves.

Table 2 shows the particle velocity and frequency values of seismic waves generated by pilot and group blasts measured on seismographs.

Table 2. Vibration and frequency values recorded from pilot and group blasts

Seismograph	Groups	Measurement Distance, m	T mm/s	V mm/s	L mm/s	PPV mm/s	Dominant Frequency Hz
Micro	**Pilot**	51	4.839	5.588	12.43	13.36	9.75
	Group 1	60	10.3	6.936	11.97	13.55	12.75
	Group 2	63	5.029	4.658	8.859	9.335	6.69
14465	**Pilot**	92	1.397	1.016	3.302	3.665	7.5
	Group 1	90	4.826	3.429	4.572	5.242	6
	Group 2	96	2.667	1.27	3.048	3.391	5.25
12269	**Pilot**	120	1.143	0.381	1.27	1.356	7
	Group 1	130	2.286	1.778	3.937	4.042	6
	Group 2	140	2.794	0.762	1.905	3.314	5.25
13638	**Pilot**	97	0.635	1.016	2.413	2.646	9.25
	Group 1	158	1.651	1.397	3.429	3.657	5.75
	Group 2	161	1.778	1.016	1.778	2.044	5.25
12270	**Pilot**	-	-	-	-	-	-
	Group 1	182	0.635	1.651	2.667	2.814	4.88
	Group 2	192	1.143	1.143	1.27	1.571	5.25

The vibration values caused by Group 2 blasting, which is done by assigning electronic delays determined using Seisblast Promax software to the holes, are below the vibration values caused by Group 1. Electronic capsules were used in both groups of detonations, but the main difference here is that in group 2, in addition to the classical delays, they were determined by the principle of seismic wave analysis. When the longitidunal component values of seismographs 12269 and 13638 are examined, it is seen that the 2nd group minimizes the vibration by about 1/3.

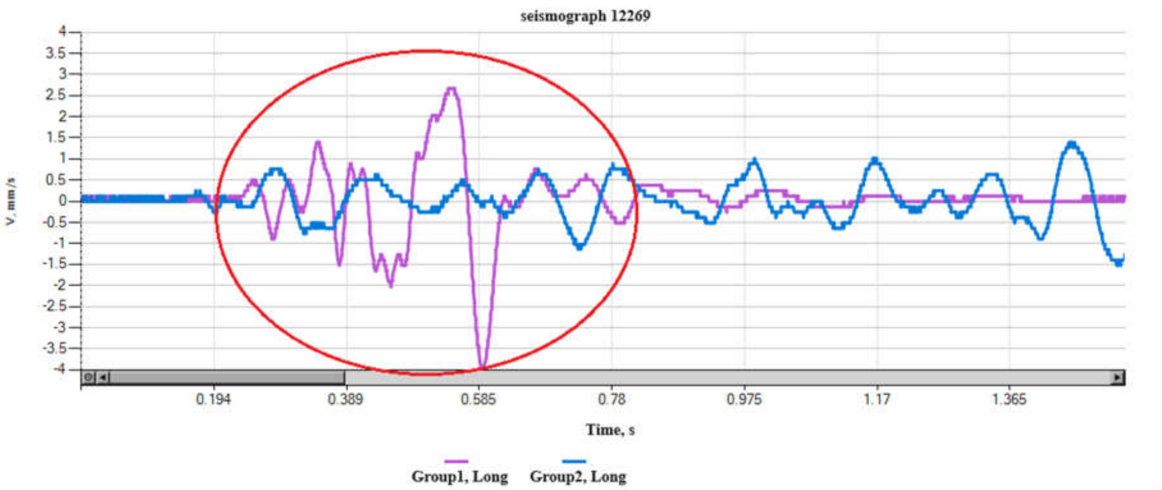

Figure 7. Comparison of group1 and group2 from seismograph 12269 in the longitidunal component

Figure 7 shows that for seismograph 12269, the seismic signal in the long component of Group 1 (purple color) has higher amplitudes than Group 2 (blue color). Especially during the main seismic activity period between 0.389 and 0.585 seconds, the velocity values of Group 1 are up to ±3.5 mm/s, while the velocity values of Group 2 remain around ±2 mm/s. This suggests that the blast or seismic event in Group 1 was stronger and produced a larger velocity change. Both groups stabilized in the period after the main seismic activity.

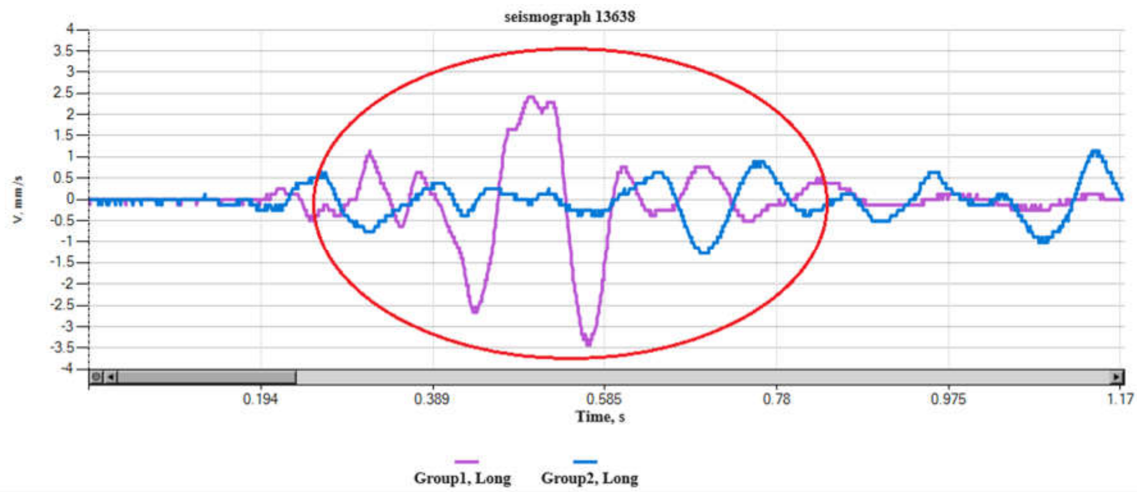

Figure 8. Comparison of group1 and group2 from seismograph 13638 in the longitidunal component

Figure 8 shows that for seismograph 13638, the seismic signal in the long component of Group 1 (purple color) has higher amplitudes than Group 2 (blue color). Especially during the main seismic activity period between 0.389 and 0.585 seconds, the velocity values of Group 1 are up to ±3.5 mm/s, while the velocity values of Group 2 remain around ±2 mm/s. Both groups stabilized in the period after the main seismic activity.

4 Conclusion

In modern mining and civil engineering applications, the use of electronic delay systems in blasting processes is becoming increasingly common. Electronic delay systems offer a number of advantages by giving the user precise control over the timing of the blasting process. Electronic delay systems offer much more flexibility than traditional mechanical and chemical delays. These systems allow users to customize blasting layouts and timings to suit their needs. For example, where vibrations during blasting need to be minimized or fracturing needs to be optimized with a specific orientation, electronic delays can be used to create ideal timing combinations. This leads to more controlled and targeted blasting results. The use of electronic delay systems in blasting processes significantly improves both safety and operational efficiency with their user-friendly features and flexibility. The possibilities offered by this technology allow blasting operations to be carried out in a more controlled, safe and environmentally friendly manner in modern mining and civil engineering applications. In this context, the use of electronic delays is considered an important development in blasting design and applications.

In this study, we used Seisblast Promax software to analyze the seismic waves and determine the delays that will dampen each other as a result of this signal analysis. Group 2 blasting with the delays we determined using Seisblast Promax software reduced the vibration by one third compared to Group 1 blasting with conventional delays. In addition, there was no heave and the fragmentation was more homogeneous.

Contrary to what is known, by modeling the seismic signals received from the blasting of a single hole, group blasts of 400-500 holes can be planned that will not harm the environment. International patents and international publications on this scientific fact are abundant in the literature. What is important here is not the number of holes, but the right blasting design and the implementation of this design with the right blasting elements.

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