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THE SCANNING OF ACOUSTIC SIGNAL AS A COMPONENT OF MONITORING THE ROCK DISINTEGRATION PROCESS

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ABSTRACT
A classical monitoring system enables measuring of the thrust, revolutions and power supply as input values and advance rate of the tool as an output value during the disintegration process. The monitored data provide a source for calculation of the specific volume disintegration energy and consequently the working ability as a ratio of advance rate and specific volume energy. Both variables serve as the rating values of disintegration process efficiency.
The acoustic oscillations arise during the rock disintegration process. The sources of the oscillations are all of the components taking part in disintegration, i.e. the disintegration equipment, the disintegration tool and the rock.
The classical monitoring system was adjusted to acoustic signal scanning in the experimental laboratory conditions. After the scanning, the acoustic signal was evaluated and studied, showing the dependencies between the input values and the acoustic signal characteristics. This experience leads to the potential use of acoustic signal for evaluation and control of the disintegration process.

KEYWORDS: acoustic signal, monitoring, disintegration process, rock

1. INTRODUCTION

At present stands are used as model experimental pieces of equipment for the purpose of imitating rock disintegration at several scientific institutions. The Institute of Geotechnology of the Slovak Academy of Sciences in Košice possesses a stand adapted for the rotary drilling of rocks by small-diameter drilling instruments. Cylinder or block shaped rock samples with a length of 30 cm and width of 20 cm are used for experimentation. Diamond drilling bits up to a diameter of 7 cm are tested.

At present the workplace is solving a research task that also involves the use of the acoustic signal, which arises during the disintegration process.

2. DISINTEGRATION PROCESS MONITORING

The system is accommodated to scan and record several input values of the disintegration process, mainly thrust, revolutions and disintegration output, as well as the speed of the tool advance in the rock as an output quantity. Scanned values are recorded by a computer and subsequently processed and evaluated. Other values, e.g. specific volume work of the disintegration and work capacity of a tool as a quotient of velocity and specific volume work of the disintegration can be calculated from them.

The rock disintegration process is accompanied by significant noise. Acoustic oscillations result from the rock disintegration. The source of acoustic oscillations in the rock disintegration process are in fact all the components that participate in the disintegration process, i.e. drilling equipment, in our case the drilling stand, all its components as well as the tool and rock itself. They put the air in motion and are the source of the noise.

In order to use the acoustic signal somehow in the disintegration process, it must be scanned, processed and studied. Therefore a classical monitoring system has been enhanced by a microphone, which is located in a defined place within the acoustic territory, and registers the acoustic oscillations that pass through the environment to the microphone. The scanned acoustic signal is processed by means of a Fourier transformation and it decomposes a general non-harmonic periodical process in harmonic elements that can be used for the characterization of the rock disintegration process. There are several possibilities and methods for the acoustic signal evaluation, (Krepelka et al., 2002).

It should be noted that the microphone registers a complex surrounding noise that comes to it from the environment, therefore it is desirable to eliminate the noise not connected with the disintegration process. Despite meeting the above stated requirements, the signal which is not a direct result from a particular disintegration process is also included in the evaluation, as principally, under the conditions of the stand research, two basic conditions can be distinguished, mainly, noise at idle run and noise resulting from the rock disintegration.

The noise at idle run has the following components:

- -driving aggregate noise,
- noise resulting from drilling water, which is directed towards the rotating tool and rock,
- irregular detaching of vortices on the tool edges, which are referred to as vortice noise,
- periodical variable forces.

The noise resulting from the disintegration consists of the following components:

- noise caused by the rock, like the noise generated by drilling, resulting directly from the tool edge engagements,
- noise caused by disintegration. When drilling, both the tool and the rock are excited by short pulses of cutting force to the oscillation. The more oscillation sensitive the rock is, i.e., the more flexible it is, the louder the noise. The noise is affected not only by the rock properties, but also by the way the tool acts,
- the effect of noise, caused by the edge blunting, on the noise resulting from processing is decisive only at higher degrees of blunting.

It is easier to control noise resulting from the idle run than the noise caused by drilling. It would be ideal to suppress the noise caused by the idle run totally, however it is not possible.

3. OBTAINING EXPERIMENTAL DATA

The evaluation of a scanned acoustic signal requires digital processing. With this in mind purpose the monitoring system is equipped with a standard IBM PC, enhanced by an auxiliary input-output PCL 818L card from the American company Advantech Co., the task of which is to transform the signals from the sensors into digital form. As the signal from the microphone is evaluated in the frequency area, a high sampling frequency must be ensured. The method of a "direct memory access" (DMA) using a specially integrated circuit Intel DMA 8237 is used for scanning the signal by the microphone, (Leššo et al., 1997).

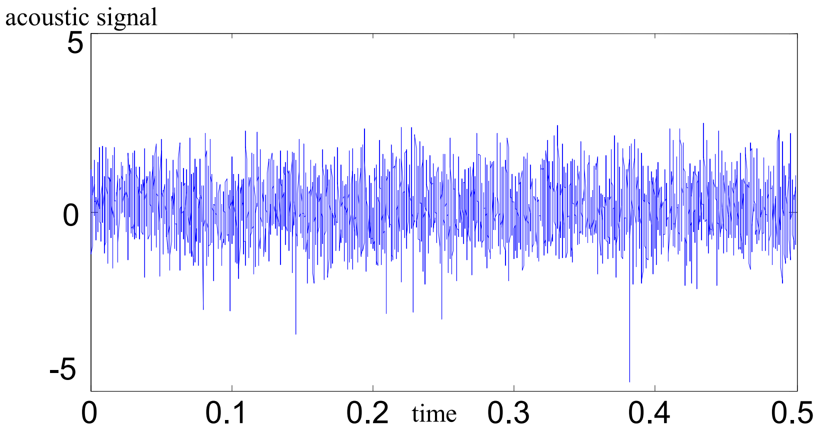

Fig. 1 Change of the acoustic signal amplitude during drilling

Figure 1 shows the scanned acoustic signal, or the time-dependent change of the acoustic signal amplitude, particularly for drilling andesite by means of a diamond bit.

In order to obtain at least a partially verifiable result of the research task, an ample number of experimental data on the disintegration process is required. The disintegration process can occur with various kinds of rocks as well as various types of tools. There may be another requirement to control the process so that it is optimum according to certain criteria, such as the requirement of a maximum momentary disintegration speed, minimum specific disintegration work, maximum tool service life or another criteria, (Krepelka a kol., 2001). Each of these requirements results in a significant multiplication of experiments.

In our current research we have selected modes with constant revolutions and constant thrust for our experiments. Acoustic signals have been scanned and recorded along with the scanning of thrust, revolutions and other values.

4. EXPERIMENTAL DATA ANALYSIS

When analysing the noise it is important to define the exact reason of its origin, i.e. its source and ways of propagation, or take such an indicator as the noise quantity, which enables the characterisation of the noise generator or reasons for its change unambiguously.

The power spectral density seems to be such a noise indicator. It shows its maximum values in the frequency band of between 500 and 1000 Hz and has proven to react to the change of the disintegration process mode. Figure 2 illustrates the course of these characteristics for the discreet frequency bands. As the difference between the power spectral density for the individual rocks samples is the biggest in this particular frequency band, we have decided to include into the evaluation the values of the power spectral density from this particular frequency band and tried to relate it with revolutions and thrust of the disintegration process.

For the experiments an impregnated diamond bit was used as a drilling tool and granite from the Hnilec region and andesite from Ruskov were drilled. Constant revolution levels of 800, 1100 and 1400 min^{-1} were selected. Our aim was to keep the thrust constant, however, it increased slightly during one experiment, therefore only a narrow part of the drilling, where the thrust increased by a little, was included in the evaluation.

Some results are processed and illustrated in figures 3, 4 and 5. These are the dependences of the power spectral density on revolutions of a selected mode. Individual points are connected by lines in the figures, for a better illustration. The power spectral density values have been scanned at the frequencies of 500 Hz and 1000 Hz. Therefore there are always two lines for one rock in the figures, and in the legend they are distinguished by numbers 500 or 1000 at the appropriate rock. Revolutions were kept at the nocstant level during one drilling. As for the thrust, we have included sections with the trust between 6 500- 8 500 N in the evaluation. We do not state the value of the power spectral density, as it is a stress quantity and its size is not important.

As can be seen in figure 3, in all cases the trend of increasing the power spectral density with the increase of revolutions is preserved. Only in one case, with the granite 500, is it different. Within the revolution range from 800 to 1000 min^{-1}, the power spectral density increases, however with a further increase in revolution it decreases. Therefore we have tried to compare our experiment with another one, with a different thrust at a revolution of 1100 min^{-1}. Figures 4 and 5 show the results of the same experiments as figure 3, but for granite 500 an experiment at a revolution of 1100 min^{-1} with a thrust of 5000 N (figure 4) and with a thrust of 9000 N (figure 5).

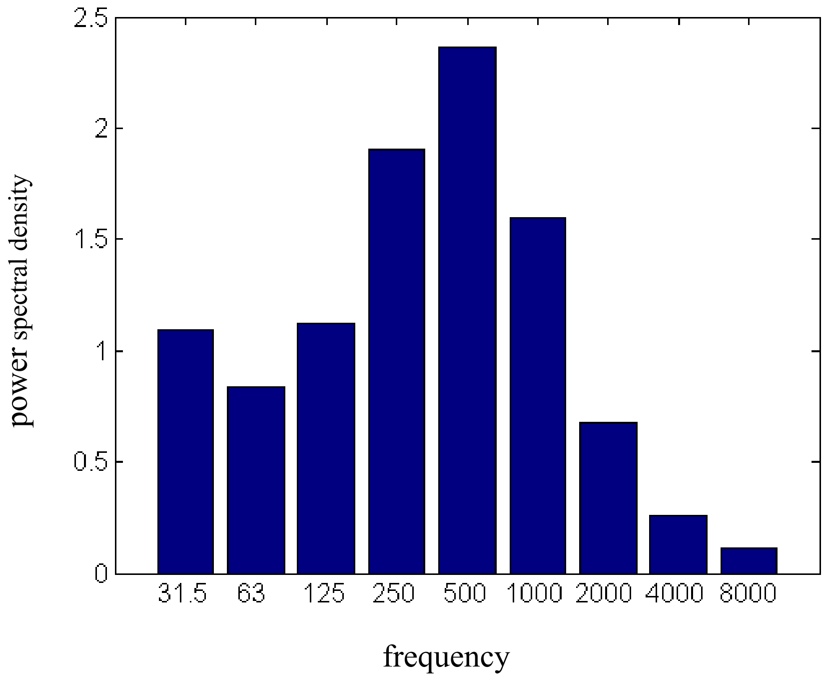

Fig. 2 The power spectral density for the discreet frequency bands

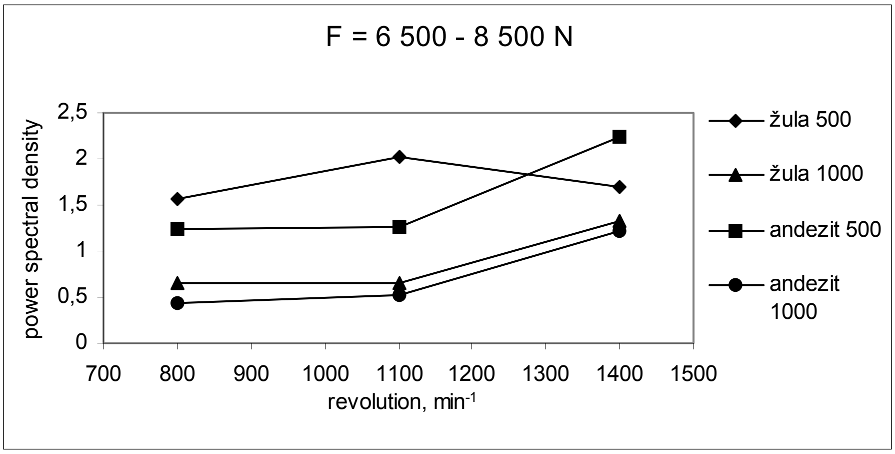

Fig. 3 Trends of the dependences of the power spectral density on the disintegration process revolutions
F = 6 500 N – 8 500 N

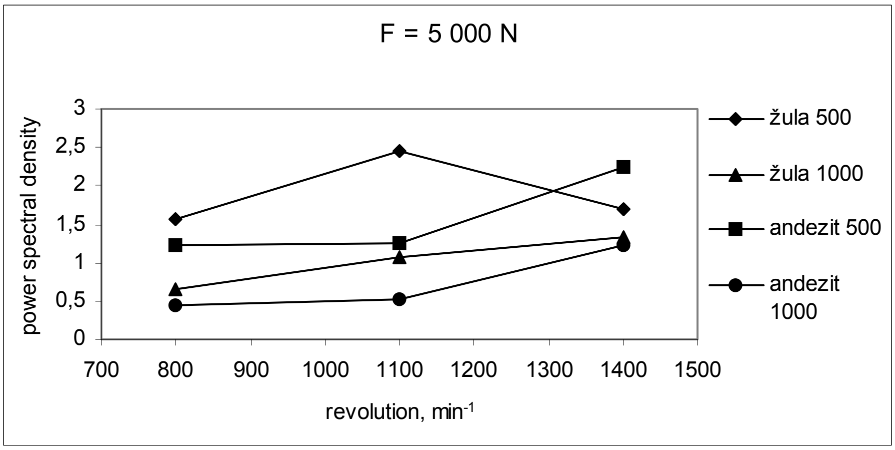

Fig. 4 Trends of the dependences of the power spectral density on the disintegration process revolutions
F = 5 000 N

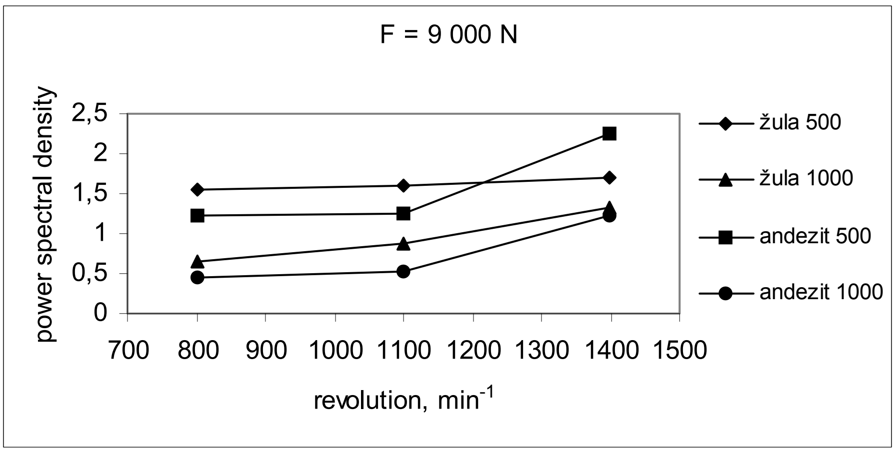

Fig. 5 Trends of the dependences of the power spectral density on the disintegration process revolutions
F = 9 000 N

The comparison of all figures shows that the decrease of the power spectral density from 1 000 min^{-1} to 1 400 min^{-1} slows down with the increasing thrust, and Figure 5 even shows its increase.

5. CONCLUSION

The aim of the research task was to include the acoustic signal in the control of the rock disintegration process through the scanning and processing of this signal, as it accompanies the disintegration process.

Based on the stated results it can be pointed out that the disintegration process modes significantly affect the acoustic signal characteristics.

A concrete specification of the disintegration process and its mode based on the acoustic signal characteristics requires a great deal of verifying experiments, including a sufficient amount of various rocks and tool types.

The aim of the research is to identify and describe such new values depending on the thrust and revolutions, derived from the acoustic signal by means of a Fourier transformation, by means of which we can control the rock disintegration process without a classical monitoring of the rock disintegration process, i.e. without scanning the thrust and revolution.

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