EXPERIMENTAL INVESTIGATIONS INTO ACOUSTIC EMISSION IN COAL SAMPLES UNDER UNIAXIAL LOADING

V. L. Shkuratnik, Yu. L. Filimonov*, and S. V. Kuchurin

UDC 622.02:539.2

The results are presented for the experimental investigations into acoustic emission during mechanical uniaxial testing of coal sample at the assigned rates of loading. Proceeding from a comparison between the parameters of acoustic-emission and stress-strain curves, the stages of deformation are identified and the physicomechanical properties of coal are determined.

Coal, acoustic emission, deformation stages, ultimate strength, experiment

INTRODUCTION

Acoustic emission (AE) is a phenomenon that accompanies any, even the most insignificant irreversible and partially reversible changes in structure of solids under the action of various external physical factors. In this connection, it is apparent that AE is a promising method of investigating deformation and failure of rocks. It is no coincidence that from the 1950s, recording and analysis of AE parameters has been used to predict hazardous dynamic phenomena in mines [1]. At the same period of time, the first laboratory investigations into AE regularities have begun on coal sample [2]. These studies established qualitative interrelations of AE parameters with strength and degree of inhomogeneity and showed that different stages of deformation are characterized by the particular features of emission.

It should also be noted that most acoustic emission investigations on coal were conducted in sound and low ultrasound frequency ranges, and the corresponding gaging equipment had low sensitivity and noise-immunity. As a consequence, taking into account high frequency-dependent attenuation of elastic waves in coal [3], AE allowed examination predominantly of macrofailure of geomaterials and did not provide an information on the “fine” structure dynamics. While this knowledge is required for revealing the mechanisms and quantitative regularities of deformation and failure of samples. Besides, there is up to now a limited number of the acoustic emission investigations that are carried out on coal samples. The investigations do not cover all practically important regimes, and AE features, which are characteristic of elastic and plastic rocks, cannot be studied on coal. This circumstance is explained by coal specificity owing to its very complex structure and properties (anisotropy, inhomogeneity, jointing, physicochemical activity, etc.). From the physicomechanical point of view, instaneous strain, elastic hysteresis, and irreversible plastic strain are intrinsic to coal as a viscoelastic material [4]. Coal is characterized by a variety of genetic types and petrographic composition, and by genesis peculiarities (biogenic high-polymeric sedimentary rock), which somewhat complicates interpretation of the received acoustic-emission information. There also exist technological problems since it is difficult to manufacture regular-shaped samples without additional disturbance and with reliable conditions of contact between transducers and the object under control.

Moscow State Mining University, E-mail: ftkp@mail.ru, Moscow, Russia. *“Podzemgazprom” Joint-Stock Company, E-mail: saltmary@stt.ru, Moscow, Russia. Translated from Fiziko-Tekhnicheskie Problemy Razrabotki Poleznnykh Iskopаемых, No. 5, pp. 42-49, September-October, 2004. Original article submitted July 5, 2004.
Acoustic emission investigations are extremely acute, as, first of all, microseismic activity of a whole coal-bearing rock mass is associated with coal failure. This fact is governed by lower strength and greater disturbance of coal as compared with enclosing rocks.

This paper is aimed at establishing AE regularities at different stages of coal deformation and estimating possibilities of determination its physicomechanical properties with due regard for the mentioned regularities.

**METHODOLOGY OF THE EXPERIMENTS**

The object of the present investigation was coal of the former “Zapadnaya” mine in the territory of Novoshakhtinsk town of the Rostov Region (Eastern Donets Basin). The measurements were conducted on cylindrical anthracite samples from the “Stepanovskiy” stratum. The samples were drilled from solid blocks extracted from a depth of about 700 m and were 50 mm in diameter and 100 mm in height.

These anthracites are related to the genetic type III (low-recovery) with high anisotropy of vitrinite reverberation. They belong to mixed clarains, durain-clarains, and rare to clarains-durains; with respect to petrographic compositions, they slightly differ from other medium-carbonic coals of the Donets Basin.

The characteristic averaged values of microcomponent composition and content of mineral admixtures of coal substance are presented in Table 1. The data indicate a peculiar geology of pet formation. Practically all microcomponents of coals vary greatly, and mineral admixtures are mainly represented by clayey substance. In the studied sample of coal, epigenetic minerals of formations of carbonates, quartz, and sulfide iron are present in interstitial cavities.

Enclosing rocks and rock interlayers are mostly clayey and sandy shales with an organic substance content of up to 40–45% and are classified as coaly ones. Clays have predominantly hydromicaceous mineral composition.

Coals of the studied samples belonged to the subgroup of the third vitrinite anthracite. With respect to the values of volatile substance yield, organic mass density, volume yield of volatile substances, and logarithm of specific electric resistance, the described stratum coals are related to metamorphism groups 13–14 $A_2$.

The averaged parameters qualitatively characterizing the coals investigated are cited in Table 2.

On the whole, physicomechanical properties of the coal samples investigated are typical to their grade and petrographic composition, also, the samples have high mechanical indices as strong and very strong coals.

**TABLE 1**

<table>
<thead>
<tr>
<th>Vitritine</th>
<th>Semi-vitrinite</th>
<th>Inertinite group</th>
<th>Content in coal, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>semi-fusinite</td>
<td>fusinite</td>
</tr>
<tr>
<td>71.0</td>
<td>1.3</td>
<td>8.9</td>
<td>9.8</td>
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