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DETERMINATION OF MOISTURE CONTENT IN HARD COALS USING MICROWAVE METER

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DETERMINATION OF MOISTURE CONTENT IN HARD COALS USING MICROWAVE METER

POMIAR VILGOTNOSCI WĘGLI KAMIENNYCH METODĄ MIKROFALOWĄ

ИЗМЕРЕНИЕ ВЛАЖНОСТИ КАМЕННОГО УГЛЯ МИКРОВОЛНОВЫМ МЕТОДОМ

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AKADEMIA GÓRNICZO-HUTNICZA IM. S. STASZICA W KRAKOWIE

Wydanie 1. Nakład [illegible]+20 egz. Ark. wyd. 0,25, ark. druk. 0,5
Papier [illegible] A. III. V/71 g Oddano do produkcji [illegible]
Zamówienie nr 230/88 Cena zł 40 – Druk ukończono w [illegible]

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Summary.

The paper presents the results of hard-coal moisture-content measurements, performed with the aid of the ZAM-WILMER microwave meter. Over 80 ground coal samples, weighing 1.5 kg (approx.) each, were examined. The moisture content values ranged from 0 to 15 wt%, with the mean standard error being equal to 0.8 wt%.

Streszczenie.

W pracy przedstawiono wyniki pomiarów wilgotności węgli kamiennych, przeprowadzonych przy użyciu mikrofalowego miernika typu 63-1 produkcji ZAM-Wilmer. Przebadano ponad 80 próbek.

Próbki rozdrobnionego węgla o masie około 1.5 kg miały wilgotność w przedziale od 0 do 15% wag.

Średni błąd standardowy wyznaczania wilgotności wynosi 0.8% wag.

Резюме.

В работе представлены результаты применения микроволного прибора типа 63-1, сделанного заводом ZAM-Wilmer, для определения влажности каменного угля.

Измерено больше чем 80 образцов различных углей весом около 1.5 кг каждый. Влажность образцов изменялась в пределах 0-15 вес%.

Средняя величина стандартной ошибки определения влажности составляет 0.8 вес.%.

1. Introduction

The knowledge of the moisture content is required at various stages of hard coal utilization. Many methods have been described which can be used for determining this parameter [1].

In particular, Cutmore et al [2] reported the use of the nuclear magnetic resonance spectrometery (NMR). Sowerby [3] used for the same purpose intensity measurements of 2.22 MeV gamma radiation resulting from interaction of neutrons with hydrogen. Both of these methods need a very sophisticated and bulky "machinery". A method based on an attenuation of a microwave beam has been applied by Hubert and Turek [4] to determination of moisture in brown coals.

2. Physical basis of the microwave moisture content measurements

The principle of determination of moisture content of various materials has been described in details by Kraszewski et al [5]. Here we shall give only the basic information.

Microwaves belong to the family of electromagnetic radiation which in their case is characterized by the frequencies in the range of 0.3 GHz - 300 GHz, which corresponds to wave lengths 100 cm - 1 mm.

The behaviour of materials in the microwave field can be described by two components of the complex electric permittivity: the dispersion ε' and the dissipation ε''. The dispersion component is responsible for the storage of radiation energy and is called the dielectric constant of the material. The dissipation component is responsible for the loss of energy and is called therefore the loss factor. In technical applications the first component ε' is related to the phase shift of the radiation passing through the sample and the second one ε'' to its amplitude attenuation. The used here VILMER 63-1 microwave meter produced by Vilmer Instruments and Measurements (subsidiary to the Institute of Physics, Polish Academy of Science) works with the microwave frequency of 9.4 GHz (λ = 3.2 cm). At this frequency the dielectric constant equals for water about 60 and for other materials between 2 - 3. Similarly, the loss factor for water is above 20 and for other materials less then 0.1. It is to be expected therefore that attenuation of a collimated beam of microwaves by a sample should depend very little on changes of its chemical composition and very much on its water content, granulation and density.

3. Microwave measuring set-up.

The VILMER microwave meter allows regulation of two parameters of a microwave beam: its intensity and the phase shift value. The meter uses the bridge compensation principle: the setting up to null of the reading on the bridge indicator (gauge) means that attenuation of radiation passing through the coal sample is the same as that obtained over the regulated reference path (the power from the microwave source is divided between two paths: one passing through the sample, and the other over the reference path). The readings of microwaves attenuation Nm, are taken in decibells.

4. Results of measurements.

Coal samples weighing about 1.5 kg each were crushed and ground so as to obtain the grain size less than 2 mm. Then they were filled into the measuring container, weighed and inserted into the microwave apparatus. The measurements were carried out in transmission geometry registering the sample attenuation N_M. The measured signal values N_M(dB) were plotted versus the corresponding moisture content values measured by the standard method (by drying the sample up in an oven at 378 K) and expressed in gcm^{-3}. The plot thus obtained was a calibration curve and we tried to find the best fitting functions. Calculated formulae as well as appropriate correlation coefficients and RMS errors are shown in Tab. 1. One can see that the square function (the second one) despite of not the highest correlation coefficient gives the smallest RMS error, so it seems to be the best fitting function in this case (Fig.1). Comparison between calculated and measured values is shown on Fig. 2.

Table 1.

Fitting function $\hat{\rho}$ $(gcm^{-3}) = f(N_M(dB))$	Corr.coef. R	RMS error σ (gcm^{-3})
$\hat{\rho} = 3.053\cdot10^{-3}N_M + 2.022\cdot10^{-3}$	0.956	$8.35\cdot10^{-3}$
$\hat{\rho} = -6.405\cdot10^{-5}N_M^2 + 5.378\cdot10^{-3}N_M - 1.544\cdot10^{-2}$	0.980	$5.67\cdot10^{-3}$
$\hat{\rho} = (5.478\cdot10^{-3}N_M - 2.437\cdot10^{-3})^{0.875}$	0.984	$8.85\cdot10^{-3}$

5. Conclusions.

The presented here microwave method of measurements of hard coal moisture allows to determine the moisture content with a standard error of about 0.8%.

Samples have to be ground prior to measurements. To avoid the influence of the grain sizes variability, final results should be averaged from several independent measurements. After each of them the measuring container should be emptied and then filled up afresh.

It is advantageous that the samples weigh about 1.5 kg.

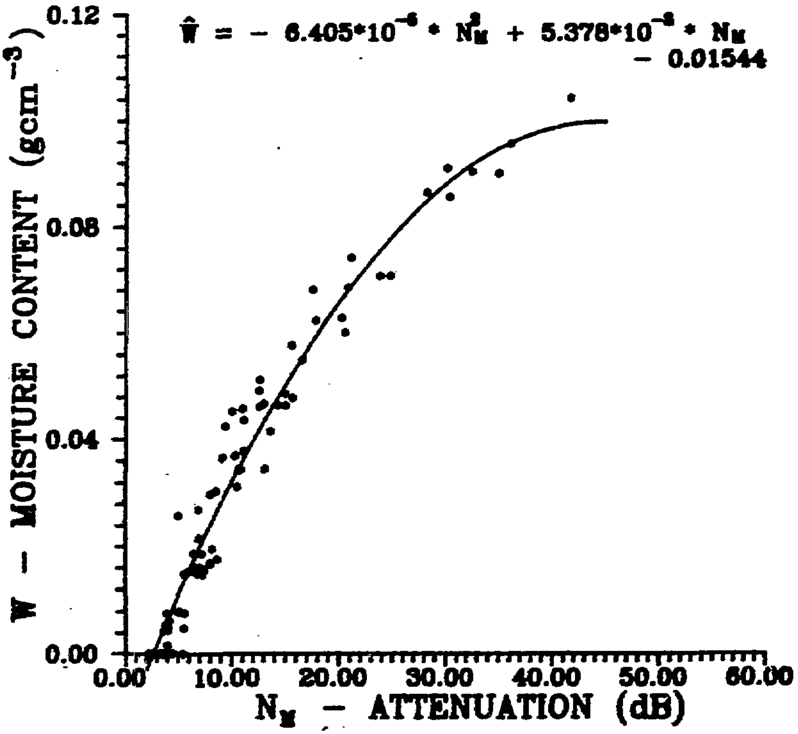

Fig. 1. Relation between attenuation (dB) and moisture content (gcm^{-3}) and the calibration curve obtained from the square fitting function.

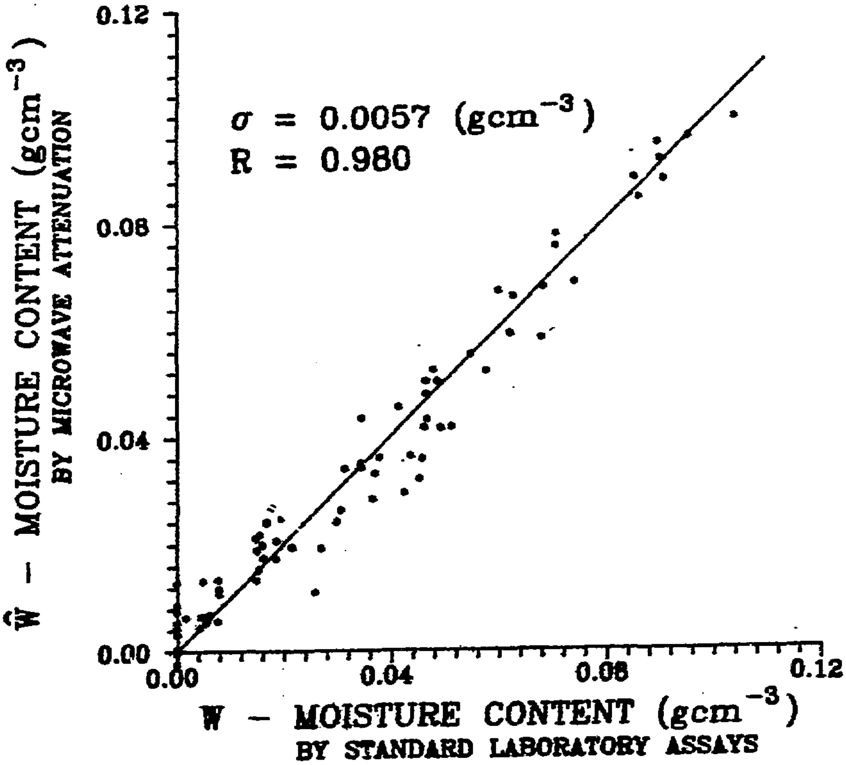

Fig. 2. Comparison of moisture content from standard laboratory assays with those obtained from the square fitting function.

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