Journal of Thermal Analysis, Vol. 38 (1992) 2189-2194

AUTOMATIC AND CONTINUOUS MEASUREMENTS OF TEMPERATURE IN MINING HEADINGS

K. Chmura, M. Suschka and S. Twardoch

INSTITUTE OF APPLIED GEOLOGY, SILESIAN TECHNICAL UNIVERSITY, 44–100 GLIWICE, POLAND

The problem of the actual rock mass temperature poses considerable difficulties in practical mining engineering. So far, measurements have been made with the use of thermistor thermometers. These do not provide infallible data on temperature, particular as concerns a certain distance from a rib into the rock mass, and they do not allow continuous data logging. Accordingly, a device has been designed and made for measuring the rock mass temperature, together with a thermal probe.

Experiments and tests carried out with this device indicate that it complies with the requirements relating to the needs of underground mining.

Keywords: mining, rock mass temperature

Introduction

The working of coal deposits deep underground involves various technical problems. Temperature is one of the most crucial factors determining the work comfort of miners, and the temperature in headings is mainly dependent on the heat coming through the rocks to the heading. The actual rock mass temperature depends on the thermal properties, which in turn influence the nature of the geothermal flux intensity. Exact determination of the actual temperature makes it possible to use the geothermal flux energy to evaluate the mechanical properties of the rock mass.

The mining services have always encountered difficulties in measuring the actual temperature in rock massifs with regard to predicting the heat flow from the rock mass to the mine air.

Because of this, the necessity has arisen to design a device which would measure the rock mass temperature and which would provide continuous data on the temperature prevailing from the rib into the rock mass.

John Wiley & Sons, Limited, Chichester
Akadémiai Kiadó, Budapest

General data concerning the device

The device consists of three parts:

– a measuring and transmitting system,
– a receiving system,
– a thermal probe.

Because of the presence of coal dust and the methane hazard, the device has been installed in a spark-safe chamber (KWSI-160).

Tests of the rock mass temperature in the 'Halemba' coal mine formed the basis of the design, which is briefly presented in this paper. The thermal probe is a functional element of the rock mass temperature-measuring system in the mine. It operates conjunction with a microprocessor and a COM PAN-ZAZ computer.

Apart from the surface unit, the thermal probe consists of the following sub-units:

– quartz sensors, together with microprocessing thermal probe generators,
– an underground microprocessing thermal probe unit,
– a computer and additional devices.

The surface unit fulfils the following functions:

– cooperating with three measuring and transmitting units and probes (each probe has 6 quartz sensors for measuring temperature);

– cooperating with the computer's digital output module, decoding the sensor address and the probe address;

– controlling the channel transmitter system in order to choose the probe address in the underground unit;

– receiving the result word from the transmission line via the channel transmitter;

–transforming the result word from serial to parallel form;

– cooperating with the computer's digital output module, generating a signal which is a digital representation of the measured temperature;

– signalling the unit's operating conditions via diode sensors;

– supplying the transmission line in accordance with the CTT standard;

– supplying the channel receivers.

The underground unit of the microprocessing thermal probe is also a functional element of the rock mass temperature-measuring system used in the mine. It is meant to cooperate with the measuring probe, so it carries out the following functions:

– permitting the reception of signals which initiate the measurement, the choice of a probe temperature sensor number and the transmission of the measurement results in the frequency transmission system along one pair of circuits;

– decoding the temperature sensor number;

– connecting the probe with a power source while measurements are being made;

– measuring the output frequencies from the temperature sensor, these frequencies being representations of the measured temperature;

– adjusting the result word parameters to the channel transmitter system;

– signalling when the device is on, when the probe is supplied, when the sensor is working, and when the word is transmitted.

The accuracy of the sensors is ±0.05 de., the time of receiving temperature data by one sensor is determined as 2 s, the time of transmitting the measurement from the rock mass to the dispatch room is about 8 s and the range of temperature measured is from 0° to 100°C.

A block diagram of the dev ice is presented in Fig. 1.

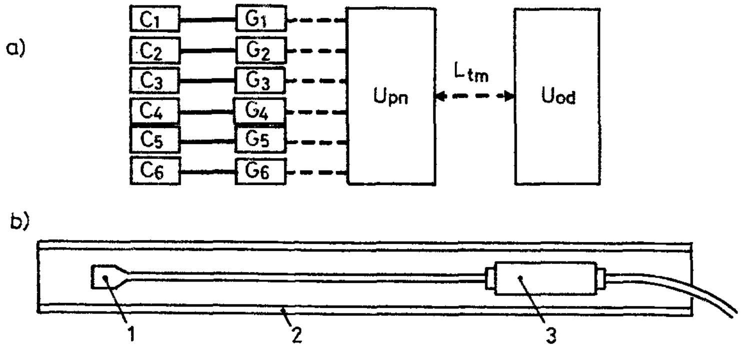

Fig. 1 Block diagram of the device together with the probe unit
a) block diagram,
C_1–C_6 – quartz sensors, G_1–G_6 – converters, U_{pn} – measuring and transmitting system, U_{od} – receiving system, L_{tm} – transmission line
b) probe unit,
1 –quartz sensor, 2 – probe fender, 3 – converter

How measurements are made

While headings are being worked, the heat flux from the rock mass to the heading is a complex process, mainly because the rocks in a rock mass take a long time to chill. Accordingly, there is a need for the continuous and accurate measurement of temperature, from the rib into the rock mass.

Measurements were started in the 'Halemba Gleboka' coal mine in the cross-heading worked in sandstone. Five test holes were made in the heading. As experiments indicate, an intact rock mass is characterized by a certain variability in geostatic pressure.

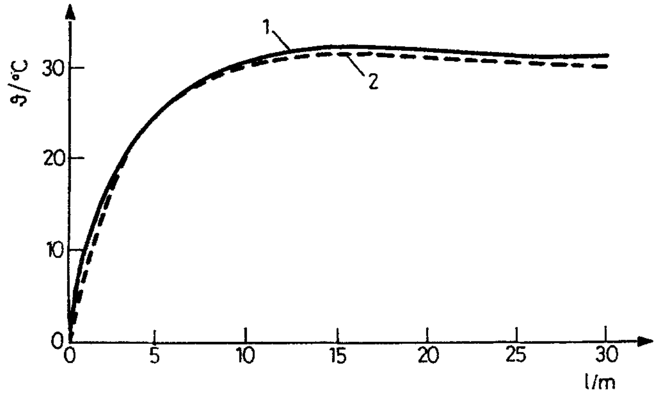

Fig. 2 Temperature diagram in relation to the distance from the rib
1 – unpiped hole, 2 – piped hole

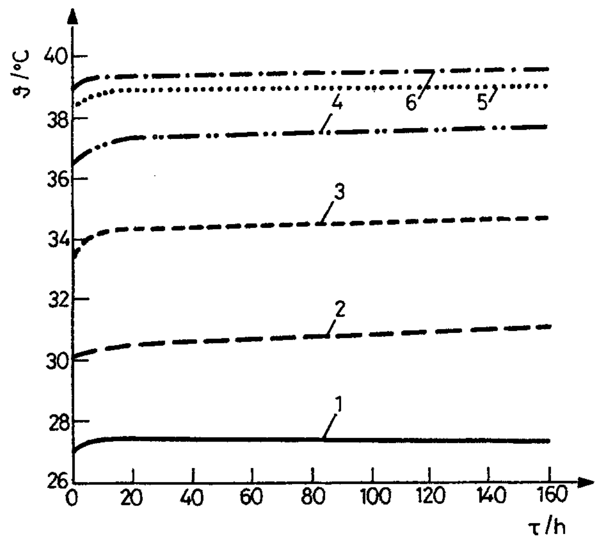

Fig. 3 Characteristics of the stability of temperature for particular sensors in time
1 – a 4.5 m distance between the sensor and the rib
2 – a 9.0 m distance between the sensor and the rib
3 – a 13.5 m distance between the sensor and the rib
4 – a 18.0 m distance between the sensor and the rib
5 – a 24.0 m distance between the sensor and the rib
6 – a 30.0 m distance between the sensor and the rib

This pressure causes the clamping of drill-holes. Therefore, in order to prevent damage to he probe, pipes were put into the holes. First, the influence of the pipes in the holes on the measurement of temperature was examined. To achieve this, two holes each 30 m deep were made in the rib, and pipes were put into only one of them. The temperature in the piped hole was measured for 70 h, i.e. until the measurement results became stable. The temperature in the other hole was then checked in the same way. The results shown in Fig. 2 make it clear that there are only very slight differences in the temperature values. These differences indicate that it is possible to use steel pipes in difficult geological and structural conditions when the probe might be damaged, and this will not affect the results of measurements. Since every sensor receives the heat from the rock mass at the point of its installation, the characteristics of the stabilized measurement results for particular sensors were determined in a definite time, i.e., during 72 h (Fig. 3).

Figure 3 indicates that quartz sensors are characterized by considerable functionality, great sensitivity and speed of detecting the thermal energy, and they are adequate devices to measure the geothermal and dynamic phenomena observed round the headings. Generally, it may be assumed that the stable heat conditions in the sandstone rock mass may be detected 24 h after a hole is made and the probe installed, if the water and gas conditions are stable and if there are no variable underground water flows in the area of the rock mass where measurements are made.

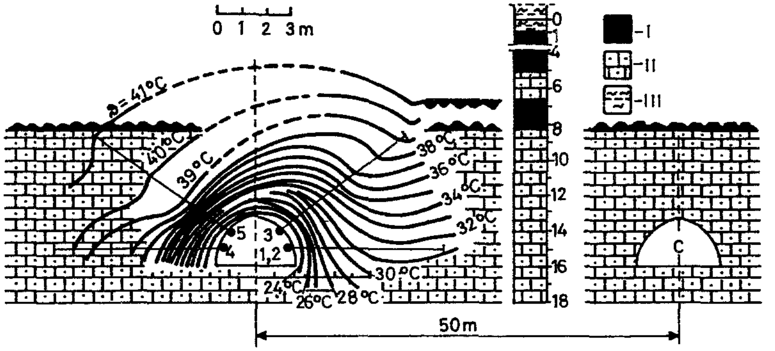

Fig. 4 Distribution of temperature round the heading
1, 2, 3, 4, 5 – drill holes, I – coal, II – sandstone, III – mudstone-izothermal lines, C – drain way

After testing of the temperatures in the piped and unpiped holes, the temperature round the heating was checked. The actual distribution of temperature is presented in Fig. 4. It indicates that the course of the isothermal lines is not uniform. There is a density of isothermal lines in the left rib (holes 4 and 5), which points to a greater accumulation of thermal energy in comparison with the right rib (holes 1, 2 and 3), where the temperature drops, due to the existence of the water-course in the vicinity of the test point.

The device for measuring the rock mass temperature and the probe meet the theoretical and practical requirements of underground mining.

Concluding remarks

The continuous measurement of temperature in coal mine headings plays an important role in predicting the climatic conditions in mines and the dynamic phenomena that occur in the rock mass subjected to mining.

The designed thermal probe permits exact determination of the actual rock mass temperature round the headings, particularly when they are located deep underground.

Zusammenfassung — Die Frage der aktuellen Gesteinstemperatur schafft in der Bergbaupraxis beachtliche Schwierigkeiten. Bisher wurden Messungen mit Hilfe von Thermistorthermometern durchgeführt. Diese liefern jedoch keine unfehlbaren Temperaturangaben, besonders für eine gewisse Entfernung von Streben in der Gesteinsmasse, außerdem bieten sie keine kontinuierliche Datenaufzeichnung. Aus diesem Grunde wurde ein Gerät und ein Ther-mofühler zur Messung der Gesteinstemperatur konstruiert und gebaut.
Die durchgeführten Experimente und Tests dieses Gerätes zeigen, daß es den Anforderungen des Untertage-Bergbaues genügt.