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COMPUTER CONTROLLED SYSTEM FOR DIFFERENTIAL THERMAL ANALYSIS

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The paper gives a brief overview of computer controlled differential thermal analysis system. The system consists of a personal computer, software, data acquisition card and interface for the provision of the necessary conditions for the analysis and adaptation of input and output signals. The entire control system, as well as the acquisition, recording and processing of measured data is solved by software. The application is based on the programming package LabVIEW from National Instruments company.

Keywords: differential thermal analysis; hardware; software; LabView.

Differential thermal analysis (DTA) is a technique in which the difference in temperature between a substance and reference material is measured as a function of temperature while the sample and reference are subjected to controlled temperature program [1,2]. Typical DTA measurement system consists of a sample holder, thermocouples, sample containers, furnace, temperature programmer and a recording system. In this system, PC with data acquisition device and a cheap hardware interface is used for temperature programmer and a recording system purposes.

It has several advantages compared to ordinary stand-alone DTA device:

- High-resolution measuring;
- Compact design;
- Can be easily adapted and/or modified for any type of measurement;
- Compatibility with any type of thermocouples, furnaces and balances;
- Much more affordable.

Hardware. For signal generation and data acquisition was developed a measuring and control system based on personal computer (Fig. 1). Beside PC, hardware consists of AD/DA converter and external interface for analog signals conditioning. AD/DA conversion is performed using commercially available converter NI 6221 from National Instruments. National Instruments high-speed multifunction data acquisition (DAQ) devices are optimized for superior accuracy at fast sampling rates. They have an onboard NI-PGIA2 amplifier designed for fast settling times and high scanning rates, ensuring 16-bit accuracy even when measuring all channels at maximum speeds. All high speed devices have a minimum of 16 analog inputs, 24 digital I/O lines, seven programmable input ranges, analog and digital triggering, and two counter / timers [3,4].

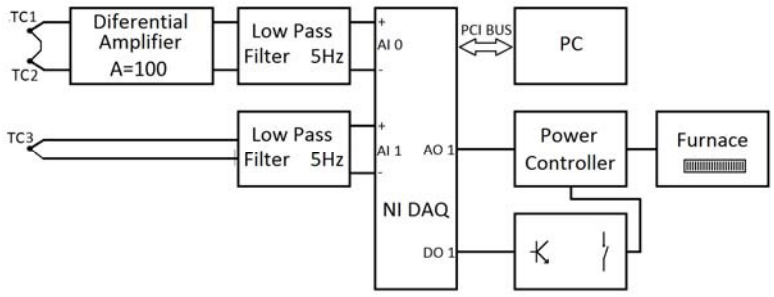

Fig. 1 Block diagram of differential thermal analysis hardware.

Differential amplifier is used for amplification of temperature difference signal between two thermocouples (TC1 and TC2) while the third thermocouple (TC3) is for furnace temperature measurement. Low pass filters eliminate any noise from the signals. Power controller regulates the heater intensity and also switches the whole system on and off on demand.

Measurement interface designed for the needs of the DTA device is calibrated using high accurate measurement instruments predicted for laboratory instruments adjusting and have the next characteristics:

- one control voltage input ±10 V for DTA signal;
- one control voltage input ±10 V for measuring furnace temperature with built in cold junction correction;
- one voltage output ±10 V for furnace control;
- one differential amplifier with amplification constant A=100;
- furnace temperature range 0—1500°C.

Software. The software platform for predicted measurement methods was National Instruments LabVIEW package, which is regarded as a high standard in the area of modern virtual instruments. LabVIEW is based on the principles of virtual instruments with the graphical user interface [5]. Graphical user interface has two windows:

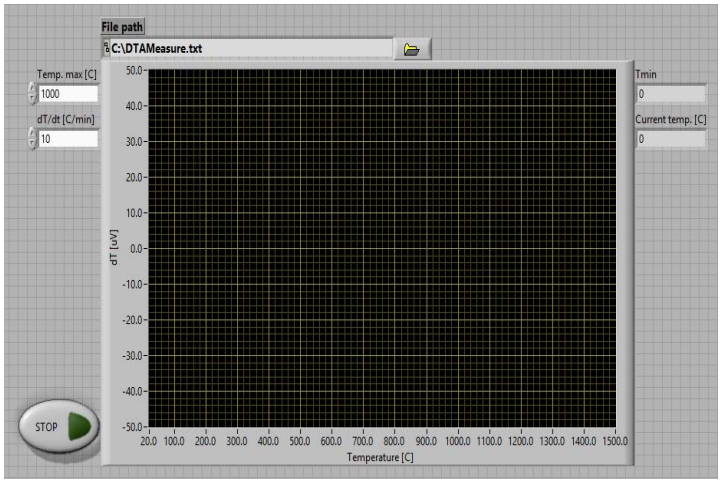

Fig. 2 Application front panel

- Control panel for process control and monitoring;
- Application diagram which presents used virtual instruments, relations between them, the course of signals and error detection.

In LabVIEW, one builds a user interface by using a set of tools and objects.

The user interface is known as the front panel (Fig. 2). One then adds code using graphical representations of functions to control the front panel objects [6]. The block diagram contains this code (Fig. 3).

DAQ Assistants are used for acquiring the input and generating output

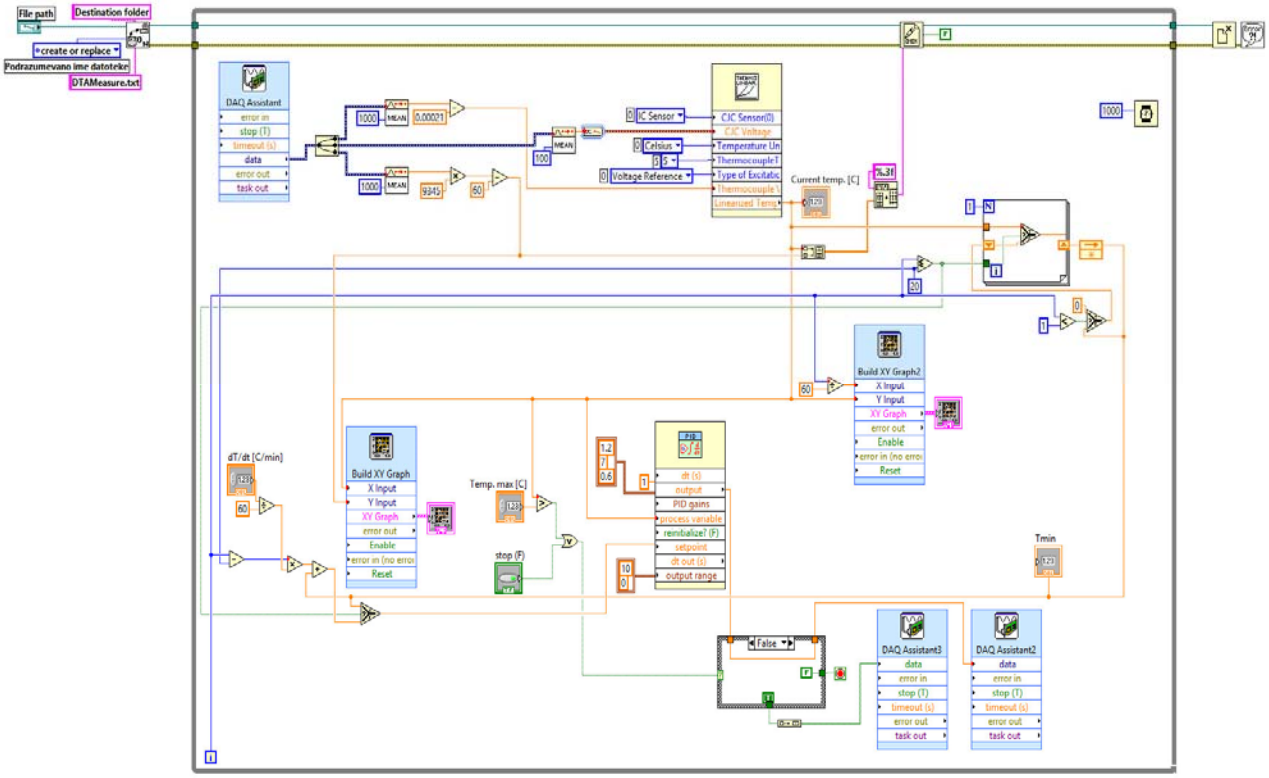

Fig. 3 Application block diagram

signals. Acquired signals from thermocouples are averaged because of eventual noise and measurement errors cancelation and sent to thermocouple linearizer which converts them to an actual temperature. Then PID controller [7] calculates current value of the output signal for the power controller based on desired heating rate. Graphs, text inputs, text controls and switches are also visible on the front panel and accessible to user for parameters input and viewing the results.

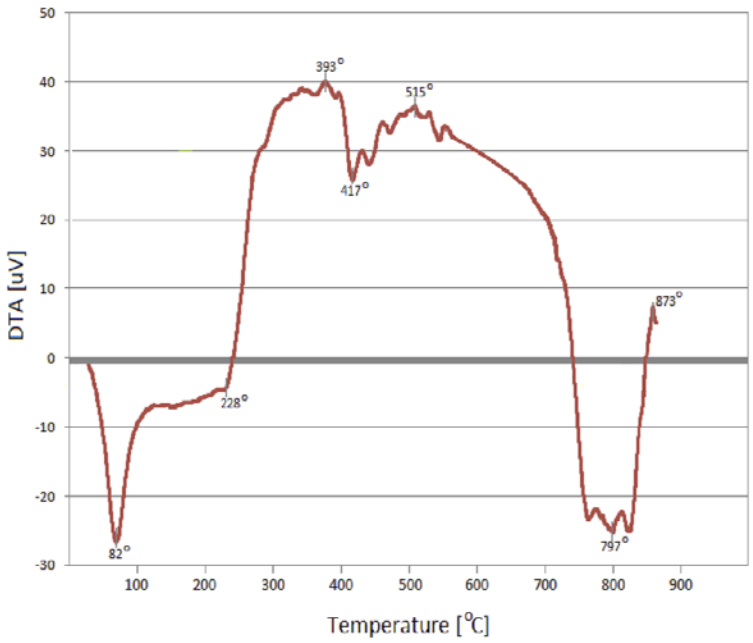

Fig. 4 Measured DTA diagram – sample of land from the mining field

Results. Hardware and software of the presented system were implemented. Separate modules and the whole device are examined and adjusted by the laboratory 5½ digits instrument PRIMA B7-21A (voltmeter and ampere-meter) and PRIMA B7-38 (voltmeter). Amplifying, voltage offset were adjusted, temperature stability was checked, noise immunity and temperature were measured. The interface and the whole device are stable and measurement error is below 0,1%.

The system is applied for big number of tests successfully done with various materials, temperature ranges and working environments. The system has proven its reliability and accuracy. A sample result of DTA obtained with this system is shown in Fig. 4.

Conclusions. The system for differential thermal analysis with compact design and high-resolution measuring interface is developed using affordable devices. It has characteristics similar to most of commercial products of this type and can be used in all phases of research, quality control, production operations and it is much more affordable than other systems.

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Керована комп'ютером система для диференційного термічного аналізу.

У доповіді наведено опис диференційної системи термічного аналізу з комп'ютерним управлінням. Система складається з персонального комп'ютера, програмного забезпечення, карти збору даних та інтерфейсу для надання необхідних умов для аналізу та адаптації вхідних і вихідних сигналів. Процеси отримання, запису і обробки даних вимірювань виконуються за допомогою програмного забезпечення. Додаток засновано на програмному пакеті LabVIEW від компанії National Instruments.

Ключові слова: *диференційний термічний аналіз; апаратних засобів; програмне забезпечення; LabView.*