COMPUTER-AIDED SYSTEM FOR MEASURING TEMPERATURE OF ROTATING ELEMENTS

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Summary: The paper includes a review of currently used devices for measuring temperature of rotating parts of machines. In the subsequent section it describes a computer-aided measuring system developed by the authors. Using the optoelectronic measuring path, the system is employed for measuring temperature of cylinder block of an axial multipiston pump.

Besides, the application of DasyLab software package for the above mentioned measurements is presented.

1. INTRODUCTION

Temperature measurements are often a necessity in the course of industrial operation. A method of such measurement is selected on the basis of the following factors: the range of temperature measured, the rate of its changes, the conditions of heat transfer on the inside surfaces, rotation speed, size and shape of the object examined as well as accessibility of surfaces for the contact or remote measurement.

The systems transmitting measuring signals from the mobile elements to the stationary parts of the measuring device can be of various kinds. A popular method of temperature measurement of rotating parts uses thermoelements, or, less frequently, thermistors, whose measuring signals are transmitted by means of contact links. With brush connectors, the accuracy of measurements does not exceed ±0,5K. When the tangential velocity of a slip-ring is high, the brush and other elements heat up due to friction, which causes an increase in unwanted thermoelectric forces, and consequently, deteriorates the accuracy of measurement. In order to eliminate such harmful phenomena compensation systems are employed, an example of which is presented in Fig.1.[2].

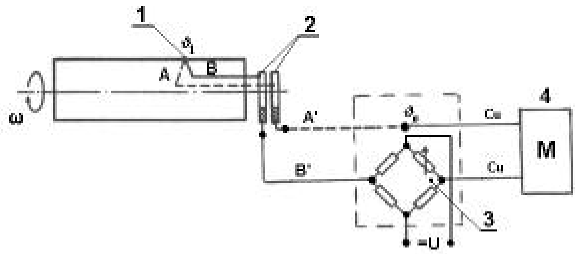

Fig.1. Temperature measurement of rotating part: 1- thermoelement, 2-system of brush rings, 3-Wheatstone bridge, 4-thermoelectric force meter

Characteristic of this kind of system is a bridge attachement 3 correcting online changes of environment temperature ϑ_0. A thermoelement is connected in series with a Wheatstone bridge, which is typically in the state of equilibrium in temperature ϑ_0 about 20° C. The measurement of thermoelectric force (STEM) is performed by means of a magnetoelectric milivoltmeter, or by means of a compensation method (under laboratory conditions). Meter 4 is calibrated in Celsius degrees for specifically determined resistance of connecting conductors and electrodes of thermoelement AB.

An interesting concept of temperature measurement, employed in machine rotors or car tyres, is presented in Fig.2 in the form of a block diagram [5].

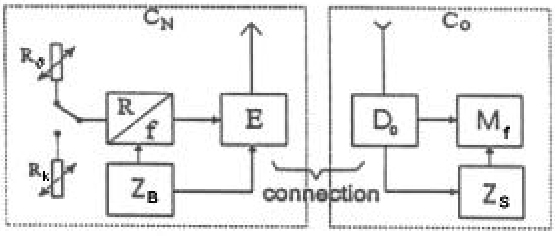

Fig.2. Diagram of the measuring device

The crucial element of this device is a semiconductor sensor - thermistor $R_{\tilde{o}}$, whose resistance is a function of the temperature measured. The device consists of two units, in which sending unit C_N comprises all the subsystems placed on rotating parts. Apart from the above mentioned thermistor $R_{\tilde{o}}$, the unit consists of an electronic resistance converter into frequency R/f, emitter E as well as stabilized power pack Z_B. Also reference resistor R_k is included for verifying the indications of the system or, if necessary, correcting them. Stationary unit C_O of the device consists of detector D_O, frequence meter M_f (scaled in temperature units) and stabilized power pack Z_S. Signal emitter E and detector D_O constitute a specific telemetric connection.

Among the flaws of the system under consideration one can mention low accuracy (about 2%) and low durability of the converter power pact Z_B.

2. A DESIGN OF THE MEASURING SYSTEM

A system for measuring temperature of an axial pump cylinder block was constructed on the basis of the authors' original design [1]. The experiments followed a period of preparaions in which temperature sensors were placed inside the cylinder block next to the pistons and electrical signals were led through a connection placed in a hollow shaft to the multivibrator of the optoelectronic converter. The measurements of cylinder block heating were performed by the changing quantities of pump load and input oil temperature.

The examination of temperature distribution in the multipiston pump cylinder block should lead to the better understanding of the phenomena occurring inside it, and consequently, to an improvement of construction. Fig.3 shows a block diagram of this measuring system.

The system consists of two units: the mobile one and stationary one. The mobile unit, coupled to the cylinder block of the multipiston pump, is fed from AC generator 1 through rotating transformer 2 and rectifier 3. The changes in temperature ϑ of the cylinder block cause changes in resistance R_{ϑ} of thermistor 4, which influences the frequency of electric impulses generated by multivibrator 5. These impulses are converted into light impulses by LED 6 and transmitted axially to phototransistor 7, where they are turned back into electric impulses of frequency identical to that of multivibrator 5. After being standardized in monovibrator 8 they are transmitted by means of the measuring card to computer 9. The resulting values of frequency obtained are a function of temperature $f = F(\vartheta)$.

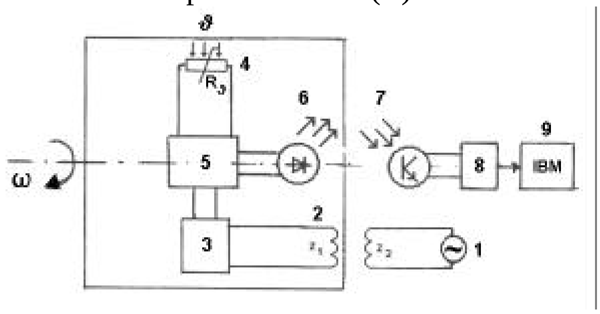

Fig.3 Block diagram of the measuring system

In the process of calibrating the device it was demonstrated that the rotation of the LED does not influence the operation of monovibrator 8, or the digital indications of frequency measurement.

The software is a vital component of the measuring system as it determines how effectively the hardware is used. Moreover, it enables a convenient process of controlling the measurement procedure, recording of data and access to them for the sake of analysis and processing, as well as a visual presentation of results in a required form.

DasyLab package applied in the system enables the user to solve problems associated with data sets and their analysis in a complex manner. An unquestionable advantage of the software is its simplicity and clarity - a script of analysis is created by means of icons. The connected icons represent the direction of data flow and their analysis, forming a data flow sheet shown in Fig.4.

Measuring signal acquisition from the electronic system is performed by means of measuring card PCL 818. Developed within DasyLab package, the algorithm for signal recording and analysis processes the signals on-line, calculates the results and presents them visually.

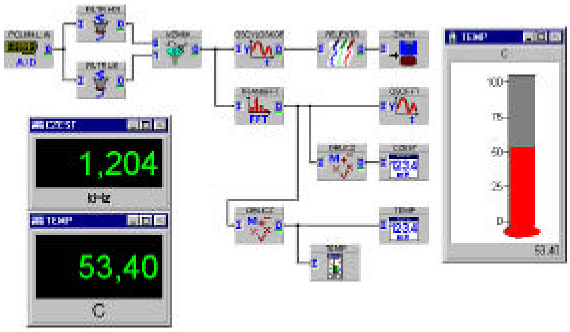

Fig. 4. System for recording and analysis of measuring signal

The system performs the following functions [4,6]:

- acquisition of electric signal from the measuring card (module PCL818L AI);
- signal filtering (modules FILTR H i FILTR L);
- signal amplification (modu³ WZM);
- finding signal amplitude characteristic by means of a FFT algorithm and calculating frequency (module TRANSFFT, OSCFFT, OBLICZ, CZEST);
- finding the temperature of the cylinder block (modules OBLICZ, TEMP);
- visualization – OSCYLOSKOP;
- data recording – ZAPIS, REJESTR.

The measuring frequency signal (Fig.5) is filtered, amplified and sent to the input Of the FFT module (TRANSFFT) to determine the value of frequency.

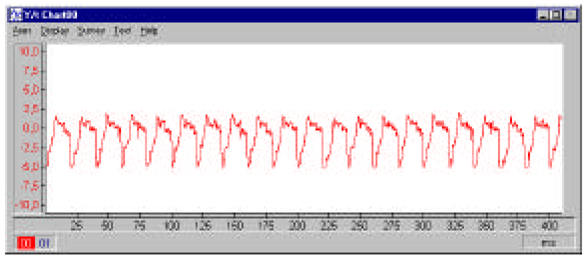

Fig. 5. Example of a measuring signal

The characteristic obtained on the basis of calibration of the dependence of frequency on temperature f = F (ϑ) was input to the algorithm (module OBLICZ) in order to calculate the temperature of the cylinder block.

3. CONCLUSIONS

The analysis described in the present paper lead to the following concluding remarks:

- The developed and constructed measuring system is compact, reliable and more accurate than systems with thermoelectric sensors;
- The study made it possible to find the temperature of the cylinder block next to the pistons of a multipiston pump depending on the operation parameters of the pump. A remote method of measurement was applied in which an optoelectronic sensor played an important role;
- Analytic studies demonstrate that the temperature measurement inside a working pump is indispensable for the examination of phenomena occurring in the components of the pump. A possibility is open of further research using computer-based methods (such as provided by DasyLab package) leading to an improvement of the parameters of pump operation.

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