⇒ the presented design of the measuring stand provides the possibility of increasing the number of measuring points and also of measuring and controlling other vital parameters of industrial processes;

⇒ the accuracy of measurements is high; there exist a vast potential for their processing and the analysis of the results;

⇒ the designed system is an open-ended solution, so it can be further extended and modified.

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MONITORING OF THE PARAMETERS OF PUMP OPERATION BY MEANS OF A COMPUTER-BASED MEASURING SYSTEM

The paper presents a design of a computer-based measuring system for monitoring the basic operating parameters of an axial multipiston pump, which are subsequently used for determining the current efficiency of the pump. Besides, the paper contains a block diagram of a hydraulic experimental stand as well as the analysis of characteristics of measuring converters used in the computer-based measuring system.

Due to the high exploitation cost of machines and devices and also due to increasing expectations concerning reliability, designers and producers take measures towards lowering exploitation costs and improving reliability and durability of machines. Among the most important factors affecting the exploitation cost are unpredicted shutdowns and repairs [1].

Hydraulic drives and controls have many well-known advantages. Because of that they are applied in a number of devices. The basic component of each hydraulic system is a positive displacement pump, which changes mechanical energy into the energy of the pressure of a liquid operating agent. The energy of the agent is subsequently transmitted to a hydraulic engine, in which it is changed back into mechanical energy.

Axial multipiston pumps are quite popular. Since they can operate by high pressures and high power, they reach satisfactory values of power efficiency coefficients, defined as the ratio of power to mass or volume. Axial multipiston pumps are most often applied in the drives of complex devices which must fulfill higher efficiency and reliability requirements [2].

In a perfect pump no power losses occur so that the power obtained from the drive engine is equal to the power conducted to the system by means of the operating agent, according to the following formula:

$$N_t = M_t \cdot \omega = Q_t \cdot \Delta p \tag{1}$$

where
N_t is the theoretical power,
M_t is the theoretical torque at the pump shaft,
ω is the angular velocity of the shaft,
$\Delta p = p_2 - p_1$ is the difference between forcing pressure p_2 and suction pressure p_1,
Q_t is the theoretical efficiency of the pump.

In real pumps volumetric and hydraulic-mechanical losses occur. Online monitoring of the losses as well as determining the efficiency as the ratio of effective energy to input energy is of vital importance for users.

One of the possibilities of lowering exploitation cost is monitoring and diagnosing of the condition of an exploited object. It reduces the number of unpredicted shutdowns (Fig. 1).

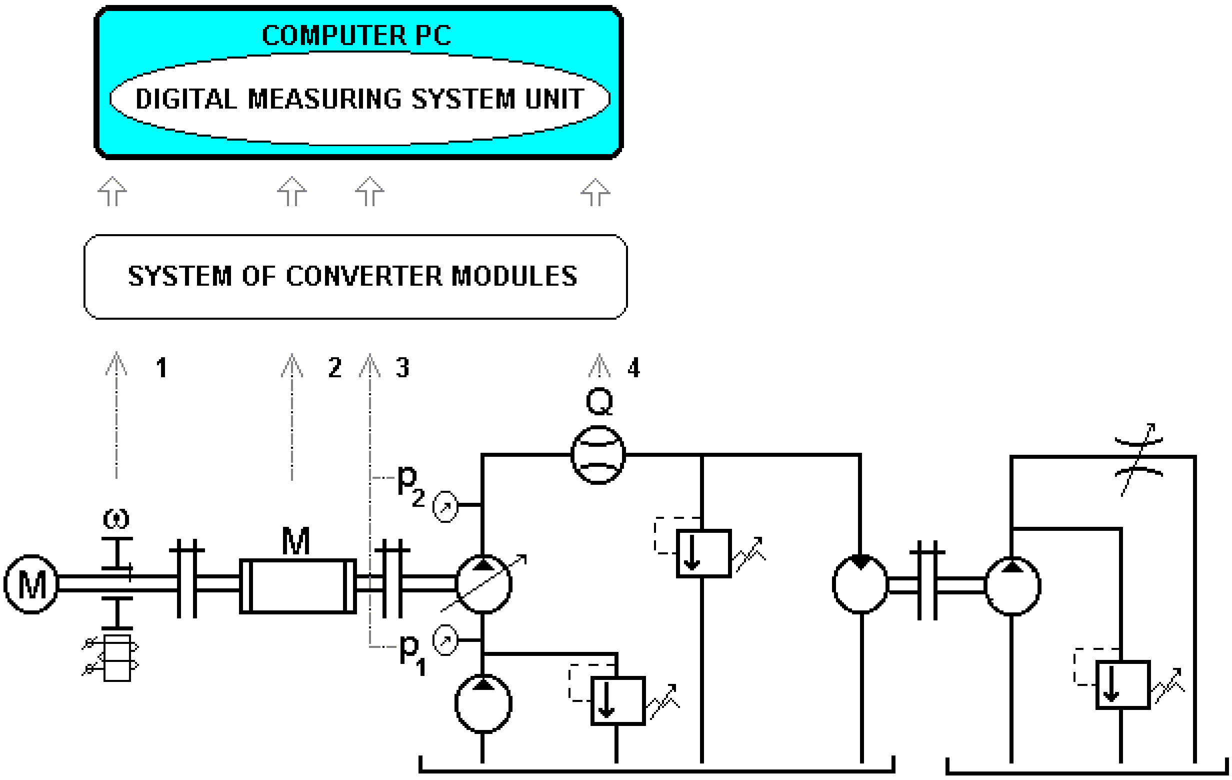

Fig.1. Structural schema of the laboratory stand:
1 – angular velocity converter at the shaft of the engine-pump system;
2 – torque converter; 3 – measurement of pressure difference between the forcing channel and the suction channel of the pump;
4 – flow intensity converter

With continuous monitoring it is possible to observe the technical condition of the device and to determine the causes of flaws, if any. It is also possible to predict the duration of a current condition.

Microprocessor technology applied to measuring devices makes it possible for such devices to perform a number of functions simultaneously, for example to measure various quantities at the same time.

The object of the present study is an axial multipiston pump monitored by means of a computer-based measuring system, which determines the online volumetric and mechanical-hydraulic efficiency [2]. A structural diagram of the measuring system is presented in Fig. 1.

The data received from the measuring converters is at the same time displayed and saved on the disc. Moreover, the system not only monitors and records the results, but also controls the course of the experiment. The user him/herself can program the course of the experiment and make the system follow it.

The designed and developed measuring system is intended for automatic handling of the experiment with the use of a standard PC.

Because of the modular structure of the system, the measuring stand can be easily modified. The user may connect a sensor of some physical quantity to any channel of the system. Then, a converter suitable for the sensor must be installed in this channel.

The system includes a unit containing a digital measuring system with a processor, collecting signals from the system of converter modules: temperature, pressure, rotational speed, flow intensity and torque. Each unit may contain up to 16 modules. It is connected to a standard PC through interface RS – 232. The unit processor enables serial transmission from the modules to the PC. With interface RS – 485 the system may include even 31 such module-units. The operation of the system is similar to that of a sampling oscilloscope [3,4,5,6,7].

The efficiency coefficient for an axial multipiston pump is determined in the following way:

⇒ Flow intensity is measured by means of a measuring set consisting of a turbine converter and a counting analog flow meter. The measured intensity is converted into an (analog) electrical quantity by means of an axial turbine converter. The rotor of the turbine is made of ferromagnetic material. When the rotor is rotating, sinusoidal or impulse electromotive force is induced in the winding situated within the housing. For every single rotation of a turbine blade with respect to the winding, a single impulse is induced. The angular velocity of the turbine rotor is theoretically assumed as a linear function of intensity $Q(t)$ of the flowing oil.

⇒ The angular velocity of the pump shaft and the engine is measured by counting the impulses sent by a magnetic disc converter situated at the engine shaft. The impulses are counted by means of a table digital frequency meter, type NT2, which can simultaneously measure rotations.

⇒ The torque at the pump shaft is measured by means of an inductive torque meter Mi5 [8]. The measuring system of the inductive torque meter consists of a torque converter and an electronic measuring subsystem.

The measured moment is converted into an analog electrical quantity by means of a system consisting of a measuring torsional shaft, induction coil and Wheatstone bridge (Fig. 2). The action of the torque results in the torsion of the measuring shaft. The loss of equilibrium of the inductive converter built in the Wheatstone bridge is proportional to that torsion. The inductive converter is powered by voltage 5 V and frequency 5 kHz from the carrier frequency generator through a

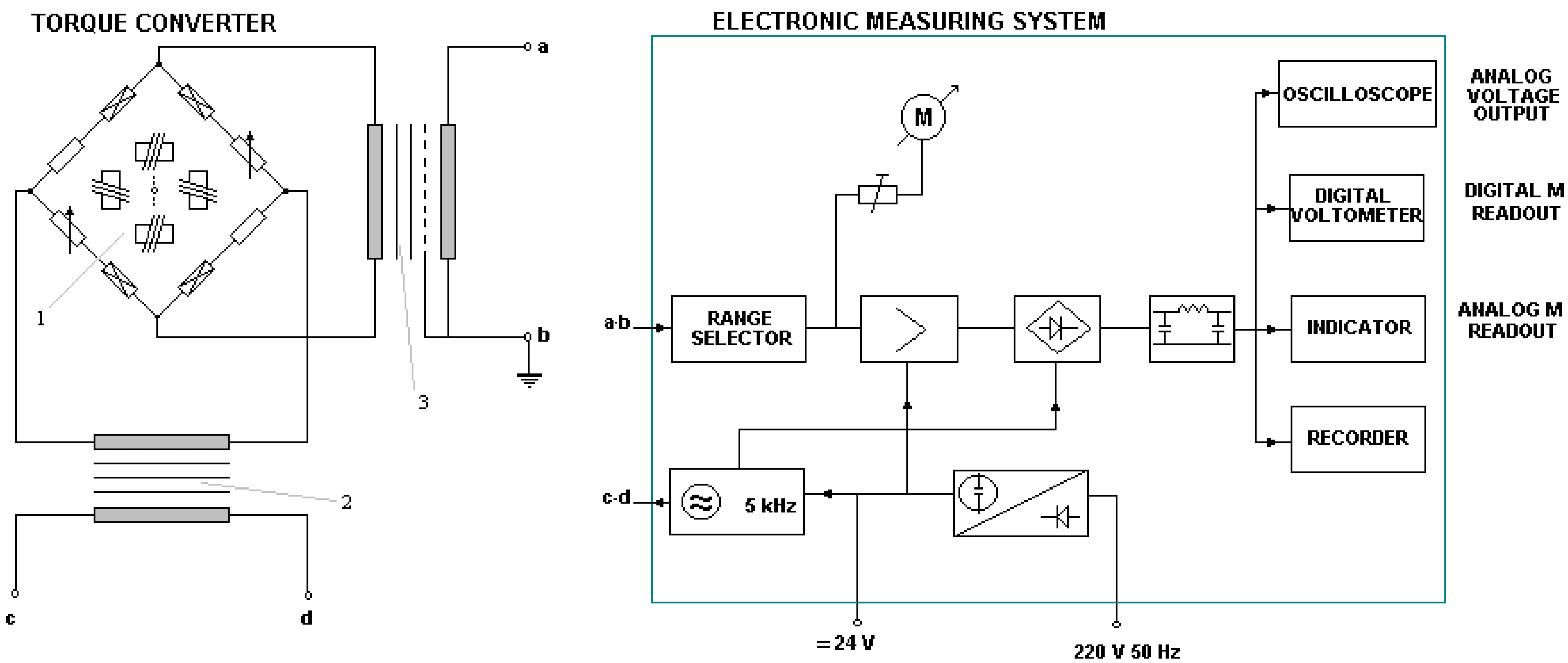

Fig.2. Schematic diagram of the inductive torque meter [8]:
1 – inducive converter with the Wheatstone bridge; 2 and 3 – rotational transformer

rotating transformer (Fig. 2.). Then, the electric measuring signal is transmitted from the Wheatstone bridge to the electronic measuring system through another rotating transformer. In the electronic measuring system the amplified and filtered signal is indicated by the analog meter scaled in torque units, or by a digital meter in a discrete form.

⇒ The difference in pressures is measured by means of electronic membrane pressure sensors.

A diagram of a pneumatic-electric converter, which functions as a manometer with an output electric signal is presented in Fig. 3.

The pressure is converted into an electric signal by means of the piezoelectric sensor. Resistors connected in a bridge are diffused in a quartz plate. The pressure deforms the plate, the diffused resistors change their resistance, and the bridge loses the equilibrium. Subsequently, the output signal of the bridge is transformed in the electronic system into a current signal whose value is proportional to the measured pressure. As it can be seen in Fig. 3, the converter does not contain any moving parts and its construction is very simple. Due to the use of intermediary liquid, such as siliceous oil, the converter is protected from the influence of the agent whose pressure is being measured. The measured pressure is exerted on the membrane, which transmits the pressure onto the surface of the converter through the intermediary liquid [9].

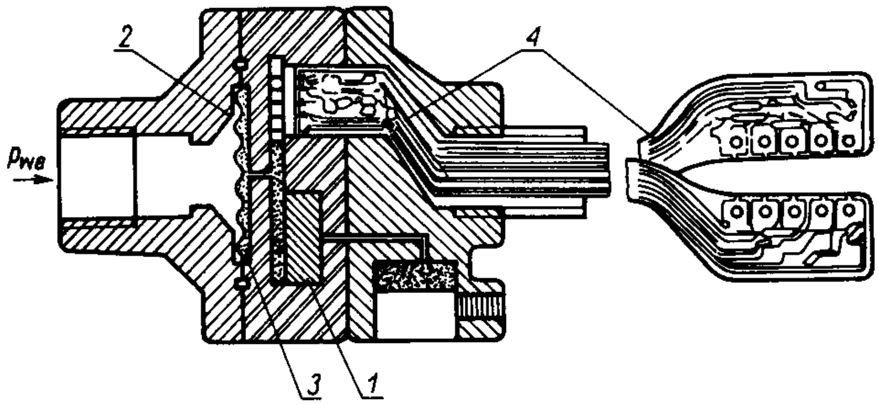

Fig. 3. Diagram of the measuring head of the converter for measuring pressure [8]:
1 – silicon pressure sensor; 2 – siliceous oil;
3 – separating membrane; 4 – electric terminal

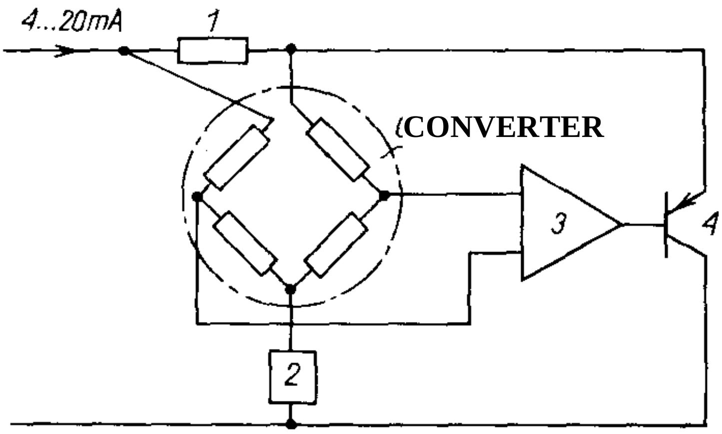

Fig. 4. Diagram of the converter of pressure into current with a piezoresistive sensor:
1 – feedback resistor; 2 – regulator of current powering the converter;
3 – amplifier; 4 –current regulator

The values of the parameters of the pump operation are displayed on the screen of the measuring system (Fig. 5, 6).

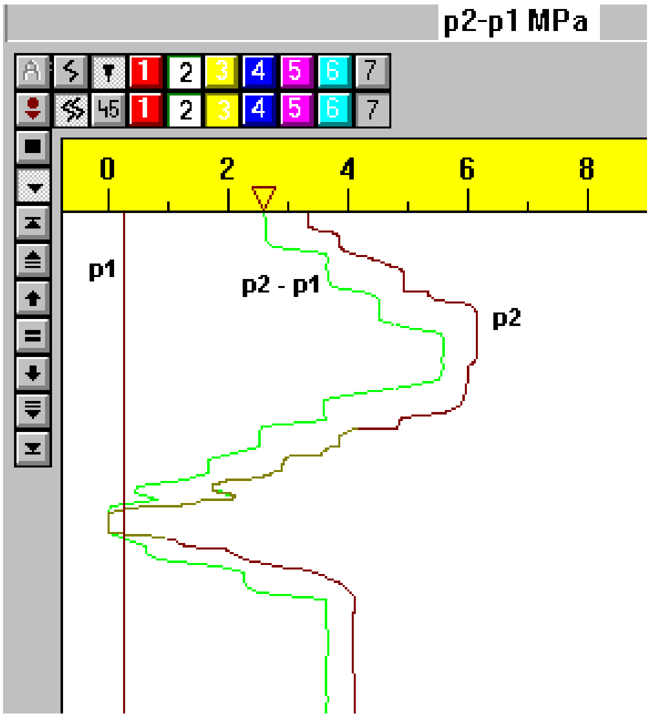

Fig.5. Graphic representation of the results of the measured pressure

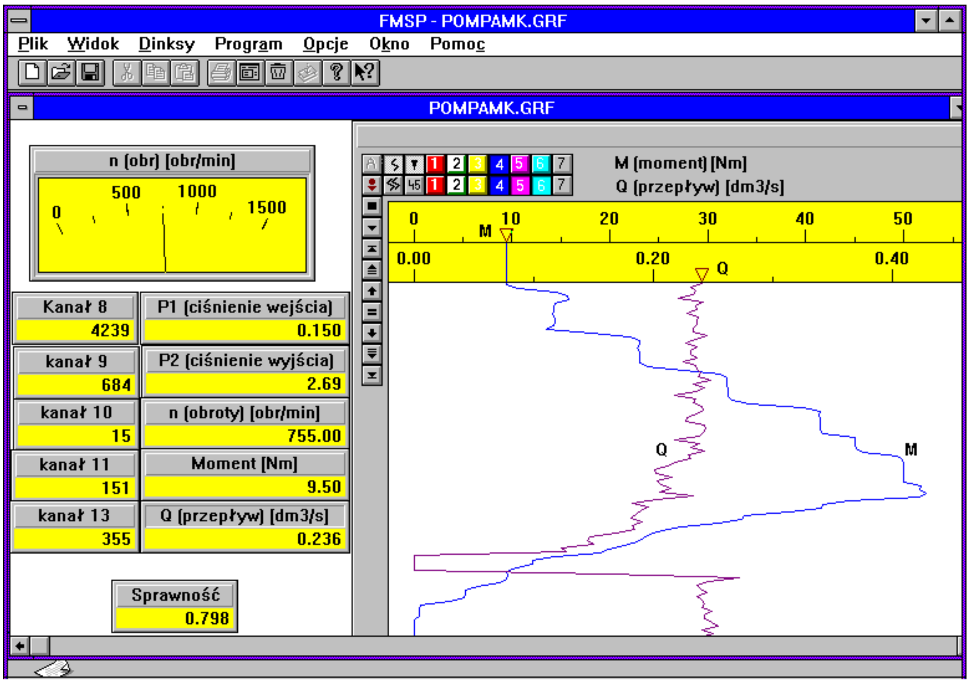

Fig.6. Graphic representation of the results during a change in the pump parameters

The analyses of the results obtained in the experiment lead to the following conclusions:

- The parameters of the pump operation can be monitored online by means of the computer-based measuring system.
- Apart from monitoring and displaying the results, the system makes it also possible to control the experiment.
- Standard measuring converters can be applied in the system for indirect assessment of the pump efficiency.
- The accuracy of the obtained results depends mainly on the metrological parameters of the intermediary systems, i.e. modules converting the measuring signals.

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