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MONITORING THE CONSUMPTION OF ENERGY MEDIA IN TECHNICAL DEVICES

Key words

Electricity, gas flow controller, water consumption.

Abstract

The knowledge about and optimisation of the consumption of energy and technical media is an important issue in the maintenance of technical objects and technical plants. In ITeE – PIB, newly designed devices are equipped with systems for monitoring the consumption of electricity and other media. Applied measurement systems allow the assessment of the cost of research or the conducted process. In the case of a three-phase power supply, the devices that operate alternately can be used equally. The article presents the developed subsystems for monitoring the electricity consumption as well as water and compressed air consumption for nitriding, server room operation, a device for cooling water in a closed circuit, compressor room operation, and a fumigation chamber. Information from the measurement systems can also be used to diagnose the condition of the equipment.

Introduction

Monitoring energy and technology media consumption in devices have been developed in ITeE – PIB. The first operation for which the monitoring equipment has been installed for the consumption of the media was for gas nitriding [1]. In process for gas nitriding the following devices were installed:

- Electricity meters for single and triple phase were installed for the nitriding furnace, neutralisator, dissociator, and water cooling system. The applied electricity meters had mechanical counter and pulse output (1000 pulses/ /1 kWh of electricity), which is connected to the counters in the PLC program. With this approach, we are able to determine the consumption of electricity, from the beginning of the operation of the device or for a given period, e.g. a month or week, or during a process.
- Gas mass flow controllers (N_2, NH_3 i NH_3^+) provide the actual flow of gas in dm^3/h. The controller has an input signal representing the set value (SV) and the output representing the resulting flow (PV) – 4–20 mA standard. Software implemented in the PLC used a totalizer with a reading of flow every 30 seconds. We have precise information on the amount of nitrogen and ammonia consumed in the process. In addition, if the resulting flow is not equal to the set value with the desired accuracy, it generates diagnostic information, e.g., a lack of gas supply, damaged valves, or a pressure increase in the output of the regulator.
- Water flow meters were installed with pulse transmitters in the apparatus for cooling the water in a closed circuit, which supplies water to cool the cover of the retort of the nitriding furnace [2]. Encoders are connected to the inputs of the PLC. Software counters implemented in the controller determine the amount of water used in the process. In addition, when the pump is switched on and there is no pulse from the water meter at a specified time, a signal is generated to indicate a leak in the duct, blocking of flow, etc.

As shown on the example of the nitriding furnace, monitoring the media consumption in devices also provides valuable diagnostic information. Currently, for monitoring the power and technological media consumption, newer technical devices are used as follows:

- Measurement of electricity: The counters with pulse output were still used in cheaper and simpler solutions. The new solutions are N43 meters for the 3-phase network parameter measurements or the 1-phase type N27P from Lumel [4]. A meter with Modbus RTU protocol is usually selected. This simplifies the inclusion of meters into the media monitoring system. The information obtained from these analysers greatly exceed the needs for diagnosing the technical equipment (phase voltage, phase-to-phase voltage, phase current, powers: active, reactive, apparent, active power factor, tan φ, the angle φ, active energy fed back and charged, capacitive and inductive reactive energy, apparent energy, frequency, jitter, etc.).

- Measurement of gas flow: Bronkhost's mass regulators were used (there are also versions for selected liquid).
- Compressed air measuring and filter stations were from Festo or SMC, for example.
- Water: We still used water meters with pulse outputs or remote reading.
- As an extension of media monitoring, vibration was measured in the technical devices (vibration sensor with 4–20 mA output and relay output).

The media monitoring system and technological power were connected directly in the control-measurement system of the technical device or monitoring system, which was designed as a standalone system with a PLC included in the control-measurement system via Modbus RTU or a controller with its own network ID – Modbus TCP Client / Server.

1. An apparatus for cooling water in a closed loop

Figure 1 shows the developed CW-1 device for cooling the water in the closed loop [2]. It was constructed for the purpose of cooling the seal of the retort of the nitriding furnace [1]. The device worked flawlessly for a period of approx. 4 years. Throughout the lifetime, there was no need to supplement the water in the tank. The UV lamp used for the disinfection of water has caused the water to be clear and free of odours. The upgraded water-cooling device in a closed loop was made for ELKAT.

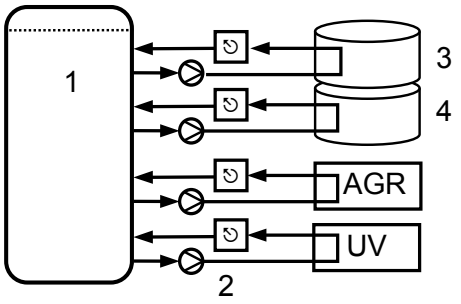
The control-measurement system is a stand-alone device, with the external control system for the gas nitriding system working as a Modbus Slave RTU controller. The information provided are the cooling water temperature, operating states of sensors and actuators, states of emergency, and the actual consumption of water and electricity (Fig. 1b). The water level sensor protects the circulation pumps against dry run.

The operation algorithms are as follows:

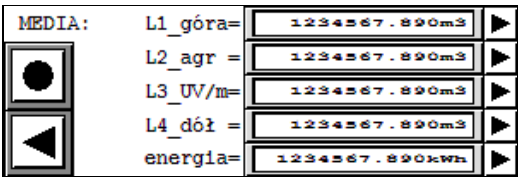
- The process of maintaining the temperature in a given range is accomplished through the plate heat exchanger of the chiller (AGR). The circulation pump in the duct of the unit also provides mixing of water in the tank (1).
- When the unit is not operating, the circuit with a UV lamp is started in cycles of 45 minutes with a 15-minute exposure to UV.
- Pump circuits (3) and (4) provide cooling of the seals in the nitriding furnace.
- When the pump is turned on and after a certain time there is no change in the encoder of the water meter, an alarm is generated.

The control-measuring system was developed based on a FC5A-D16RS1 controller and HG1F touch screen operator panel.

a)



b)



c)

Fig. 1. CW-1 device for cooling the water in a closed system [2]: a) block diagram, b) screen of operator's panel, c) implementation of the device; 1) reservoir with a capacity of 1 m^3 of water with a level sensor and temperature sensor, 2) Circulation pumps with water meter and pulse outputs, 3) retort lid cooling circuit, 4) furnace retort seal cooling circuit, AGR – chiller with plate heat exchanger, UV – circuit with UV lamp for disinfecting water

Additional software counters operating per second report the operation time of the device, the operation time of each pump, the operating time of UV lamp and the chiller, and the number and type of alarms. It is a valuable source of diagnostic information.

2. Monitoring the media in the pressure chamber

The pressure chamber is intended as a fumigation chamber (Fig. 2a) for the preservation of wood, paper, and fabric in anaerobic atmospheres of low oxygen content at a level not exceeding 1%, with a high proportion of non-reactive gas, greater than 99%. The chamber allows the atmosphere to produce high levels of nitrogen and argon, vacuum forming, measuring the oxygen content, and temperature and humidity regulation [3].

Media consumption monitoring fumigation chamber includes the following:

- Monitoring of gas consumption: The selected gases are kept inside the chamber in hyperpressure by the control-measurement system. The chambers are connected to two cylinders of nitrogen and two cylinders of argon, operating in the ramp system (Fig. 2d). When the gas pressure in the first cylinder is low, it is automatically switched to the second cylinder. There is no need to control the amount of gas consumption.
- Measurement of the electricity consumption of the entire chamber is accomplished by a 3-phase meter (Fig. 2b), and the energy consumption of the lubricant-free compressor is measured by a 1-phase meter.
- Measurement of the operation time of vacuum pumps: Software counters count the time of operation of the pumps and after exceeding the time of 2000h and report the need to replace oil.

Just as in the device CW-1, additional software counters report the operation time of the device, the operation time of each pump and solenoid valves, and the number and type of alarms. Diagnostics of the sensors is provided by analogue input and output modules of the PLC controller,[1] and they allow easy conversion of analogue measured values into "engineering units" without writing software. The control-measurement system was developed based on a FC5A-D12S1E controller with built-in webserver and a HG3F multimedia touch screen operator panel. These devices work on an Ethernet network. It is possible to remotely access them through a web interface.

[1] Macro command of ANST controller.

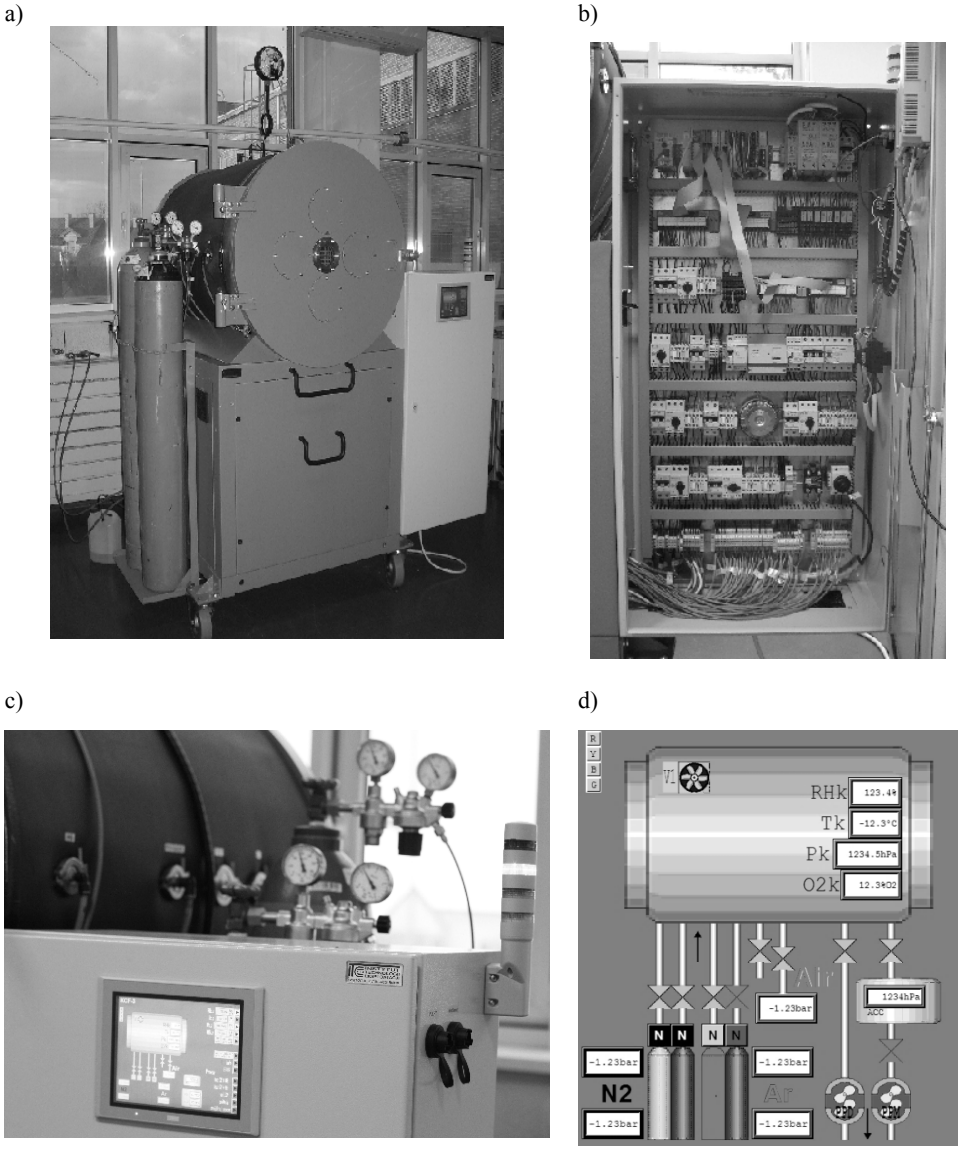


Fig. 2. Fumigation chamber: a) Realized chamber, b) The control-measurement system of the chamber – in the middle the 3-phase electricity meter, c) A view of the touch operator panel, d) Fragment of a monitoring screen for cylinders and vacuum pumps

3. Monitoring the electricity consumption

To monitor the electricity consumption, three, three-phase N43 meters were used that operate on the Modbus RTU with a dedicated RS485 port, where one

measures the electricity consumption of the cabinet with PLC and actuators, and two measure the power consumption of the 47kW furnaces. The N43 meters were used with inputs for direct measurement of current up to 63A (Fig. 3a). The operator panel displays basic information about the voltages, currents, and powers.

a)

b)

c)

Fig. 3. Measurement of electric energy: a) N43 meters in electric furnaces, b) Operator panel with key data from N43 meters c) Operator panel with details of energy consumption for each phase

The PLC operators' panels operate through a local Ethernet network, and all of them can be accessed remotely in the Institute network or outside. Built-in panel software allows remote control of temperatures as if the operator was physically at the HMI panel. In addition, the PLC has an implemented Modbus TCP Server. This facilitates the development of monitoring software.

Summary

Modern hardware electricity metering devices allow programming the electricity consumption for the various phases. Therefore, by switching, the individual lines can be loaded evenly. Increased energy consumption or no consumption is an information supplied to check the status of the power systems of the device.

Monitoring the energy and technology media consumption in devices and software control of the operation time and the number of events are important information about the status of the unit. Analogue modules of the PLC provide diagnostic information about the status of the analogue circuits – no power supply and tract initialization, exceeding the parameters, breaking the current loop, etc. This information from the measuring systems can also be used to diagnose the condition of the equipment.

Currently, the price of media consumption monitoring devices is a fraction of the cost of the entire device. Information about operation times of components, the number of failures, etc. are valuable information about the operation of technical objects and technological lines. Newly designed devices at ITeE – PIB are, by standard, equipped with monitoring software.

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Monitorowanie zużycia mediów energetycznych w urządzeniach technicznych

Słowa kluczowe

Energia elektryczna, regulator przepływu gazów, zużycie wody.

Streszczenie

Znajomość i optymalizacja zużycia mediów energetycznych i technologicznych jest ważnym zagadaniem w eksploatacji obiektów technicznych i linii technologicznych. W ITeE – PIB w nowo projektowanych urządzeniach są stosowane urządzenia do monitorowania zużycia energii elektrycznej, a także innych mediów. Zastosowane systemy pomiarowe pozwalają na ocenę kosztu realizowanego badania lub procesu technologicznego. W przypadku zasilania trójfazowego możemy równomiernie wykorzystać urządzenia, które pracują naprzemiennie. W artykule zaprezentowano zrealizowane podsystemy monitorowania zużycia energii elektrycznej, wody i sprężonego powietrza w linii do azotowania, serwerowni, urządzeniu do schładzania wody w obiegu zamkniętym, sprężarce, w komorze fumigacyjnej. Informacje z układów pomiarowych można także wykorzystać do diagnozowania stanu urządzeń.