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Results of the Development of an Energy-effective Automatised Solar Battery Cooling System with Frequency Control

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ABSTRACT: The article presents the results on the development of a schematic solution for the efficient regulation of an automated frequency-controlled solar panel cooling system, which will ensure the achievement of smooth start-up modes and energy-efficient control of the solar panel cooling system by controlling the rotation speed of their drive induction motors. The scheme allows by maintaining the required value of head in the cooling system and smooth variation of pump performance through a frequency-controlled electric drive to ensure rational use of hydropower resources.

KEY WORDS: frequency-controlled cooling system, solar panel, drive induction motor

I.INTRODUCTION

As is known, solar energy is one of the weightiest among alternative energy sources and the most promising in terms of the amount of resources and high environmental friendliness [1]. As we know, a number of problems can arise in the operation of alternative power sources based on solar panels from a practical point of view, one of which is to ensure their quality cooling [2]. On summer days the temperature on the surface of a solar panel may be around 70 - 80 0C. For normal operation of the solar panel it is necessary to reduce the temperature of its surface to 25 0C, which is achieved by using a water cooling system.

II. SIGNIFICANCE OF THE SYSTEM

This paper presents the results of the development of an automated solar panel cooling system with a closed-loop water cooling system. Fig. 1 below shows the process flow diagram of the solar water cooling system with closed-loop water cooling system.

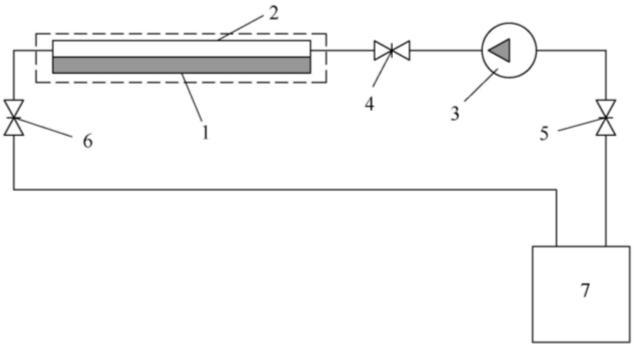

Fig 1: General technological scheme of the water cooling system solar panels:
1 - glass vessel; 2 - solar panel; 3 - pump; 4, 5, 6 - solenoid valves; 7 - tank

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The water-cooling system works as follows. Water from tank 7 with open state 4 and 5 valves and in closed state of valve 6 with pump 3 on is directed into a glass vessel installed on the surface of solar panel 1. Filling of the vessel is controlled by a level sensor VS and water temperature in the vessel is controlled by a temperature sensor TS. When the vessel with water is full, the VS sends a signal to the control system of the automated electric drive of the pump, and this signal corresponds to switching it off and closing of solenoid valves 4 and 5. Further, the temperature sensor TS controls the water temperature and when the water temperature in the vessel reaches a steady temperature value, a signal is sent to open the solenoid valve 6 and accordingly the pump and valves 4 and 5 are activated.

III. LITERATURE SURVEY

One of the promising ways of qualitative solution to the cooling problem is the use of automated electric drive system of solar panels cooling system based on frequency-controlled asynchronous electric drive [1-3].

IV. METHODOLOGY

The present work is devoted to the development of functional scheme of automated control system for solar panel cooling (Fig. 2).

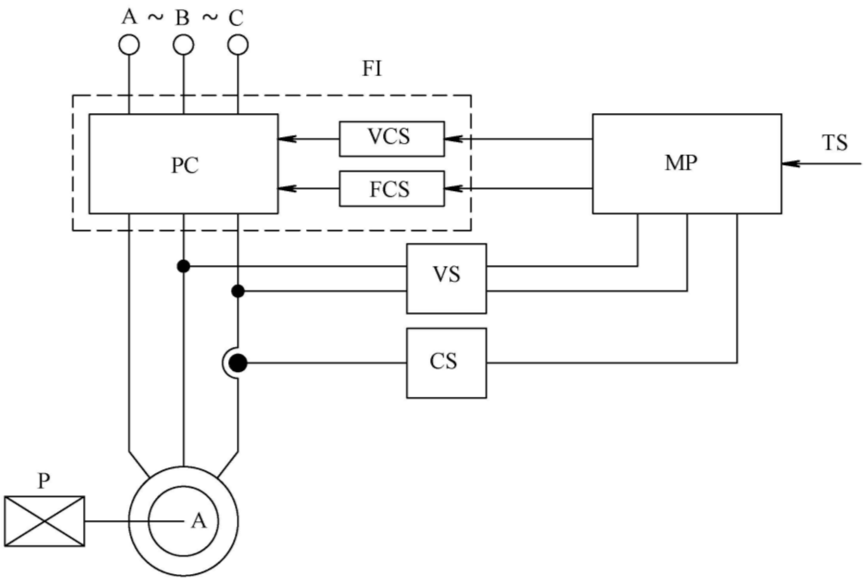

Fig 2: Functional diagram of an automated solar panel cooling system:
A - asynchronous motor; P - pump; VI - frequency converter; PC - power circuit; VCS and FCS voltage and frequency control systems respectively; MP - microprocessor; VS, CS, TS - voltage, current and temperature sensors respectively.

The operation of the frequency-controlled induction motor system is based on the sensor temperature value. When the temperature of the solar panels is above the permissible value, the microprocessor selects the frequency and amplitude of the induction motor supply voltage that will provide the required parameters. The voltage and frequency signals are then fed from the control system to the power circuitry of the frequency converter. Thus, for induction motor speed control is used frequency method with possible optimization of energy parameters of frequency-controlled induction motor which is carried out with the help of subprograms installed in the microprocessor by means of voltage correction in the stator winding via the frequency converter voltage control system. This way of asynchronous motors speed regulation means also increasing of its power characteristics by voltage regulation on asynchronous machine stator winding. It is proposed to produce voltage regulation on stator windings with the help of semiconductor converter. It is necessary to note, that the electric motor of the pump with frequency converter regulation takes from a network a starting

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current much less, than at direct start. Thus, the rated currents and the size of the electrical equipment are reduced and the power consumption is also reduced.

A universal frequency converter based on high-frequency integral-hybrid inverters controlled by microprocessor systems in an environment Ardino IDE. An open-source platform based on a microcontroller was chosen as the platform for the control system Arduino Uno with interface Application programming interface (API). The platform includes programming environment libraries and ready-made software modules for peripheral devices and various sensors. System hardware Arduino Uno consist of an 8-digit microcontroller ATmega328P, Power supply unit and interface with USB. The system has 14 digital inputs or outputs, of which 6 are analogue (8-digital PVM). SPI and I2C buses serve as digital interfaces [4 -6].

The control system of the automated solar panel cooling system must monitor the solar panel heating temperature rise, monitor the pump run time and provide wireless control of the cooling system to meet the safety conditions under long term solar panel operating conditions. The structural diagram of the developed system consists of two main modules - the power circuit and the control system based on Arduino Uno. Both the writing and debugging of the microcontroller software was done in an environment Arduino IDE (publicly available programming environment) in the C++ programming language, using publicly available software modules created by the engineering community. Subprograms for digital sensors and external devices are published under a free license GPL, this license allows you to modify the software code for your own purposes. So during development it turned out that the resources of the ATmega328P (2kB RAM, 27kB ROM) are not enough to use several libraries simultaneously, so the code was optimized for the available resources. It should be noted that the use of unregulated cooling system implies direct switching of the pump electric drive, which leads to the fact that the windings have 6 - 10-fold starting currents, which lead to large electrodynamic and mechanical forces, as a result of which the motor windings are subject to increased wear, significantly reducing the service life of mechanical and electrical parts of the electric drive and mechanism. In addition, after reaching a steady-state speed of rotation, the electric drive operates in an under loading mode, as a result of which there is an unjustified overconsumption of full power consumption, and as a result the technical, economic, energy and operational performance of the installation as a whole is reduced. At the same time, the specific power consumption per unit of output increases.

In order to reduce inrush currents of asynchronous motors and increase energy efficiency of automated electric drive operation in steady-state modes of operation at relatively low load of mechanisms, it is necessary to optimize energy parameters, according to various optimality criteria (minimum stator current, maximum efficiency and power factor).

V. CONCLUSION

The use of thyristor frequency converter on the basis of high-frequency integral-hybrid inverter during implementation of the automated electric drive also allows increasing functional capabilities of the system, both in static and dynamic modes of operation. The application of microprocessor control system provides, while maintaining the constancy of the structure of the automated electric drive, to implement the selected criterion of optimality of energy parameters of the system, to ensure smooth start-up and effective protection against emergency modes of operation.

Proceeding from the aforesaid it is possible to ascertain, that development and creation of power saving technology providing qualitative work of solar batteries with high power indicators on the basis of modern semiconductor technique, taking into account their industrial features, is one of actual problems, and development, research and creation of power saving technologies of new generation which most meet modern requirements from the point of view of power engineering is an actual research object.

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