Energy saving when measuring the flow rate of Russian oil wells

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Abstract. The paper describes the design of a mobile unit for measuring oil, water and associated gas flowrates. The source of electrical and thermal energy used by the measuring unit is a fuel cell battery which uses associated gas released from the products by means of a separation plant. The autonomous power source allows for saving a significant amount of electricity and makes it unnecessary to lay power supply communications at the initial stage of oil field development.

1. Introduction
For measuring the flow rate of oil and gas wells, various measuring units are used to ensure the required accuracy of production measurement for each production stage.

Given the variety of geological and technical conditions at different oil fields as well as the features of their operation at different development stages (initial or final), the domestic industry produces a wide range of stationery and mobile measuring units [1-3].

Although the measuring units used by the energy industry of Russia satisfy oil-producing companies in terms of their measuring and accuracy properties, they have one significant drawback - a sufficiently large energy capacity rate which varies from 10 kW for mobile units to 25 kW for stationary ones [4].

This drawback is aggravated by the lack of an important functional unit in domestic measuring facilities which is a utilizer of associated petroleum gas (APG). It protects the environment which is very important in modern conditions, serves as a source of energy for functional units and reduces energy consumption for producing one ton of oil which is especially important for most Russian oil fields at the final operation stage [5, 6].

It is known that fuel cells and power plants based on these fuel cells are the most effective APG utilizers.

Fuel-cell-based APG utilizers generate electric power of any power capacity (up to 500 kW or more) heat which can be used for heating the operation room of the measuring unit pipeline communications in order to prevent paraffin deposits and reduce viscosity of the reservoir fluid which is especially important in Extreme North and Arctic conditions [7-10].

2. Materials and methods
Accounting for the relevance of energy saving, we developed a design of a measuring unit designed for automatic measurement of the oil, water and associated gas production rates. Fuel cells utilizing
associated gas separated in the measuring process are used as a source of electrical and thermal energy [9].

The block diagram of the mobile measuring unit is shown in Figure 1. The unit is connected to the well through pipeline 1, equipped with shut-off valve 2 which are connected to separation tank 5 which is connected through gas pipeline 6 with gas collection tank 7 connected to the output gas pipeline equipped with shut-off valve 8 connected through gas meter 18 and shut-off valve 9 with fuel cell 10 electrically connected to control processor 3 and battery 4.

Heat-generating channel of fuel cell 10 is connected to coil 15 located in duct 16 equipped with air fan 17.

Air intake channel 12 consists of shut-off valve 11, air meter 19, compressor 14 driven by electric motor 13 and connected via air intake channel 12 to the other pole of fuel cell battery 10.

Separation tank 5 is connected through outlet pipe 22 to shut-off valve 23, liquid phase meter 20, moisture meter 21 and outlet 25 to the field pipeline and through it to the oil park.

The following functional units of the mobile measuring device are placed in housing 25 mounted on wheeled chassis 26 in the form of a trailer or on the platform of a vehicle with an increased payload and a throughput.

The unit is operated by radio communication through receiving-transmitting antenna 27 coupled with processor 3.

The measured products move from the well or the well cluster through the switch along inlet pipe 1 through check valve 2 which is controlled by processor 3 which is powered from battery 4.

![Figure 1. Block diagram of the mobile measuring unit.](image-url)
command of processor 3, shut-off valve 11 located on intake manifold 12 opens and electric motor 13 of compressor 14 starts up and atmospheric air flows to the opposite pole of fuel cell 10 through air duct 12.

By a command of processor 3, fuel cell 10 is launched from battery 4 in which the physicochemical reaction begins to utilize hydrogen from the APG and oxygen from the atmospheric air accompanied by heat and electricity generation. The heat through coil 15 enters duct 16 from which the hot air with the help of fan 17 goes to separation tank 5 which accelerates the oil degassing process and increases the volume of gas in gas collection tank 7. The increase in the APG volume is controlled by gas meter 18. Information from this meter enters processor 3 in real time. Processor 3 receives data from meter 19 in air intake line 12.

As battery of fuel cells 10 accumulates electric power, processor 3 switches the power of electric motor 13 to the power supply from fuel cells 10.

Along with the APG utilization, the amount of oil and water passed through separation tank 5 is recorded by meter 20 and moisture meter 21 embedded in discharge pipe 22. If necessary, the flow of products through pipeline 22 can be stopped by a command from processor 3 using shut-off valve 23. If the APG pressure in gas collecting tank 7 is above the predetermined limit, it can be lowered using the flow line through emergency shut-off valve 24 by a command from processor 3.

3. Results and discussion
Calculations show that if the cost of a battery of fuel cells with a capacity of up to 10 kW is about 600$ (when purchased from foreign suppliers), their payback as a source of electricity and heat at 3 rubles per 1 kilowatt-hour will occur after 1.5 years of continuous operation.

4. Conclusion
Based on the description of the design features and operation principles, it can be concluded that the measuring unit has technological and economic advantages, since it is known that fuel cells have high efficiency (up to 70-80%) and do not require repairs for up to 5 years of continuous operation.

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