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The modular concept of building an adaptive system of thermostating for hybrid and electric vehicles

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Summary

According to the forecasts, by 2025 at least 50% of the world's produced vehicles will be on electric traction. The task of thermostating an electric vehicle components is relevant in the Russian Federation. At present, the vehicle has a number of components (electric motor, inverter, charger, high-voltage battery) that need a certain temperature mode. The paper will consider the use of modular concept of building an adaptive system of thermostating for hybrid and electric vehicles. The article will present vehicles where such a concept is currently implemented.

Keywords: HEV (hybrid electric vehicle), EV (electric vehicle), thermal management, heating, cooling

1. Introduction

The development of electric transport in the European Union has become one of the three priority areas of the European economy, and in Russia energy efficiency is declared as the main direction of the country's development in the coming years. According to the forecasts, by 2025 at least 50% of the world's produced vehicles will be on electric traction. The modern level of technology development allows you to create more advanced and environmentally friendly vehicles [3]. One of the systems that ensure the performance of such vehicles is the temperature control system for the main components. The task of thermostating a vehicle components is very relevant in the Russian Federation with its wide range of environmental conditions [4]. If previously it was necessary to cool and heat only the internal combustion engine of a vehicle, then at present the vehicle has a number of components (electric motor, inverter, charger, high-voltage battery) that also need a certain temperature mode [1, 2, 6, 8]. To solve such problems, the FSUE “NAMI” developed a modular concept of the temperature control system, which allows it to adapt to different climatic and road conditions.

2. Theoretical part

Fig. 1 shows an example of constructing a temperature control system for a high-voltage battery of a hybrid or electric vehicle. The presented system of thermostating of high-voltage battery 3, consists of the following components: radiator with fan 1; pump 2; expansion tank 4; electromechanical valve 5 and temperature sensors 6, 7, 8. The system maintains the optimum temperature mode by regulating the coolant flow through the housing of the high-voltage battery.

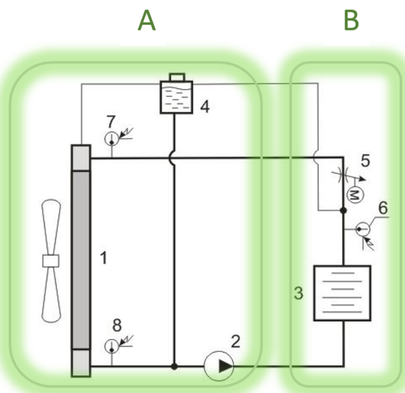

Figure1: The thermostating system of high-voltage battery

The fluid flow rate is controlled by automatically opening and closing the electromechanical valve 5, according to a signal from the temperature sensor 6. The using of degassing channels ensures the removal of air from the system. In the warm-up mode of the high-voltage battery, the electromechanical valve 5 is closed. In Fig. 1, two contours are highlighted. Circuit "A" includes a radiator with a fan 1, a pump 2, an expansion tank 4 and temperature sensors 7, 8. Circuit "B" includes a high-voltage battery 3, an electromechanical valve 5, a control temperature sensor 6. Instead of a high-voltage battery, another component that requires temperature control, such as an inverter, an electric motor, or a charger, can be installed in the circuit.

If there are several components, it is possible to assemble a general scheme of system of thermostating. Such an approach can be called a modular construction principle.

Fig. 2 shows an example of constructing a system of thermostating for several components of a hybrid or electric vehicle.

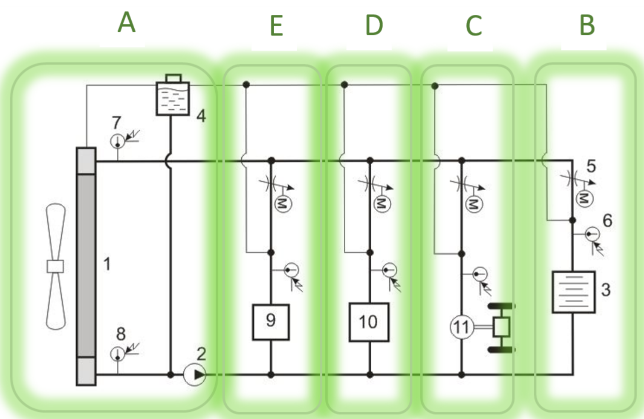

Figure 2: The system of thermostating for components vehicle

In the presented ~~the~~ system of thermostating, together with high-voltage batteries 3 (module B) is temperature controlled the charger 9 (module E); inverter 10 (module D) and electric motor 11 (module C). All components are connected in parallel. This allows you to adjust the temperature of each component separately.

3. Practical part

According to this principle, a modular scheme of the system of thermostating was built for a prototype electric vehicle. The scheme was implemented on the Russian electric car VAZ - 1817 (Ellada). The scheme in Fig. 3 includes the following components: radiator with fan 1, expansion tank 4 and pump 6 (module A); charger 9 (module B); inverter 10 (module C); electric motor 11 (module D); high-voltage battery 3 (module

E); coolant heater 15, coolant cooler 14, cabin heater 16 with mechanical valve 17 (can be electromechanical) (module F). In the starting mode of the temperature control system, all electromechanical valves are closed, except for positions 12 and 18. To quickly warm up the system, the circuit provides for the circulation of coolant to bypass the main radiator 1. The scheme has a coolant heater for heating the high-voltage battery and heating the cabin of the car. In the cooling mode of the high-voltage battery or the system as a whole, electromechanical valves switch to another position.

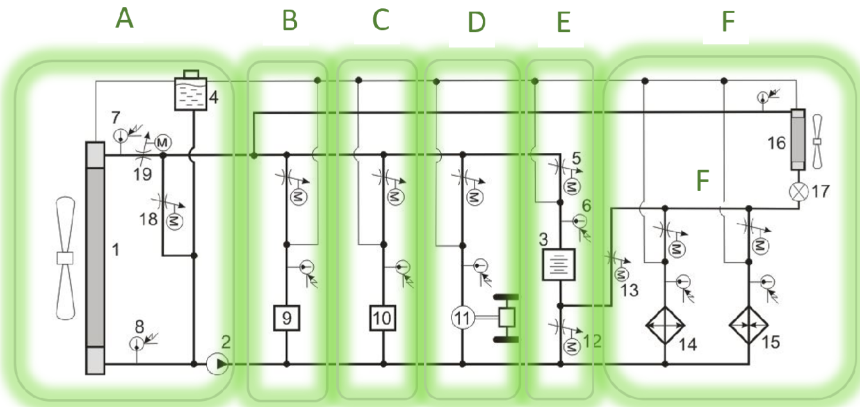

Figure 3: The modular scheme of the system of thermostating electric vehicle

If more intensive cooling or heating of other vehicle components is required, then it is possible to connect the cooler 14 and the heater 15 to the corresponding line. The developed modular system is implemented on the electric vehicle as Fig. 4, 5 [9, 10].

Figure 4: Electric vehicle equipped with the developed thermostating system
(A – charger, B – pump, C – electric motor, D – inverter, E – high-voltage battery, F – cooler of liquid, G – expansion tank , H – electric heater of liquid, K – radiator with fan)

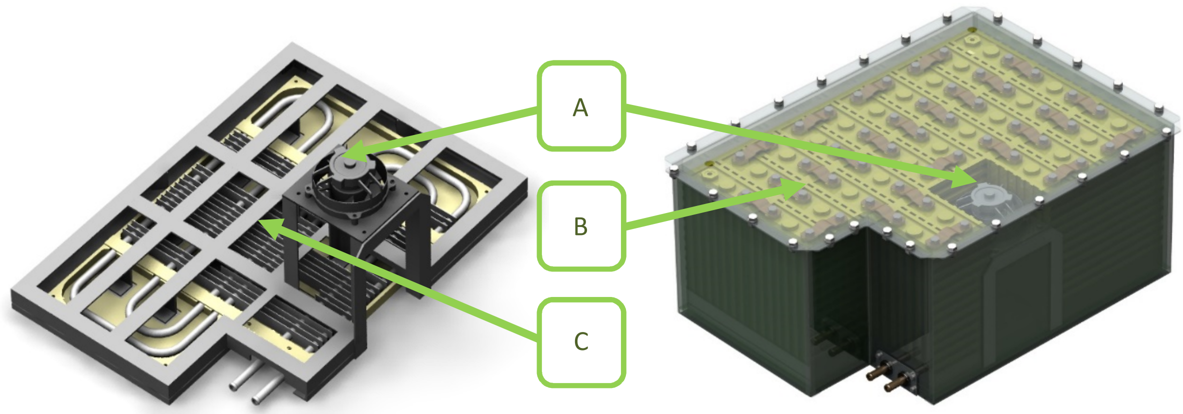

Figure 5: 3D-Model of high-voltage battery (A – fan, B – cells, C – heat exchanger of high-voltage battery)

In addition, the modular scheme of the system of thermostating (Fig. 6) was built for a prototype electric vehicle with a Range Extender [5, 7].

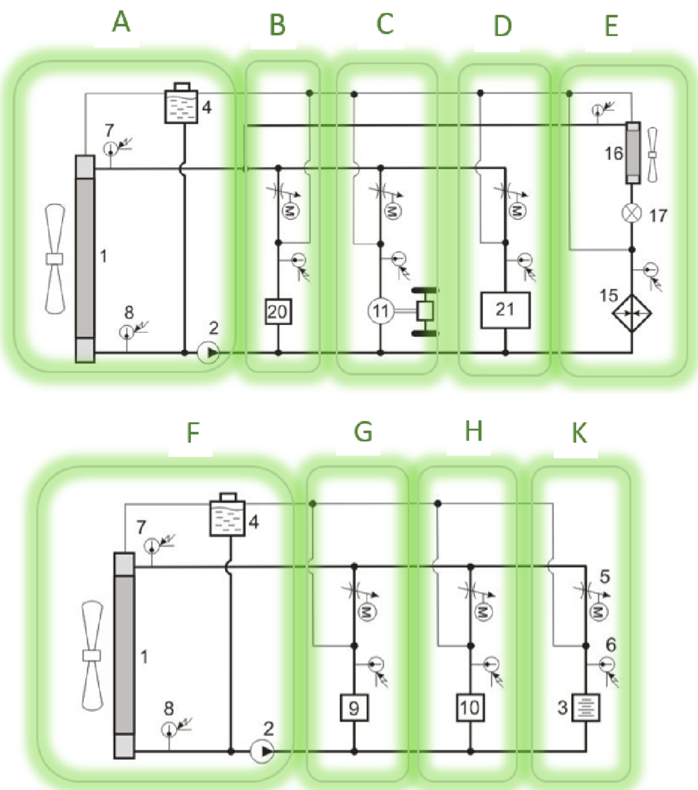

Figure 6: The modular scheme of the system of thermostating electric vehicle with a Range Extender

In the presented thermostating system there are two main circuits of thermostating. In the first circuit, the temperature of the coolant is not more than 90 degrees, and in the second circuit, the temperature is not more than 60 degrees. The first circuit includes the following components: radiator with fan 1, expansion tank 4 and pump 2 (module A); electric motor 11 (module C); a generator 20 (module B) and the engine 21 from range extender (module D). Also in the circuit there are: the coolant heater 15, a cabin heater 16 with mechanical valve 17 (module E). The second circuit includes the following components: radiator with fan 1, expansion tank 2 and pump 5 (module F); inverter 9 (module G); charger 10 (module H) and high-voltage battery 3 (module K). In the water circuit for high-voltage battery, Peltier elements are used for additional heating or cooling. The developed modular system is implemented on the electric vehicle as Fig. 7, 8, 9.

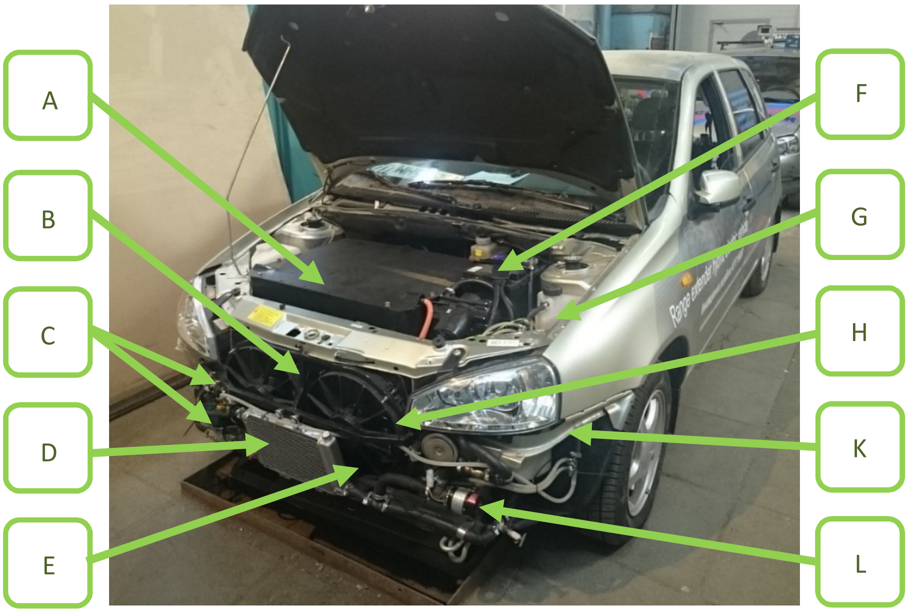

Figure 7: Electric vehicle with a Range Extender (A – high-voltage battery, B – primary radiator, C – electromechanical valve, D – radiator of the second circuit, E – electric motor, F – charger, G – expansion tank , H – inverter, K – pump 1, L – pump 2).

Figure 8: Electric vehicle with a Range Extender (M – Range Extender, N – electromechanical valve)

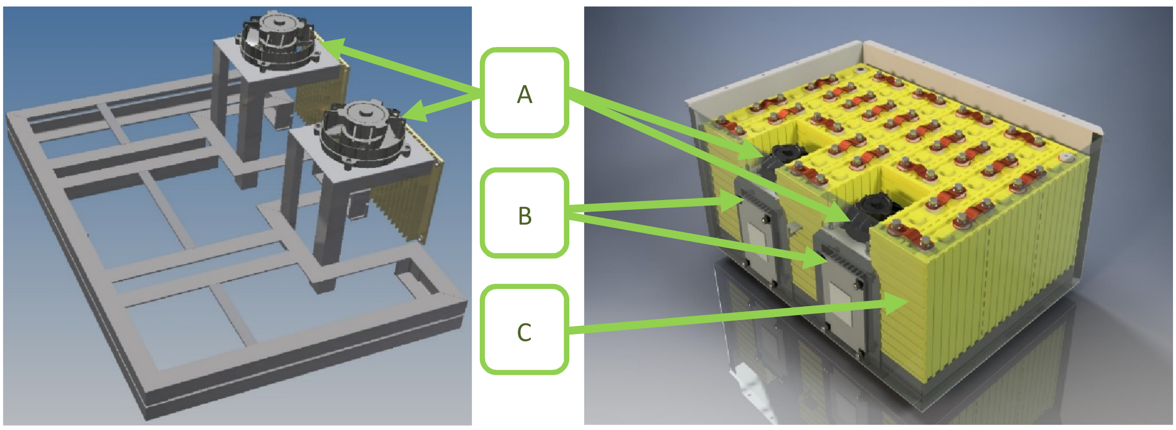

Figure 9**:** 3D-Model of high-voltage battery (A – fan, B – radiators of high-voltage battery, C – cells)

4. Conclusion

Vehicle tests have shown the effectiveness of the developed design of the temperature control system. It is currently planned to test the electric vehicle on hard conditions to show the efficiency of the developed design of the thermostating system. The article describes several schemes of the system of thermostating, which were built according to the modular principle. This concept allows you to create different combinations of such systems, while providing the specified temperature parameters of the components. To control the temperature control system developed software. Adjustment and verification of system parameters can be done both at the time of assembly and during operation. Such an integrated approach to the creation of the systems of thermostating allows to improve the performance and increase the reliability of hybrid and electric vehicles.

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