OBTAINING EXPERIMENTAL TEST RESULTS

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This article describes the process of conducting experimental tests of a passenger car cooling system with a mechatronic control system and the main indicators obtained as a result of these tests. The experiments were conducted on a specially designed laboratory stand, simulating the operating conditions of a real car cooling system.

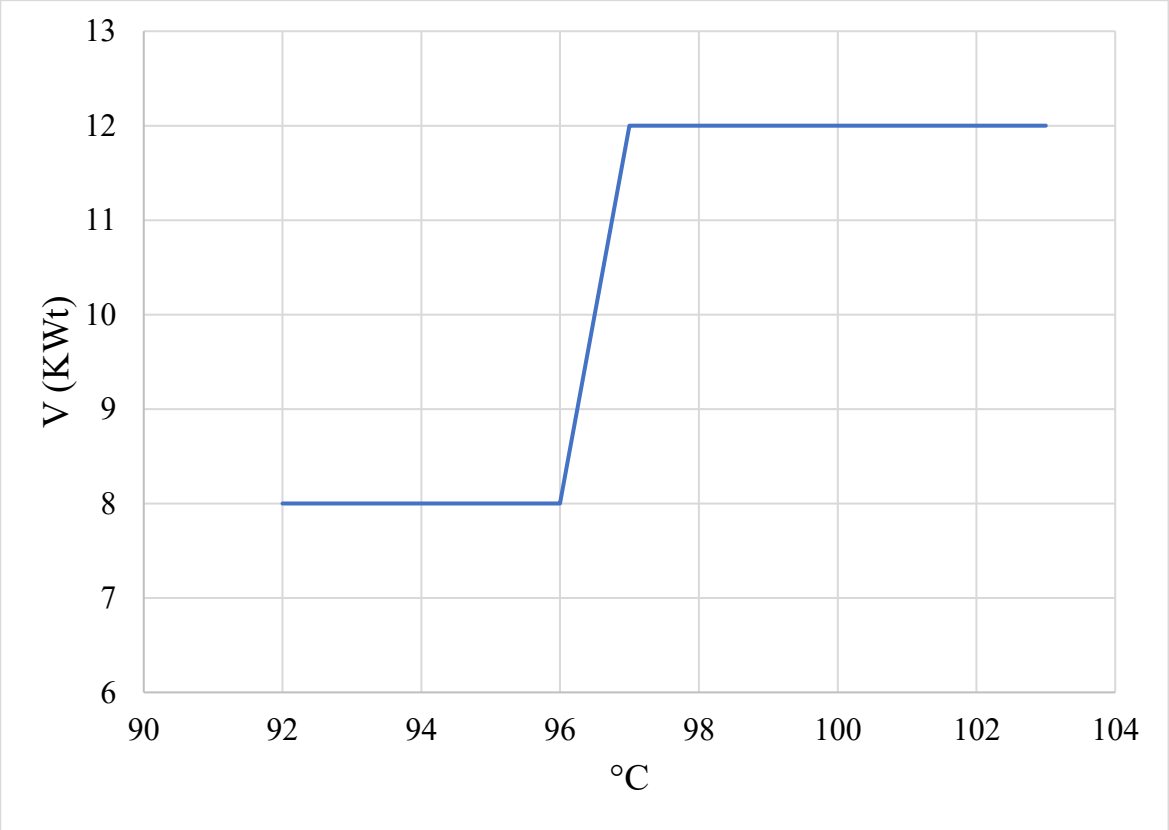


Figure 1. Default control system

During the experimental tests, the temperature response of the system, the operating modes of the fan and pump, and the dynamics of changes in control signals were recorded. The tests were conducted in two control modes: traditional relay (step-by-step) control and mechatronic (adaptive PWM-based) control.

To assess temperature changes, the temperature was gradually increased in several ranges (for example, -10...0°C, 0...10°C, 10...20°C, and high-temperature zones) in accordance with the engine's operating zone (Table 2). The response and stabilization state of the system were recorded in each range.

2-table

№	Engine coolant temperature sensor reading range for main fan (°C)	Operating range of the engine coolant temperature sensor for the auxiliary electric fan (°C)	Ambient temperature (°C)	Voltage to main fan (V)	Voltage to auxiliary fan (V)
1	-	-	от -10 - до 0	-	-
	96 - 92	-	от 0 - до 10	6	-
	96 - 92	-	от 10 - до 20	6	-
	96 - 92	-	от 20 - до 30	8	-
	96 - 84	96 - 92	от 30 - до 40	8	8
	96 - 80	96 - 84	от 40 - до 50	8	8
2	100 - 96	-	от -10 - до 0	-	-
	100 - 96	-	от 0 - до 10	8	-
	100 - 96	-	от 10 - до 20	8	-
	100 - 96	100 - 96	от 20 - до 30	10	8
	100 - 96	100 - 96	от 30 - до 40	12	10
	100 - 96	100 - 96	от 40 - до 50	12	12
3	103 - 100	-	от -10 - до 0	12	-
	103 - 100	-	от 0 - до 10	12	-
	103 - 100	-	от 10 - до 20	12	-
	103 - 100	103 - 100	от 20 - до 30	12	8
	103 - 100	103 - 100	от 30 - до 40	12	12
	103 - 100	103 - 100	от 40 - до 50	12	12

The experimental results showed that the temperature change in the relay control system was of a jump-like nature, and discrete fan modes of 0V–8V–12V were observed. This led to the formation of a hysteresis zone in the system and an increase in temperature fluctuations.

In the mechatronic control system, the fan speed fluctuated smoothly as a result of continuous control based on PWM. This condition ensured stable temperature maintenance and led to a smooth flow of transient processes. As a result, the system response time decreased, and the amplitude of temperature fluctuations decreased.

During the tests, the following key data were recorded:

• values of temperature change over time T (t) T (t) T (t);

• fan control signal (relay or PWM);

• system stabilization time;

• maximum temperature deviation.

The obtained experimental results served as the basis for mathematical processing and graphical analysis at the next stage. These results also made it possible to compare the efficiency of the systems and substantiate the superiority of mechatronic control.

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