European Journal of Research Development and Sustainability (EJRDS)
Available Online at: https://www.scholarzest.com
Vol. 6 No 12 December 2025
ISSN: 2660-5570

PROBLEMS ENCOUNTERED IN THE OPERATION OF AUTOMOBILE COOLING SYSTEMS AND THEIR SOLUTIONS

Abdiqodirov Shavkat Abdixamidovoch
Associate Professor, PhD, Termez State University of Engineering and Agrotechnologies
e-mail. shavkatabdiqodirov@mail.ru
Trainee Lecturer, Termez State University of Engineering and Agrotechnologies
Abduqahorov No'monbek Oybek o'g'li
e-mail. abduqahorovnomonbek@gmail.com
International University

Article history:	**Abstract:**
Received: 11th August 2025 **Accepted:** 10th September 2025	This article provides an in-depth analysis of the major issues encountered in the operation of automobile engine cooling systems, their root causes, and effective solutions. It highlights the importance of the cooling system in maintaining the engine's thermal balance and examines factors affecting its efficiency. Key components such as the radiator, thermostat, water pump, temperature sensors, and coolant quality are scientifically analyzed. The study also discusses modern diagnostic methods for identifying cooling system malfunctions, optimal maintenance intervals, and strategies for eliminating heat-exchange disruptions during operation. The article is practically valuable for specialists in vehicle operation, technical maintenance, and automotive engineering technology.

Keywords: Automobile cooling system, engine, heat exchange, radiator, thermostat, water pump, coolant, sensor, diagnostics, maintenance, operation

INTRODUCTION

During its operation, an automobile engine generates a significant amount of heat energy. In internal combustion engines, only 25–35% of the fuel energy is used for useful work, while the remaining 65–75% is released as heat through exhaust gases, engine components, and the cooling system into the environment. If this heat is not properly dissipated, it can lead to overheating of engine parts, breakdown of the lubricant film between components, increased friction, and, ultimately, serious engine damage. Therefore, the cooling system is one of the most critical systems ensuring the technical reliability of a vehicle. The cooling system performs several operational functions, including maintaining the engine at an optimal temperature, dissipating excess heat to the environment, stabilizing fuel consumption, and extending engine life. The engine's nominal operating temperature usually ranges from 85 to 95°C, which ensures maximum efficiency. The coordinated operation of the thermostat, pump, radiator, fan, and coolant maintains the engine within this optimal temperature range. Currently, two types of cooling systems are used in vehicles: air-cooled and liquid-cooled systems. The liquid-cooled system is the most widespread due to its higher heat exchange efficiency, ease of control, and ability to maintain engine temperature quickly and precisely. However, since it consists of many elements such as pipes, hoses, valves, and pumps, various malfunctions can occur during operation. According to statistical data, 30–40% of engine failures are related to cooling system malfunctions. The main causes of these issues include:

- Decreased quality or improper selection of antifreeze;
- Contamination of the radiator surface or blockage of internal channels;
- Mechanical wear of the pump;
- Thermostat sticking closed or remaining permanently open;
- Deterioration of hoses and connections;
- Fan system failure.

These problems can cause engine overheating, reduced performance, and increased fuel consumption. If not addressed in time, they may result in severe technical failures requiring major engine repairs. Therefore, regular maintenance of the cooling system, monitoring the quality and level of coolant, and diagnostics of critical components such as the radiator, thermostat, and pump are essential. This article analyzes the most common problems in vehicle cooling systems, their causes, and practical solutions based on scientific research.

RESEARCH METHODOLOGY

Design and Operational Significance of Cooling System Components

The automobile cooling system is a complex thermodynamic system that regulates the engine's heat balance, with each component playing a critical role in heat exchange processes. The system consists of the following key components:

Radiator. The radiator comprises two main parts: the upper and lower tanks and the heat exchange channels. Its primary function is to transfer the heat accumulated in the coolant to the external airflow. Modern automotive radiators are typically made of aluminum, which has high thermal conductivity (200–240 W/mK), thereby enhancing cooling efficiency. The radiator's performance depends on several factors: The spacing between fins (lamellae), Airflow velocity, Cleanliness of the radiator surface,

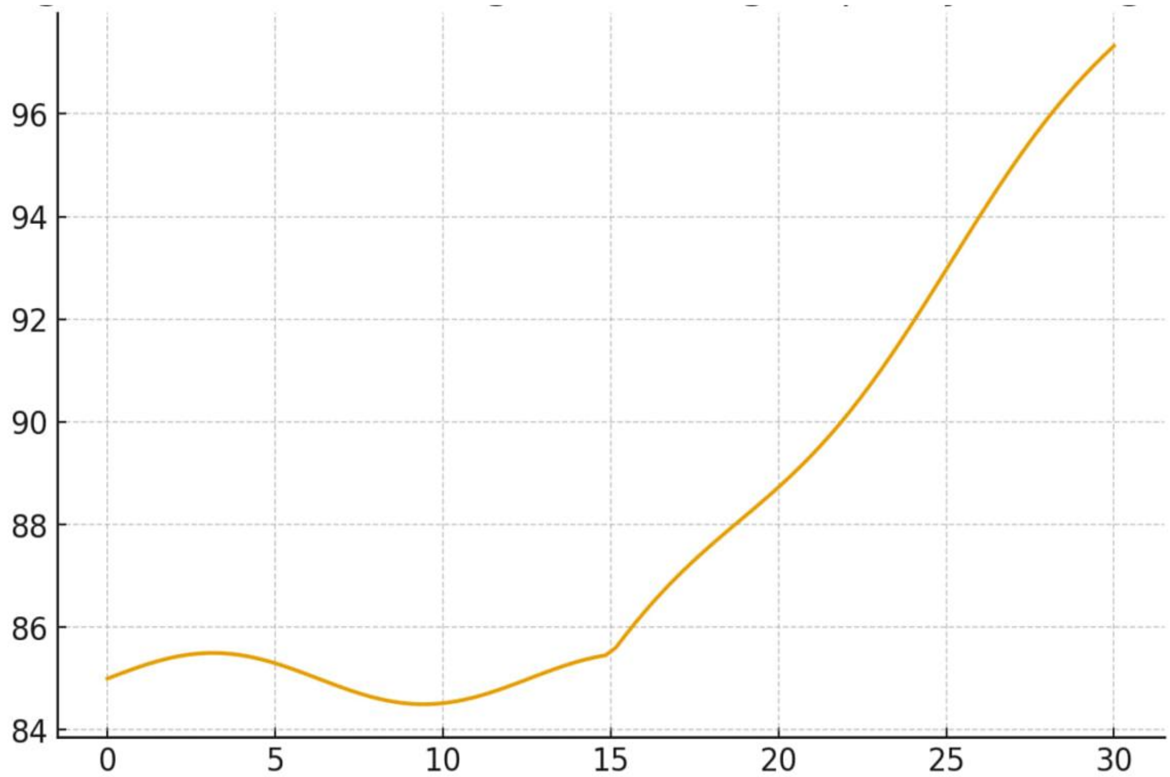

Figure 1. Increase in engine coolant temperature over time

PROBLEMS IN THE COOLING SYSTEM AND THEIR SCIENTIFIC ANALYSIS

Reduced Heat Transfer Efficiency. Radiator performance decreases under the following conditions: Clogging of 30–40% of the coolant channels reduces the heat transfer coefficient by up to 50%. External dust, insects, debris, and residues accumulate between radiator fins, reducing airflow. **Physical Basis:** Heat transfer in the radiator occurs according to Fourier's law. Narrowed channels reduce the heat exchange surface area and ΔT (temperature difference), lowering the overall heat transfer. Coolant flow rate.

The main composition of the coolant (antifreeze) includes 45–55% ethylene glycol or propylene glycol, water, corrosion inhibitors, and anti-cavitation additives. Key properties of the coolant are: Boiling point: 108–120°C Freezing point: –35 to –65°C . Low electrolyte content to reduce corrosion Degradation of the coolant can lead to clogged radiator channels, intensified cavitation, and pump impeller wear.

Pump. The pump operates on the centrifugal principle. As the impeller rotates, the coolant is pushed outward and circulated throughout the system. The pump's performance depends on the engine's rotation speed, providing an average circulation of 6–12 liters of coolant per hour.

Thermostat. The thermostat automatically regulates the engine temperature. Its functions include: During engine cold start: circulating coolant in a small loop to quickly raise the temperature, When the engine is hot: directing the coolant to the radiator to maintain optimal temperature. The opening temperature of the thermostat is typically 85–92°C.

Solutions: Check for obstructions in the condenser in front of the radiator. Diagnose the electrical parameters of the fan.

Degradation of Coolant Physical-Chemical Properties. Over time, coolant undergoes the following changes:

- Glycol decomposition → decreased pH, increased corrosion;
- Increased metal ions → formation of oxide layers on channel walls;
- Inhibitors lose effectiveness → pump bearings wear out.

Statistics: 25–30% of cooling system failures are associated with degraded coolant quality.

Solutions: Replace the coolant completely every 2 years. Flush the system with distilled water Measure pH with an indicator to monitor acidity.

Thermostat Malfunction. If the thermostat remains closed, the engine can overheat within 5–10 minutes. If the thermostat stays open, the engine operates cold, increasing fuel consumption by 10–15%.

Causes: Failure of the paraffin capsule, corrosion, or sticking of the thermostat valve. **Testing:** Thermostats are tested in a water bath at 80–90°C. **Solution:** Thermostats should not be repaired; they must be replaced entirely.

Pump Failure. If the pump fails, coolant flow sharply decreases, leading to "hot spots" in the engine block where temperatures may rise to 150–180°C. **Causes:** Impeller seizure or breakage, bearing overheating, worn sealing rings.
Hoses. At high temperatures, hoses lose elasticity, resulting in: Microcracks, Coolant leakage under pressure, Air ingress, intensifying cavitation. Visual inspection every 20,000 km, Use high-pressure-resistant hoses,

Check air release valves. **Electric Fan Malfunctions.** The fan is controlled by the engine temperature sensor. **Problems:** Sensor inaccuracies, relay failure, fan motor breakdown. **Analysis:** The fan can move 20–40 m³ of air per second. A decrease in this capacity reduces radiator heat transfer by 2–3 times. **Modern Solutions:** Electronic thermostats allow precise engine temperature control, increase fuel efficiency by 3–5%, and reduce emissions. Advanced sensors detect coolant boiling point, density, and level.

CONCLUSION AND RECOMMENDATIONS

The conducted scientific analysis demonstrates that the cooling system is one of the most critical factors for safety and reliability during the operation of an automobile engine. Maintaining the engine at a stable temperature directly affects its technical lifespan, fuel efficiency, environmental performance, and overall operational effectiveness. Any malfunction in the cooling system can lead to engine overheating, excessive thermal expansion between components, and breakdown of the lubricant film, significantly increasing maintenance costs. The analysis identified the primary causes of cooling system failures as:

- Degradation of coolant quality,
- Clogging of radiator channels,
- Unstable thermostat operation,
- Mechanical wear of the water pump,
- Electrical malfunctions in the fan system,
- Loss of sealing integrity in hoses and connections.

Neglecting operational conditions and delaying regular maintenance and preventive measures are major factors that exacerbate these failures.

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