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Engine Cooling System Maintenance

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Abstract: The efficiency and longevity of modern automobile engines depend significantly on their thermal conditions, especially in desert-sandy areas where overheating is a frequent issue. The cooling system plays a crucial role in maintaining optimal thermal conditions, and its reliability is influenced by factors such as water pump efficiency, radiator cleanliness, and coolant quality. The accumulation of scale within the cooling system can severely impact heat dissipation, leading to engine wear and possible failure. Various chemical and mechanical methods are available for descaling and flushing the cooling system, thereby improving engine performance and preventing overheating. Additionally, the use of softened water and anti-corrosive additives can enhance the durability of the cooling system. This paper discusses the maintenance procedures, descaling techniques, and best practices for ensuring efficient engine cooling.

Keywords: Engine cooling system, overheating, scale formation, descaling, water hardness, radiator maintenance, thermal efficiency.

Introduction: The cooling system of an automobile engine is essential for maintaining optimal operational temperatures and preventing overheating. This is particularly important in high-temperature environments, such as desert-sandy areas, where excessive heat can negatively impact engine performance. The engine's thermal stability depends on several factors, including load conditions, ambient air temperature, and the functionality of the cooling system.

A properly functioning cooling system ensures that excess heat is effectively dissipated, preventing wear and tear on engine components. However, issues such as scale formation, coolant leaks, and radiator clogging can lead to thermal inefficiencies. Scale deposits on the walls of the cooling jacket significantly reduce heat transfer due to their low thermal conductivity, resulting in increased engine stress and potential failure. This paper explores the importance of maintaining the cooling system, methods for removing scale, and best practices for using water and chemical treatments to enhance system reliability.

Research

High thermal stress of engine operation occurs due to the harmful effect of scale, formed on the walls of the cooling system jacket. This is explained by the fact that the thermal conductivity coefficient of scale is approximately 20-30 times less than the thermal conductivity coefficient of cast iron, steel or brass. Consequently, in the presence of scale, the conditions for heat removal from the cylinder-piston group of the engine worsen, and the resulting overheating of the parts increases the intensity of their wear.

The presence of a scale layer in the engine cooling jacket is the cause of cylinder scoring and clogging of the radiator tubes. To remove scale and flush the cooling system, you can use a 6% lactic acid solution or a 10% caustic soda solution. The time required to remove scale with lactic acid is 1-3 hours, and with caustic soda 6-8 hours. Soda-kerosene solutions are widely used to flush the cooling system of diesel engines. Such solutions are prepared using caustic soda, kerosene and water. The composition of the solution: caustic soda - 7, kerosene - 2.3, water - 90.7%. To flush one engine, on average, the following is required: soda 4.8-5.8, kerosene 1.5-1.9, water 60-75 liters. The prepared solution is poured into the cooling system, the engine is started and allowed to run at medium speed for 5-10 minutes, the engine is stopped and the solution is kept in the cooling system for 10-12 hours; the engine is started again and warmed up; the solution is drained from the cooling system; the cooling system is flushed with water in a volume of two to three times the capacity of the system.

The clogging of the radiator and engine cooling system can be determined by filling it with water coming from a measuring tank installed 300-400 mm above the radiator neck and connected to it by a flexible hose. In this case, the time and volume of water required to fill the entire cooling system or the radiator and the cylinder block jacket space separately are determined. The data obtained are compared with the time and volume of water required to fill the engine cooling system of a new car of the same brand.

The cooling system can also be cleaned by using an air-water jet in the direction opposite to the circulation of liquid in the cooling system. To do this, the cooling liquid is released from the cooling system, the upper and lower connecting hoses are disconnected and a special tip is installed in the lower radiator pipe or the engine block pipe, through which water and air are supplied under pressure. The pressure of the air supplied to the radiator should not exceed 0.5-0.75 N/cm2, since at higher pressure the radiator may be destroyed. Flushing should be done until clean water without traces of silt deposits comes out of the radiator neck. It is advisable to perform this method of cleaning the cooling system after treating the system with special flushing solutions. The cooling system of most modern automobile engines is closed, i.e. sealed, due to which the pressure in it exceeds atmospheric. An increase in pressure by every 0.1 N/cm2 above atmospheric increases the boiling point of water by 2.4-2.5 °C. To prevent excessive pressure in the system, a safety valve is installed in the radiator cap. Usually, caps are used that provide excess pressure of 0.28 and 0.49 N/cm2. The boiling point of water with the first cap will be 106.7 °C, with the second 111.7 °C.

Increasing the water temperature in the cooling system improves engine efficiency, which reduces fuel consumption, and excess pressure prevents cavitation, especially in the low-pressure zone of the water pump. When preparing for summer operation, the radiator cap should be checked for tightness of the neck closure and correct operation of the safety valve. Cooling system caps can be checked with a device (Fig. 1), consisting of a pump with a pressure gauge installed on it. In this case, the tested cap is fixed in the device, and the pump creates the required pressure, which should be stable for 10 seconds.

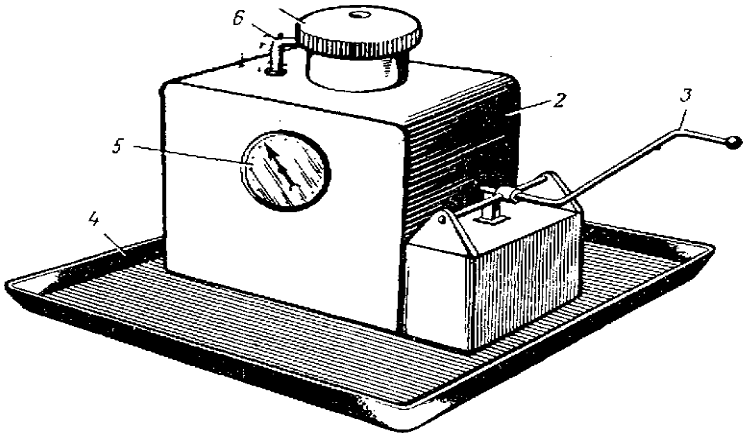

Figure 1. Device for checking the steam-air valves of the radiator caps and the condensation tank of the cooling system: 1-test plug; 2-device body; 3-pump; 4-tray; 5-test pressure gauge; 6-test drain tube

When checking the engine cooling system for leaks, this device is installed on the radiator neck and, using a pump, excess pressure of 0.6-0.7 N/cm2 is created in the cooling system, under the action of which leaks can be detected. Then it is advisable to start the engine and warm it up at idle speed to 45-50°C.

In this case, the fluctuation of the pressure gauge needle indicates the presence of an internal leak in the cylinder head gasket. However, as operating practice has shown, if the system is normally filled, but the water boils, then the reasons for the increase in temperature in the cooling system may be, for example: excessive back pressure at the outlet, incorrect adjustment of the brakes and clutch mechanism, malfunction of the valves of the engine distribution mechanism, abnormal clearances between pistons and cylinders, incorrect ignition setting, worn spark plugs.

During the process of preparing the vehicle for operation, all of the above mechanisms must be carefully checked and any faults detected must be eliminated. When operating vehicles in hot climates, intensive evaporation of water from the cooling system occurs, which makes it necessary to periodically top up the radiators with water. Frequent refilling of the cooling system with water increases the intensity of scale formation, especially when using water that is highly hard and contaminated with mechanical impurities. Using a closed cooling system, you can significantly reduce (by 70-80%) the water consumption for refilling.

Water used to fill engine cooling systems may contain a large number of various dissolved substances, consisting mainly of calcium and magnesium carbonates, which cause water hardness. Depending on the content of various salts and carbonate compounds of calcium and magnesium in water, temporary and permanent hardness are distinguished. Temporary hardness is caused by the presence of bicarbonate salts of calcium and magnesium (bicarbonates) in water, which, when boiling water, become insoluble and are deposited on the walls of vessels! When filling the cooling system with water with a high content of salts of temporary hardness without preliminary treatment, the salts settle on the walls of the engine cooling jacket and radiator tubes and form scale. Therefore, it is recommended to use clean water with a minimum content of calcium and magnesium salts to fill the cooling system. Before filling the cooling system with water having high temporary hardness, it should be pre-boiled in hot water boilers or water-oil heaters.

Permanent water hardness is caused by the presence of soluble salts in it, which do not precipitate when boiling water. These salts are less dangerous for the cooling system. However, a large number of salts of permanent hardness destroys radiator tubes and thermostats. General hardness consists of temporary, eliminated by boiling, and permanent, which remains after boiling.

The unit of hardness is milligram equivalent per liter (mg-eq/l), which is equal to the content of 20.04 mg of calcium carbonate salts or 12.16 mg of magnesium salts in 1 liter of water. Sometimes water hardness is expressed in old units of hardness - German degrees. One degree of hardness corresponds to the content of 10 mg of calcium oxide (quicklime) in 1 liter of water. Water with a hardness of less than 8° is considered soft, from 8 to 10° - medium hardness, from 12 to 30° - hard and over 30° - very hard. Water with a hardness of up to 12 mg-eq/l or up to 20° is suitable for filling the engine cooling system without artificially reducing its hardness. If the water hardness is higher than 12 mg-eq/l, then before filling the vehicle, it is necessary to reduce its hardness by preliminary boiling or chemical treatment.

You can reduce scale formation by adding up to 3 mg of hexametaphosphate powder per 1 liter of water. You can use calcined soda (Na_2CO_3) and trisodium phosphate ($NaPO_3$) to soften water, which are capable of releasing salts from water that cause its temporary hardness.

Washing soda and trisodium phosphate should be dissolved in water in small quantities before adding it to the cooling system:

- to soften medium-hard water 1.0 g $NaPO_3$ per 1 liter;
- to soften hard water from 1.5-2.0 g per 1 liter.

The cooling system can only be filled with settled water. It is not recommended to dissolve these substances directly in the cooling system, since the precipitation can clog the radiator tubes.

Soften the water as follows. Pour the required amount of trisodium phosphate into a barrel of water and stir until completely dissolved. Then the water is settled for 2-3 hours, after which it is ready for use. To soften the water, you can use a softening mixture consisting of sodium phosphate, caustic soda and oak extract.

The consumption of chemicals depends on the hardness of the water (Table 1). Prepare a solution from a mixture of substances as follows. First add the required amount of caustic soda and oak extract to a clean bucket of hot water, and then add sodium phosphate.

Table 1. Water softening chemical consumption

Chemicals	Chemical consumption per 10 liters of water of varying hardness, g				
	15°	20°	25°	30°	over 30°
Sodium Phosphate	1	1,5	2,0	2,0	2.0
Caustic Soda	2,5	3,0	3,0	3,5	4,0
Oak extract	0,5	0,5	0,5	0,5	0,5

After the mixture has completely dissolved, mix it with the required amount of water and let it settle for 2-3 hours. When repairing the cooling system, softened water must be collected in a separate container.

The most effective substance for reducing scale formation is chrompic acid ($K_2Cr_2O_7$). This substance easily dissolves in water and forms a protective oxide film on the parts, which protects the parts from corrosion. Chrompic acid can be dissolved directly in the cooling system in an amount of 0.5% of its volume.

It is not allowed to use water whose hardness has not been established to fill the cooling system, as this may lead to intensive scale formation and corrosion of the radiator tubes. In order to reduce the consumption of cooling water, a condensation tank is installed on cars, the installation of which does not require design changes in the standard cooling system. Steam emitted from the radiator enters the condensation tank, where, cooling and condensing, it again enters the engine cooling system.

When installing a condensation tank on a vehicle, the following conditions must be met: install the tank on the vehicle, if possible, so that it is cooled by the air flow; place the tank at the level of the upper part of the radiator; securely fasten the tank; the connecting tubes must not have sharp bends; ensure a tight connection between the condensation tank and the radiator, while all hoses connecting the radiator and the condensation tank are installed on nitro paint; coolant is simultaneously poured into the radiator and 1.5-2 liters of it into the condensation tank so that the end of the tube inside the tank is always below the liquid level; the radiator plug, as well as the plug on the condensation tank, must be tightly screwed in at all times; when draining coolant from the cooling system, it must also be drained from the condensation tank (through the tap located in the bottom of the tank).

CONCLUSION

Maintaining the engine cooling system is critical for ensuring optimal performance, especially in high-temperature conditions. The presence of scale deposits in the cooling system can drastically reduce heat dissipation, leading to engine overheating and increased wear on components. Regular descaling using chemical solutions such as lactic acid, caustic soda, and soda-kerosene mixtures can effectively clean the system and restore its efficiency. Additionally, using softened water and anti-corrosion additives minimizes the risk of scale formation and extends the lifespan of the cooling components. By implementing proper maintenance practices and regularly inspecting the cooling system, vehicle operators can significantly improve engine reliability, reduce fuel consumption, and enhance overall vehicle performance. Considering the high soil hardness of water in hot climates due to the high salt content, it is necessary to soften the water in a timely manner and use effective substances to reduce scale formation, which will ensure reliable operation of the engine cooling system.

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