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Causes and Maintenance Methods of Insufficient Cooling of Automobile Air Conditioners

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Abstract: Nowadays, all passenger cars are equipped with air conditioners, yet various faults will occur after long-term operation, among which insufficient cooling is the most common malfunction. This paper mainly analyzes the causes leading to insufficient cooling of automobile air conditioners and puts forward corresponding maintenance methods.

Keywords:automobile air conditioner; insufficient cooling; condenser heat dissipation; refrigerant leakage; system blockage ; refrigeration cycle

1.INTRODUCTION

The refrigeration system of an automobile air conditioner lowers the temperature inside the vehicle when the ambient temperature outside the car is high, creating a cool and comfortable riding environment for passengers. After prolonged use, air conditioning systems are prone to malfunctions, with insufficient cooling being the most frequent issue. Therefore, mastering the analysis of fault causes and corresponding maintenance methods is essential for automotive maintenance technicians.

2.COMPOSITION AND WORKING PRINCIPLE OF AUTOMOBILE AIR CONDITIONING REFRIGERATION SYSTEM

The refrigeration system of an automobile air conditioner mainly consists of an evaporator, a compressor, a condenser, an expansion valve, a receiver-drier and other components. All parts are connected via copper or aluminum tubes and high-pressure rubber hoses to form a sealed closed system. During refrigeration, refrigerant circulates inside the closed system in different physical states. Each circulation goes through four fundamental processes: evaporation, compression, condensation and expansion (see Figure 1). This cyclic process continuously reduces the air temperature around the evaporator.

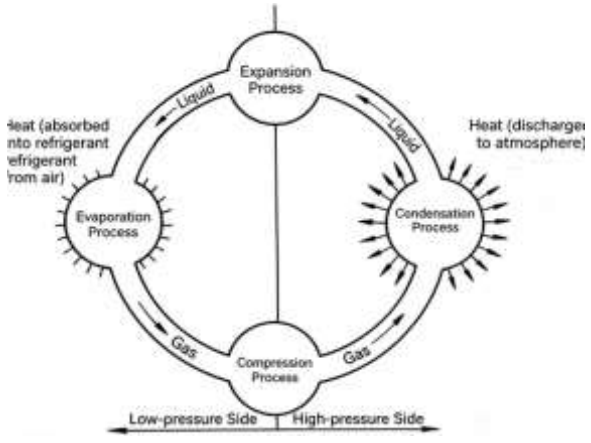

Figure 1. Schematic Diagram of Automobile Air Conditioning Refrigeration Cycle

3.FAULT CAUSES AND MAINTENANCE METHODS OF INSUFFICIENT COOLINGN

Whether an automobile air conditioning system can meet specified performance standards is mainly judged by whether the cabin temperature can reach the preset value. Under normal air conditioner operation, when the external temperature is around 35℃, the cabin temperature should stay between 20℃ and 25℃.To satisfy this basic design requirement, the vehicle cabin must maintain good airtightness, and the air conditioning system must deliver adequate cooling capacity. Multiple factors can weaken air conditioning cooling performance, which are categorized into five main types as analyzed below.

3.1 Reduced Heat Dissipation Capacity of the Condenser

The condenser is mounted at the front of the engine compartment. Oil stains, mud, debris and other contaminants tend to accumulate on its surface as the vehicle operates in various environments, which impairs its heat dissipation efficiency. In addition, malfunctions of the cooling fan—such as loose drive belts leading to low fan speed or the absence of high-speed fan mode—will also degrade the condenser's heat dissipation performance.

Maintenance Method: Clear dirt and debris on the condenser surface with a soft brush, and troubleshoot any cooling fan malfunctions promptly.

3.2 Loose Compressor Drive Belt

A slack drive belt for the air conditioning compressor slips during operation, lowering transmission efficiency and reducing compressor

rotational speed and refrigerant delivery volume, which directly weakens the system's cooling capacity.

Maintenance Method: With the engine turned off, twist the middle section of the drive belt by hand; an optimal belt allows a 90° twist. If the belt twists more than 90°, it is too loose and needs tightening. If the belt cannot be twisted by hand, it is overly tight and requires slight loosening. If tightening adjustments fail or the belt shows cracks, aging or other damage, replace it with a new drive belt.

3.3 Excessive or Insufficient Refrigerant

3.3.1 Excessive Refrigerant

This fault is usually caused by overfilling refrigerant during previous maintenance. An overcharged refrigerant system raises pressure on the low-pressure side and elevates the boiling point of refrigerant, hindering refrigerant evaporation. Moreover, excess liquid refrigerant flows into the evaporator beyond its heat absorption capacity and fails to fully vaporize. According to refrigeration cycle principles, substantial heat exchange relies on the phase change of refrigerant; without adequate vaporization inside the evaporator, heat transfer is severely limited, resulting in poor cooling performance.

Maintenance Method: Observe the sight glass on top of the receiver-drier. If no bubbles appear in the sight glass while the air conditioner runs, and no bubbles form after the compressor shuts down, the refrigerant charge is excessive. Slowly release refrigerant from the low-side service port of the air conditioning system until the charge reaches the standard level.

3.3.2 Insufficient Refrigerant

Insufficient refrigerant is mostly caused by minor leakage throughout the sealed system. Low refrigerant supply reduces the volume of refrigerant sprayed into the evaporator via the expansion valve, which cuts down total heat absorption during evaporation. In severe cases, refrigerant vaporizes before fully entering the evaporator, leading to frosting on the expansion valve; mild shortages simply reduce cooling output.

Maintenance Method: Inspect the sight glass on the receiver-drier with the air conditioner operating normally. Slow, continuous bubbles in the sight glass indicate low refrigerant levels; violent churning bubbles signal severe refrigerant shortage. Under normal operation, both high-side and low-side system pressures will read below standard values when refrigerant is insufficient.

3.4 Air or Moisture Intrusion into the Refrigeration System

Air trapped inside the system increases compressor load, as air is incompressible. Air locks block refrigerant circulation and raise pipeline pressure, causing insufficient cooling. This issue arises from poor system sealing or incomplete vacuum pumping during maintenance procedures.

The receiver-drier inside the refrigeration system absorbs moisture mixed in refrigerant to prevent ice blockage at expansion throttling components, which would otherwise suppress cooling output. Once the desiccant inside the receiver-drier becomes saturated with moisture, it can no longer absorb water. As refrigerant flows through the narrow orifice of the expansion valve, pressure and temperature drop sharply. When the temperature falls below the freezing point of water, residual moisture freezes inside the orifice, obstructing refrigerant flow, increasing circulation resistance, and even cutting off refrigerant circulation entirely.

Maintenance Method: A key diagnostic sign is temporary restoration of normal cooling after shutting down the system and waiting for ice to melt. Many vehicles feature color-changing desiccant visible through a side sight port on the receiver-drier: blue desiccant indicates low moisture levels, while red desiccant signals excessive water content in the system. For systems contaminated with excess moisture, replace the desiccant or the entire receiver-drier, re-evacuate the system under vacuum, and refill with fresh refrigerant at the correct volume.

3.5 Excessive Impurities or Partial Blockages in the Refrigeration System

Excessive dirt and sludge mixed in refrigerant and compressor oil clog filter screens throughout the system. This restricts refrigerant flow, increases circulation resistance, and reduces the refrigerant volume delivered to the expansion valve, ultimately weakening cooling performance.

Maintenance Method: Diagnose blockages by feeling pipeline temperatures. Obvious temperature differences should only appear at both ends of the expansion throttling device and the compressor; all other pipelines and components should have uniform surface temperatures on both sides. Distinct temperature gradients at other components indicate potential partial blockages. The core repair step is to drain contaminated refrigerant and refill the system with qualified, clean refrigerant.

4. CONCLUSION

Most malfunctions such as insufficient cooling and degraded cooling performance of automobile air conditioning refrigeration systems stem from compromised system sealing. Modern automotive refrigerants feature high permeability, which demands strict airtight standards for the entire system. Even tiny leaks in refrigeration pipelines or valves will trigger insufficient cooling faults.

When repairing refrigeration systems, technicians must use dedicated tools for leak detection, strictly follow standardized maintenance procedures with careful attention to detail, and repeatedly recheck system performance before and after test runs to fully eliminate faults.

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