Investigation on the Effects of Intake Grill on Performance of Cooling Module in the Vehicle Working Conditions

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Abstract: Air path model of cabin for cooling module simulation for vehicle has been built according to the test, and the simulation results are compared with the test data to verify the authenticity of the module. This simulation model provides an effective platform for vehicle thermal management analysis. The module is used to simulate the different intake grills and to find how different grills to effect the performances of the cooling module. The intake grill affect significantly influences the performance of airflow into the cabin.

Keywords: Cooling module, intake grill, simulation, vehicle.

1. INTRODUCTION

The shape of the front car design on the one hand determines the airflow of cabin and pressure effective for the frontal area, and on the other hand is the starting point for interior flow field of the cabin. Therefore it affects the aero-dynamic of cabin. As we all know, the internal flow situation of the cabin is extremely complex, subtle changes in structural characteristics of the entire flow field have a great impact on the cooling module. Because the cooling module of the cabin where the work environment becomes complex [1-3].

2. SIMULATION

2.1. Engine Input Dates

The parameter of engine is used as shown in Table 1. It is determined by the heat balance test and the drag test in vehicle working for the energy distribution of combustion to measure the temperature of coolant as shown in Fig. (1).

<table>
<thead>
<tr>
<th>Engine Main Date</th>
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<tr>
<td>Displacement: 2.0T</td>
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<td>Cylinder: 4</td>
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Cooling module input dates as shown in Table 2.

Table 2. Cooling module input date.

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<thead>
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<th>Cooling Module Input Date</th>
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<td>1</td>
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<td>10</td>
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</table>

2.2. Cabin Air Path Model Input Dates

By the CFD instead of the wind tunnel, get air characteristic parameters are obtained, which help the KULI to be build as shown in Figs. (2, 3) [4, 5].

Fig. (1). The engine heat map for cooling system.

The model of cooling module for heat balance test is shown in Fig. (4). Steady simulation is maintained at a temperature of 35℃, with the cooling fan running at full rotation, and the vehicle being at a speed of 40km/h.
3. VERIFICATION AND ANALYSIS

The simulation results are compared with the test data, as shown in Figs. (5, 6) error of 5% within, is caused by very complex flow field in the cabin. There is heat reflux in a part of the cooling module making the simulation difficult. The model for cooling system can predict and analyze the performance of the cooling system.

3.1. Analysis Intake Boost Coefficient CP

According to the Bernoulli’s equation of fluid mechanics, when the air flows through the grill, suddenly the cross-section becomes smaller [6, 7]. There is a high-pressure zone near the cabin outside. So, the outside pressure of cabin is higher than the inside pressure. It is much easier to flow the air smoothly into the cabin. This phenomenon is defined as the intake inertia, and expresses an intake boost coefficient CP. The grill surface of measured pressure value is converted to the form of the pressure coefficient Cp.

\[
CP = \frac{P}{(0.5 \times \rho \times V^2)}
\]

where in: P is the pressure near the intake grill, \(\rho\) is the air density and V is the vehicle speed. Fig. (12) shows the fan load of 100%, the relationship between the boost coefficient CP and vehicle speed.

This paper focuses on the typical operating conditions of the vehicle at low speed and high torque engine under load on the cooling module performance analysis and calculation of 3 cases of intake grills as shown in Fig. (7).
Investigation on the Effects of Intake Grill

The coolant of radiator temperature.

By the CFD, we get the CP as shown in Fig. (8).

CASE 1: the upper grill to modify the angle of the wind guide.

CASE 2: lower opening, the upper grill styling changes.

CASE 3: lower without opening the intake grill and CASE 2 are the same.

3.2. The Intake Grill Affect on the Flow of the Cooling Module

The analysis of different intake grills for the airflow of cooling module is shown in Figs. (9, 10). The simulation data indicate that the different intake grills, and the airflow of the cooling system are much sensitive. In case 1, CAC airflow increased by 1.23% compared with the original value. Radiator airflow improved by 7.35 of the original value. In case 2, CAC airflow increased by 1.49% compared with the original value. Radiator airflow increased by 3.04% compared with the original value. In case 3, CAC airflow increased by 1.75% compared with the original value. Radiator airflow increased by 3.54% compared with the original value.

3.3. The Intake Grill Affect on the Heat Transfer of the Cooling Module

The analysis of different intake grills for the heat transfer of cooling module is shown in Figs. (11, 12). The data showed that with different shapes of the cooling module front air intake efficiency has less influence and can affect the heat transfer performance of the cooling module. The CP of the different grill has a different temperature of CAC, but the heat transferred between RAD and engine is slightly different. Because the grill is the starting point of the flow field inside the cabin, it can change the direction of airflow into the cabin interior. Proper angle of grill and layout can make a reasonable airflow into the cabin, and cooling module needs more airflow to take heat away.

CONCLUSION

CP is expressed as the capacity of air into the cabin. The larger the CP, the better is the ability of air to enter cabin. It is effective to improve the velocity so that the grill can cause greater airflow, by changing the angle of the intake grill. The results show that for the car that only changes the shape of the intake grill, the capacity of air into the cabin is different. A different CP leads to different airflow. But the performance of the cooling module has nothing to do with the CP. We can change the CP and airflow by changing the shape of the intake grills and cooling modules to improve the efficiency of heat transfer.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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Declared none.
REFERENCES