CRITERIA FOR EXPERIMENTAL SIMULATION ON PASSENGER CAR ENGINE COOLING

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ABSTRACT

The evaluation of a car cooling system has been either by on-road testing or placing the car on a dynamometer and creating some of the climate properties that exist on the road in an environmental chamber around the vehicle. Modern car shapes typically are restricting the air intake areas and the correlation between road and environmental chamber data is decreasing. In order to specify the criteria for experimental simulation of passenger car engine cooling, a series of tests will be carried out in different wind tunnels and on road. The key outcome of this research is anticipated to be specification of the minimum conditions of the wind-tunnel aerodynamic parameters to achieve adequate simulation of the engine cooling.

INTRODUCTION

In order to deal with the global environment issue, lower fuel consumption is one of the major requirements. Overcoming aerodynamic drag takes a large share in useful engine work at crankshaft, hence the reduction of aerodynamic drag is one measure for lowering the fuel consumption. Since air flow around the car body has been improved, aerodynamic drag caused by air flow through the engine compartment becomes a sensitive factor. The air flow through the engine compartment depends on the requirements of engine cooling. Consequently, to save energy, engine cooling must be optimised. However, engine cooling is now becoming a very difficult design issue and subject to several conflicting requirements:

(a) the need to reduce total energy requirements of the vehicle, hence reduce total drag by minimising airflow through the engine compartment;
(b) low vehicle speeds in congested (and often hot) cities reduce ram air and increase yaw angles;
(c) a desire for longer periods between car maintenance, and the environmental needs for longer car life generate the need for lower temperatures of the operating lubricants; and
(d) improved power from smaller engines have increased the ratio of heat rejected to volume (the car designers tend to absorb the extra space available into the cabin).

Since many factors influence the performance of an engine cooling system (eg. vehicle styling features), cooling system design practice has been a combination of experience and on-road and wind-tunnel experimental work. Though many papers have been published on the subject of radiator heat transfer and design, relatively few papers have assessed the wind tunnel simulation of the car cooling system. Hawk and Godfrey (1959) tested engine cooling in a controlled-climate wind tunnel and compared the results with those from on-road tests, and found that a wind tunnel simulation could provide a means for continuing development work on engine cooling. Hird et al (1986) first performed engine cooling simulation with the front part of a vehicle in a 3 m x 2 m wind tunnel and found very small changes in vehicle front-end geometry resulted in significant improvement in heat rejection from the radiator. The wind-tunnel tests carried out by Hird and Saunders (1992) showed that the wind tunnel could be used at high blockage to evaluate relative rankings of changes of geometry effects on radiator performance. Because of the complexity of cooling system wind-tunnel simulation, no information, such as minimum conditions of the wind-tunnel aerodynamic parameters for adequate simulation of the engine cooling, has been published.

A doctoral research program investigating the above effects will be now discussed.

RESEARCH OBJECTIVES

On modern passenger cars, the front-end design has a decisive influence on the air flow through engine compartment. Because of the lack of the correlation between road and environmental chamber data, it sometimes lets in more ram airflow than it is necessary for the engine cooling thus increasing a drag penalty.

For cooling system development in the wind tunnel, we believe that it is important to simulate the following aerodynamic parameters in order to get good correlation between the on-road and tunnel data:

(a) correct simulation of the external pressure field (ie. low blockage ratios),
(b) test velocity;
(c) yaw angle; and, perhaps,
(d) turbulence.

Consequently, this project will focus on following objectives:

1. Analyse the major factors which affect the operation of a passenger car cooling system, which will include:
   (a) aerodynamic parameters (eg. test velocity, yaw angle, turbulence and etc);
   (b) car operating parameters (eg. water coolant flow, car speed, load and etc); and
   (c) environmental parameters (eg. ambient temperature, atmospheric pressure, humidity and etc).

2. Design of a passenger car test platform which will be used as a "transducer" to reliably measure the following parameters in different wind tunnels (some utilising dynamometers) and on road:
   (a) car speed;
   (b) engine speed and load;
   (c) radiator coolant inlet and outlet temperatures;
   (d) coolant mass flow rate;
   (e) air mass flow rate,
   (f) ambient temperature and air humidity;
   (g) atmospheric pressure; and
   (h) wind velocity, direction (simulated in wind tunnels by yawing the car) and turbulence.
3. Compare the test results from both wind-tunnel and on-road tests.
4. Understand the sensitivity of testing in different environments under different operating conditions.
5. Establish correlations of those results and indicate the limits of utilisation of each wind tunnel for cooling system simulation.

PROSPECTED OUTCOMES

The key benefit of this research is anticipated to be specification of the minimum conditions of the wind-tunnel aerodynamic parameters to achieve adequate simulation of the engine cooling. Furthermore, a description of the rational utilisation of different types of wind tunnels and the correlation between the results from wind-tunnel tests and on-road tests will be established. With the results of this project, engineers will be able to simulate the car engine cooling in wind tunnels more accurately during the development period of passenger cars. Consequently, this technology cannot only reduce the cost of car development, but also shorten the time of development cycle.

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