Aerodynamic Influence on Rim Design for Effective Cooling of Automotive Disc Brake

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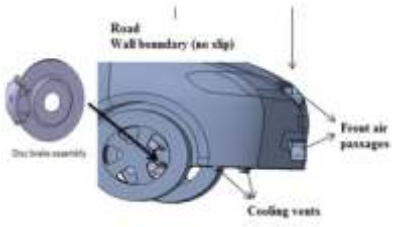
Keywords: Disc Brake Assembly, Conjugate Heat Transfer, Temperature Distribution, Brake Cooling

Abstract:

Cooling of braking system has always been a major concern in the automotive industry. The brake system is a critical part of any road vehicle and its failure could endanger passenger safety. The brake system has to be designed carefully to prevent the disc from overheating, which reduces braking efficiency or could lead to complete system failure. Thermal performance of disc brake relies upon the characteristics of airflow around the brake rotor and other components. Aerodynamic cooling of the brake disc through convection is the key mechanism for maintaining the brake within acceptable temperature levels. Computational Fluid Dynamics (CFD) gives better insights and detailed analysis of such critical flow physics across braking system. The current work aims at investigating the cooling effect of the braking system and also air flow pattern in the under-hood part of passenger car at different vehicle velocities using CFD simulations.

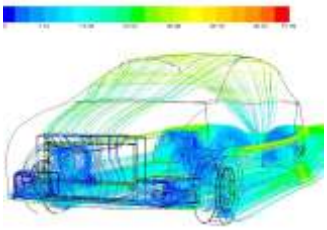
In the current work, steady state CFD analyses were carried out to understand the thermal behavior of disc brake system and also the air flow pattern in the under-hood portion of a passenger car. Initially literature survey was carried out on brake cooling, under-hood thermal management, convective heat transfer and also material aspects of braking system. Honda City passenger car was selected for investigations on the cooling performance of the braking system. The simplified car model with complete braking systems (disc brake rotor, caliper and pads), simplified under-hood with grill and air outlets along with fluid domain was modeled using CATIA V5 and discretized in ANSYS ICEM CFD. Steady state CFD simulations were carried out on the fluid domain for different vehicle velocities to get the temperature distributions, heat transfer and airflow pattern across the braking system.

Parametric studies were carried out for different vehicle velocities and cooling performances of solid and ventilated discs were compared. Suggestions were made to improve the airflow pattern and better heat dissipation in the under-hood portion and across the braking system.

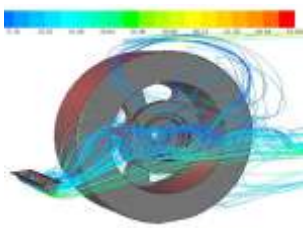


Disc brake assembly and air intake passages

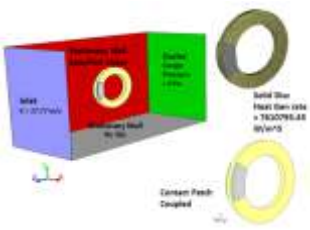
Meshed computational domain



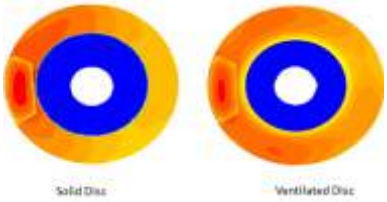
Airflow distribution in the underbody side



Airflow is guided across the braking system



Boundary conditions for the conjugate heat-transfer on the disc brake assembly



Comparison of temperature distributions of solid disc and ventilated disc rotors