Thermal Comfort Analysis on Passenger Car Cabin with Spot Cooling Approach using CFD Simulation

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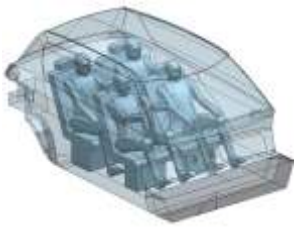
Keywords: Spot Cooling, Temperature Distribution, Air Flow Directivity, Thermal Comfort, Solar Calculator

Abstract:

The assessment of thermal comfort in a passenger car is very complex because of internal and external disturbances such as, external environment, speed of the vehicle, temperature of the engine, number of passengers inside the cabin and so forth. A substantial part of our time in present day scenario is spent on travel. Hence, the demand of thermal comfort of passengers in vehicles has significantly increased. Air conditioning system in a car should be designed to maintain a comfortable thermal environment inside the cabin. Conventional air conditioning systems are not able to meet comfort levels at all zones inside the passenger cabin and may tend to consume more engine power to meet the cooling requirements. Spot or distributed cooling and heating is an energy efficient way of delivering comfort to occupants inside the car, meeting ASHRAE standards.

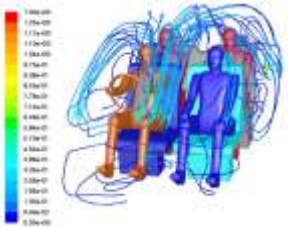
In this project, an effort has been made to study the spot cooling method to improve the thermal comfort level of driver and passengers at different locations inside a car cabin. The hatchback car model was used in these studies. A simplified computational domain representing car interior volume with seats was generated using CATIA V5 software. Four 50th percentile Manikin models, representing one driver and three passengers, were assembled each in seated position. Computational grid was generated using ICEM CFD pre-processing software. Steady state CFD simulation was carried out on the baseline model under Bangalore weather condition (using solar calculator model) to get the temperature and velocity distribution inside the passenger cabin using ANSYS FLUENT software. Subsequently, parametric studies were carried out to simulate spot cooling approach considering chest, face and lap cooling to get the temperature and velocity distribution around the passengers.

From the numerical simulation on the baseline model, it was found that the air stream from the inlet air vents was not properly guided towards the head and chest of the front passengers. However, a change in the air flow directivity from the inlet vents was able to guide the air stream towards the head and chest of the passengers, which considerably reduced the temperatures locally to meet the comfort levels.

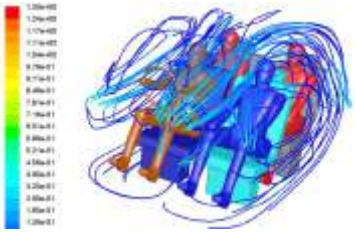


Car interior with occupants

Computational grid



Airflow inside the car cabin with all vents open – baseline case



Airflow inside the car cabin with spot cooling of face + chest + lap