

Abstract

Personal vehicle transportation represents an important aspect of quotidian life of people nowadays. Due to novel regulations in energy consumption and sustainability, the society today is found in full transition to electric vehicles. The HVAC equipment is one of the most energy consuming item from the auxiliary systems in vehicles, leading to a significant impact on the driving range and the train power when electric vehicles are discussed. When interior conditions are discussed, condensation phenomenon is frequently found in passengers' cabin due to small volume of the vehicle, constantly changing parameters, such as solar radiation, wind, precipitations etc. Hence, this work proposes to study the condensation phenomenon inside a vehicle's cabin, more specifically on the windshield, and propose new configurations that can lead to a reduction in HVAC energy consumption without restricting the comfort conditions and more importantly, maintaining a safe environment for the passengers.

The present work evaluated the condensation phenomenon on a windshield of a vehicle by means of a numerical approach. As CFD evaluations allow a thorough assessment of the exact place, amount and evolution in time and space of the condensation process, the main part of this work was based on this numerical assessment. The condensation process was evaluated by means of numerical simulations built based on previous models proposed by the International Energy Agency. The study contained also an experimental stand consisting of a real scale vehicle cabin which was constructed inside the climatic chamber of UTCB. This construction represented the groundwork for the numerical approach.

The first part of this research contains a bibliographic synthesis regarding indoor conditions in vehicles' cabin as well as the energy consumption, types of HVAC equipment exploited in vehicles, and condensation process in vehicles.

The second chapter of this thesis is focusing on the condensation phenomenon, types of condensation, properties of the materials which influence the process and their impact on the results. This chapter is completed with a presentation of different methods of evaluation of the condensation phenomenon (analytical, experimental, and numerical).

The third chapter is concentrated on the numerical aspects of the CFD models, presenting a thorough evaluation of all the aspects that can influence the results. This part has the purpose to set the base for the next chapter which presents the numerical development of the present condensation model.

The study continues with an exhaustive presentation of all steps following the numerical and experimental evaluation conducted within this work. The fifth chapter offers hence a perspective of all the numerical cases analysed in different exterior conditions, winter and autumn, considering the vehicle in idle position, as well as running at a constant speed.

The last part of this study presents the conclusions of this research work incorporating all the cases analysed, highlighting the importance of recirculation ventilation in defrosting mode and different scenarios for reducing the energy consumption while maintaining a condensation free windshield.