Proceedings of the Canadian Society for Mechanical Engineering International Congress 2022
CSME Congress 2022
June 5-8, 2022, Edmonton, AB, Canada

EFFECT OF COLD CLIMATE ON ENERGY CONSUMPTION OF A PLUG-IN HYBRID ELECTRIC VEHICLE

Amir Ansari, Hamidreza Abediasl, Mahdi Shahbakhti*
Department of Mechanical Engineering, University of Alberta, Edmonton, Canada
*mahdi@ualberta.ca

ABSTRACT

Vehicle powertrain technology is shifting towards electric and hybrid electric vehicles, while the energy requirements and energy conversion efficiency of electric or hybrid electric vehicles require in-depth investigations for extreme cold climate operations. The energy consumption of these vehicles increases when operating under cold climates due to low powertrain efficiency and extra energy required for battery thermal conditioning and cabin heating.

In this study, a plug-in hybrid electric vehicle (PHEV) is tested for 30 times in cold climate conditions with ambient temperatures ranging from 0 to -25℃, to investigate the variations in energy consumption and efficiency for different powertrain modes including electric, hybrid electric, and internal combustion engine operations. To this end, a Ford Escape PHEV MY2021 was driven consistently in a 20-km route including urban and highway areas, in Edmonton, Canada in 2021-2022 at different weather conditions including sunny, cloudy, and snowy. Instantaneous and cumulative fuel consumption were measured and battery energy usage was collected from the vehicle telematics during each test. In addition, the vehicle was equipped with a CAN data logger to collect on-board diagnostics (OBD) data such as vehicle speed and engine coolant temperature to assist in the analysis of the vehicle operation.

The vehicle operation was studied for different operating modes. For instance, EV Later mode is a hybrid electric mode in which electric motor and gasoline engine are both involved to maintain a fixed battery charge level. The results in this mode showed reducing the ambient temperature from 0 to -25℃ increased the total energy consumption from 45.1 to 76.5 kWh/100km, when both tests included a cold start. Similarly, $CO_{2,eq}$ emission was increased from 118 $g_{CO2,eq}$/km to 203 $g_{CO2,eq}$/km and the percentage of gasoline engine use increased from 40% to 92%. In the hybrid electric mode, in which the vehicle tries to minimize the energy consumption, the total energy consumption and $CO_{2,eq}$ emission were increased from 34.3 kWh/100km and 186 $g_{CO2,eq}$/km to 56.6 kWh/100km and 227 $g_{CO2,eq}$/km, respectively when the ambient temperature decreased from -1˚C to -22℃, and both tests included a warm start. Similarly, the percentage of the engine use increased from 8% to 39%. Overall, the results from this study show over 65% increase in the energy consumption of the vehicle when operating at temperatures below -20℃ compared to the freezing temperature (~ 0℃).