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ANALYSIS OF THE INFLUENCE OF AIR CURTAIN ON REDUCING THE HEAT INFILTRATION AND COSTS IN URBAN ELECTRIC BUSES

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ABSTRACT−In tropical countries, the power demand from the air conditioning system of an electric vehicle can be up to 40 percent of the total power demand of the traction battery. It is therefore essential to investigate methods that improve the efficiency to reduce the capital and operational costs of the vehicle. In public transportation, the frequent opening and closing of doors at bus stops results in a large influx of warm, humid ambient air into the cabin that increases energy consumption. The use of an air curtain is a potential solution that can minimise the infiltration of ambient air into the vehicle. The feasibility of implementation of an air curtain is however dependent on various factors such as the frequency of consecutive bus stops, duration of dwell time at bus stops, efficiency of the air conditioning system and the power consumed by the air curtain device. This paper investigates and compares the reduction of the air conditioning power consumption and the associated battery and energy costs with the use of air curtain in a 6 m mini-bus driving on selected bus routes in Singapore. The use of air curtain in an urban mini-bus is found to be economically feasible as the air conditioning power consumption for the studied routes reduced in the range of 20 ~ 28 %. Subsequently, energy and battery lifecycle costs reduced by 6 ~ 10 % based on the route, the frequency and duration of door openings.

KEY WORDS : Air curtain, Air conditioning, Energy costs, Battery costs, Electric buses

NOMENCLATURE

AC : air conditioning
CFD : computational fluid dynamics
3D : 3-dimensional
sh : specific humidity
RH : relative humidity
T : temperature, °C
Q : heat load, kW
C : overall costs, $
r : discount factor, %
$\dot{m}$: mass flow rate, g/s

SUBSCRIPTS

H_2O : water vapour
i : time step
cha : charger
bat : battery
elect : electricity

1. INTRODUCTION

Electrification of road-based public transport systems has the advantage of eliminating local emissions in urban cities and reducing operational costs due to the high efficiency of the electric powertrain (Lajunen, 2018). The limiting factor to the electrification of urban buses is the higher capital costs of the electric buses (Lajunen and Lipman, 2016) compared to diesel buses and the additional infrastructure costs to set up charging stations.

The battery cost of electric vehicles has the highest contribution to the overall cost of the vehicle (Kochhan *et al*., 2014; Dhand and Pullen, 2015). The battery cost and operational cost are proportional to the energy demand of the vehicle. The costs can be reduced by investigating methods that improve the energy efficiency of the vehicle consequently minimising the total energy demand of the vehicle.

Most literature on electric vehicles focuses on improving the efficiency of the powertrain (Chang *et al*., 2018; Krapf *et al*., 2018; Wang *et al*., 2018), and there has been less focus on improving the performance of auxiliary systems such as the air conditioning system. In tropical countries, the cooling demand of the vehicle from the traction battery can be as high as 30 ~ 40 % of the total driving demand (Subiantoro *et al*., 2014). It is, therefore, necessary to investigate methods to improve the efficiency of such systems.

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