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ADAPTIVE ENERGY MANAGEMENT STRATEGY FOR SUSTAINABLE OPERATION OF HYBRID ELECTRIC VEHICLE

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Abstract: Hybrid electric vehicles (HEVs) in the transportation sector is spearheading the industry towards embracing green technology to ensure the sustainability of the environment. HEVs offer significant reduction of exhaust emissions while retaining vehicle performance achieved via a revolutionary energy management strategy (EMS) which reforms the management of power flow from the dual energy sources of a HEV. However, researchers are faced with challenges to extract the maximum performance out of HEVs due to the contradicting nature between its main objectives, namely vehicle performance, fuel consumption and cost. In this study, an investigation focusing on the fuel-saving potential of a power-split type HEV using a fuzzy logic-based EMS is conducted. The purpose of this research is to explore methods to improve fuel efficiency of a HEV through a smart and adaptive EMS. The power flow in the proposed model is decided based on its current vehicle speed and the global discharge rate value derived from the real-time battery state-of-charge and remaining trip distance. From simulations over standard drive cycles, the proposed controller is able to outperform a rule-based EMS by an improvement of up to 65.4% in terms of fuel consumption which subsequently reduces the volume of pollutants released to the atmosphere.

Keywords: HEV, energy management strategy, fuzzy logic, fuel efficiency, global discharge rate.

Introduction

Fossil fuel is a finite substance that has been driving the world's industrial revolution since its inception. However, dependency on its combustion properties has negatively affected the atmospheric quality as hazardous tailpipe fumes are emanated to the air from all sorts of human activities. The COVID-19 pandemic, which halted economic growth worldwide in 2020 has caused the annual demand for oil to drop by 9% from 2019 (International Energy Agency [IEA], 2021). The transportation sector was the biggest contributor of CO_2 emission behind power generation at around 25% in 2018 (IEA, 2020). Strict emission standards are imposed to force manufacturers to produce more energy-efficient vehicles (EEVs). These standards imposed by governments and related agencies aim to aggressively reduce fuel consumption and exhaust emissions. To abide to these stringent regulations and as fuel prices are fickle to the unstable conditions of the market, the transportation sector has seen innovations towards greener vehicles with the ultimate objective of achieving zero emission as car manufacturers and researchers are finding ways to push the industry forward while dealing with these challenges in the best way possible.

Hybrid electric vehicles (HEVs) with the combination of internal combustion engine (ICE) and electric motor (EM) at their core of propulsion are currently the most popular selection in the EEV segment. In their operation, HEVs still produce exhaust emissions due to the inclusion of the ICE but with the presence of the electrical drivetrain and proper power flow management strategies, HEVs operate with lower fuel consumption and produce lesser emissions as a result (Enang & Bannister, 2017; Singh *et al.,* 2019; Sabri *et al.,* 2021). With