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Control Strategy for a 42-V Waste-Heat Thermoelectric Vehicle

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A 42-V waste-heat thermoelectric vehicle is employed as a potential application of thermoelectric generators for fuel economy improvement and emissions reduction. The 42-V waste-heat thermoelectric vehicle currently in development employs an assemblage driving system consisting of a waste-heat thermoelectric generator, a 42-V powernet, and an integrated starter and generator (ISG). The waste-heat thermoelectric generator also functions as a power supply. To optimize the utilization of the waste-heat energy generated by the thermoelectric generator, an electric assist control strategy and a torque split control strategy are proposed herein. Through the development of relevant systems and strategies, including the thermoelectric generator and an electric bus system, two vehicle models are established and compared using the ADVISOR platform based on MATLAB/Simulink. The calculation results show improved fuel economy and emissions performance resulting from the integration of the torque split control strategy into the 42-V waste-heat thermoelectric vehicle.

Key words: Waste-heat thermoelectric, control strategy, electric assist control, torque split control

INTRODUCTION

The value of 42-V has been widely considered to be a safe powernet voltage for future vehicles.[1] A vehicle model for the new Toyota Mild Hybrid System (THS-M), which was the first mass-production vehicle with dual voltage (42 V/14 V), was launched onto the Japanese market in August 2001.[2] Baek-Haeng Lee[3] proposed a new storage system using a battery with high energy density and an ultracapacitor with high power density in parallel, and this system could be appropriate for energy storage in high current charge/discharge operation. Lee[4] proposed control logic for a 42-V system in development, which was implemented and verified for the experimental Hybrid-Electric Vehicle (HEV) system.

Deng[5] proposed an electrical and hybrid driving system, which was an assemblage of a waste-heat thermoelectric generator (TEG), a 42-V powernet, and an integrated starter and generator (ISG). It is well known that the choice of a suitable control strategy can strongly influence the overall performance of the system. In this driving system, the operating modes of the engine, generator, and ISG change under different working conditions. Therefore, a major concern regarding the driving system is how to effectively supply the vehicle and preferably balance power resources. In this regard, two control strategies, namely an electric assist control strategy (EACS) and a torque split control strategy (TSCS), are presented and compared herein.

MODELING OF THE WASTE-HEAT THERMOELECTRIC GENERATOR

Figure 1 illustrates the topological connections of the thermoelectric generator modules. For the thermoelectric generator modules, the thermoelectric plates are arranged in m layers with n rows and n columns, with those in a column connected in parallel and those between columns and in layers connected in series.[5] In this paper, the thermoelectric generator modules have four layers and five rows. To improve the calculations and analysis, the thermoelectric generator modules are assumed to

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