

Development of Forward Simulation for Novel PHEV System using The Autonomie

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Summary

Global automobile manufacturers are increasing the interest in vehicles with the fuel economy of 1l/100km. PHEV, Plug-in Hybrid Electric Vehicle, with a large capacity battery is a suitable alternative that can satisfy these requirements. In addition, the development of Powertrain system to match PHEV should be considered. In our previous studies, Novel PHEV system for improved fuel economy have been proposed. In order to develop the controller of the PHEV, Forward simulator consisting of a dynamic model is required. In this study, Forward simulator for novel PHEV system was developed using Autonomie that is the commercial software made by Argonne National Laboratory.

Keywords: PHEV(plug in hybrid electric vehicle), parallel HEV, powertrain, modeling, simulation

1 Introduction

Recently global automobile manufacturers have announced vehicles with the fuel economy of 1l/100km. Conventional internal combustion engine vehicle system can not achieve this fuel economy. In order to meet these requirements, a PHEV system for applying the high capacity battery must be considered as essential. PHEV system has very high share of the EV drive mode, unlike the conventional HEVs. By focusing on this point, it has been proposed novel PHEV system for improved fuel economy in the previous study. Through backward simulation based on dynamic programming, the possibility of improving the potential fuel economy of the proposed system was verified [1]. But it was only a relative comparison using the optimal fuel consumption of quasi-static conditions. It includes the impossible states. To develop and validate a controller with more realistic, the forward simulation is required. The forward simulators have been developed for analyzing a wide variety of hybrid powertrain system. Typical forward simulator was The Autonomie developed in Argonne National Laboratory.

2 Vehicle system

2.1 Configuration

According to the characteristic of PHEV system with wide electric range, a structure that can improve the efficiency of EV driving has been proposed. This is shown in Figure 1. Here, the solid line represents a mechanical power flow and the dotted line represents an electrical power flow.

The proposed architecture includes EV mode that is to drive two motors. By driving the motor has a higher efficiency according to the speed of the vehicle, it is possible to improve the efficiency.

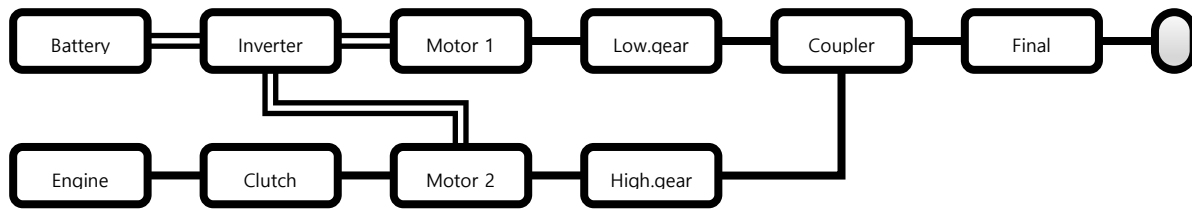


Figure1: Architecture of Proposed PHEV system

2.2 Specification

The target vehicle of hybridization is based on the specification of the compact sedan vehicle released from K Company. The specifications of the target vehicle are as follows:

Table1: Specifications of the target vehicle

Parameter	Value	Unit
Vehicle mass	1321	kg
Final drive efficiency	95	%
Tire radius	0.317	m
drag coefficient	0.33	
Frontal area	1.55	m ²
Air density	1.29	kg/m ³
Rolling resistance coefficient	0.01	
Final drive gear ratio	3.83	

Specifications of the power sources for hybridization of the vehicle are as follows:

Table2: Specifications of the power sources

Parameter	Value	Unit
Engine - Power	43	kW
Motor 1 - Power	10	kW
Motor 2 - Power	30	kW

2.3 Improved performance in EV drive

The proposed architecture is used to combine the two motors with different capacities. Unfortunately, this system has the disadvantage having a lower power than using one large motor in the high-speed range. But this system has a high power performance and wide high-efficiency region than to using one large motor in the low-speed range and midium-speed range. Figure2 and Figure3 shows the electric vehicle driving efficiency for the two cases.

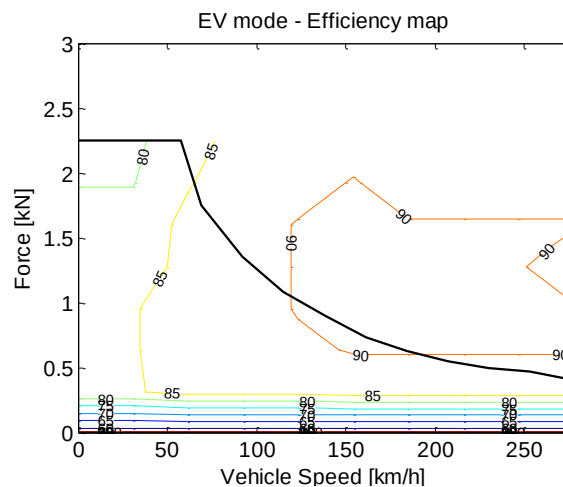


Figure2: Efficiency of 1-motor[40kW] EV drive

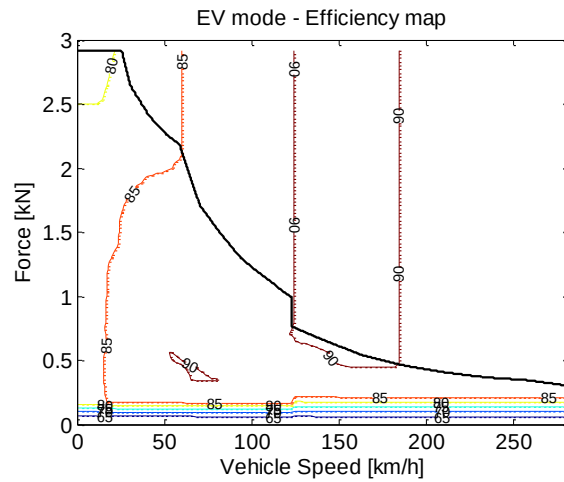


Figure3: Efficiency of 2-motor[10kW+30kW] EV drive

The mean efficiency of the electric drive unit is as follows:

Table3: Comparison of mean efficiency 1-motor EV drive and 2-motor EV drive

Case	Motor1	Motor2	Mean efficiency
1-Motor drive	0[kW]	40[kW]	82.15[%]
2-Motor drive	10[kW]	30[kW]	83.82[%]

The mean efficiency has relatively increased by approximately 2%. When the selection of the optimum gear ratio, it will be further improved.

3 Forward simulator

There are a variety of commercial applications for configuring the forward vehicle simulator [2]. In this study, we used Autonomie developed by Argonne National Laboratory. Autonomie contain a variety of powertrain systems and the controller models. The component models have been sufficiently verified by experiments. Using the model of each component in Autonomie, it modeled the proposed powertrain system. Figure4 shows that powertrain model for proposed PHEV system is configured by using the Autonomie.

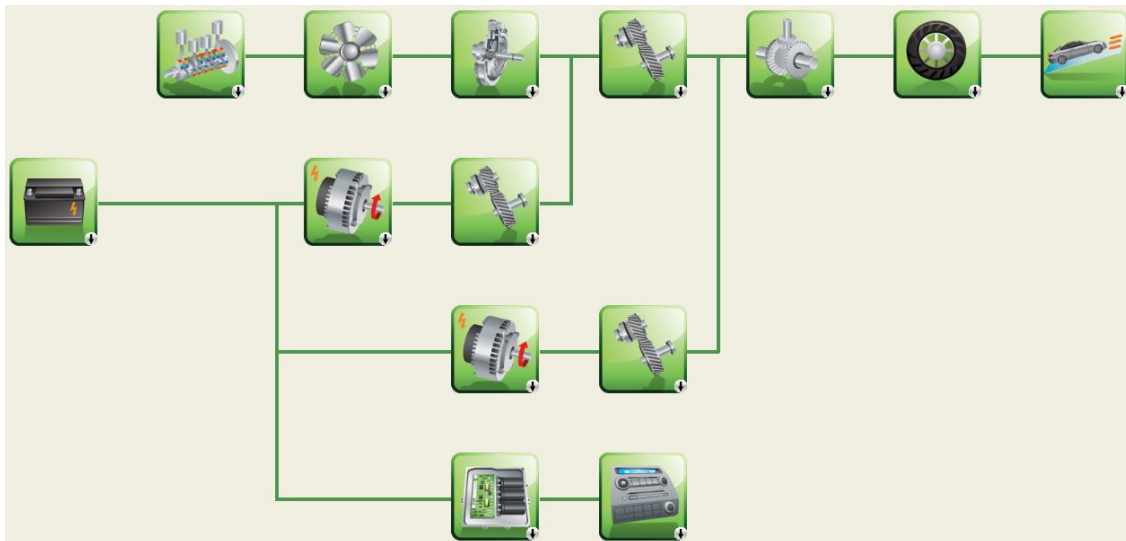


Figure4: Powertrain model for Proposed PHEV system

The vehicle propulsion controller was used controller model of Autonomie built-in similar system. by using a controller that does not yet fit the developed model, required speed as figure5 did not follow properly. But this could be improved by adding to develop a control model in the future.

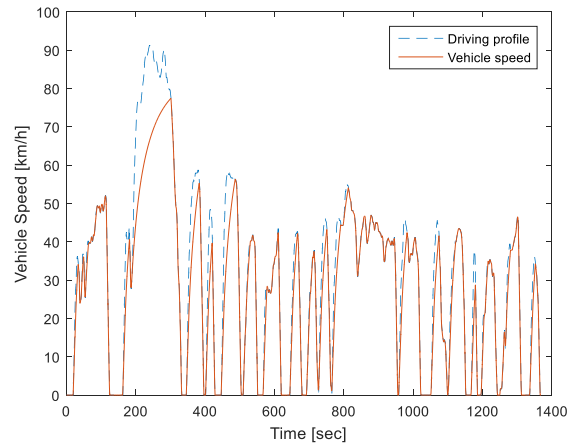


Figure5 : Simulation Result

4 Conclusion

Using the Autonomie, it developed a forward simulator for novel powertrain system for a PHEV. Because it has not yet been added to the appropriate control model, it shown as not satisfying the power performance in many sections.

In the future, it will develop the control models that can properly control this system.

Acknowledgments

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