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EQUIVALENT STIFFNESS MODELING METHOD OF A BATTERY SYSTEM FOR EVALUATING VEHICLE REAR-END COLLISION PERFORMANCE

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ABSTRACT−The battery system of a vehicle is critical for its good operation, and in the event of vehicle collision, damage to the parts or displacement of the battery can significantly affect performance. Nonlinear characteristics must be considered when designing elastic parts for vehicle's collision analysis, and nonlinear dynamic finite element analysis simulations should be used to derive dynamic responses through collision simulations. Existing models examine the overall behavior without specifically configuring each part, and therefore, we need a model that can derive dynamic responses through collision simulations at the part level. Thus, we propose an equivalent stiffness model for a battery system to evaluate the vehicle's rear-end collision performance in the early design stage. The model showed errors of 7.54 % and 6.12 % in the peak-to-peak values for the x-axis and z-axis acceleration responses, respectively, on the upper part of the battery; the root mean square value was within the margin of error. Simulation results confirmed that the proposed model is as accurate as the real vehicle test and nonlinear dynamic finite element analysis model. Thus, it can be used in the early design stage to predict system performance for collision test in a system whose geometry has not been determined.

KEY WORDS : Equivalent stiffness model, Battery system, Kelvin model, Force elements, Vehicle's rear-end collision, Hybrid test track (HTT)

NOMENCLATURE

m	: mass, kg
m'	: mass to solve the equation of motion, kg
c	: damping coefficient, N·s/m
k	: spring stiffness, N/m
v_0	: input velocity, m/s
a_0	: input acceleration, m/s^2
d	: displacement, m
d'	: displacement to solve the equation of motion, m
f	: frequency, Hz

1. INTRODUCTION

Vehicle collision safety performance is among the basic performance requirements such as collision safety; ride and handling; noise, vibration, and harshness; acceleration; braking and durability that must be adhered to when developing vehicular components. The battery system of a vehicle is necessary for starting the vehicle, and it acts as a power source for various other control systems such as the ignition; therefore, it is an indispensable component of a vehicle. In most vehicles with an internal combustion engine, the battery is located in the engine room at the front of the vehicle, where it is supported with a battery bracket connected to the battery tray through the side member. Due to this structure, the separation of the battery is affected by the components that support the battery in the event of vehicle collision, designing is required at the component level of the battery system.

Nonlinear characteristics should be considered for elastic parts when designing parts for vehicle collision analysis, and nonlinear dynamic finite element analysis (FEA) simulations should be used to derive the dynamic responses through collision simulations (Liu *et al.*, 2014; Shen *et al.,* 2013; Lee and Park, 2017). Nonlinear dynamic FEA has an accuracy close to real vehicle test data; however, the geometry of the parts must be determined when FEA modeling. Furthermore, design change-based modeling and analysis are time-consuming tasks when the geometry is not used as-is in the early design stage. To overcome these problems, several studies have focused on constructing mathematical models that can represent the mass, spring, and damper for vehicle systems in collision simulations

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