International Journal of Automotive Technology (2024) 25:627–637
https://doi.org/10.1007/s12239-024-00049-z

CHASSIS, ELECTRIC, FUEL CELL, AND HYBRID VEHICLE, TRANSMISSION AND DRIVELINE, VEHICLE DYNAMICS AND CONTROL

Meta-Model Based Blade Optimization Design Considering the Fluid Characteristics of Vehicle Energy Harvesting

Hyung Jun Kim[1] · Seong Min Kang[1] · Seon Myeong Kim[1] · Jin Ho Kim[1]

Received: 25 August 2023 / Revised: 30 October 2023 / Accepted: 23 December 2023 / Published online: 9 March 2024
© The Author(s), under exclusive licence to The Korean Society of Automotive Engineers and Springer-Verlag GmbH Germany, part of Springer Nature 2024

Abstract
The advancement of transportation machinery has played a crucial role in driving global economic and societal growth. However, this progress has also given rise to challenges, such as the depletion of chemical resources and the escalating impact of climate change. As a result, automobile companies are now prioritizing energy efficiency and transitioning towards eco-friendly vehicles. In response to this demand, various efforts have been made to harvest energy and improve the efficiency of eco-friendly vehicles, with energy-harvesting dampers emerging as a promising solution. This study focuses on the optimization of the shape and design of a rotary power generation system integrated within an energy harvesting system. The primary objective of the rotary power generation system is to convert mechanical motion into electrical energy, thereby enhancing the overall efficiency and sustainability of eco-friendly vehicles. By considering the specific characteristics of SAE 30 W working oil within the damper, the optimal blade shape and generator can be determined to maximize the power generation capabilities of the system.

Keywords CFD analysis · Energy harvesting · Rotary generator · Vehicle suspension · Design of experiments · Design · Optimization · Meta-models

List of Symbols

A	Area, m^2
T	Torque, Nm
ω	Angular velocity, rad/s
Re	Reynolds number
U	Fluid velocity, m/s
L	Characteristic length, m
v	Kinematic viscosity, m^2/s
μ	Dynamic viscosity, Pa·s
ρ	Fluid density, kg/m^3

Subscripts

Pm	Rotational power, W
Pe	Electric power

✉ Jin Ho Kim
jinho@ynu.ac.kr

[1] Department of Mechanical Engineering, Yeungnam University, Gyeongsan 38541, Korea

1 Introduction

The advancements in transportation technology have had a significant impact on economic and social development. For instance, an efficient transportation system improves traffic efficiency and promotes economic growth in countries and cities. Due to the development of transportation infrastructure and systems, commercial trade activities have increased and logistics between domestic and foreign markets have become more efficient (UNCTAD, 2019). The development of transportation technology is closely linked to industrial progress. Numerous manufacturers, component suppliers, service providers, and research institutions contribute millions of dollars in direct and indirect employment to the modern automobile industry (International Organization of Motor Vehicle Manufactures (OICA), 2020). Moreover, the development of transportation technology has a significant impact on energy efficiency and environmental tolerance. Research and development of environmentally friendly vehicles contribute to decreasing reliance on fossil fuels and greenhouse gas emissions. According to the International Energy Agency (IEA), the market for environmentally