World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:17, No:09, 2023

# Numerical Modal Analysis of a Multi-Material 3D-Printed Composite Bushing and Its Application

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**Abstract :** Modal analysis is a crucial tool in the field of engineering for understanding the dynamic behavior of structures. In this study, numerical modal analysis was conducted on a multi-material 3D-printed composite bushing, which comprised a polylactic acid (PLA) outer shell and a thermoplastic polyurethane (TPU) flexible filling. The objective was to investigate the modal characteristics of the bushing and assess its potential for practical applications. The analysis involved the development of a finite element model of the bushing, which was subsequently subjected to modal analysis techniques. Natural frequencies, mode shapes, and damping ratios were determined to identify the dominant vibration modes and their corresponding responses. The numerical modal analysis provided valuable insights into the dynamic behavior of the bushing, enabling a comprehensive understanding of its structural integrity and performance. Furthermore, the study expanded its scope by investigating the entire shaft mounting of a small electric car, incorporating the 3D-printed composite bushing. The shaft mounting system was subjected to numerical modal analysis to evaluate its dynamic characteristics and potential vibrational issues. The results of the modal analysis highlighted the effectiveness of the 3D-printed composite bushing in minimizing vibrations and optimizing the performance of the shaft mounting system. The findings contribute to the broader field of composite material applications in automotive engineering and provide valuable insights for the design and optimization of similar components.

**Keywords :** 3D printing, composite bushing, modal analysis, multi-material
**Conference Title :** ICAMAME 2023 : International Conference on Aerospace, Mechanical, Automotive and Materials Engineering
**Conference Location :** Lisbon, Portugal
**Conference Dates :** September 18-19, 2023