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Finite Element Modeling of a Fiber Reinforced Plastics Composite Materials in Automatically Deployable Rollover Protective Structure

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Abstract

Finite Element Analysis (FEA) is an important tool for evaluation of new safety structures. Over the past years, researchers at the National Institute for Occupational Safety and Health and West Virginia University have been focusing on designing and optimizing automatically deployable structures AutoROPS. One problem with the latest design is the large amount of effort needed to reset the AutoROPS after deployment. This is attributed to the fact that the springs used were selected to be strong enough to lift the load exerted by the mass of steel tubes of the deployable section. Selecting a material that has much lower density than steel and with mechanical properties that would not compromise the workability of the system was the main goal. After reviewing the literature of several types of materials, the properties of fiberglass-reinforced plastics (FRP) composites were found to satisfy the goal stated above.

In this research, mechanical engineering analysis and design were performed to create a model deploying structural unit, using fiberglass reinforced plastic (FRP), for the optimized NIOSH AutoROPS. The model was designed to satisfy SAE J2194, a test standard adopted to test rollover protective structures. The process of the design involved parametric modeling, computer aided design sketches and the application of mechanical engineering design concepts. FEA was performed on the parametric model of the composite AutoROPS prototype to ensure its structural integrity under loading conditions, specified by the SAE J2194, and comparable to those of an actual rollover. A testing apparatus was designed to deliver those loading conditions. FEA was also performed to ensure that the structure of the testing cell will not fail. Results from the FEA show agreement with the theoretical results obtained by applying structural design theories on the composite AutoROPS. The experimental data compare favorably with the FEA and theoretical results. The three analysis methodologies demonstrate the functionality on composite AutoROPS.

Key words: finite element analysis, FRP, composite materials, AutoROPS