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OPTIMAL DESIGN OF FILAMENT WOUND TRUNCATED CONES UNDER AXIAL COMPRESSION

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Abstract

In this study, filament wound truncated cones under axial compression are optimized with the objectives of minimizing the total weight and maximizing the failure load, which is defined as the minimum of the buckling and the first-ply failure (*FPF*) loads. The numerical results are obtained using an axisymmetric degenerated shell element based on a refined first-order shear deformable shell theory and a 2D degenerated shell element is used for verification purposes. It is shown that, *FPF* is more critical than buckling for thicker cones with lower cone angles.

Optimal designs, where *FPF* and buckling are imposed as design constraints, are presented for filament wound cones using Micro-Genetic Algorithms. The results show that, using more layers having different winding angles has negligible influence on the failure load and the optimal design is not *FPF* critical for moderate levels of axial compression. The influence of the rotational boundary conditions on the optimal failure load is also demonstrated.

Keywords: *Cone; buckling; finite elements; genetic algorithms; design optimization*

1. INTRODUCTION

In this study, optimal designs for axially compressed filament wound truncated cones are presented. The primary objective is to maximize the failure load which is defined as the minimum of the buckling load and the first-ply failure load and the secondary objective is to minimize the total weight.

Filament winding is a fabrication technique well suited to automation and several studies exist in the literature on the buckling behavior of filament wound laminated composite cones [1-10]. The main cause of the complexity regarding these structures is that, thickness and ply angles of filament wound cones along the axial direction are not constant, as stated by Morozov [1], Goldfeld and Arbocz [2, 5], Goldfeld *et al*. [3,4,6], Patel *et al*. [7], Blom *et al*. [8], Goldfeld [9,10], and Maleki and Tahani [11].

Optimal design of thin-walled fiber reinforced composite structures under compressive loads have received considerable attention in the literature as these structures are prone to buckling. Design/optimization of filament wound truncated cones under buckling loads has been treated previously by several researchers. Brown and Nachlas [12] presented the optimal ply angles maximizing strength. Goldfeld *et al*. [3] obtained optimal lamination angles for variable thickness laminated cones using response surface method. Kabir and Shirazi [13] obtained optimal laminate configurations for filament wound laminated cones under axial compression using the penalty function method. Maleki and Tahani [11] considered variable thickness conical shell panels under thermo-mechanical loads. Naderi *et al*. [14] studied the influence of fiber paths on buckling loads of laminated cones under axial compression. Shadmehri *et al*. [15] used Ritz Method to analyze axially compressed filament wound cones and made some recommendations for design. However, *FPF* has not been considered in these studies. To the authors knowledge, the present study is the first study where a *FPF* constraint is considered in design/optimization of axially compressed cones. Also, the influence of the