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S. Sahmani, M.M. Aghdam, M. Bahrami

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On the postbuckling behavior of geometrically imperfect cylindrical nanoshells subjected to radial compression including surface stress effects

S. Sahmani, M.M. Aghdam*, M. Bahrami

Department of Mechanical Engineering, Amirkabir University of Technology, P.O. Box 15875-4413, Tehran, Iran

Abstract

The main objective of the present study is to investigate the effect of surface stress on the nonlinear buckling and postbuckling behavior of cylindrical nanoshells with initial geometric imperfection subjected to radial compressive load. Gurtin-Murdoch elasticity theory is implemented into the classical shell theory to develop a size-dependent shell model which is capable to capture surface stress effects efficiently. In order to satisfy balance conditions on the surfaces of nanoshell, a linear variation through the thickness is considered for the normal stress component of the bulk. The principle of virtual work is put to use in order to formulate the non-classical governing differential equations. Afterwards, a boundary layer theory is employed including the nonlinear prebuckling deformations, initial geometric imperfection and large postbuckling deflections. Finally, a two-stepped singular perturbation methodology is utilized to obtain the size-dependent critical buckling loads and the postbuckling equilibrium paths of imperfect nanoshells corresponding to both lateral and hydrostatic pressure loading cases. It is found that for the positive and negative values of surface elastic constants, the both critical buckling load and critical end-shortening of nanoshell increase and decrease, respectively.

Keywords: Nanomechanics; Cylindrical shell; Surface free energy; Size effect; Boundary layer theory.

1. Introduction

Great promise for a wide diversity of applications of nanostructures in the area of nano-electro-mechanical systems (NEMSs) has motivated researchers to broaden their investigations to determine the mechanical properties of the structures at nanoscale. On the other hand, owning to significant increase of surface to volume ratio, the physical and mechanical characteristics at nanoscale exhibit size-dependent. Agrawal et al. [1] presented an experimental and computational approach to unambiguously quantify size

*Corresponding author. Tel.: +98 21 66405844, Fax: +98 21 66419736.
E-mail address: aghdam@aut.ac.ir (M.M. Aghdam).