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Surface growth and residual stress in a cylindrical vessel

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Abstract

We consider an axysimmetric cylindrical vessel grown by surface deposition at the inner boundary. The residual stress in the vessel can vary, e.g. depending on the loading history during growth. Can we represent and characterize a stress free material (a.k.a reference) configuration for the vessel? Extending an idea initially proposed for surface growth occurring on a fixed boundary, the material configuration is introduced as a two dimensional manifold immersed in a three dimensional space. The problem is first formulated in fairly general terms for an incompressible neo-Hookean material in plane strain and then specialized to material configurations represented by ruled surfaces. An illustrative example using geometric and material parameters of carotid arteries shows the characterization of different material configurations based on their three-dimensional slope and computes the corresponding residual stress fields. Finally, such slope is shown to be in a one to one relationship with the customary measure of residual stress in arteries, i.e. the opening angle in response to a cut. The present work introduces a framework for residual stress and shows its applicability in a special setting. Several generalizations and extensions are being considered in the following, e.g. to thermal and plastic strains, to further test and assess the proposed method.

Keywords:

residual stress cylindrical vessel surface growth reference configuration