Circumferential buckling of thick-wall hyperelastic tubes under radial pressure

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Abstract

Nonlinear elastic tubes in pressure are encountered in many fields of mechanics (pipes in pressure) and biomechanics (arteries, airways, urethral duct). In many cases soft materials and tissues are multi-layered in thickness, e.g. due to a circumferential growth process, and this is source of abnormal behaviour with regards to their mechanical stability. Under this condition, in fact, differential forms of instability are induced between the inner and outer edge of the tube [1]. Studies in this sense have involved growing spherical shells [2], and axially loaded growing pipes [3]. A recent analytic expression for the critical pressure for homogeneous thick tubes under radial pressure has been also derived by Papadakis [4].

A numerical model defined in the framework of hyperelastic materials and the theory of finite elasticity is developed to study the circumferential buckling of multi-layered tube systems. It is shown that a minimum occluding pressure is necessary to contrast buckling instability due to radial pressure, as well as to allow the reopening of the lumen area without occurrence of forms of instability.

Specifically, the stabilizing bifurcation properties of the system under different scenarios are discussed in function of the geometric aspect of a two-layer tube configuration, and the occluding pressure.

References

[1] Moulton, D.E., Goriely, A. (2011). Circumferential buckling instability of a growing cylindrical tube. *J. Mech. Phys. Solids* 59, 525–537.

[2] Amar, M.B., Goriely, A. (2005). Growth and instability in elastic tissues. *J. Mech. Phys. Solids* 53, 2284–2319.

[3] Vandiver, R., Goriely, A. (2009). Morpho-elasto-dynamics: the long-time dynamics of elastic growth. *J. Biol. Dyn*. 3(2), 180–195.

[4] Papadakis, G. (2008). Buckling of thick cylindrical shells under external pressure: A new analytical expression for the critical load and comparison with elasticity solutions. *Int. J. Solids Struct.* 45, 5308–5321.