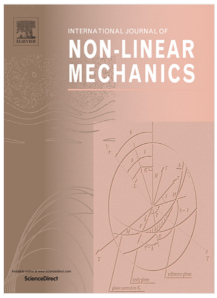

Accepted Manuscript

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PII: S0020-7462(18)30040-4
DOI: https://doi.org/10.1016/j.ijnonlinmec.2018.05.019
Reference: NLM 3027

To appear in: *International Journal of Non-Linear Mechanics*

Received date : 18 January 2018
Revised date : 28 March 2018
Accepted date : 23 May 2018

On the Use of Biphasic Mixture Theory for Investigating the Linear Stability of Viscous Flow through a Channel Lined with a Viscoelastic Porous Bio-Material

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Abstract:

Linear stability of viscous fluids flowing through a two-dimensional channel lined with a poroelastic layer which is saturated with the same viscous fluid is numerically studied in this work. Having assumed that the solid matrix of the poroelastics layer obeys the standard linear solid (SLS) model, the basic flow/deformation was obtained for this fluid-solid-interaction (FSI) problem using the "biphasic mixture theory". The vulnerability of the basic solution so-obtained to infinitesimally-small, normal-mode perturbations was then investigated using a temporal, normal-mode, linear stability analysis. An eigenvalue problem was obtained which was solved numerically using the Chebyshev pseudo-spectral collocation method. The main objective of the present work was to investigate the role played by the inhomogeneity/anisotropy of the poroelastic layer on the critical Reynolds number for the core flow. From the obtained results, we have reached the conclusion that anisotropy has no significant effect on the stability picture of the main flow. The effect of inhomogeneity on the critical Reynolds number, however, was found to be significant and highly dependent on the permeability number being smaller or larger than a threshold.

Keywords: Poroelastic, anisotropy, inhomogeneity, channel flow, linear stability, SLS model, biphasic theory.

1. Introduction

Flow of viscous fluids through channels lined with poroelastic layers are quite common in biomechanical systems.- One can mention, for example, the glycocalyx layer which covers the inner walls of blood vessels serving different purposes [1]. The articular cartilage in human joints can also be mentioned as another important example where such layers are naturally encountered in physiological systems [2,3]. To this list should be added the intervertebral disc in our spine system which is known to be poroelastic [4]. Poroelastic scaffolds developed in the field of tissue engineering further signifies the importance of this field of research [5,6]. Flow through or above poroelastic materials is also encountered in many engineering processes such as filtration [7], hydraulic fracturing [8], and geological systems [9,10], among others. In polymer industry, the unique features of poroelastic materials has culminated in the development of poroelastic foams and plastics which can be used in soft robots and artificial hearts [11]. In recent years, the interest in analyzing flow through or above poroelastic layers has significantly increased when it was discovered that poroelastic coatings can be used as efficient drag-reducing agents [12].