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Analyzing nonlinear vibrations of metal foam nanobeams with symmetric and non-symmetric porosities

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Abstract. This article is concerned with the investigation of geometrically non-linear vibration response of refined thick porous nanobeams. To this end, non-local theory of elasticity has been adopted to provide the nanobeam formulation. Voids or pores can affect the material characteristics of the nanobeam. So, their effects have been considered in this research and also there are various void distributions. The closed form solution of the non-linear problem has been used that is adopted from previous articles. Then, it is focused on the impacts of non-local field, void distribution, void amount and geometrical properties on non-linear vibrational characteristic of a nano-size beam.

Keywords: non-linear vibration; refined beam theory; metal nanobeam; nonlocal elasticity

1. Introduction

There is one type of metal material known as metal foam with low weight due to possessing different variations of porosities in it. The variation of porosities in this material causes a significant difference between metal foams and other perfect metals. In a non-perfect metal, the material characteristics are notably influenced by pore variations. Also, this variation in pores can affect the vibration frequencies of engineering structures made of metal foams. This issue can be understood from the works done by Chen *et al.* 2015 and 2016, Rezaei and Saidi (2016). Different from metal foams, there are also functionally graded (FG) or ceramic-metal materials in which pore variation effect is very important (Mechab *et al.* 2016, Mirjavadi *et al.* 2018, 2019a). In this material, pores may be produced in a phase between ceramic and material. Engineering structures made of this materials are studied to understand their vibration behaviors as reported in the works of Wattanasakulpong *et al.* (2014), Yahia *et al.* (2015), Atmane *et al.* (2015a,b).

Recent studies focus on engineering structures at nano-scales due to their involvement in nano-mechanical systems or devices. However, the main issue in these studies is to select an appropriate elasticity theory accounting for small scale impacts. The impact of size-dependency might be considered with the help of a scale parameter involved in non-local theory of elasticity Eringen (1983). The word "non-local" means that the stresses are not local anymore. This is because we are talking about a stress field of nano-scale structure. Many authors are aware of these facts and they are using this theory to analysis mechanical characteristics of small size engineering

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