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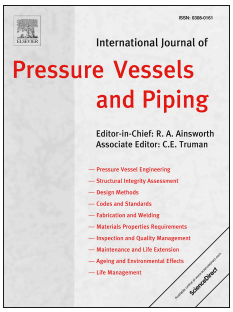

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Stresses minimization in functionally graded cylinders using particle swarm optimization technique

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Abstract

In the present work, minimization of the induced stresses in functionally graded cylinders due to pressure loading is carried out considering the plane-stress geometrical conditions. The functionally graded cylinder is made up of layers each of which is assumed to be isotropic while the properties of each layer are different from those of the others. Also, the number of layers is varied up to ten while all layers have the same thickness. For the optimization methodology, the evolutionary particle swarm optimization technique is applied in order to solve the nonlinear optimization problem. The optimization variables are the volume fractions of the constituent materials that lead to the moduli of elasticity of the layers and therefore the modulus of elasticity of the multi-layer cylinder varies in the radial direction. Since failure may occur at the interface between any two successive layers, due to its weakness, the maximum hoop-stress-jump at the interfaces is considered as an extra objective along with the maximum hoop stress through the cylinder thickness. The optimization is attained by minimizing these two objectives through the evaluation of the proper optimization variables using the finite difference numerical method. The obtained stresses are compared to the nonoptimized ones in order to have some insight about the effectiveness of the proposed analyses. Based on the obtained numerical results, it is found that the stresses are considerably decreased by applying the proposed methodology. Eventually, failure probability can be decreased and/or the pressure capacity can be increased by applying the evaluated optimized parameters.

Keywords: Particle swarm optimization, Multi-layer cylinder, Functionally graded materials, Finite difference method, maximum stresses.

1 Introduction

The concept of functionally graded materials (FGMs) is proposed in the literature to increase the pressure capacity and/or to decrease the failure probability of pressurized cylinders in different applications. FGMs are composite materials with microstructures that vary spatially due to the variation of the volume fractions of the constituent materials in certain directions. Accordingly, the effective properties of FGMs vary in these directions resulting in enhanced performance of various components in different engineering applications [1]. The Investigation of the behaviors of different finite and infinite cylindrical components subjected to various loading conditions, whether mechanical, thermal and/or rotational, attracted many researchers using both the analytical and numerical methods, [2-5].

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