10th International Congress on Civil Engineering, 5-7 May 2015
University of Tabriz, Tabriz, Iran

Thermo-Elasto-Plastic Analysis of Functionally Graded Spherical Reservoirs Subjected to Temperature Gradient

A. Heydari[1], M. T. Kazemi[2]

1- PHD Student of Structural Engineering, Tabriz University
2- Associate Professor of Civil Engineering, Sharif University of Technology

a_heydari@tabrizu.ac.ir

Abstract

Thermo-Elasto-Plastic analyses of thick-walled spherical tanks made of functionally graded materials are investigated analytically. These tanks are subjected to positive or negative temperature gradient loadings. The power law modeling has been used for through-the-thickness variation of mechanical and thermal properties of reservoirs. von Mises yield criterion and Elastic-Perfectly-Plastic assumption are used for description of material behavior in plastic zone. Comparing the results of Elasto-Plastic analyses of FG vessels made of AL A359/SiCp with those of isotropic vessels, it is concluded that these vessels have improvement in Thermo-Elasto-Plastic behavior. The validity of results is confirmed by simplifying the results for the special case of isotropic vessels.

Keywords: Analytical Analysis, Thermo-Elasto-Plastic Stresses, Functionally Graded Materials, Spherical Thick-Walled Tanks, Temperature Gradient

1. INTRODUCTION

Elastic analyses of thick-walled circular tanks subjected to internal and external pressure carried out by Johnson and Mellor [1] and Cook and Young [2]. Elasto-Plastic and Thermo-Elasto-Plastic stress analyses of spherical tanks have been also done by Whalley [3] and Mendelson [4] for thick-walled tanks. Thermoelastic studies are also conducted by Nowaki [5]. Exact solution for Elastic-Perfectly-Plastic behavior of spherical tank under thermal gradient is obtained by Cowper [6]. He also investigated an approximate solution method by neglecting elastic strains. This simplification led to conclusion that approximate solution in the case of thermal gradient is almost same as the exact solution. Investigation for initiation of yielding zones for various temperature-pressure and radius ratios of thick-walled homogeneous spherical tanks has been done.

Effect of using non homogenous materials in strength and deformation of FG thick-walled cylindrical tanks subjected to internal pressure with assumption of plane strain condition has been investigated by Fukui and Yamanaka [7]. Fukui et al [8] continued researches with Thermo-mechanical analyses of FG cylinders subjected to temperature gradient. Elastic–plastic analysis of two-dimensional functionally graded materials under thermal loading has been investigated by Mahmoud Nemat-Alla et al [9]. Eslami et al. [10] obtained general solution for the one-dimensional steady-state thermal and mechanical stresses in a hollow thick-walled sphere made of FG material. Shao and Wang [11] solved a steady-state thermal and a nonuniform mechanical loading problem for a FG cylindrical panel with finite length. Thermoelastic analysis of a FG cylindrical vessel was performed by Peng and Li [12].

There are a few works concentrating on Thermo-Elasto-Plastic analyses of thick-walled FG tanks. Lack of access to experimental results led to difficulties in the analytical investigation of FGM's behavior. On the other hand, by increasing industrial demands for such materials, investigation of FGM's behavior is in the focus.

In this paper Thermo-Elasto-Plastic analyses of FG spherical thick-walled tanks subjected to positive or negative temperature gradient have been investigated analytically. Comparing the results of Elasto-Plastic analyses of FG vessels with those of isotropic vessels, it is concluded that these vessels have improvement in Thermo-Elasto-Plastic behavior. The validity of results is confirmed by simplifying the results for the special case of isotropic vessels.