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Optimum yield pressure of linearly graded sphere

Mohammad Sheykhepour[1]

1. Department head of network & facilities of water & wastewater utilization, Sarab region, Water & wastewater company, East Azarbaijan province, Iran
sheykhepour-m@abfaazarbaijan.ir

Abstract

The elastic response of the thick-walled heterogeneous spherical reservoir made up of metallic materials with linear gradation in the radial direction caused by internal pressure is calculated. Beltrami-Michell equation is obtained based on axisymmetric condition assumptions by combining equilibrium equations of stresses, compatibility equations of strains and constitutive relations in the spherical coordinate system. The linear material behavior is assumed; therefore Hooke's law is employed as stress-strain constitutive relation. The shear stresses are vanished due to axisymmetric conditions and body forces are neglected; consequently the coordinate parameters can be used as principle axes. The elasticity modulus, yield stress and Poisson's ratio are assumed to be linear functions of radius. The mechanical boundary conditions are applied and governing equation is solved via finite difference method (FDM) due to lack of analytic solution. The maximum effective stress of von Mises yield criterion is occurred at inner surface; as result the negative sign for the parameter of the linear yield stress gradation should be considered to calculate optimum yield pressure. The numerical example is conducted and diagrams of radial and circumferential stresses, radial and tangential strains as well as radial displacement in the elastic tanker are presented.

Key words: Spherical container, Elastic analysis, Linear material gradation, Optimum yield pressure, Finite difference method (FDM)

1. Introduction

Spherical tank high-pressure liquid (storage of propane, butane, etc) and high-pressure gas (storage of city gas) holders are the normal shape for high-pressure storage because the pressurized gas tries to expand as a sphere, and the stress by inner pressure becomes equal. An analysis has been carried out on the fire and explosion risk associated with a storage sphere holding some 600 tons of liquefied flammable gas under pressure and protected by a spray system [1]. The accessible plate width and length, machining allowance, prices of steel and labor cost are the limiting factors in design for the mixed