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Elastic-plastic analysis of functionally graded rotating disks with variable thickness and temperature-dependent material properties under mechanical loading and unloading

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Abstract

This work presents an analysis of the thermo-mechanical behavior of rotating discs made of functionally graded material (FGM) with variable thickness. The solutions are obtained by variable material property (VMP) theory. In this theory, the domain is divided into some finite sub-domains in the radial direction, in which the thermo-mechanical properties are assumed to be constant and the form of the elastic response is used to solve elastic-plastic problems. The results obtained by the VMP method are then compared with the results obtained by the finite element analysis using ANSYS software. In addition, the unloading and reverse yielding behavior of FG rotating disk are investigated and the residual stresses are then calculated with the same values of pressure and temperature by VMP theory and FE analysis. The results reveal that the mentioned methods are in very good agreement in both elastic and elasto-plastic states. Also, the effect of considering the temperature-dependent material properties is discussed. It is found that the results obtained by ignoring the temperature-dependent material properties lead to high discrepancies in comparison with those by considering that. Subsequently, the effect of various parameters including the disk geometry, temperature distribution, and boundary conditions on the stress behavior of disk is investigated. The results show that unlike the uniform rotating discs in which the yielding necessarily initiates from the inner radius, in the FG rotating discs, plasticity can be initiated from any point.

Keywords: *functionally graded rotating disk; unloading behavior; residual stress; variable material property theory(VMP); temperature-dependent material properties*

1. Introduction

Functionally graded materials (FGMs) are a new type of advanced composites, which have been used for many engineering applications. The main application of FGMs is in high temperature such as automotive, aircrafts, turbine rotors, flywheels, gears etc. In these materials, the volume fraction of the two or more materials is varied steadily and nonhomogeneously as a function of

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