A THREE-DIMENSIONAL ELASTICITY SOLUTION OF
FUNCTIONALLY GRADED MATERIAL WITH
PIEZOTHERMOELASTIC LAYER

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Summary. A three dimensional solution is presented for a simply supported functionally graded
finite cylindrical panel with piezothermoelastic layer subjected to thermo-electro-mechanical
load. The variables are expanded in Fourier series to satisfy the boundary conditions at the end
and to reduce the equations of equilibrium, which are coupled partial differential equations, to
ordinary differential equations (o.d.e). The resulting o.d.e are solved by the Galerkin finite-
element method. Numerical results are presented for a FG finite cylindrical panel with
piezothermoelastic layer. The influence of the material property gradient index and radius-to-
thickness on the variables of mechanical field is studied.

INTRODUCTION

Piezoelectric materials have been widely used as an actuator or sensor in recent years.
Piezoelectric actuators are usually constructed as either stacked or bimorph forms by bonding
together two or more piezoelectric ceramic sheets in different forms. The stacked piezoelectric
actuators are used where large forces are needed and a small displacement is sufficient. In
contrast, where large displacements are necessary and small forces are sufficient the bimorph
piezoelectric actuators are suitable (i.e. displacement transducers, micropositioners and rotary
actuators) [1].

A functionally graded material (FGM) is a material in which the composition and structure
gradually change resulting in a corresponding change in the properties of the material. This
FGM concept can be applied to various materials for structural and functional uses.
In order to create FGMs, the architecture of design, processing, and evaluation needs to be
developed because comprehensive study of such non uniform materials has not been carried out
previously. The concept of integrating incompatible functions such as the refractoriness of
ceramics and the toughness of metals with the relaxation of thermal stress, lead to a research
project for the development of FGM architecture in 1987 [2]. In fact, it is possible to integrate
a variety of dissimilar materials and properties if the thermal expansion mismatch or lattice
mismatch can be relaxed and chemical compatibility can be maintained. Many applications
exist that require high temperature resistance or thermal shock resistance, where the FGM
concept can be applied.[3]

In this study a simply supported finite FGM cylindrical panel with a piezothermoelastic layer
is considered under thermo-electro-mechanical load. The FGM cylindrical panel is assumed to
be made of many isotropic sub-panel and FGM properties resulted by suitable arrangement of layers in the multi layer panel [4]. In each interface between two layers, stress and displacement continuity are satisfied.

CONCLUSIONS

- The Fourier series expansion is suitable for the mechanical, electrical and thermal analysis.
- The effect of the radius-to-thickness to the displacements and normal stresses in the FGM panel has been studied.
- It is shown that reduce substantially both the displacements and the peak value of normal stress in FGM panel due to thermal and mechanical loading by suitable application of the potential difference across the piezoelectric actuator is possible.
- It is also shown that the location of peak value of stress in FGM panel can be changed and it is possible to reduce the displacements by changing in material property gradient index.

REFERENCES