DISTRIBUTION OF NORMAL STRESS UNDER THE INFLUENCE OF TEMPERATURE ON BEAM LAYER ON NON LAMINATED VARIAITION STRESS

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Abstract- In this study, the properties of the material depend on the temperature which varies in a continuous way according to the thickness according to a power law, we use a multi-layered beam not stratified to study the distribution of the stress along the thickness for the structure studied, the industrial and economic sector requires the properties of the materials requested, we work with the analytical method to define the expressions of the stresses, the effects of the distributions of all types of material parameter are presented, The results show that the previously mentioned effects play a very important role in the dynamic behavior of the beams studied.

Keywords: stress, temperature, thickness, multilayer.

1. Introduction

A new class of composite materials, known as functionally graded material (FGM), has received considerable attention. Functionally graduated materials (FGM) are characterized by a class of materials where the microstructures are spatially calibrated to obtain specific thermal and / or mechanical properties according to the functionality of the structure [1], the properties of the material vary from continuously in the direction of the thickness according to the distribution of the power law. A three-dimensional solid element is used for a more precise modeling of the properties of the material and the temperature field in the direction of the thickness. The nonlinear deformation-displacement relation of Green-Lagrange is used to take into account a significant deflection due to a pressure and uniform thermal loads and the incremental formulation is applied for nonlinear analysis [2].

Structural elements subjected to high temperatures, large temperature differences and uneven heating rates are inevitable during the operation of gas turbines, nuclear reactors, molded parts, forgings, radiant burners, tubes in heat exchangers, guns artillery, etc. The elements result from a sudden exposure to a very large amount of heat observed during the launch of the rocket, spatial structural components subjected to radiant solar heat [3] and [4].

Functionally Evaluated Material (FGM) is a new type of inhomogeneous composite. It has a microstructure and continuously varying mechanical properties. The main advantage of FGM is that there are no internal limits and that concentrations of interfacial stresses can be avoided. In addition, materials with a functional gradient (FGM) can be designed to obtain specific properties and the gradation of the properties of the material can optimize the distribution of stresses. Rocker motor casings and packaging materials in the microelectronics industry [5].

Composite materials are those that are formed by combining two or more materials on a macroscopic scale so that they have better engineering properties than conventional materials, for example metals. Most artificial composite materials are made from two materials: a reinforcing material called fiber and a base material, called matrix material. The stiffness and strength of fibrous composites comes from stiffer and stronger fibers than the same bulk material. The matrix material holds the fibers together, acts as a charge transfer medium between the fibers and protects the fibers from exposure to the environment [6].

The field of displacement for this study, of which are and are the two components of displacement of a point lc x l in the neutral axis, is the rotation of the normal around the neutral axis, expressed as follows:

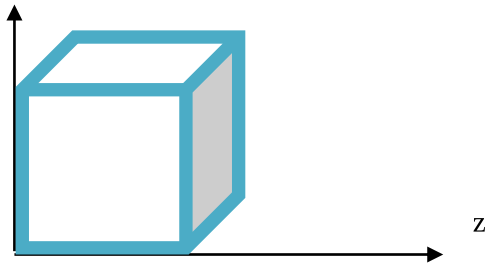


Fig. 1. Structure gradually evaluated material

$$u_x(x,z,t) = u_0(x,t) + z\phi(x,t) - \alpha z^3(\phi(x,t) + w_{0,x}(x,t)) \quad (1)$$

Reproduction of this equation in matrix form:

$$u_x = [1 \quad 0 \quad -\alpha z^3 \quad z - \alpha z^3]\begin{Bmatrix} u_0 \\ w_0 \\ w_{0,x} \\ \phi \end{Bmatrix} \quad (2)$$

The deformation-displacement relationship is given by the following expression::

$$\varepsilon_x = \partial u_x / \partial x \quad (3)$$

By substituting equation (1) in (3), we obtain:

$$\varepsilon_x = \partial u_x / \partial x = \partial u_0(x,t)/\partial x + z\partial\phi(x,t)/\partial x - \alpha z^3(\partial\phi(x,t)/\partial x + \partial^2 w_0(x,t)/\partial x^2) \quad (4)$$

On the other hand, the expression of the deformation in the form of matrix is given by

$$\varepsilon_x = [1 \quad z - \alpha z^3 \quad -\alpha z^3 \quad 0]\begin{Bmatrix} \partial u_0(x,t)/\partial x \\ \partial\phi(x,t)/\partial x \\ \partial^2 w_0(x,t)/\partial x^2 \\ \phi(x,t) + w_{0,x}(x,t) \end{Bmatrix} \quad (5)$$

The stress strain relationship is given by:

$$\sigma_x = E\varepsilon_x - \alpha\Delta T \quad (6)$$

For the materials gradually evaluated the expressions of the strains and Young's moduli follow a power law

$$E(z) = \begin{cases} E_1 & pour \quad 0\langle z \langle h_1 \\ E_1\left(\dfrac{h_1+h_2-z}{h_2}\right)+E_2\left(\dfrac{z-h_1}{h_2}\right) & pour \quad h_1\langle z\langle h_1+h_2 \end{cases} \tag{7}$$

$$\varepsilon(z) = \begin{cases} \varepsilon_1 & pour \quad 0\langle z \langle h_1 \\ \varepsilon_1\left(\dfrac{h_1+h_2-z}{h_2}\right)+\varepsilon_2\left(\dfrac{z-h_1}{h_2}\right) & pour \quad h_1\langle z\langle h_1+h_2 \end{cases} \tag{8}$$

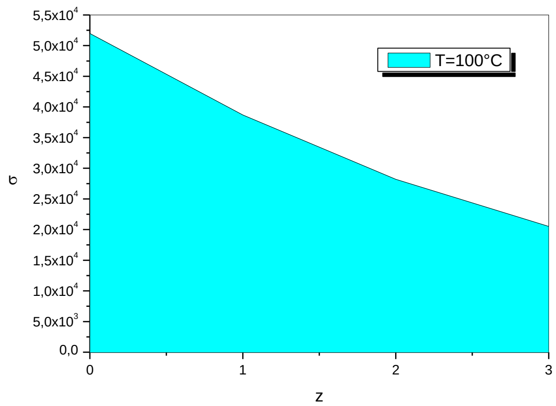
$$\sigma_x = E_1\varepsilon_1 + \left(E_1\left(\frac{h_1+h_2-z}{h_2}\right)+E_2\left(\frac{z-h_1}{h_2}\right)\right)\left(\varepsilon_1\left(\frac{h_1+h_2-z}{h_2}\right)+\varepsilon_2\left(\frac{z-h_1}{h_2}\right)\right)-\alpha\Delta T \tag{9}$$

2. Results and discussion

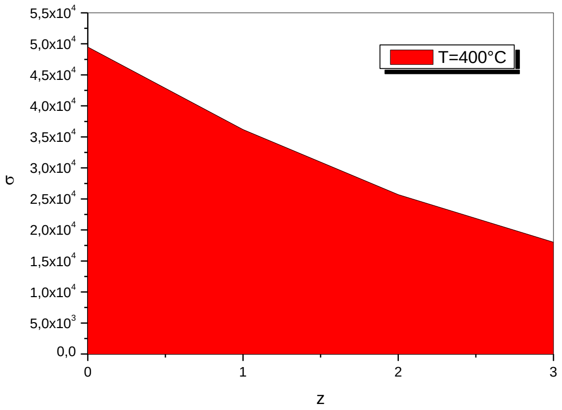
Consider an FGM beam, the parameters used are:

ε_1=0.098799, ε_2=0.074799, h_1=1m, h_2=1,5m, E_1=204,04.10^9 Pa E_2=224,26.10^9 Pa ,

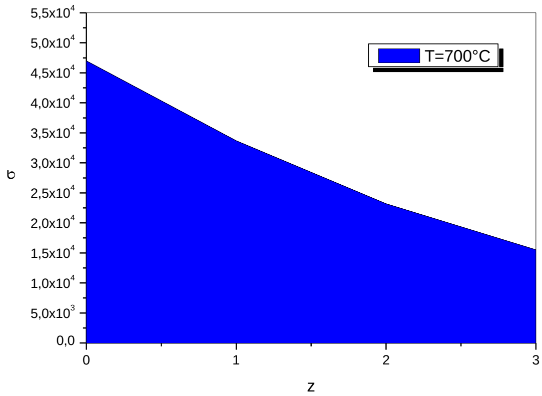
$\alpha = 4/3h^2$



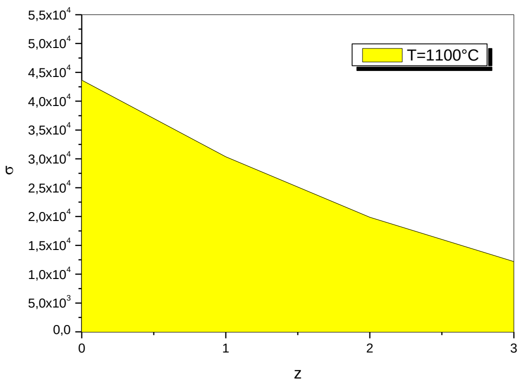
(a)


T=400°C
σ
z
5,5x10^4
5,0x10^4
4,5x10^4
4,0x10^4
3,5x10^4
3,0x10^4
2,5x10^4
2,0x10^4
1,5x10^4
1,0x10^4
5,0x10^3
0,0
0
1
2
3

(b)


T=700°C
σ
z
5,5x10^4
5,0x10^4
4,5x10^4
4,0x10^4
3,5x10^4
3,0x10^4
2,5x10^4
2,0x10^4
1,5x10^4
1,0x10^4
5,0x10^3
0,0
0
1
2
3

(c)


T=1100°C
σ
z
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5,0x10^4
4,5x10^4
4,0x10^4
3,5x10^4
3,0x10^4
2,5x10^4
2,0x10^4
1,5x10^4
1,0x10^4
5,0x10^3
0,0
0
1
2
3

(d)

Fig. 2. (a, b, c, d): Distribution of the normal stress along z as a function of the temperature

Figures 1 to 4 show the influence of the temperature variation on the stress distribution for a gradually evaluated beam, the concentration is very suitable in the lower part of the beam, the stress decreases along the thickness of the beam, the intensity of stress decreases with increasing temperature.

Conclusion

In this study, the effect of the increase in temperature is shown in the normal stress distribution for a beam gradually evaluated, for this type of material, the maximum value only appears on the upper part of the beam, the properties of materials change through the thickness of the beam according to the power law which gives a difference in the results of the stress, we note that the choice of the material is necessary in the construction of the structures.

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