INFLUENCE OF ELECTROSTATIC CHARGING WITH INCLUSION OF TEMPERATURE ON THE STRAIN OF STRUCTURES GRADUATED

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Abstract -In this work, we are interested in a very important goal for all researchers, it is the deformation of structures, this combination is composed of two layers, the first has the role of passing the electric field in this structure (active layer) and the second is the substrate, to determine some parameter we use a power law, the deformation of this graduated structure is calculated according to the temperature, the variation of the latter depends on the thickness, the expressions of inertia are calculated based on the height of the layers, electrostatic charging is considered to be intelligent mechanisms, the results were found is interpreted in this study.

Keywords: deformation, electrostatic charge, structure, temperature

I. Introduction

A mismatching of the properties of the material through an interface of two discrete materials bonded together in composites, causes concentrations of stresses under mechanical and thermal loads. The use of the gradual variation of the constituents of the material and therefore the gradual variation of the physical and mechanical properties can eliminate these effects. Materials whose properties vary gradually to achieve functional performance are called functionally graduated materials (FGM). Genital mutilation involves gradual transitions in the microstructure and composition, which are designed to meet functional requirements that vary depending on location in a single component and to optimize the overall performance of the component. Plasma coating materials, aircraft propulsion system, cutting tools, engine exhaust coatings, aerospace structures, thermal protection coatings for turbine blades and heat-resistant tiles are all examples where materials must operate in environments transients at extremely high temperature. Conventional super heat-resistant materials, such as those found on the outside of space shuttles, are made of heat-resistant ceramic tiles and bounded by metal structures. In these materials, the temperature gradients cause stress concentrations in the interfaces and the stress concentration causes detachment or cracking of the ceramic tiles. Compared to the layered system, for example a ceramic coating on a metal substrate, MGFs avoid the discontinuity of the properties of the material across the interface and therefore reduce these stress concentrations [1,2].

Numerous research and development works have been carried out to study FGM functionally graduated materials for various applications using gradients of physical, chemical, biochemical and mechanical properties. The main characteristic that distinguishes FGM from conventional composite materials is the possibility of adapting the composition and the microstructure graduated in an intentional way, intended to achieve the desired function. The design of FGM structures is based on an attempt to make the most of the integration of the functions of refract, hardness of high wear resistance, resistance to thermal shock, and corrosion resistance of ceramics on the one hand as well than the strength and toughness of metals on the other hand. This has led to a variety of structural applications [3]. FGM produced from a mixture of metal and ceramic is generally characterized by a regular and continuous change in mechanical, physical and chemical properties from side to side [4-6].

Functional gradient materials (FGM) are macroscopically inhomogeneous composite materials, in which the volume fraction of the two or more materials varies continuously and continuously as a function of the position of the material according to one or more dimensions of the structure. These materials are primarily designed to operate in high temperature environments. In conventional laminate composite structures, the homogeneous elastic lamellae are bonded together to obtain improved mechanical and thermal properties. The main drawback of such an assembly is to create stress concentrations along the interfaces and more particularly when high temperatures are involved. This can lead to delamination, matrix cracks and other damage mechanisms that result from the sudden change in mechanical properties at the interface between layers [7].

In this study, the results are found analytically, the variation of the material is considered to be continuous along the thickness. The stress-strain relationship in this case is given by: A mismatching of the properties of the material through an interface of two discrete materials bonded together in composites, causes concentrations of stresses under mechanical and thermal loads. The use of the gradual variation of the constituents of the material and therefore the gradual variation of the physical and mechanical properties can eliminate these effects. Materials whose properties vary gradually to achieve functional performance are called functionally graduated materials (FGM). Genital mutilation involves gradual transitions in the microstructure and composition, which are designed to meet functional requirements that vary depending on location in a single component and to optimize the overall performance of the component. Plasma coating materials, aircraft propulsion system, cutting tools, engine exhaust coatings, aerospace structures, thermal protection coatings for turbine blades and heat-resistant tiles are all examples where materials must operate in environments transients at extremely high temperature. Conventional super heat-resistant materials, such as those found on the outside of space shuttles, are made of heat-resistant ceramic tiles and bounded by metal structures. In these materials, the temperature gradients cause stress concentrations in the interfaces and the stress concentration causes detachment or cracking of the ceramic tiles. Compared to the layered system, for example a ceramic coating on a metal substrate, MGFs avoid the discontinuity of the properties of the material across the interface and therefore reduce these stress concentrations [1,2].

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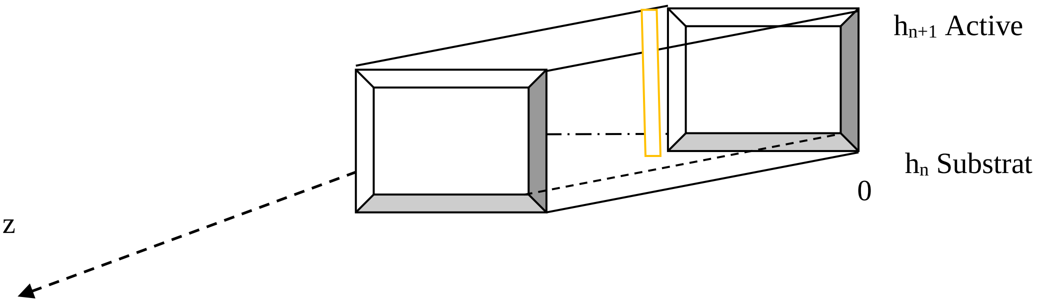

Fig. 1. FGM beam

$$\sigma(z)=Q(z)\left[\varepsilon-\alpha\Delta T-d_{31}(z)E_z\right] \tag{1}$$

We integrate equation (1) along the thickness we will have:

$$\int_0^{h_1+h_2}\sigma(z)dz=\int_0^{h_1+h_2}Q(z)\left[\varepsilon-\alpha\Delta T-d_{31}(z)E_z\right]dz=0 \tag{2}$$

The power law used for the different terms is written as follows:

$$P(z)=P_1+(P_2-P_1)\cdot V(z) \quad for \quad 0\le z\le h_1+h_2 \tag{3}$$

The expression of the volume fraction is given by:

$$V(z)=\left(\frac{z}{h_1+h_2}\right)^2 \tag{4}$$

(a) denotes active and (s) denotes substrate, the terms of the elastic moduli for the two layers active and substrate are given by:

$$Q(z)=Q_s+(Q_a-Q_s)\cdot\left(\frac{z}{h_1+h_2}\right)^2 \tag{5}$$

The coefficient similar to the piezoelectric strain:

$$d_{31}(z)=d_{31}^s+(d_{31}^a-d_{31}^s)\cdot\left(\frac{z}{h_1+h_2}\right)^2 \tag{6}$$

We apply the power law, equation (2) is written:

$$\int_0^{h_1+h_2}\sigma(z)dz=\int_0^{h_1+h_2}\left(Q_s+\Delta Q\cdot V(z)\right)\left[\varepsilon-\alpha\Delta T-(d_{31}^s+\Delta d_{31}\cdot V(z))E_z\right]dz=0 \tag{7}$$

We integrate each part separately, so:

$$\int_0^{h_1+h_2}\sigma(z)dz=\varepsilon\int_0^{h_1+h_2}\left(Q_s+\Delta Q\cdot V(z)\right)dz-\int_0^{h_1+h_2}\left[\alpha\Delta T+(d_{31}^s+\Delta d_{31}\cdot V(z))E_z\right]dz=0 \tag{8}$$

We replace each term with the expression we get:

$$\int_0^{h_1+h_2}\sigma(z)dz=\varepsilon I_0-J_0=0 \tag{8}$$

$$\varepsilon I_0-J_0=0 \tag{10}$$

$$\varepsilon = \frac{J_0}{I_0} \tag{11}$$

Avec:

$$I_0 = \int_{0}^{h_1+h_2} Q(z)\,dz \tag{12}$$

Et

$$J_0 = \int_{0_1}^{h_1+h_2} d_{31}(z)Q(z)\,dz \tag{13}$$

II. Results and discussion

$E_1=214.10^3$, $E_2=380.10^3$, $\alpha_1=15.4.10^{-6}$, $\alpha_2=7.4.10^{-6}$, $h_1=1m$, $h_2=2m$.

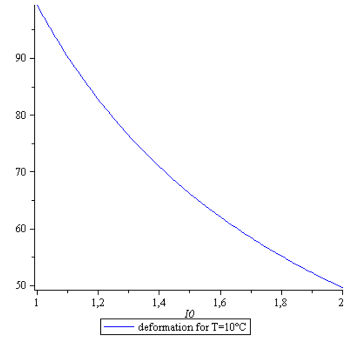

Fig. 2. Variation of deformation as a function I_0 with T = 10 ° C.

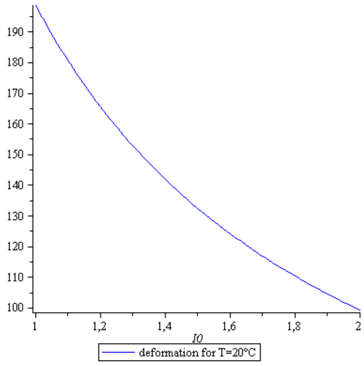

Fig. 3. Variation of deformation as a function I_0 avec T = 20 ° C.

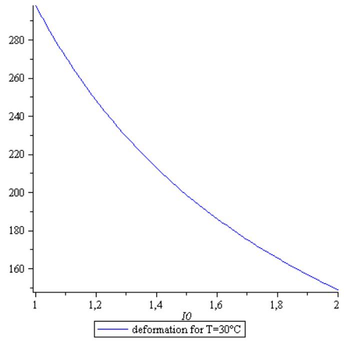

Fig. 4. Variation of deformation as a function I_0 avec T = 30 ° C.

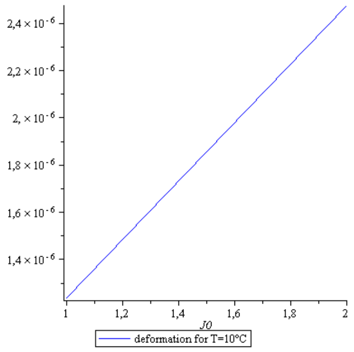

Fig.5. Variation of deformation as a function J_0 avec T = 10 ° C

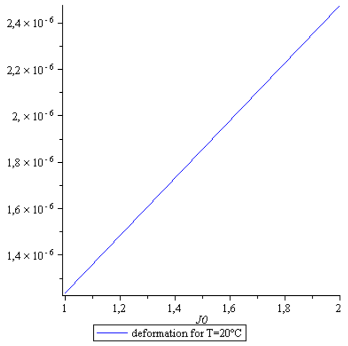

Fig.6. Variation of deformation as a function J_0 avec T = *20 ° C.*

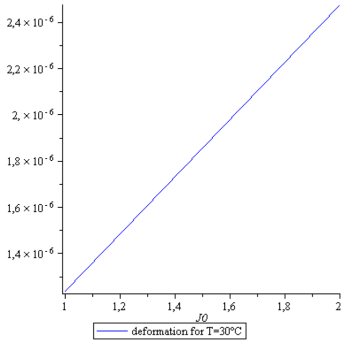

Fig.7. Variation of deformation as a function J_0 avec T = *10 ° C.*

Figures 2-4 show the variation of the deformation as a function of the term I0, variant T with an interval of 10, the variation is parabolic, the deformation of the structure increases with high values of T and decreases with the increase in I0 , on the contrary in Figures 5-7, the variation is a straight line, the deformation is very small, the deformation increases with the increase in J0.

3. CONCLUSION

This study shows that the use of graduated structures (FGM) is important in civil engineering, because of these mechanical and geometric characteristics and that it is able to withstand high temperatures despite the lightness of its weight. The deformation values for any structure are the essential role of all researchers.

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