DYNAMIC RESPONSE OF PLATE UNDER TEMPERATURE FIELD PULSE

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1. INTRODUCTION

FGMs are composed of a mixture - mostly of metal and ceramics, in different proportions across the wall thickness. The material properties can slightly and continuously change from one surface to another one, excluding the stress concentration e.g. FGMs can be used in the ultrahigh temperature field such as nuclear plants, aerospace, thermal ballistic shields or space vehicles etc.

Na and Kim [1] conducted the thermal buckling and postbuckling analyses for FGMs up to an uniform and non-uniform temperature rise on the basis of the finite element method. Authors of paper [2] analysed the buckling phenomenon for static and dynamic loading (pulse of finite duration) of functionally graded plates subjected to uniform temperature increment.

2. PROBLEM DESCRIPTION

The presented studies concern the behavior of functionally graded square plate of the side length of 1 m and thickness of 0.01 m, subjected to the thermal pulse loading. The problem was solved by means of the finite element method. The temperature rise through the plate thickness was assumed to be uniform, linear or sinusoidal. The analysis was developed in the ANSYS 14.5 software. The duration of thermal loading equal to a period or half a period of natural fundamental flexural vibrations of given structures has been taken into consideration. An evaluation of dynamic response of structures was carried out on the basis of Budiansky-Hutchinson criterion [2].

3. COMPUTATION RESULTS

The plates analysed in current paper have continuously varying material properties only in the thickness direction. On the top surface of the plate, pure metal was assumed and it grades up to the bottom surface containing ceramics only.

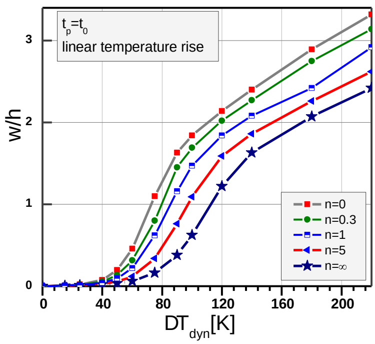
The overall material properties (for each component, see Table 1) in relation to the layer position (denoted as z) through the plate thickness (denoted as h) can be expressed as:

$$P(z) = P_m \cdot V_m(z) + P_c \cdot V_c(z) = P_c + (P_m - P_c) \cdot \left(1 - \frac{z}{h}\right)^n \tag{1}$$

Figs. 6a and 6b show the plate response maximal deflections under the thermal pulse loading for linear temperature rise and sinusoidal temperature rise, respectively. The diagrams show the plate deflection for the pulse duration equal to one period.

Table 1. Material properties of components

properties	ceramics	metal
Young's modulus [GPa]	393	200
Thermal expansion coefficient [$1/K$]	$13.3\cdot10^{-6}$	$8.8\cdot10^{-6}$
Poisson's ratio [-]	0.25	0.3
Density [kg/m^3]	2000	7800

a) 

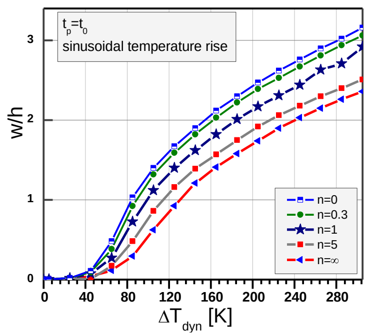
b) 

Fig. 1. Maximal deflection of the plate vs. dynamic thermal loading for a) linear temperature rise and b) sinusoidal temperature rise

4. SUMMARY

The work dealt with the numerical simulation of functionally graded plate under thermal pulse loading. It was stated that the great influence on the plate response had the distribution index, the duration and the kind of the temperature rise.

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REFERENCES

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[2] Czechowski L., Kowal-Michalska K., Static and Dynamic Buckling of Rectangular Functionally Graded Plates Subjected to Thermal Loading, Strength of Materials, 6, 2013, pp. 45-55.