Eigenfrequency analysis of cutouts Exponential FGM plate

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1. INTRODUCTION & OBJECTIVE

FGM is the product of advanced of material science and engineering after composite material. Not only it has high strength to weight ratio, its ceramics surface makes the metal part corrosion resistant and there is no scope of delamination. Material grading of FGM is classified in 3types, namely, PFGM, SFGM and exponential functionally graded material or EFGM. Panel or plate is a common three-dimensional structure which is generally as plane stress structure. Floor of a building or a naval structure which are essentially plates, may undergo vibration. Engineers needs to modify the structure accordingly to prevent the incident of resonance. Deck of a ship or spaceship needs gaps or cutout for extra passage, lift, window etc. These cutouts can significantly affect the dynamic behavior of the plate.

In this article, nine noded isoparametric elements will be used for finite element analysis (FEA). Each node of these elements will have five degrees of freedom and these displacements will follow first order shear deformation theory. As material properties changing in height direction, new physical neutral surface will be used in place of traditional midplane neutral surface. This does not affect the computational time but makes the FEA formulation more logical. First, some examples from EFGM plate and cutout isotropic plates is showcased as validation, then new results on EFGM will be presented. Variation of frequency due to thickness ratio, aspect ratio, different boundary condition, internal edge support, cutout arrangement etc. is discussed for rectangular EFGM plate.

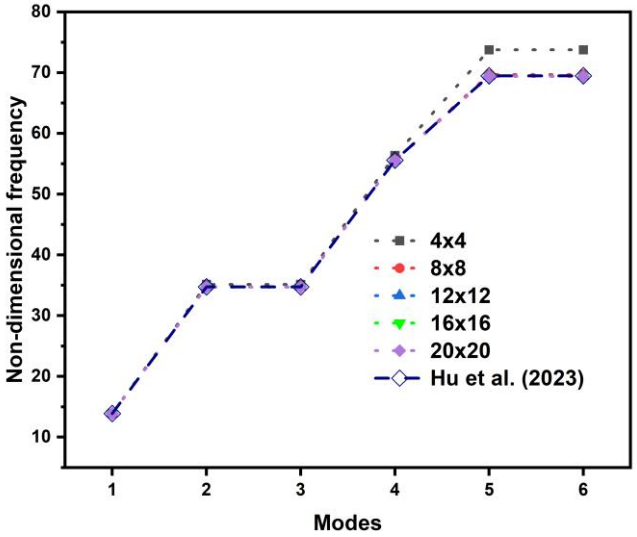

Figure 1. Convergence and validation study of EFGM plate

Table 1. Non-dimensional frequency of square EFGM plate (h= 0.01) with central cutout (0.3a × 0.3a) under various support conditions

Support condition	Modes					
	1	2	3	4	5	6
SSSS	13.666	30.922	30.922	51.799	64.165	83.138
CCCC	28.623	45.671	45.671	70.441	83.002	109.521
CFFF	2.343	5.564	14.354	18.401	21.251	38.801
CSCS	21.887	34.352	43.338	61.943	71.948	93.330
CFCF	16.144	18.319	31.599	39.881	45.743	48.429

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

At first validation and convergence study of present finite element program is done for a simply supported square plate. Non-dimensional frequency parameter is taken as $\hat{\omega} = \omega a^2 \sqrt{\frac{\rho_C h}{D_C}}$. This EFGM plate is composed of alumina (ceramic) and aluminum (metal). The present and reference frequencies (Hu et al.) are computed for the various modes and element sizes in **Figure 1**, which is showing converging trend in early modes. As mesh becomes finer, percentage variation with published result is negligible. In **Table 1**, variation of first six non-dimensional frequency of a EFGM plate with central cutout of size 0.3a × 0.3a has been showcased for different type of boundary condition.

Next Variation of frequency due to thickness ratio, aspect ratio, different boundary condition, internal edge support, cutout arrangement etc. will be discussed for rectangular EFGM plate. These new results will enhance the literature on the field of FGM structure.

REFERENCES

1. Z. Hu, Y. Shi, S. Xiong, X. Zheng, and R. Li, "New analytic free vibration solutions of non-Lévy-type porous FGM rectangular plates within the symplectic framework," Thin-Walled Structures (Elsevier BV). 185, pp. 110609. 2023.