ICCES, vol.24, no.1

Tech Science Press

DOI: 10.32604/icces.2022.08765

PROCEEDINGS

Post-Buckling and Panel Flutter of Pre-Heated Functionally Graded Plates

Wei Xia[1, 2,*], Weilin Kong[1], Yupeng Feng[1] and Shengping Shen[1, 2,*]

[1]State Key Laboratory for Strength and Vibration of Mechanical Structures, School of Aerospace Engineering, Xi'an Jiaotong University, Xi'an 710049, China

[2]Shaanxi Engineering Laboratory for Vibration Control of Aerospace Structures, School of Aerospace Engineering, Xi'an Jiaotong University, Xi'an 710049, China

[*]Corresponding Authors: Wei Xia. Email: xwei@mail.xjtu.edu.cn; Shengping Shen. Email: sshen@mail.xjtu.edu.cn

ABSTRACT

Post-buckling and panel flutter behaviors of ceramic-metal FGM plates are studied for the skins of supersonic aircrafts. The effects of asymmetric material and temperature distributions, as well as the aerodynamic loads, on the thermo-mechanical response of FGM plates are discussed using finite element simulations. The aero-thermo-elastic model is established by using the simple power law material distribution, the rule of mixture for material effective properties, the nonlinear Fourier equations of heat conduction, von-Karman strain-displacement nonlinear relations, and the piston theory for supersonic aerodynamics. The finite element equations are established using the first-order shear deformable plate elements. The thermal post-buckling equilibrium deflections are calculated from the reduced-order model, and the flutter stability is furtherly evaluated around these equilibriums. The post-buckling equilibriums are found asymmetric about the initial position of the plate, and the critical flutter speed from the post-buckling model is much higher than the linear flutter speed on the initial position. Numerical results show that the effect of thermal gradient on the post-buckling deflection of FGM plate decreases with the increase of the material gradient index. With the increase in volume fraction of ceramics (decrease in volume fraction index), the critical flutter aerodynamic pressure of the ceramic/ metal plate increases. The flutter response amplitude increases with the increase in volume fraction index.

KEYWORDS

Functionally graded materials (FGM); panel flutter; post-buckling; supersonic flight

Acknowledgement: The calculations were performed by using the HPC Platform in Xi'an Jiaotong University.

Funding Statement: This work was supported by the National Natural Science Foundation of China (Grant Nos. 12172275, 11632014), the '111' Program (B18040), and the Chang Jiang Scholar program.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

References

1. Marzocca, P., Fazelzadeh, S. A., Hosseini, M. (2011). A review of nonlinear aero-thermo-elasticity of functionally graded panels. *Thermal Stresses, 34(5–6),* 536–568.
2. Xie, F. T., Qu, Y. G., Guo, Q. W., Zhang, W. M., Peng, Z. K. (2019). Nonlinear flutter of composite laminated panels with local non-smooth friction boundaries. *Composite Structures, 223,* 110934.
3. Ye, L. Q., Ye, Z. Y. (2021). Theoretical analysis for the effect of static pressure differential on aeroelastic stability of flexible panel. *Aerospace Science and Technology, 109,* 106428.
4. Zhou, J., Xu, M. L., Gu, Y. S. (2021). Suppression of panel flutter response in supersonic airflow using a nonlinear vibration absorber. *International Journal of Non-linear Mechanics, 133*, 103714.
5. Xie, D., Xu, M. (2015). A comparison of numerical and semi-analytical proper orthogonal decomposition methods for a fluttering plate. *Nonlinear Dynamics, 79(3),* 1971–1989.
6. Xia, W., Feng, Y. P., Zhao, D. W. (2015). Finite element multi-mode approach to thermal postbuckling of functionally graded plates. *Computers, Materials & Continua, 46(2),* 125–144.