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ORIGINAL PAPER

Combined Effect of Thickness Stretching and Temperature-Dependent Material Properties on Dynamic Behavior of Imperfect FG Beams Using Three Variable Quasi-3D Model

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Abstract

Purpose The multi-step sequential infiltration technique or sintering process usually produces porosities in functionally graded structures. It is confirmed that the porosity significantly influences the static responses of FGM beams, but its influence on their thermodynamic response is still worth studying.

Methods To highlight this influence, the dynamic behavior of simply-supported porous FG beams with effective temperature-dependent material properties is examined by using a novel integral three variable quasi-3D high-order shear deformation theory for the first time. Notably, different thermal gradients varying along the thickness are considered. The governing differential equations of motion have been established based on Hamilton's principle and solved by employing the Navier-type closedform solution.

Results The present theoretical results are validated with the existing literature, and excellent agreement is identified between the results. Besides, material temperature dependence, power-law index, porosity parameter, temperature rising, and slenderness ratio effects are discussed. Results show that dynamic behavior using temperature-dependent and independent material properties would produce different natural frequencies. With the rise of porosity, the natural frequency decreases significantly at high temperatures.

Conclusions The beam with a higher slenderness ratio is more sensitive to the stretching effect. Finally, to improve the thermodynamic behavior of such structures, ceramic constituents with a lower thermal expansion coefficient would be recommended.

Keywords Porosity · Thermal loading · Thermo-dynamic coupling · Navier's technique · FG beams

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