



The Research Progress of Mechanical Properties of Composite Laminates



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Abstract

Composite materials are widely used in modern industry because of their high specific strength and specific quality. Based on composite material laminates is hot research topic in recent years to consult, discusses the modeling of piezoelectric fiber laminated plates with bending theory equation to solve the results, composite laminates of higher order shear deformation theory, the heat is abnormal load response for the bottom of the plywood and participation and viscous damping for laminated plates such aspects as the influence of the introduction of composite laminates research present situation and the future research direction.

Keywords: Composite laminates; Piezoelectric fiber; Higher order shear deformation; Extreme loads; Heat exchange; Viscous damping

Introduction

Composite material is composed of two or more kinds of materials through a certain way together, it has the excellent performance of a single material, but also take into account the comprehensive performance of a variety of materials composite, all kinds of materials complement each other, produce synergistic effect, so composite material due to its advantages of composite application in all walks of life. In this paper, the latest research emphases on composite laminates in recent years are described according to the time sequence. It mainly includes: Research progress of piezoelectric composites [1-3], Theory of high order shear deformation of composite laminates [4-6], Response of composite laminates under external loads (periodic vibration, shock, subsonic compressive airflow) [7-11], The response of composite laminates with heat input [12-15], The influence of viscoelastic damping on composite laminates [16-18]. And so, on aspect carries on the elaboration.

Research Progress

Literature [1-3] respectively studied the new idea of establishing piezoelectric composite laminated plates by using the variable kinematics plate modeling method, proposed the extension of iso-geometric method to study the dynamic response of CNTRC plates, and proposed a four-variable fine plate theory for the bending analysis of piezoelectric fiber reinforced composites. In this kind of research, by using the idea of variable kinematics

modeling, the isopach distribution of positioning and moving field and electric potential is adopted to obtain the two-dimensional plate equation. The dynamic response of the piezoelectric carbon nanotubes reinforced materials is studied by using the geometric method, and the linear function of the laminates is obtained. This method has high reliability. In the analysis of improving the bending of piezoelectric fiber, the application of four-variable refinement theory combined with MATLAB for numerical solution also has a higher solution.

Literature [4-6] mainly optimizes the theory of high-order shear deformation of composite laminated plates. It includes putting forward a new theory of laminated C^0 -type high order shear deformation, which is applied to laminated composite interlayer, so that the plane displacement and transverse shear stress within the layer have a high continuity. The static, buckling and free vibration directions of composite are studied by using the improved shear theory. The constitutive relation is established by finite volume discretization and so on. Literature [7-11] studies the response of composite materials under ballistic impact, periodic load and subsonic airflow load. In ballistic impact, the response and residual energy relation of different impact regions are studied. The response problem with small diameter and high-speed impact has a great research prospect. The vibration parameters of conical laminated plates under cyclic fatigue load are set, and the results show that the conical structure has better fatigue resistance than

the plate structure under rotational load. The stability and vibration characteristics of the laminated plate are taken into account by the fluid model, and the threshold value of plate instability is obtained.

Literature [12-15] mainly studies laminated plate theory of composite materials and heat-buckling behavior under heat exchange. In the study of thermal-buckling mechanical response of inclined functionally gradient materials with initial defects, the C^0 -type shear deformation theory mentioned above is used to derive the governing differential equation based on the variational principle, which is widely used in this kind of research. In the study of various plate theories, the theoretical formulas of composite laminated plates and sandwich plates under thermal loading are given, which are verified by pushing down and experiment and have high accuracy, which provides a theoretical basis for the study of composite response under thermal loading in the future. In addition, the effect of stratification on the composite shell in the hot and humid environment is also discussed. The stratification effect under the influence of temperature and humidity in the external environment is given by combining the experimental operation and theory.

Literature [16-18] studied the progressive analysis of adding viscous damping to the laminated plate and the viscoelastic analysis of the laminated plate as a whole. The viscous damping is filled into the laminated plate, and it is concluded that this kind of large structure dissipative material as viscous material has a good application prospect when the laminated plate is subjected to low-frequency load. The first order shear deformation theory is improved to improve the viscoelastic responsiveness of laminated plates. Compared with other literatures, this kind of theory has high accuracy.

Conclusion

Through the research and analysis of composite laminated plates in recent years, the conclusions are as follows:

The dynamic response and bending analysis of piezoelectric fibers are studied by optimization modeling and new geometric methods. In general, the current theoretical development and mechanical analysis of piezoelectric fiber is not very perfect, which will be the main direction of composite material research in the response of composite laminates under impact load, relatively complete studies have been conducted on low speed and low energy, while few studies have been conducted on extreme conditions (fatigue, subsonic). If composite materials are widely used, such studies will also be a hot topic in the research on the response of composite laminates with heat exchange, viscous damping and viscoelasticity, the main research direction at present is theory and experiment, which can be further analyzed by finite element simulation, which is also a research direction research on the dynamic response of composite laminated plates in the direction of vibration and buckling is a kind of direction for future research, and there are few references available, which can be expanded in these aspects.

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References

1. D'Ottavio M, Dozio L, Vescovini R, Polit O (2018) The ritz – sublaminated generalized unified formulation approach for piezoelectric composite plates. *International Journal of Smart & Nano Materials* 2018: 1-22.
2. Nguyen-Quang K, Vo-Duy T, Dang-Trung H, Nguyen-Thoi T (2018) An isogeometric approach for dynamic response of laminated FG-CNT reinforced composite plates integrated with piezoelectric layers. *Computer Methods in Applied Mechanics & Engineering* 332: 25-46.
3. Rouzegar J, Abbasi A (2017) A refined finite element method for bending analysis of laminated plates integrated with piezoelectric fiber-reinforced composite actuators. *Acta Mechanica Sinica* 34(4): 1-17.
4. Thai CH, Wahab MA, Nguyen-Xuan H (2018) A layer wise C^0 -type higher order shear deformation theory for laminated composite and sandwich plates. *Comptes Rendus Mécanique* 346(1): 57-76.
5. Adim B, Daouadi TH, Rabahi A (2016) A simple higher order shear deformation theory for mechanical behavior of laminated composite plates. *International Journal of Advanced Structural Engineering* 8(2): 1-15.
6. Golubović A, Demirdžić I, Muzaferija S (2016) Finite volume analysis of laminated composite plates. *International Journal for Numerical Methods in Engineering* 109(11): 1607-1620.
7. Mohamadipoor R, Zamani E, Pol MH (2018) Analytical and experimental investigation of ballistic impact on thin laminated composite plate. *International Journal of Applied Mechanics*, 10(2): 1850020.
8. Arumugam AB, Rajamohan V (2017) Dynamic characterization and parametric instability analysis of rotating tapered composite plates under periodic in-plane loading. *Iranian Journal of Science & Technology Transactions of Mechanical Engineering* 2017(3): 1-22.
9. Zouggar K, Boukhoulda F B, Haddag B, Nouari M (2016) Numerical and experimental investigations of S-Glass/Polyester composite laminate plate under low energy impact. *Composites Part B Engineering* 89: 169-186.
10. Yao G, Li FM (2016) Stability and vibration properties of a composite laminated plate subjected to subsonic compressible airflow. *Meccanica* 51(10): 2277-2287.
11. Rezaiee M, Shahabian F, Tavakoli FH (2016) Stress analysis of free-edge laminated composite plates by two bending elements. *International Journal of Computational Methods* 13(01): 1650008.
12. Tomar SS, Talha M (2018) Thermo-mechanical buckling analysis of functionally graded skew laminated plates with initial geometric imperfections. *International Journal of Applied Mechanics* 10(2): 1850014.
13. Mantari JL, Ramos IA, Zenkour AM (2016) A unified formulation for laminated composite and sandwich plates subject to thermal load using various plate theories. *International Journal of Applied Mechanics* 8(8): 624-651.
14. Nanda N, Sahu SK, Bandyopadhyay JN (2013) Effect of delamination on nonlinear transient response of composite shells in hygrothermal environment. *International Journal of Structural Integrity* 4(3): 349-367.

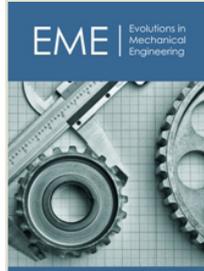
15. Ahmadi I, Aghdam MM (2011) Heat transfer in composite materials using a new truly local meshless method. *International Journal of Numerical Methods for Heat & Fluid Flow* 21(3): 293-309.
16. Zhou XQ, Yu DY, Shao XY, Wang S, Zhang SQ (2016) Asymptotic analysis for composite laminated plate with periodically fillers in viscoelastic damping material core. *Composites Part B Engineering* 96: 45-62.
17. Han JW, Kim JS, Nguyen SN, Cho M (2016) Improved viscoelastic analysis of laminated composite and sandwich plates with an enhanced first-order shear deformation theory. *Journal of Applied Mechanics* 83(3): 4900-4905.
18. Zhao SY, Xue P (2014) Continuum description of damage and failure of composite laminates based on viscous regularization. *Multidiscipline Modeling in Materials & Structures* 10(4): 525-536.



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