DYNAMIC BEHAVIOR OF COMPOSITE LAMINATED PLATE WITH ECO-FRIENDLY MATRIX AND NATURAL FIBERS AND BIO-INSPIRED STACKING

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1. General

The aim of this paper is to investigate of dynamic behavior of bio-inspired and ecofriendly laminated fiber-reinforced composite plate subjected to central dynamic load. In this paper, the dynamic response of laminates with renewable bio-epoxy and recycled plastic matrix has been evaluated in comparison with other resins such as traditional epoxies and polymer products. Moreover the influence of natural fibers and innovation bio-inspired stacking has been investigated. For this purpose finite element analysis software is conducted for evaluation of central deflection and stresses in forced vibration of laminated plate.

2. Problem description

Regarding the Aggour and Sun's work [1], a 140×140 mm square plate with 4.29 mm thickness and clamped boundary conditions is considered. The dynamic patch load applied on the center of plate. The dynamic load is a function of time and spatial coordinates and often can be written as Eq.1:

$$F_z = f(t)\times P(x,y) \qquad (1)$$

Where f(t) implies the time-dependent amplitude and P(x,y) mentions the spatial distribution of the applied pressure. Assuming that, the applied load is uniformly distributed over a small circular area with radios R also the time-dependent part is assumed pulse and sinusoidal.

3. Natural fibers

Natural fibers, as reinforcement, have recently attracted the attention of researchers because of their advantages over other established materials. They are environmentally-friendly, fully biodegradable, abundantly available, non-toxic, non-abrasive, renewable and cheap, and have low density. Moreover Joshi et al. [2] with life cycle assessment technique showed that the natural fibers are maybe to be environmentally superior to glass in most applications. Interest in natural fiber is not only based on ecological aspects, in fact composites containing vegetable fibers indicate appropriate vibration and acoustic damping capacity. This behavior is usually related to the fibrillar nature of vegetable fibers [3].

Different laminates with 50% vol. epoxy Der332 matrix and different natural fibers include cotton, jute, flax, hemp, sisal, kenaf, pineapple, coir, E-glass and carbon conducted for evaluation of maximum stresses and deflections in forced vibration.

4. Ecofriendly matrixes

As a matter of fact, polymer-based epoxies have remarkable performance as matrix in laminates, but they are non-biodegradable and have been produced from non-renewable sources. Di Landro et al. [3], investigated ecofriendly composites with bio-based epoxy matrix and natural fibers which fabricated with a vacuum assisted resin transfer molding process. Their static and dynamic mechanical tests indicated that bio epoxy resin (polylactic acid – PLA, blends of PLA with polyethylene glycol-PEG) significantly increases the plastic field, thus enhancing its toughness compared to RTM6 epoxy.

Another eco-friendly matrix can be fabricated from recycled plastic wastes. Selke et al. [4] used virgin and recycled HDPE (high density polyethylene) derived from milk bottles for manufacturing the wood fiber/polyolefin composites. Their experiments show that the composites made from recycled HDPE have appropriate mechanical performance like tensile and impact strength compared to composites made from virgin HDPE. In this part we investigated dynamic behavior of laminates with %50 E-glass fiber and these two mentioned matrixes compared to other traditional resins include Polyethylene, Nylon, Polyester and different grades of epoxy (Der332, 934, 3501, 5208, 1962, ester 1222, 7241, Epon),

5. Bio-inspired stacking

Cheng et al. [5] presented innovation bio-inspired stacking of laminate regarding to distinctive helicoidal morphology observed in the exoskeletons of crustaceans. This staking sequence consists of gradual rotation of fiber's orientation in the multi-layered laminate composite, for more illustration fiber's angle in 24-piles laminated plate is [0/7.8°/…/180°]. They showed that this staking achieved significant improvement in mechanical performance of laminate over the cross-ply and other conventional stacking.

It has been accepted that delamination destructive mode is related to differences in bending rigidities between the two piles. Mismatch coefficients can be defined as eq. 1:

$$M= [D_{ij}(\theta_b) - D_{ij}(\theta_t)] / [D_{ij}(0°) - D_{ij}(90°)] \qquad (2)$$

Where Dij(θb) and Dij(θt) are the rigidity of the bottom and top layers of laminate respectively. For initial estimation, only D11 could be considered [6]. Maximum delamination occurred when the angle difference of fiber orientation in two adjacent layers is 90°. Thus this bio-inspired stacking is appropriate way for reducing of delamination area in laminate after applying dynamic load. We investigated the dynamic behavior of 24 layers composite laminated with bio-inspired stacking include [0/7.8°/…/180°], $[0/16.4°/…/180°]_S$, $[0/7.8°/…/85.8°]_S$ in comparison with traditional stacking such as [0/90/0/…0/90] and $[0/-45°/45°/90°]_{3S}$.

6. References

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