11693 | Vibration of composite plate with attached mass using parabolic shear deformation theory
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In this study, vibration of composite plate with attached point mass is studied. Parabolic shear deformation plate theory is used in the formulation. Ritz method with algebraic polynomials are used in the solution of the problem. Effects of the different material and geometrical properties on the vibration characteristics of the composite plate with attached mass are investigated in detail.

11695 | A mesh-free method for thermo-mechanical analysis of heterogeneous cylinder in transient heat conduction
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Abstract In this paper a thick hollow cylinder with finite length made of two dimensional functionally graded material (2D-FGM) subjected to transient thermal boundary conditions is considered. The volume fraction distribution of materials, geometry and thermal boundary conditions are assumed to be axisymmetric but not uniform along the axial direction. An efficient meshfree method with graded material properties within each node is used to model the structure and the Crank-Nicolson finite difference method is implemented to solve time dependent equations of the heat transfer problem. Two- dimensional heat conduction in the cylinder is considered and variation of temperature with time as well as temperature distribution through the cylinder is investigated. Effects of variation of material distribution in two radial and axial directions on the temperature distribution and time response are studied. The achieved results show that using two-dimensional FGM leads to a more flexible design so that transient temperature, maximum amplitude and uniformity of temperature distributions can be modified to achieve required specifications by selecting a suitable material distribution profile in two directions. On the other hand combining the numerical meshfree algorithms and the special finite difference method could have very good efficiency in solving such problem.

11724 | Comparison of higher-order shear deformation theories on static analysis of rectangular plates
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Static analysis of laminated compoiste plates has been investigated via different higher-order shear deformation theories. First-order, third-order, hyperbolic, sinusoidal, and zeroth-order shear deformation theories have been used as kinematic relations. After the governing equations for bending of laminated composite plates have been derived, the method of discrete singular convolution is used for solution of the related equations. The deflections, bending moments, and stress values have been obtained via different higher-order shear deformation theories. The performance of the method of DSC is investigated for each theory considered in these analyses. The effects of some geometric parameters on results have also been investigated. The convergence and comparison studies have been performed for different cases. In general, close agreement between the obtained results and those of other researchers has been found. It is noticed that the present DSC methodology can predict accurately the static response of laminated compoiste plates.

11746 | Integral CFRP spoiler with shock bump control
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The desired increase in aerodynamic efficiency of future civil aircrafts can be achieved by using laminar wings. A fully integrated design (system and structure) of a laminar air foil provides highest-performance during cruise conditions and furthermore extents laminar flow to other flight conditions e.g. flying at a higher Mach number. As such new and innovative designs for aircraft control surfaces are required. This publication describes an innovative spoiler concept for laminar wings. Laminar airfoils (with low sweep) suffer from increased wave drag at high Mach numbers due to strong compression shocks. Additionally, laminar wings can exhibit "laminar buffeting" under certain circumstances characterized by strong oscillating compression shocks, which can lead to a separation of the flow over a large part of the air foil, leading to a rapid decrease in lift and rapidly altering the loading on the wing structure. This undesired behavior may be mitigated by using adaptive structures to locally adjust the aerodynamic profile of the airfoil. To that end, the shape of the structure is changed in the very zone of

the compression shock, which is in the present case designed to be located on the spoilers. This design principle is termed shock control bump. However, the realization of such an aerodynamic concept requires new and innovative structural concepts. Hence, a multifunctional adaptive spoiler structure and actuation concept is presented, adding shock control bump and variable camber functionality to today's existing spoiler features. As such, the spoiler itself changes shape to form the shock controlling bump or variable camber form while guaranteeing the contour accuracy of the aerodynamic surface at cruise conditions. The spoiler's structure is realized with a tapered sandwich structure, where the location of the shock control bump exhibits a relative low bending stiffness to enable the change in shape. Furthermore, the spoiler makes use of a flexible hinge bridging the gap between the center wing box and the spoiler. This flexible hinge provides an integral connection between the static wing and the movable spoiler. The necessary high curvatures at full deployment angles are supported by a guided actuation mechanism yielding the minimum geometrically possible stresses, permitting the use of a state-of-the-art CFRP material. By integrating the spoiler in the design of the laminar airfoil even higher efficiency at cruise conditions may be achieved, accompanied by an overall increase of the usable flight envelope of aircraft. To obtain the presented design extensive analytical, linear and nonlinear stress and CFD analysis were performed. The verification of the design is achieved by a series of static and dynamic sub-component tests taking pre-stressed states and environmental conditions during flight and on ground into account. The project is part of the German nationally funded LuFo-V program. The collected results prove the general applicability and technological readiness of today's materials for application in tomorrow's adaptive structures.

11764 | Multi-objective memetic algorithm for optimal design of composite structures including material choice and robustness
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The optimal design of hybrid composite stiffened structures considering sizing, topology and material selection is addressed in a multi-objective optimization framework (Pelletier and Vel, 2006; Awad et al., 2012). A structural robust design approach that simultaneously considers minimum weight/cost, minimum strain energy and minimum sensitivity to uncertainty propagation related to robustness is presented. The trade-off between the performance target, depending on given stress, displacement and buckling constraints imposed on composite structures, against robustness, is searched. The design variables are ply angles and ply thicknesses of shell laminates, the cross section dimensions of stiffeners and the variables related to material distribution. Multi-objective Memetic Algorithm (MOMA) searching Pareto-optimal front is proposed. MOMA applies multiple learning procedures exploring the synergy of different cultural transmission rules. The approach is based on multiple populations, species conservation, migration, self-adaptive, local search, controlled mutation, age control and features-based allele's statistics. These aspects are associated with some kind of problem knowledge and learning classified as Lamarckian or Baldwinian (Krasnogor and Smith, 2006). The memetic learning procedures are used aiming to improve the exploitation and exploration capacities of MOMA. It is implemented the selfish gene theory using a fusion of concepts. The age structure (Conceição António, 2013) is applied together with feature-based allele's statistics analysis used in the learning procedure. This is performed considering an age structured virtual population (VP). The age structured VP plays important role in evolutionary process based on two rules: the first one is to store the ranked solutions aiming to obtain the Pareto front and the second one is to evolve as a virtual population of alleles. Continuous statistical parameters of alleles are obtained and its relationship with dominance is established. The most promising alleles are selected for genes emulating the cultural and genetic evolution. A self-adaptive genetic search incorporating Pareto dominance and elitism is presented in the proposed approach MOMA. Two concepts of dominance are used: the first one denoted by local non-dominance is implemented at the isolation stage of populations and the second one called global non-dominance is considered at age structured VP. The age control emulates the human life cycle and enables to apply the species conservation paradigm. A new mating and offspring selection mechanisms considering age control and dominance are adopted in crossover operator applied to age-structured VP. The concept of species associated with material choice and distribution on composite structures is used. A detailed analysis of solutions/individuals at the Pareto-optimal front reveals that they belong to different species. From this it can be concluded that MOMA is successful in preserving the population diversity. Furthermore, MOMA is able to indicate alternative optimal designs based on different species what might be very important for the designers in multi-objective design optimization of stiffened composite structures.