sults can be explained. Closer observation in the damaged zone revealed that the process of micro fracture depends on the fiber orientation.

PMC-30: Design Procedure of CFRP Rotors for Durability Part 1 - Material Design and Fundamental Rotor Design -

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This paper is concerned with the durability design of a high speed rotor made by carbon fibre reinforced plastics (CFRP). CFRP has very high specific strength compared with other conventional materials, however, displays the time dependent behaviour, which is caused by the viscoelasticity of the matrix resin. With these characteristics considered, designing a durable high-speed rotor will require focus on both material failure and instability of vibration. We developed the design procedure of CFRP rotors for the purpose of durability. Our procedure consists of material design, fundamental rotor design, parts design and total rotor design. In this paper, we explain the material design and fundamental rotor design. To select the carbon fibre and the matrix resin we evaluate the forming ability as well as mechanical properties including fatigue and creep for candidate CFRP. For the fundamental rotor design, the basic specifications, e.g. the parts composition, the normal angular velocity, and the dimension of the rotor are fixed considering the time dependent fatigue and creep behaviour of CFRP as well as the motor characteristics and the bearing system. The procedures of parts design and total rotor design will be described in the following papers.

PMC-31: Effect of Water Absorption on Interaction between Matrix Cracking and Fiber Bridging for Stress Corrosion Cracking of PMC

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Effect of water on fiber bridging of polymer matrix composites (PMCs) has been studied for stress-corrosion cracking (SCC). The fiber bridging during crack propagation in the PMC was observed directly using a transparent polymer matrix. Specimens were immersed and weighed just before conducting crack propagation test. Contribution of mechanical degradation caused by the water to the bridging was measured as a function of weight gain due to water absorption. A critical energy release rate of a matrix decreased with increase of the water absorption. An energy release rate of bridged crack was varied by the water absorption. To investigate the variation of bridging mechanism under water environment, we calculated bridging stress $\sigma$, and $\Delta G$ based on a single fiber bridging mechanism with the interfacial debonding length and the interfacial debonding energy. The debonding length was measured directly and the debonding energy was obtained in fragmentation test. The calculation showed that increase of the interfacial debonding length influenced the fiber bridging mechanism.

PMC-32: Long-Term Durability of Plain-Woven CFRP Laminates under Water Conditions

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This paper is concerned with the influence of water absorption on the time-temperature dependent flexural strength of plain-woven CFRP laminates for advanced marine use. The CFRP laminates consist of plain-woven PAN-based carbon fiber and vinyl ester resin, which were treated under the three conditions of Dry (by drying after molding), Wet (by absorbing water after drying) and Wet-Dry (by re-drying after absorbing water). Three-point bending constant-strain rate (CSR) and fatigue tests for these three types of specimen were carried out under various loading-rates and temperatures. The flexural CSR and fatigue strengths depend remarkably on the water absorption as well as time and temperature. The applicability of time-temperatures superposition principle was experimentally confirmed for these strengths, therefore, the master curves for fatigue strengths can be obtained. It is cleared on the master curves that the fatigue strength decreases remarkably with time to failure, temperature and water absorption, however decreases scarcely with number of cycles to failure. Concretely, the flexural fatigue strength decreases in 40% during 50 years, 27% by 0.6% water absorption and only 5% by $10^{-5}$ load cycles.

PMC-33: Analysis of Matrix Cracking in CFRP Angle-ply Laminates

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Matrix cracking initiation and development in CFRP angle-ply laminates under tensile loading are evaluated experimentally. Soft X-ray radiography is used to detect matrix cracks. Matrix crack density is measured as a function of applied laminate stress. To discuss the experimental results, a stress analysis procedure considering the material nonlinearity is employed.

PMC-34: Numerical and Experimental Study of Compression After Impact Strength of Stitched CFRP Laminates

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Despite its high specific stiffness and strength, an FRP laminate has low interlaminar strength and toughness. Impact loads in the out-of-plane direction easily generate delamination, significantly reducing the compressive strength of the laminate. Hence, compression after impact (CAI) strength is the limit factor for use of the FRP laminates. Stitched laminate composite is one of the most cost-effective and high-efficiency solution for this problem. This research studied compression after impact strength of stitched CFRP laminates by using both analytical and experimental method. Half-SACMA size specimens are used for the CAI tests. Tests are carried out for various impact energy and stitch density. Comparison of results shows that higher stitch density makes CAI strength higher. And higher impact energy makes CAI strength lower, but strength degradation seems to be saturated in the impact energy which is higher than 3.0J/mm for all stitch density. The local buckling of laminate may be responsible for this saturation of the CAI strength degradation. Hence, the finite element analysis is carried out for simulating the local buckling behaviour of the stitched laminate composite with the delamination. The stitch threads are modeled by using the truss elements, and introduced into the laminates modeled by solid elements, and specially developed non-linear spring elements connect these two types of elements. Each statistical strength value is allocated to the truss element. When the tensile stress reaches the strength, the load and stiffness of the element are reduced to zero. Post-buckling analysis of this model shows the local buckling strength of the stitched laminate is higher for the higher stitch density.

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