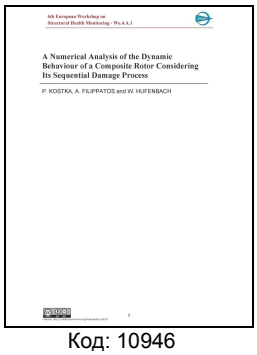

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A Numerical Analysis of the Dynamic Behaviour of a Composite Rotor Considering Its Sequential Damage Process

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Composite materials offer, in comparison to classical materials, high strength and stiffness to weight ratios, adjustable directional material properties and gradual damage behaviour. Due to such outstanding properties, a growing interest to use composite materials in weight-relevant applications of complex loaded structures is noticeable. Especially in the aerospace industry, application of composite materials is observed in the area of high-speed rotors.

One of the factors that affect the operational capability of rotors is unpredictable damage caused by impact events. This factor has a stochastic and discrete influence on the damage evolution of the rotors, which consequently affect their reliability and lifetime. Therefore, research efforts towards the development of reliable procedures for instantaneous identification of damage evolution are required. One of the most important tasks for a reliable structural integrity identification method is the selection of appropriate damage-dependent features, which could be measured in future generations of rotors with material-integrated sensors. In the presented work, a carbon fibre-reinforced epoxy disc rotor with its typical damage behaviour is numerically investigated.

In the case of composite materials, the consideration of failure as a sequence of distinct, physically based damage events depending on the damage behaviour of the composite material could provide additional knowledge in comparison to the common consideration of isolated damage events. To achieve this additional knowledge, a relation between damage evolution sequence and the damage-dependent dynamic response could be identified in order to diagnose with a higher accuracy the current damage condition compared to analyses of isolated damage conditions.

In order to acquire the damage-dependent vibration-based features, a numerical model based on the finite element method, coupled with a damage model implementing novel failure criteria based on the Failure-Mode-Concept, is created. Then, a numerical experiment corresponding to a practice relevant damage scenario was performed for a basis disc rotor made of carbon fibre-reinforced epoxy. The rotor with simulated impact-caused initial damage at different position for every test case was accelerated to the operational speed while the increasing body forces caused the initial damage to develop. The occurring damage evolution sequence was calculated using the implemented damage model. The damage-dependent dynamic response of the rotor consisting of its natural frequencies is analysed using the finite element method for each characteristic stage of the damage evolution process. A databank of multiple sequences of damage sensitive parameters is created that can be used for the similarity estimation between dynamic response sequences using distance factors in order to identify the damage condition of the rotor.

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Ключевые слова:

Содержание