Experimental Study on Relaxation Behavior of Composite laminates Impact Damages

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Abstract:

Composites are widely used in the aerospace field due to their advanced properties but may cause various impact damages in service. In maintenance, visual inspection is the first step for damage detection and 80% to 90% of impact damages can be detected by visual inspection[1]. The widespread use of visual inspection procedures for finding service damages in composite structures had led to the use of barely visible impact damage (BVID) thresholds in design sizing[2].

Aerospatiale[3] has shown that a dent depth between 0.3 and 0.5 mm is detectable, through a detailed visual inspection, with a probability better than 90%. Airbus[4] defines BVID as the minimum detectable damage surely detectable by scheduled inspection, corresponding to a probability of detection of 90% with an interval of confidence of 95%. The literature[2-5] shows that the impact dent could decay with time under the combination of fatigue and aging due to viscoelastic phenomena. In some cases, the initial impact indentation dent depth may be as much as 3 times that of the decayed dent depth. Based on this phenomenon, the paper studies the relaxation behavior of composite laminates impact dents and proposes a relaxation formula to predict dent depth.

The author holds the point that the mechanism of the composite dents relaxation is mainly divided into two aspects, one is the viscoelasticity of composite matrix, the other is the restoring force of composite fiber bending. The mechanical property of the matrix changes significantly with temperature and humidity, so in the high temperature and high humidity environment, the dent rebounded is subject to matrix viscoelasticity. When composite laminates are subjected to transverse impact in low energy levels, some of the fibers do not reach the flexural strength level then show elastic bending. This elastic deformation will gradually recover under the suppression of the matrix. Therefore, bending of the fiber plays a role under different impact

energy levels and fatigue loading cycles.

In this paper, The author conducted low velocity impact tests with different laminates (thickness 4 - 12mm) and different impact energies (10 - 200J), and then carried out the relaxation tests at normal temperature, high temperature and high humidity, and in the case of fatigue loading cycles respectively. The experimental results (Fig.1) show that the relaxation rate of composite laminates dent depth is 10%-20% under the condition of normal temperature, while the relaxation rate can reach more than 50% under the condition of high temperature and high humidity (70 ℃, 85% RH). Therefore, it is necessary to consider the service history of the composite structure in the visual inspection process, and the influence of the relaxation also needs to be taken into account in determining the BVID threshold value.

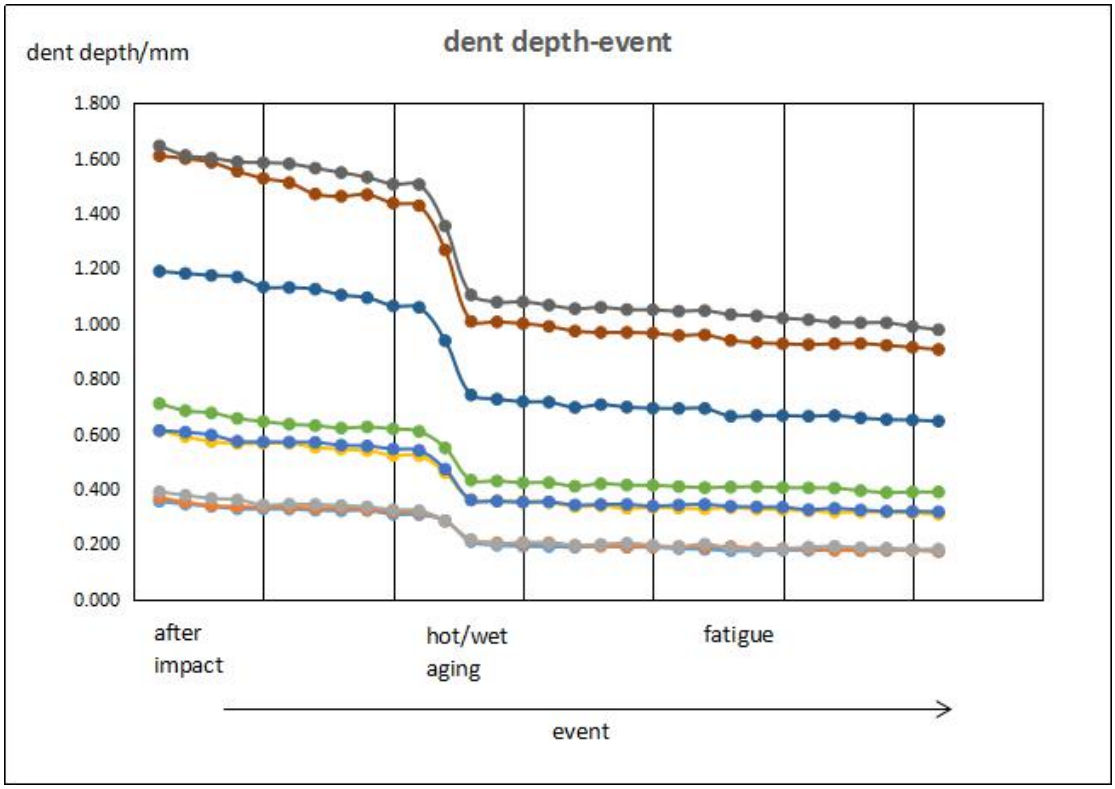

Fig.1 dent depth evolution

Keywords: BVID, Visual Inspection, Low Velocity Impact, Relaxation, Viscoelasticity

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