predictions reveal that the sequence and interaction of events has a strong influence both on the rate of damage accumulation and fatigue life. The approach is extended to a large database available in literature concerning the residual strength of glass fiber reinforced composite subjected to ordered ascending (L-H) and descending (H-L) and random block spectra using a reference spectrum with of 735,641 cycle and 22 stress levels. It is shown that from the knowledge of the model parameters obtained under constant amplitude (CA) loading the predictions of our approach agree very well with experimental results reported under variable amplitude loading, a case never encountered in literature. The robustness of our approach is definitely witnessed treating the approach against the statistical nature of the experimental data.

---

abst. 15740
Room 2
Wednesday
July 3
11h50

On the Dynamic Response of a Composite Fuselage Sub-Floor Support System

Saputo, Salvatore (salvatore.saputo@unicampania.it), Department of Engineering, University of Campania "Luigi Vanvitelli", Italy
Sellitto, Andrea (andrea.sellitto@unicampania.it), Department of Engineering, University of Campania "Luigi Vanvitelli", Italy
Di Caprio, Francesco (f.dicaprio@cira.it), CIRA-Italian Aerospace Research Centre, via Maiorise snc, 81043, Capua, CE, Italy
Riccio, Aniello (aniello.riccio@unicampania.it), Department of Engineering, University of Campania "Luigi Vanvitelli", Italy

In this work, the dynamic response, including damage onset and evolution, of the composite floor subsection of the cargo area of a civil aircraft is investigated by numerical simulations and experimental tests. The analysed structure has been subjected to impacts characterized by different energies, after a preliminary quasi-static mechanical test. Experimental data has been compared to numerical results in order to better understand and characterize the intra-laminar and inter-laminar damage onset and evolution. Preliminary quasi-static and dynamic numerical analyses have been carried out on a single subsection component to set up the numerical model in the ABAQUS FEM environment; then, in a subsequent phase, the entire structure has been numerically analysed focusing on the inter-laminar and intra-laminar damages onset and propagation. The correlation between numerical results and experimental data, with the aid of ultrasonic non-destructive inspections output images, has been carried out.

---

abst. 15750
Room 2
Tuesday
July 2
16h30

Modelling of Quasi-static and Dynamic Damage Process in Ceramic Matrix Composites

Sadowski, Tomasz (t.sadowski@pollub.pl), Lublin University of Technology, Poland
Postek, Eligiusz (ewpostek@googlemail.com), Institute of Fundamentl Technological Research, Poland
Pietras, Daniel (pietras140t@gmail.com), Lublin University of Technology, Poland
Boniecki, Marek (Marek.Boniecki@itme.edu.pl), Institute of Electronic Materials Technology, Poland
Szutkowska, Magdalena (magdalena.szutkowska@ios.krakow.pl), Institute of Advanced Manufacturing Technology, Poland

Quasi-static degradation of brittle composites exhibits different mechanical response under uniaxial tension and uniaxial compression. In this paper we analysed cracking processes and failure under quasi-static loading of 2 phase ceramic material made of alumina and zirconia mixture, subjected to tension and compression. Constitutive modelling of two phase ceramic composites obeys description of: (1) elastic deformations of initially porous material, (2) limited plasticity and (3) cracks initiation and propagation. Modelling of polycrystalline ceramics at mesoscopic level under mechanical loading is related to analysis of a set of grains, which create so called Representative Volume Element (RVE). The basic elements of the defect structure inside polycrystal are: micro- and meso-cracks, kinked and wing cracks. To get macroscopic response of the material one can calculate averaged values of stress and

strain over the RSE with application of analytical approach. Dynamic degradation process was illustrated for 2 phase ceramic matix composite and cermet, which was subjected to short compressive impulse. The pulse duration was 10-7s and the applied pressure level - 480 MPa. In the proposed more advanced finite elements formulation of the cermet behaviour is was necessary to take into account the following data and phenomena revealing inside of the RVE: (1) spatial distribution of the cermet constituents, (2) system of grain boundaries/binder interfaces modelled by interface elemnets, (3) rotation of brittle grains. The cermet response due to pulse loading is significantly different in comparison to the quasi-static behaviour, i.e. the stress distributions and microcracking processes are quite different.

The mechanical behavior of ThinPly Fibre Metal Laminates

abst. 15753
Room 2
Wednesday
July 3
09h00

Bienias, Jaroslaw (j.bienias@pollub.pl), Department of Materials Engineering, Lublin University of Technology, Poland
Jakubczak, Patryk (p.jakubczak@pollub.pl), Department of Materials Engineering, Lublin University of Technology, Poland

Fibre Metal Laminates nowadays are under intensive development, especially in aircraft industry. This is because of two decades of using this materials have shown that unique properties of FML like excellent fatigue properties and high damage tolerance including impact damage means, among other, higher safety and reliability of aircrafts. The current aim of manufacturing cost reduction and further increase of the properties of FMLs means that new materials or technologies should be used. One of the solution is the implementation of the thinner plies of metal as well as prepreg in the FMLs. The ThinPly technology is one of the future trend in composite design and manufacturing especially in aircraft industry in the field of classic fibre reinforced polymer composites. The intensive developing of such structures is because of the much more large design space that they offer, the same like really positive effects of low thickness of layer to affect their performance in various loading conditions. At the same time, the thinking about second generation of Fibre Metal Laminates which could have additional advantages in comparison to first generation of FML like GLARE or CARALL is based on ThinPly technology among other. The implementation the ThinPly in FML means that such materials have higher mechanical properties e.g. static and fatigue strength, impact resistance and other like corrosion resistance and higher damage tolerance in general. The purpose of the study was the investigation the mechanical behavior and properties of ThinPly Fibre Metal Laminates (TpFML) based on aluminum and carbon and glass fibres. The thickness of single composite layer in manufactured TpFML was 0.04 mm. The 3/2 laminates were designed. The TpFML was compared to FML based on the same materials but with the thickness of single composite layer of 0.2 mm (as in classic GLARE or CARALL). The final thickness of TpFML and FML was equal. The ASTM standard were used to samples preparation and tests conduction. As a first one a technology and microstructures of TpFML and FML were presented. Then the properties of static tensile, compression, in-plane shear stress/shear strain and interlaminar shear strength were determined. Finally, the damage analysis were presented. It was noted that TpFML are materials with shows higher strength in comparison to classic FML. This in because of microstructure, scaling effect, cracks propagation mechanisms, probability of critical defects in structure, among others. The project/research was financed in the framework of the project Lublin University of Technology - Regional Excellence Initiative, funded by the Polish Ministry of Science and Higher Education (contract no. 030/RID/2018/19). Key words: FML, Thin Ply, composites, mechanical properties

---

The analysis of crack and delamination propagation in Fiber Metal Laminates subjected to fatigue

abst. 15760
Room 2
Wednesday
July 3
09h20

Dadej, Konrad (k.dadej@pollub.pl), Lublin University of Technology, Poland
Bieniaś, Jarosław (j.bienias@pollub.pl), Lublin University of Technology, Poland
Surowska, Barbara (b.surowska@pollub.pl), Lublin University of Technology, Poland