Modelling Damage in Composite Aircraft Panels under Tyre Rubber Impact
AF Johnson, N Toso-Pentecôte, D Schwinn (German Aerospace Center (DLR))
The paper uses meso-scale composites ply damage models with an energy based delamination failure criteria in an explicit FE code to study damage progression in composite panels under impact. After code validation on idealised panels a study is made of damage in stringer stiffened aircraft panels impacted by tyre fragments. (F6:1)

Multi-Scale Damage Modeling in Abaqus
H de Boer, JJM Koppert, A Beukers, HEN Bersee (TU Delft)
A multi-scale damage model for composite materials has been developed. It is based on properties of constituents and applies homogenization methods. The multi-scale damage model, together with a graphical user interface, is implemented in the commercial software package ABAQUS. The accuracy and efficiency of the present model will be evaluated by means of an industrial example. (F6:2)

Rate Dependent Multiscale Modelling of a Fibre-Reinforced Composite
JP Foreman, D Porter, S Behzadi, PT Curtis, FR Jones (Univ of Sheffield)
A new multi-scale modelling technique is used to predict the rate dependent properties of a fibre-reinforced composite. Matrix thermomechanical and stress-strain properties are predicted using Group Interaction Modelling and fibre failure properties are calculated using Finite Element Modelling. Finally, composite strength as a function strain rate is predicted using a statistical model. (F6:3)

Multi-Scale Modeling of Thermo-Oxidative Degradation in High Temperature Polymer Matrix Composites for Advanced Aircraft
S Roy, S Singh (Univ of Alabama)
Oxidation in a PMC is modeled using a modified Fick's law of diffusion that includes terms related to the rate of the chemical reaction between the polymer and oxygen. Details of the multi-scale simulation are presented, together with experimental data for model verification, in order to study the anisotropic nature of thermo-oxidative degradation. (F6:4)

Analysis of Failure in Textile Composites via Meso-Damage Mechanics
DV Ivanov, SV Lomov, I Verpoest, K Vallons, T Troung Chi (KU Leuven)
Damage and failure of textile composites is modelled from perspective of internal architectures. Satin woven, traxial braided, and sheared non-crimp fabric carbon-epoxy composites are analysed. A new damage mechanics approach is proposed. It combines degradation scheme of Murakami-Ohno, thermodynamic material law, and considers yarn segments as basic damaging entity. (F6:5)

High Velocity Impact on CFRP
R Vignjevic, N Djordjevic, JC Campbell (Cranfield Univ)
Thermodynamically consistent damage model for fibre reinforced composites was proposed and coupled with the rest of constitutive model. Constitutive model was capable of describing shock propagation in orthotropic materials. Proposed damage model and constitutive model were implemented into Lawrence Livermore National Laboratory DYNA3D nonlinear hydrocode. The observed results were validated against three dimensional impact experimental data. (F6:6)
A Consistent Framework for Formulation and Characterization of a Sub-Laminate Based Damage Model
R Vaziri, A Forghani, N Zobeiry, A Poursartip, F Ellyin (University of British Columbia)
This study proposes a sound methodology to simulate intra-laminar damage in laminated composites. The model accounts for the initiation and growth of damage at structural (macro) level. An image processing technique has been employed to provide a full field measurement of the displacements in notched specimens and to calibrate the damage model. (F6:7)

Influence of Z-Pinning on in-Plane Shear Properties; Damage and Local Strain Variation
R Maurin, C Baley (LIMATB) P Davis (IFREMER) DDR Cartie (Cranfield Univ)
Z pins improve resistance to delamination. They are known to affect in-plane properties but little work has been performed on shear. They are shown to reduce the shear modulus and strength. The shear strain is heterogeneously distributed, and the pins change it. The major damage development is slowed by the pins, but creates a new damage mechanism. (F6:8)

A-FEM for Multiscale Modeling of Failure of Heterogeneous Materials
Q Yang, X-J Fang (Univ of Miami) B Cox (Teledyne Scientific)
A-FEM for Multiscale Modeling of Failure of Heterogeneous Materials. (F6:9)

Failure of Laminated Structures with Stress Concentrations: Use of the Fracture Characteristic Volume
S Miot, C Hochard, N Lahellec (CNRS - LMA)
To predict the failure of structures which present stress gradients, a non local ply scale criterion is proposed. This non local approach, based on mean quantities over a Fracture Characteristic Volume, was implemented into the Abaqus Software and associated to a behaviour model. Results show the efficiency of the method, even for structures with very high stress gradients. (F6:10)

A Three Dimensional Damage Model for UD Composites
J Wiegand, N Petrinic (Univ of Oxford)
A three dimensional constitutive model for unidirectional continuous fibre reinforced polymers is proposed. The three-dimensional constitutive model relies on physically based failure criteria for the prediction of the onset of damage evolution on fracture planes. Damage growth is modelled by degrading tractions on the respective fracture planes. (F6:11)

Structural Designing for Sheet Molding Compound
E Tanigaki, A Fujita, N Yamada (Mitsubishi Electric Corp) M Okano, A Nakai, H Hamada (KIT)
In this study, static tensile test and tensile fatigue test were performed by using SMC (Sheet Molding Compound) and the index of structural designing was investigated. As a result, when fatigue load was at the knee point, residual strength was almost same to static strength. The knee point was valid for structural designing in long life. (F6:12)

Numerical Simulation of Damage Propagation in Overheight Compact Tension Tests
X Li, SR Hallett, MR Wisnom (Univ of Bristol)
At the component level composites failure involves complex interaction of damage modes. Here a finite element approach which explicitly models the sub-critical damage was used to predict the failure of specimens designed to simulate damage in large scale components. Load vs. disp., delamination, splitting and fibre failure are all well predicted. (F6:13)
A Mesoscale Model for the Prediction of Composites Materials Until Final Failure
F Bordeu, PA Boucard (LMT-Cachan)
The degradation and failure prediction of composites materials is a real industrial challenge. Recent advances enable to fully understand the failure mechanisms of these materials. An enhanced version of the damage mesomodel for laminates is presented. This model coupled with a high performance resolution strategy enables us to simulate, until final failure, the degradation of industrial pieces. (F6:14)

Advanced Micromechanical Analysis of Highly Loaded Composite Structures
AE Scott, N Kalantzis, I Sinclair, SM Spearing (Univ of Southampton) M Clinch, W Hepples (Luxfer Gas)
Hybrid composite/metallic components are of increasing relevance for highly loaded structures. In the present work optimisation of such structures has been addressed via a three dimensional local finite element analysis on a micromechanical scale. The study is informed experimentally via high-resolution computed tomography imaging of damage evolution under load. (F6:15)

Multi-Mode Damage Model for Structures of Laminated Composite
F Almaskari, S Li (Univ of Manchester)
This paper presents a multi-mode damage model for composite structures. The new model provides mean to predict the developments and the effects of both intra- and inter-laminar damage modes in structure made of laminated composites. The model is incorporated into finite element for structural response. (F6:16)

Variational Approach Based Cracked Laminate Analyses Revisited
S Li, F Hafeez (Univ of Manchester)
The analyses of cracked laminates based on a variational principle are appraised. The limitations of existing analyses of more general laminate configurations have been identified and overcome. A well posed boundary value problem has been formulated. The capability of analysing cracked laminates has been enhanced. (F6:17)