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| **Slide n.°** | **Title** | **Description** |
| 1 | Title frame | * I’m going to present I’ve been doing in my PhD Project * Under joint supervision of Prof. Ayadi (EEIGM, Nancy) and Prof. Varna (LTU, Luleå) * The project is under the framework of DocMASE Doctoral Program, which I thank for the opportunity granted me; and as well thank the supervisor of the program Dr. Flavio Soldera, whose work has made this possible |
| 2 | Table of contents | * I will first briefly explain what is a thin ply and the technology behind it * I will introduce the mechanisms of damage in composite and, among them, transverse cracking * I will state the objectives I pursue and the approach designed to reach them * I will then explain the main issues and assumptions in the micromechanical modeling * I will show some reliminary results/validation results * And conclude with a summary of what’s done and what’s ahead |
| 4 | Spread Tow Technology: Introduction | * Thin plies are the product of the technological innovation called spread tow technology * Firstly developed in Japan between 1995-1998, now reaching maturity and used in structural part in applications as Solar Impulse or Solar car * Only a few producer worldwide (name at least Oxeon and NTPT, as the European ones) |
| 5 | Spread Tow Technology: Foundations | * Spread tow technology: tow is an ensemble of fibers, bounded together * The tow is opened and fiber untangled from each other by ultrasonic air jets (spreading) * Fibers aligned to form ply * Plies are thinner, VFf is higher, void concentration is lower, fiber distribution more regular |
| 6 | Visual definition of transverse cracking | * As in every material, fracture can be classified according to the mode of loading: I or opening, II or shearing, III or tearing * In composite laminates, damage can also be classified according to the physical mechanism (mode) governing it: fiber fracture, matrix crack, fiber/matrix debonding, fiber buckling, delamination * Among them, we study transverse cracking, i.e. fiber/matrix debonding + matrix cracking |
| 7 | The Thin Ply Effect | * The first experimental observations of the so-called thin ply effect can be traced back to the late 70s-early 80s * When it was observed that the ultimate transverse strength depends on ply thickness and ply orientation; describe graphic with data taken from Flaggs and Kural 1982 * The thin ply advantage is based on this property * However, most of the work is experimental, but at the ply or laminate level * Analytical solutions are not accessible (only for VFf to infinity) * Numerical work has dealt mainly with propagation (cohesive zone model) * Initiation has been neglected |
| 9 | Objectives & Approach | * Investigate initiation of damage at the fiber/matrix interface, thus at micromechanical level * Thus study the energy release rate and infere a relationship of thw type (describe equation) * As a minor aim, derive guidelines for numerical micromechanical models: choice of solver, bc, …, performance wrt solver choice, bc, effect of parallelization * Thus, approach selected is micromechanics with design of different representative volume elements, analysed with FEM |
| 11 | From macro to micro | * 3 levels of modeling in composite laminates: laminate (macro), ply (meso) and fiber/matrix (micro) * Need a connection between them * We model the laminate as a plate * We cut a section parallel to x-z plane * We focus on the thin ply * We zoom on a single fiber with its surroundings (matrix + neighboring fibers) |
| 12 | Representative Volume Elements (RVEs) | * Fiber and its surroundings modeled as a periodic system * Assumptions   + 2D space   + Linear elastic materials   + Displacement control (applied displacement)   + Different sets of Dirichlet type BC   + We apply linear elastic fracture mechanics   + Contact interaction (normal and sliding) at fiber/matrix interface |
| 13 | Mesh Design and Generation | * Solution is dependent for non linear FEM problems * Damage is a non linear, in particular a geometrical non-linear process, as it creates new surfaces, splits volumes and creates different topology * Mesh, as the discretization of the geometry, strongly affects solution of fracture simulation: mesh generation is important * Brief overview of 4-step mesh generation |
| 14 | Angular Discretization | * The main parameter relevant to describe msh effects on crack simulation is the angular aperture of an element at the interface (describe graph) |
| 15 | VCCT | * To calculate energy release rate first method is VCCT * Discrete method which uses native variables of FEM (displacements and nodal forces) * Approximation: we use forces at the crack front but displacement one element behind it * More stable, not fully analytical * We calculate mode I and mode II and sum to get the total energy release rate |
| 16 | J-integral | * To calculate energy release rate second method is J-integral * Path-integral * Analytical formulation * Contour independent theoretically, not numerically * Less stable * We calculate only the total energy release rate |
| 17 | Results’ title page | * I am going to present some preliminary results, I’m still in the validation phase |
| 18 | Numerical crack shape | * For an initial debond at 15°, we should expect normal opening and negligible sliding: show it in graph |
| 19 | Numerical crack shape | * For an initial debond at 100°, we should expect a large contact zone where there is no normal opening and only sliding: show it in picture |
| 20 | Energy release rates | * As the model studied up-to-now is symmetric (could be broken later) we should expect symmetry in energy release rate at symmetrically placed crack tips: show it in picture |
| 21 | Numerical performances | * Interesting to observe software performaces as function of the mechanical model * Wallclock time (the time the user actually waits) and cpu time (the time spent by cpu, might be greater than wallclock time if job is parallel) vs debond * Benefits of parallelization are not excessive, around 20% gain: contact formulation + LEFM weigh in * Time required decreases with debond size: less nodes bonded, less variable to compute for contact * The solution of the interface is most computationally expensive |
| 23 | Conclusions & Outlook | * Created models, their automatic generation in terms of mesh and FEM * Started simulations, aiming at validation * Next: study dependence on parameters and, as by-product, observe the dependence of computational parameters vs mechanical parameters * Repeat for different variations of the model |