**Key Goals**

Develop a detailed FE modeling framework to predict the high strain rate tensile failure of unidirectional composites while accounting for micromechanical damage mechanisms.

**Materials by design**: Use this framework to tailor interface and matrix to enhance tensile properties and energy absorption in the composite.

Develop a systematic method to translate the results from these models into inputs for homogenized models at higher length scales (e.g., MAT162 in LS-DYNA).

**How We Fit**

**Technical Approach**

- S-2 Glass fibers exhibit a statistical distribution of strength based on size and spatial distribution of critical defects.
- Due to their brittle nature, breaking of glass fibers is a locally dynamic process.
- Dynamic brittle fiber fracture using cohesive elements.
- Interface modeled as 'zero-thickness' cohesive surface.

**Micromechanical FE model**

Progression of events: Dynamic fiber fracture.

- Dynamic solution developed and validated a fiber failure model to capture the dynamic effects of a single fiber break while relaxing the inherent assumptions in theoretical shear lag models.
- Dynamic stress concentrations are shown to be significantly higher and are shown to envelop a much larger volume of the microstructure than the corresponding predictions based on quasi-static models.
- Dynamic interfacial failure is predicted where debonding initiates, propagates and arrests at longer distances than predicted by models that assume quasi-static fiber breakage.
- At larger break strengths, unstable debonding is predicted by the dynamic model.
- Agrees with experimental observation of axial splitting of fibers under tensile loading.

**Major Results**

- Unique axial fiber failure model capable of predicting interface and matrix to enhance tensile strength without changing the homogenized models.
- Improves strain rate dependence of fiber strength.
- Develops unique static and dynamic interfacial models.
- Dynamic interfacial failure is predicted where debonding initiates, propagates and arrests at longer distances than predicted by models that assume quasi-static fiber breakage.
- At larger break strengths, unstable debonding is predicted by the dynamic model.
- Agrees with experimental observation of axial splitting of fibers under tensile loading.

**Key Accomplishments**

- Dynamic model with fracture planes representing characteristic defect distributions in fiber.
- Perform Single and Multi-fiber fragmentation experiments with in-situ observation under polarized light microscope to validate model predictions.
- Extension to 3D packing of fibers.
- Effects of random fiber arrangement.

**Impact**

- Generation of a defect-distribution based model capable of predicting progression of fiber breaks under a range of applied strain rates.
- Framework for tailoring interface and matrix to enhance tensile properties and energy absorption in the composite.
- Study the interaction of micromechanical damage mechanisms inside a realistic composite system.
- Generate inputs for homogenized models at higher length scales.

**Future Directions in 2017**

- Develop and validate a fiber-level FE modeling framework to capture the dynamic effects of a single fiber break while relaxing the inherent assumptions in theoretical shear lag models.
- Dynamic stress concentrations are shown to be significantly higher and are shown to envelop a much larger volume of the microstructure than the corresponding predictions based on quasi-static models.
- Dynamic interfacial failure is predicted where debonding initiates, propagates and arrests at longer distances than predicted by models that assume quasi-static fiber breakage.
- At larger break strengths, unstable debonding is predicted by the dynamic model.
- Agrees with experimental observation of axial splitting of fibers under tensile loading.

**Materials**

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