Title

METHODOLOGY TO SIMULATE AND VALIDATE THE FAILURE BEHAVIOR OF SHORT FIBER REINFORCED POLYMER COMPONENTS USING THE FIRST PSEUDO GRAIN FAILURE MODEL

Abstract text

Short fiber reinforced polymers (SFRP) are widely used in automotive applications due to their superior mechanical properties and possibility of processing via injection molding which allows for application in mass production. To use these materials in crash relevant applications, the deformation and damage behavior has to be adequately predicted. The failure of the material can be predicted by use of various failure models (Tsai Hill, Tsai Wu, Puck, etc.). These models were originally designed for unidirectional fiber orientations. Using the first pseudo grain failure (FPGF) model these failure criteria can be applied to complex fiber orientation distributions as they appear in injection molded components.

In this paper a methodology to simulate SFRP components using a coupled mean field homogenization based microstructure and finite element based structure simulation is presented and validated. Polypropylene with a fiber content of 32 w% short glass fibers was investigated.

For the material model calibration, injection molded specimens with nominal fiber orientations of 0?, 45? and 90? were produced using a special glass fiber multi-tool which allows for a controlled fiber orientation with a narrow distribution. Tension, compression and shear tests were conducted on those specimens. In order to simulate the deformation behavior, a mean field homogenization model was generated in the Digimat Software environment and calibrated using the experiments. The FPGF model in conjunction with Tsai Hill failure criterion was added and calibrated to the tension, compression and shear tests.

In order to validate the modeling approach, a component featuring a rib-pattern was tested under different flexural loading conditions and different loading rates. The injection molding process was simulated and the local fiber orientations were extracted. These orientations were mapped to a finite element structural mesh. Consequently, finite element simulations considering the local fiber orientations using the previously determined material and failure models were performed. Implicit as well as explicit time integration methods were applied and evaluated. The force-displacement curves were determined and compared to the experiments. The sensitivities of different influences, e.g. the simulated fiber orientations, parameters of the Tsai-Hill model, etc. were analyzed. Finally, the simulated failure patterns were compared to the experiments.

Keywords

SHORT FIBERS, HOMOGENIZATION, FAILURE, POLYPROPYLENE, TSAI-HILL, COMPONENT TESTING, GLASS FIBERS, DAMAGE

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