Effect of Micro and Macro defects on FDM printed Nylon 12CF Bracket Part Performance

Reza Hajiha[1], Kurt Reichelderfer[2], Harsh Baid[1], Nima Moazami[1], Frank Abdi[1]
1AlphaSTAR Corporation, Long Beach, California 90804
2 Toyota Motor North America, Production Engineering Division, Georgetown, Kentucky 40324

ABSTRACT

Defects in Fused deposition modeling of chopped composites can be categorized in terms of the size and cause. Defects such as gas bubbles and chopped fiber pull-out are smaller in scale and are so-called “Micro defects”. While the printing errors and bald-spots caused by raster orientation, printing pattern and strategy visible with naked eyes are known as “Macro defects”. The capability to print Polymer Matrix Composites using Fused Deposition Modeling (FDM) method has persuaded the manufactures to fabricate polymer filaments including chopped fibers to elevate the part performance. Nevertheless, consideration the effect defects is a burden to effectively predict the part qualification for design purposes. The objective of this manifestation is to introduce 1) multi-physics multi-phase model aims to compensate for the systematic physical property variabilities such as formation of micro voids, shrinkage, liquid formation and movement due to melting and solidification/sintering, 2) implementing the effect of predicted micro defects into the material properties using Integrated Computational Materials Engineering (ICME) based multi-scale material/structural Nano-assisted micro mechanics modeling 3) Visualization and computation of the printing errors and bald spots to mimic the effect of Macro defects on the Finite element model of FDM printed Nylon 12CF Bracket.
Progressive Failure Analysis (PFA) was performed to predict and validate the elevated temperature mechanical properties of Nylon12CF. Multi-scale PFA then, integrated with an FE solver to simulate the FDM printing process and generate models in various loading conditions, including process derived defects and residual stresses, to show damage footprint and validate structural behavior.

Keywords: 1) Effect of defects 2) Part performance 3) FDM 4) Nylon12 CF 5) ICME 6) Nano-micromechanics 7) MS-PFA 8) In-service loading