Paper ID: 60209
student

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advancements in Materials Applications and Rapid Prototyping (5)

Author: Mr. Miguel Ramirez
Purdue University, United States, ramir145@purdue.edu

Dr. Eduardo Barocio
Purdue University, United States, ebarocio@purdue.edu
Dr. R. Byron Pipes
Purdue University, United States, bpipes@purdue.edu

PROGRESSIVE DAMAGE ANALYSIS OF EXTRUSION DEPOSITION ADDITIVE MANUFACTURED MOLDS FOR AEROSPACE APPLICATIONS

Abstract

Manufacturing complex primary or secondary aerospace structures continues to be a challenge. Extrusion deposition additive manufacturing (EDAM) is a technology that can facilitate manufacturing of complex structures. Moreover, EDAM is a process by which a sliced geometry can be made by deposition of molten material in a layer-by-layer manner. Highly-filled short fiber reinforced polymers in pelletized form can be processed by this technology; in addition, application of this technology has been successfully tailored to prototyped molds for manufacturing similar materials. Moreover, EDAM is capable of printing molds which can vary in size ranging from centimeters to several meters. Implementation of this technology within the design phase has significant economical advantages; however, an understanding of the physics involved during the EDAM process is necessary. Specifically, pelletized composite materials are viscoelastic and anisotropic, these materials are sensitive to the processing conditions such as temperature and printing history. Obtaining answers on how much residual stresses and mold deformation influences its mechanical performance is not straightforward. With this purpose in mind, a set of simulation tools has been implemented in ABAQUS/Standard (Implicit) via a user subroutine suite at Purdue University for modeling the EDAM process. This work extends these simulation capabilities to include a viscoelastic damage formulation under the frameworks of continuum damage mechanics and thermodynamics. The viscoelastic damage model is presented in incremental form and implemented in ABAQUS/Standard (Implicit) as a user material (UMAT) subroutine. To demonstrate the damage model capabilities, a 50wt.% carbon fiber reinforced Polyphenylene Sulfide (PPS) is chosen since the thermoviscoelastic material properties and Prony series coefficients are available. Damage initiation and progression along the print path and transverse to the print path is considered; however, the delamination mode is can be considered is desired. The onset of damage initiation is characterized from room temperature tensile data and assumed to not change at elevated temperature. The mechanical response of virtual tensile and three-point bending specimens for various temperatures are shown. Furthermore, the EDAM process for a pin-bracket mold is simulated for different processing conditions in addition to service conditions. The accumulation of residual stresses and load transfer for the prediction of damage initiation and evolution is studied.