Practical Developments in Multiscale Modeling of Composites

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ABSTRACT

Validated models (be they data driven or physics based) can accelerate the design, certification, and ultimate deployment of novel materials and structures by allowing rapid iteration and virtual experimentation while at the same time minimizing the need for expensive and time consuming physical experiments. Multiscale modeling is often necessary to fully capture the effects of relevant physical mechanisms spanning broad time and spatial scales that will affect performance. However, multiscale models must often balance fidelity (accurately accounting for different length and time scales) with tractability. Hierarchical multiscale models rely on precomputed homogenized properties thereby often sacrificing fidelity for computational speed while concurrent multiscale models, that explicitly incorporate microscale features at every integration point, enhance fidelity but at great computational expense. Recently, machine learning surrogate models have shown great success in accurately mimicking physics-based models with orders of magnitude reduction in relative computational speed. This lecture is intended to provide an overview of NASA Glenn's multiscale modeling toolset (based primarily on the family of method of cells micromechanics theories) and discuss practical developments toward accurately predicting the thermomechanical behavior of composite materials and structures.

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B I O

Dr. Steven M. Arnold is currently the Technical Lead for Multiscale Modeling within the Materials and Structures Division at NASA Glenn Research Center with over 30 years of experience. He also is the Technical Lead for the Materials and Structures Discipline within the Transformative Tools and Technology (TTT) project. Dr. Arnold conducts research involving theoretical and experimental investigations of structural material behavior of advanced aircraft propulsion systems and spacecraft structures. He received NASA's Exceptional Service Medal in 2019, NASA's Exceptional Technology Achievement Metal in 2014 and NASA Glenn Abe Silverstein outstanding research award in 2004. He also was awarded the ASC/DEStech Award in Composites for 2015. He is a co-author of the book, "Micromechanics of Composite Materials: A Generalized Multiscale Analysis Approach" as well as the upcoming book "Practical Micromechanics of Composite Materials". He is on the NAFEMS Americas Steering Committee; an ASM International Fellow (class of 2013); active in AIAA's Materials Technical Committee, ICME working group, and Digital Engineering Integration Committee (DEIC); and co-founder and chairman of the Material Data Management Consortium (MDMC).