Department of the Navy SBIR/STTR Transition Program

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NAVAIR 2017-740

Topic # N15A-T003

Novel Multi-scale/Multi-physics Integrated Tool for the Prediction of Manufacturing-Induced Defects in Autoclave Composite Airframe Parts

Composites Automation

WHO

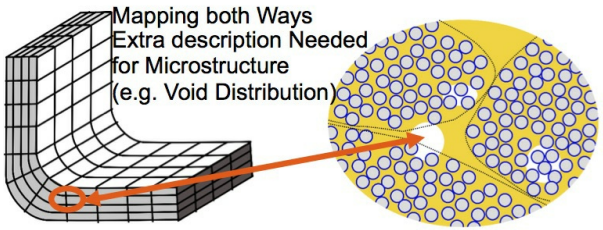
SYSCOM: NAVAIR

Sponsoring Program: PEO (A)

Transition Target: NAVAIR, NAVSEA

TPOC:
(904)790-6060

Other transition opportunities:
MQ-4C Triton UAS



WHAT

Operational Need and Improvement: OEM's have experienced fabrication issues, i.e. development of voids and delaminations, with autoclave processing of certain carbon/epoxy structural components. These defects cause part rejection which is both costly and effects program schedule. The M&S tool being developed in this STTR will predict manufacturing defects, including voids, ply waviness, delaminations, fiber wrinkling, resin rich/poor areas, and warpage caused from tool-part interaction using important processing parameters in an autoclave process, such as component internal temperature, resin kinetics and resin rheology, autoclave pressure and vacuum pressure, to model autoclave composite manufacturing.

Specifications Required: M&S tools that enable the prediction/characterization of manufacturing defects including voids, ply waviness, delaminations, fiber wrinkling, resin starvation/rich areas, and warpage caused from tool-part interaction in autoclave processing of thermoset composite materials. This tool identifies important processing parameters in an autoclave process, such as component internal temperature, resin kinetics, and resin rheology, autoclave pressure and vacuum pressure, then accounts explicitly for them to appropriately model autoclave composite manufacturing.

Technology Developed: An analytical model that describes void formation and evolution in the autoclave processing of thermoset composites has been developed. This model takes into account the material characteristics including state of cure, and various temperature dependent properties such as Tg, resin viscosity, heat generation, solubility, etc. The material properties are populated in SMARTee and integrated into Abaqus, to take advantage of the inherent solvers (temperature, diffusion, pressure etc.) to efficiently develop the void dynamics

Warfighter Value: This analysis tool will allow the NAVAIR engineer to evaluate the autoclave process for composite structures to assess if areas exist within the structure where defects may occur. Modifications to the manufacturing process can then be analytically performed to optimize the process conditions to eliminate these defects. This can also be done by the OEM's so that all parts can be produced without defects, on the first try. This should reduce or eliminate part scrap.

WHEN

Contract Number: N68335-17-C-0093

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Implement Modular Software Architecture for thermoset prepreg processing of simple geometries (planar and 1-D curve) with ABAQUS	Med	ABAQUS coupled cure kinetics, Tg, void evolution mechanism models (Phase I models)	3	October 2017
Design and Development of Graphical User Interface (GUI	Med	GUI for process/defect model setup in ABAQUS for Flat Laminate geometries only	3	December 2017
Experimental Validation: Planar geometry void evolution; Single curvature experiments	Med	Demonstrate void maps and other state variable visualization in ABAQUS	3	February 2018

HOW

Projected Business Model: It is fully anticipated that at the end of the Phase II Option, a Modeling and Simulation (M&S) tool that accurately models the thermoset prepreg manufacturing process will be developed, encompassing all process options including autoclave and out-of-autoclave methods. This tool will allow engineers to import complex 3D part geometries, establish process conditions and locally interrogate for potential defect formation at specific zones of interest and visualize defect formation over time during the process cycle. After the Phase II Option Phases, CA anticipates interactions with software developers to implement these defect models with existing solvers for composite process modeling. This will lead to the licensing of a stand-alone GUI for thermoset prepreg processing and USERMAT subroutines. CA will also set up arrangements for consulting services for companies requiring assistance with this software for their specific components.

Company Objectives: The technical success on the proposed program would result in the creation of a relevant patent portfolio to protect the IP and is anticipated to generate at least two different commercialization opportunities, including 1) to provide analytical services to analyze the thermoset composite processing procedures of OEM's and composite manufacturers to identify regions where defects may occur and assist in the modification to ensure defect free process methods; and 2) license the technology to existing composite analysis developers.

Potential Commercial Applications: The developed software has use in both Navy/DoD structures being fabricated using prepreg material as well as commercial applications such as large on- and off-shore wind blade structures. The potential to reduce or eliminate manufacturing defects from these applications will reduce scrap and will potentially enable more efficient optimized fabrication which could reduce manufacturing costs. This may also allow the OEM's to consider composite manufacturing of other components that were thought to be too difficult to produce with the quality required for the application.

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