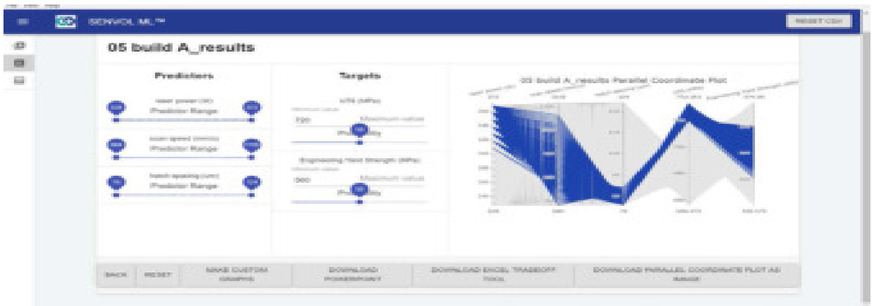
SUCCESS STORY

Demonstration of data-driven machine learning technology to reduce the cost of material design allowables development.

Established an accurate machine learning design allowable near the 90% population threshold for B-basis allowables.



The application of existing ML software capabilities for AM to reduce the time and cost of material design allowables development.

PROBLEM

Additive manufacturing (AM) enables lightweight and rapidly produced designs that are revolutionary to defense and commercial capabilities and applications. These benefits cannot be fully realized due to the time and high cost of design allowables development. Design allowables are statistically determined materials property values derived from test data. They are used to establish design limits of stress, strain, or stiffness that are allowed for a specific material, configuration, application, and environmental condition. Material design allowables development requires an enormous amount of empirical data to be generated (costing in excess of $2M over 24+ months), and is a point solution, meaning that all the empirical data must typically be regenerated from scratch every time there is a major change in the process.

OBJECTIVE

The primary objective of this project was to develop two mechanical property design allowables for AM using a single set of empirical data. The project sought to establish an approach to AM design allowables that leverages the digital nature of AM as well as machine learning (ML), a modern data analysis approach that has been effective in other industries. An ML approach is extremely flexible and able to handle any change to the AM process (e.g. changing AM material or machine), which makes this approach ideal for long term sustainment.

TECHNICAL APPROACH

Senvol applied its existing ML software capabilities to develop a build plan which generated a body of empirical data for analysis. Specifically, two different data sets were generated during project execution. The first data set was used as ML training data from which an infinite number of design allowables could be developed using ML approaches. From this single training data set, two different design allowables were developed using ML, each with its own optimized parameter set. The second data set was used to develop two different S-basis design allowables using the conventional "point solution" approach. A comparison of time and cost for generating the first and second data sets was performed in order to demonstrate that a design allowable approach that leverages ML is both more cost effective and flexible than the conventional "point solution" approach, which is the status quo in industry today.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

AM GENOME

ASTM PROCESS CATEGORY: Powder Bed Fusion

MATERIAL: Nylon 11 Flame Retardant (FR-106)

ACCOMPLISHMENTS

The project team demonstrated the development and implementation of data-driven machine learning technology that could potentially substantially reduce the cost of material design allowables development. By using data-driven machine learning algorithms, Senvol's software quantified complex and interdependent Process-Structure-Property (PSP) relationships without the need to understand the underlying physical phenomena. Senvol ML analyzed numerous changing parameters at once and elucidated the marginal contribution of each parameter. The results of this project indicate that a ML approach could potentially work for allowables development, however, further research is warranted.

PROJECT END DATE

August 31, 2021

DELIVERABLES

- Final report (including all analyses and evaluations with a comprehensive cost benefit and performance analysis of the ML approach versus the conventional approach)
- Process model
- Dataset(s) of empirical data generated (including all test data and corresponding pedigree information in various file formats) for at least two (2) mechanical property design allowable demonstrators using a ML approach and two (2) mechanical property design allowable demonstrators using a conventional "point solution" approach

All downloadable deliverables are available to members of America Makes via the Digital Storefront.

FUNDING

$262,515 total project budget
($174,986 public funding/$87,259 private funding)

PROJECT PARTICIPANTS

Project Principal:
Senvol

Other Project Participants:
Northrop Grumman Corporation
Stratasys Direct Manufacturing
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