DEPARTMENT OF COMPUTER SCIENCE AND MATERIAL SCIENCE ENGINEERING

PURDUE UNIVERSITY | Office of Undergraduate Research

PREDICTING SHAPE CHANGE COMPENSATION OF COMPOSITE PRINTED TOOLING

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CMSC

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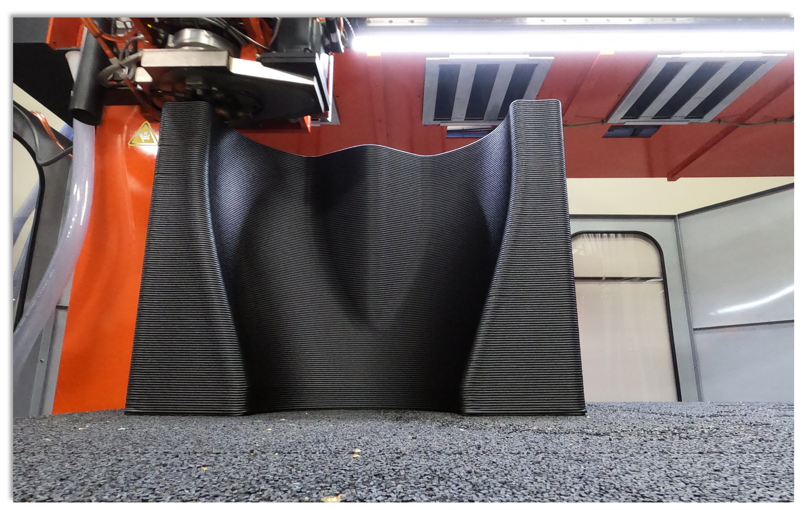
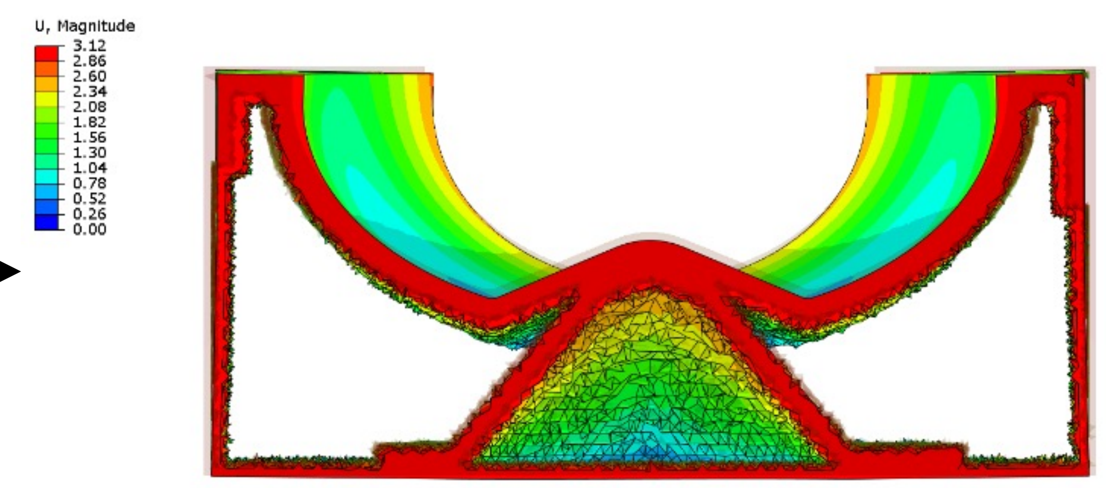
OVERVIEW

Extrusion Deposition Additive Manufacturing (EDAM) has revolutionized the field of additive manufacturing in producing large-scale geometries. With the integration of fibers, the Coefficient of Thermal Expansion (CTE) of printed materials witnesses significant enhancement in the printed direction where fibers predominantly orient. This advancement, while beneficial, complicates predicting shape change upon heating. This research integrates a physics-based framework that automates the prediction and shape compensation for tooling printed with composite materials.

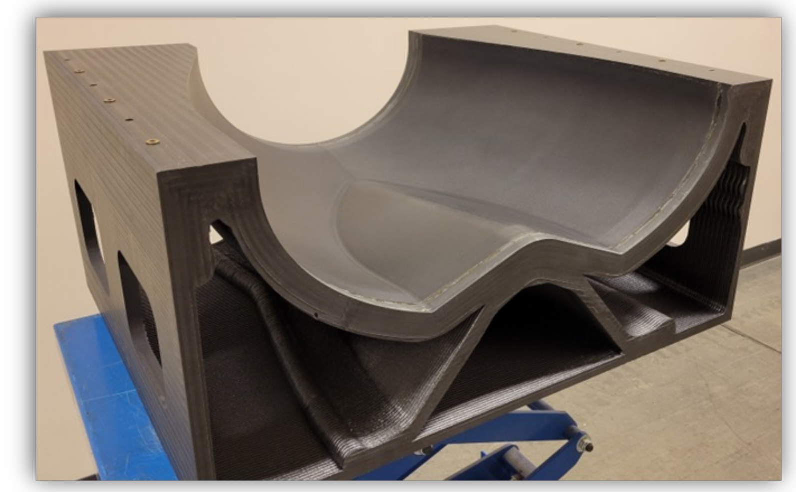
Thermwood's Large Scale Additive Manufacturing (LSAM) machine printing air inlet duct for aircraft's engine.



PRINTING OF INITIAL DESIGN



SHAPE CHANGE UPON HEATING



FINAL GEOMETRY AFTER COOLING

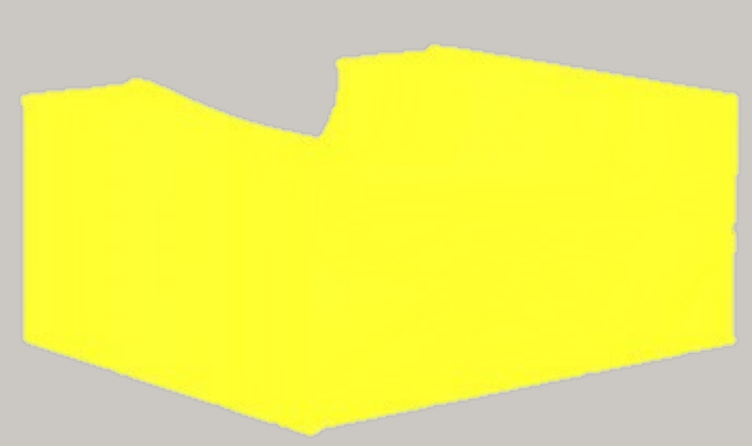
In additive manufacturing, especially in the LSAM process, shape compensation plays a vital role. The initial design is strategically modified to counteract predictable deformations, a crucial step to ensure that the final geometry aligns with the desired specifications.

This is beneficial in the production of tooling and molds, where precision is paramount. By accurately predicting and adjusting for shape changes, this research significantly enhances manufacturing efficiency and sustainability. It contributes to reducing waste and improving the overall performance of the products, making the manufacturing process more environmentally friendly and cost-effective.

1

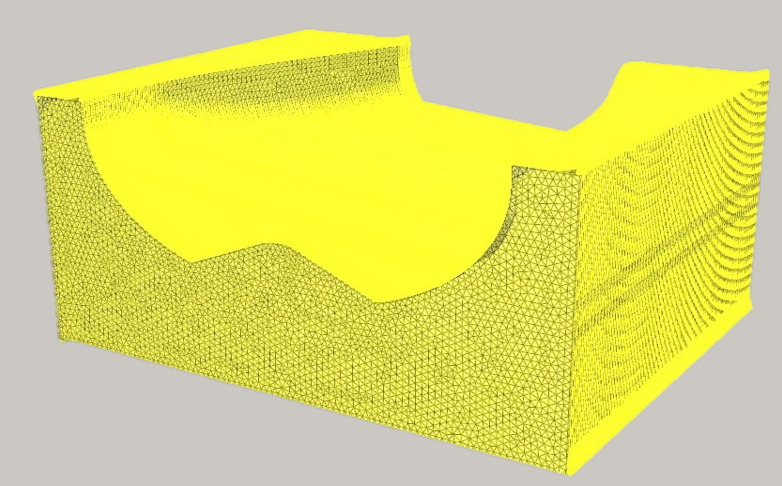
FINITE ELEMENT MESH

2



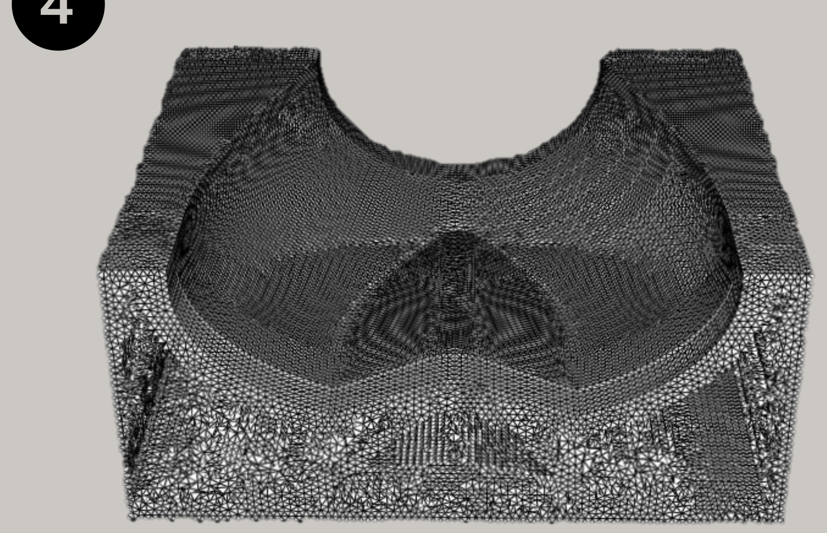
MACHINE CODE (G-CODE)

3



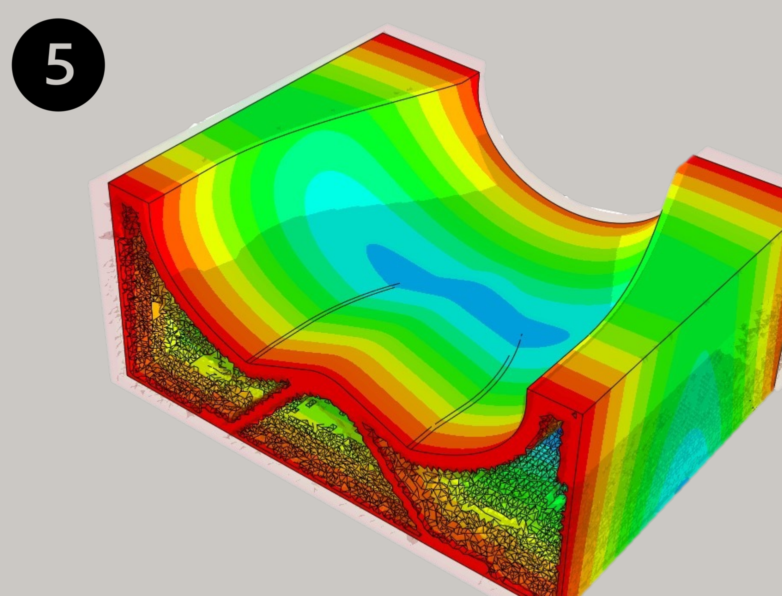
ALIGNED MESH AND G-CODE

4



MESH AFTER ELEMENT ACTIVATION

5



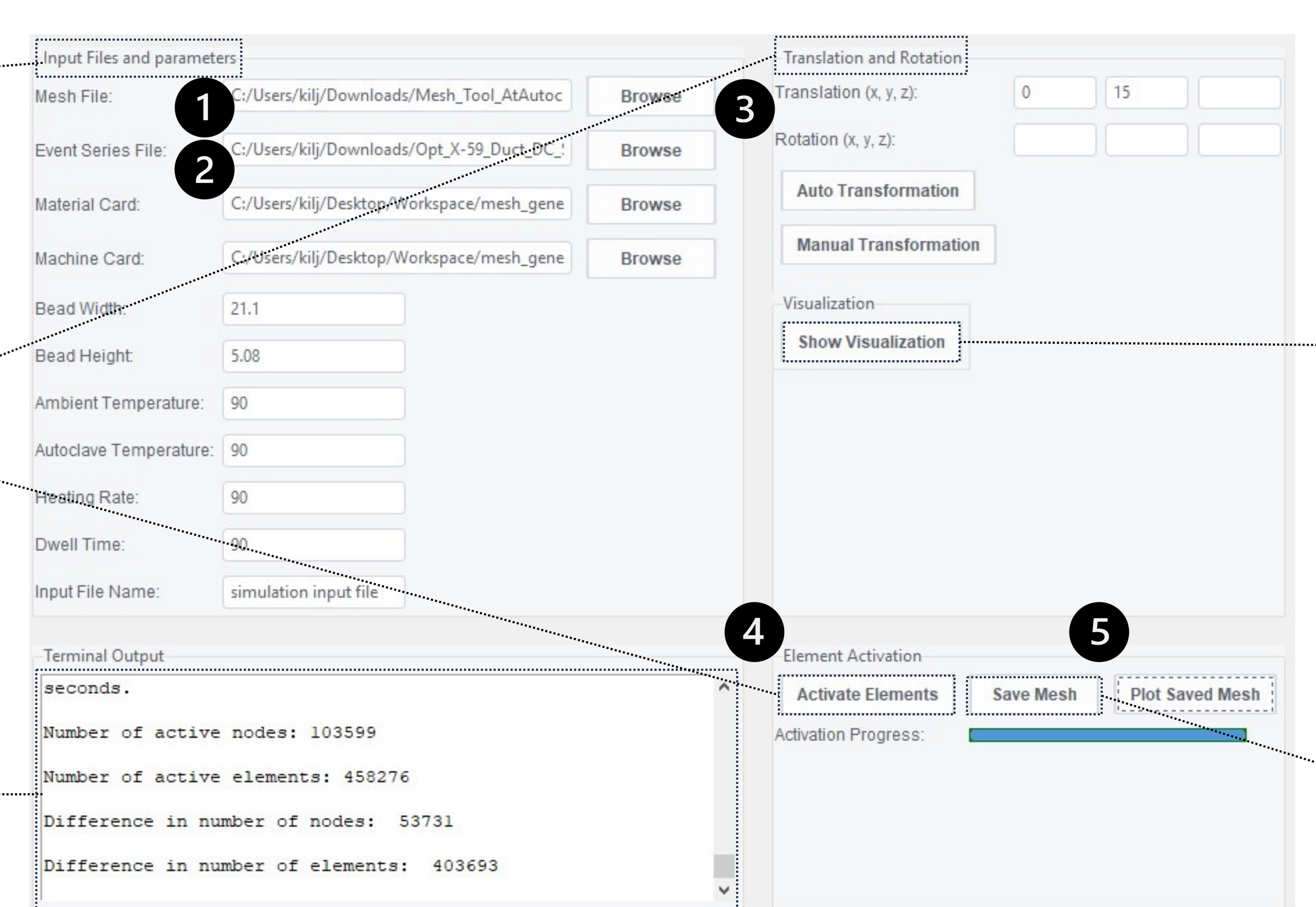
ANALYSIS FOR PREDICTION

The simulation framework integrates a diverse array of inputs, including the predicted manufacturing effects from the simulation workflow software ADDITIVE3D, the specified process conditions for tooling applications, the material properties, the machine code (G-code), and a finite element mesh.

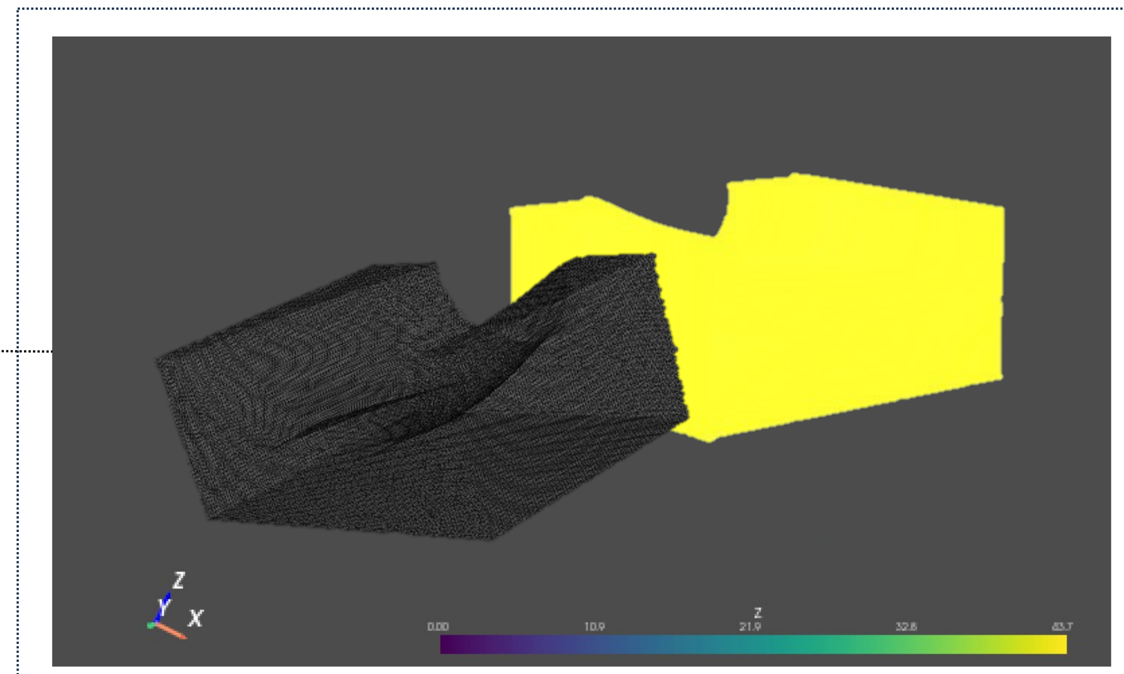
The Graphical User Interface (GUI) places a strong emphasis on user experience, ensuring a seamless fusion of these varied inputs. The GUI is built using Python with the Tkinter library, with features such as mesh alignment and element activation that correspond with the movements of the 3D printer's nozzle.

Furthermore, the GUI is equipped with robust logging features to meticulously record computational processes, and an interactive visualization module developed with PyVista. This emphasis on interactivity and transparency aims to engage users and maintain clarity across all stages of the workflow.

GRAPHICAL USER INTERFACE



VISUALIZATION OF MESH ALIGNMENT



The interactive visualization allows users to intuitively position and orient the mesh in accordance with the machine code, enhancing understanding and enabling correction.

Once the inputs have been processed, the framework incorporates the simulation parameters and automates the generation of post-processing input files into a format compatible with a Finite Element Software ABAQUS, for thermomechanical analysis.