Creative Thinking in Sustainable Aerospace Design

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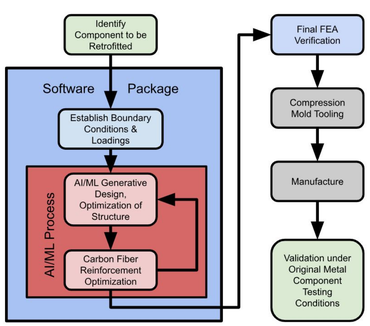
ABSTRACT

Creative thinking played a pivotal role in developing our solutions in sustainable aerospace design by exploring innovative intersections between AI/ML technology and aerospace engineering. We recognized that leveraging AI/ML in the generative design process could revolutionize how composite materials are used, providing unprecedented optimization in weight and structural integrity. By thinking beyond conventional design constraints, we envisioned using AI to generate entirely new designs from scratch, guided by performance and manufacturability constraints. Additionally, we explored the potential of AI/ML to streamline the manufacturing processes of CFRP components. Traditional manufacturing methods for composite materials are often complex and time-consuming, with significant room for improvement in efficiency and consistency. By integrating AI/ML algorithms, we can automate and optimize these processes, reducing production time and material waste. Our creative approach involved not just incremental improvements but reimagining the entire production workflow, from material selection to final assembly, ensuring each step benefits from the precision and adaptability of AI.



Generative Design Flowchart

INTRODUCTION AND PURPOSE

The aviation industry faces significant challenges in reducing CO2 emissions, which totaled 918 million metric tons in 2018 and are projected to rise [1]. Currently, airplane manufacturers are increasingly using Carbon Fiber Reinforced Polymer (CFRP) structures due to their potential for significant weight savings over traditional aluminum and steel structures. However, composite structures present challenges in design and manufacturing due to their complex failure modes and intricacies in production processes. Additionally, generative design processes and AI/ML assisted additive manufacturing is currently not widely used in the aerospace industry. The purpose of this presentation is to to improve sustainability in the aerospace industry with creative approaches to solve sustainability problems in the areas of: composites, design, and manufacturing

RESULTS AND DISCUSSION

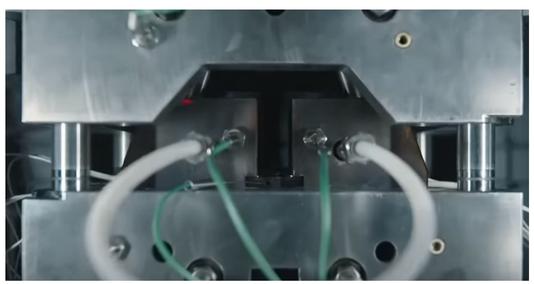
- A proven design process
  - Carbon Fiber Reinforced Polymers (CFRP) are already used in aerospace structural brackets.
  - 9T Labs company - Prominent manufacturer of CFRP components using dual-extruder FDM
  - Generative Design (ML/AI) can supplement design process
  - “Fibrify” algorithm generates carbon reinforcements, readily integrates with FEA for verification.
- Compression molding reduces porosity
- Increases strength and internal homogeneity
- Reduces variance during validation testing
- Energy efficient compared to metal feedstock production

PROPOSED SOLUTION/RECOMMENDATIONS

Our primary objective is to leverage AI/ML techniques in the additive manufacturing of composite materials and the design of composite airplane structures to reduce the overall weight of commercial airplanes. This can contribute sustainability efforts in the Aerospace Industry. A list of all the objectives are as follows:

1. Enhance structural integrity through AI-driven design optimization of composite airplane structures.
2. Streamline manufacturing processes for composite materials using AI/ML algorithms.
3. Utilize AI/ML techniques to optimize the weight distribution of commercial airplanes.
4. Contribute to Boeing's sustainability efforts by reducing the overall weight of its aircraft fleet.

Internal carbon fiber reinforcement extrusion [2]



Compression mold used by 9T labs [2]

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The method we propose for incorporating AI/ML into aerospace design includes additive manufacturing and generative design software to help with composite designs. The idea requires the development of in-house software or partnerships with leading industry experts. There are current existing software that can generate designs using AI/ML, such as fusion 360 which provides design solutions for given geometric, manufacturability, and performance constraints. Additional AI features of Autodesk fusion include: Automated modeling, toolpaths, modelling of galvanized steel beams and eco-friendly wood veneer, and automated drawings.

CONCLUSIONS

Our proposed solution incorporates AI/ML solutions through the use of generative design software, either through the development of in-house software or through strategic partnerships with industry experts. Finally, we highlighted the potential benefits of utilizing composite materials, such as CFRP, including weight reduction, extended service life, and reduced environmental impact.

REFERENCES

[1] “CO2 emissions from commercial aviation, 2018.” International Council on Clean Transportation, 18 September 2019, https://theicct.org/sites/default/files/publications/ICCT_CO2-commercl-aviation-2018_20190918.pdf. Accessed 12 May 2024.

[2] Technology | Additive Fusion Technology, the New Standard of Manufacturing | 9T Labs. https://www.9tlabs.com/technology. Accessed 17 May 2024.