Gerardo Andrés Mazzei Capote
45 N. Randall Ave, Apt. 109 • Madison, WI- 53715
(608) 622-4643 • mazzeicapote@wisc.edu
linkedin.com/in/gerardo-mazzei-capote
ORCID: 0000-0002-1951-6600

Research Summary

Fused Filament Fabrication (FFF), also known as Fused Deposition Modeling (FDM), is arguably the most widely available Additive Manufacturing (AM) technology at the moment. Offering the possibility of producing complex geometries in a compressed product development cycle and in a plethora of materials, it comes as no surprise that FFF is attractive to multiple industries, including the automotive and aerospace segments. However, the high anisotropy of parts developed through this technique imply that part failure prediction is extremely difficult —a requirement that must be satisfied to guarantee the safety of the final user. This pain point represents one of the major factors currently hindering the adoption of FFF and other AM technologies as legitimate manufacturing techniques, given that the safety of the final product is hard to guarantee since the failure behavior of the object is difficult to assess. The research I have conducted during my graduate studies is aimed at solving this issue, by exploring two strategies that allow engineers to predict the structural integrity of FFF parts. One involves the use of a failure criterion to predict the likelihood of part failure given the application of the manufactured object, while the second aims to predict mechanical properties of an FFF part using a machine learning algorithm and data generated through in-line measurements and processing parameters.

The lack of standardization in the field of AM posed a challenge: it was a necessity to develop customized test specimen geometries, mechanical testing protocols, as well as the extrusion of a customized FFF filament produced with tight geometrical constraints and controlled production parameters that ensured that fluctuations in the material dimensions and quality would not introduce lurking variables into the experiments. Additionally, some of the required bead orientations necessary to fully describe the failure function were unattainable through the use of a traditional FFF printer, requiring the deployment of custom toolpath solutions using a unique 6-axis 3D printer developed in the Polymer Engineering Center at the University of Wisconsin-Madison. Finally, the project required application of Design of Experiment techniques, statistical analysis, and development of Data Analysis and machine learning code in Python and MATLAB.

This research project has led to peer reviewed publications, three technical presentations in important AM conferences (SFF, RAPID, AMUG), and international collaborations with renowned institutes such as the Technical University of Munich (TUM), the National School of Engineers of Saint-Étienne (ENISE), as well as contributions with industry partners such as BMW and Netzsch.

Additional research venues and shorter term projects pursued during my graduate studies include the following:

1. Development and construction of a low-cost, reusable N9X mask during the COVID19 pandemic. Effort awarded with financial support from the Wisconsin Alumni Research Foundation (WARF).
2. Extrusion of a Polyethylene Terephthalate (PET) FFF filament produced using discarded bottles as the parent material. Dimensions within 2% of target value.
3. Fabrication of Heat Exchangers (HX) through material extrusion AM techniques, including units produced using a thermoplastic/metallic hybrid material.
4. Collaborative efforts with chemists and electrical engineers to refine the design of topological crystal insulators with the goal of improving manufacturability through various AM techniques. Effort involved compounding materials with high dielectric constants, and developing customized toopath solutions for crystal production using FFF and Digital Light Synthesis (DLS).