Analysis of 3-D Printed Structural Components for Cube Satellites

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Abstract

Additive manufacturing uses 3D printing to build physical parts from CAD-based designs. The technology includes fused deposition modeling (FDM) and selective laser sintering (SLS) methods. FDM deposits and fuses beads of molten thermoplastic to build prototype and limited production commercial parts, while SLS uses a moving laser beam to sinter plastic or metal powder layers heated close to the fusion point. 3D printing is of particular interest for smaller, one-of-a-kind, customizable products. A cube satellite (CubeSat) containing fiber reinforced SLS parts has been successfully launched (Ref 1).

Lower cost FDM can be less attractive for manufacturing CubeSat components, since the FDM materials cannot be fiber reinforced, and the mechanical properties are not close to aluminum. One industry solution has been to coat the 3D printed parts. The mechanical properties can be greatly improved by electroplating a metal coating to form a sandwich composite structure. Additional benefits include EMI shielding, increased temperature capability, elimination of outgassing and reduced flammability. To properly design and analyze the component structure, the output geometry of electroplating analysis must be imported into a structural mechanics module. The research investigates performing the analysis within the framework of the COMSOL Multiphysics® software.

COMSOL software was used to:
• import CAD geometries (e.g. tensile bar array) as illustrated in Figure 1.
• predict the Cu and Ni electroplated metal thickness distributions.
• analyze the load and stress distribution in the composite structure for a solid thermoplastic core electroplated with Cu and Ni shells as illustrated in Figures 2-4.

Preliminary Results include:
• The COMSOL results for electroplating thickness distributions were verified against an older legacy code.
• Variation in electroplated part arrays can be predicted for manufacturing.
• Using a linear elastic model, the predicted stress in the thermoplastic core is much lower than the stress in the metal shells. The shells carry the load up to the metal yield stress.

The benefits of analyzing the structural properties of metal-coated 3D printed parts include:
a) being able to quantify the performance improvements obtainable with the metal coatings,

b) making an informed choice between uncoated versus plated parts,
c) obtaining a better optimization of the final design properties,
d) reducing development time and cost with less need for testing, and
e) extending the use of 3D printed parts to new applications.

Reference

1) http://3dprintingindustry.com/2014/05/09/3d-printing-cube-sat-launch-satellite/.

Figures used in the abstract

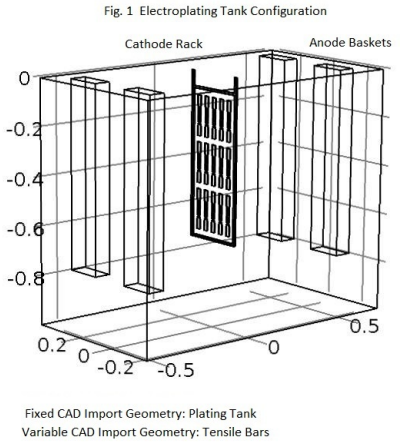

Figure 1: Electroplating tank configuration.

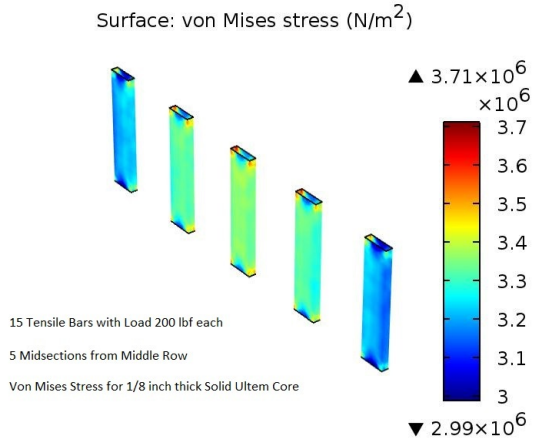

Figure 2: Von Mises stress in solid ultem core.

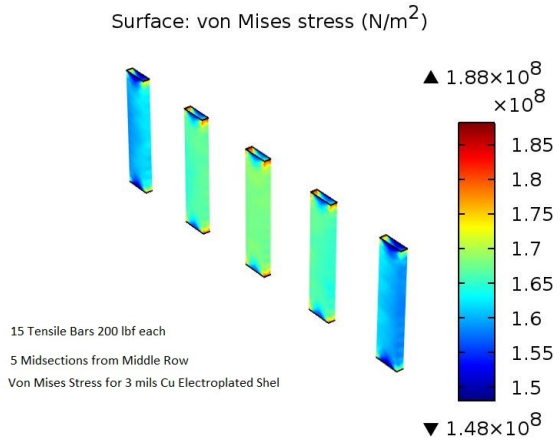

Figure 3: Von Mises stress in 3 mil Cu electroplated shell.

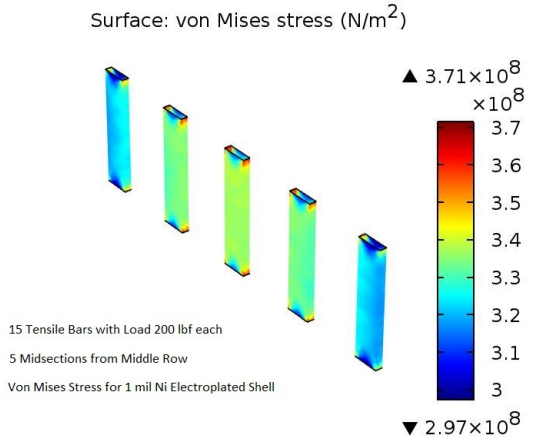

Figure 4: Von Mises stress in 1 mil Ni electroplated shell.