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Design and performance of a 3D printed liquid hydrogen tank with vapor cooled shielding for use in unmanned aerial vehicles

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Liquid hydrogen storage systems utilize various insulation methods that have direct bearing on the mass and overall volume of the tank which can be inversely related. When utilizing liquid hydrogen as a fuel source for fuel cells, the vaporized fuel must be warmed to minimize ice build-up on fuel lines and to ensure compatible temperatures with fuel cell membranes. Advances in 3D printing technologies have enabled the incorporation of the traditionally external heat exchanger into the tank structure itself, thereby reducing mass and volume while providing vapor cooling for the stored liquid hydrogen. Integrating the heat exchanger creates a complex structure that conventional manufacturing methods (e.g. machining, injection molding) are not well suited for. We use selective laser sintering (SLS) of a low density engineering polymer to create the tank liner which is then overwrapped with carbon fiber (Type IV configuration) to carry the pressure loads. Estimated final mass of the tank system is 2.8 kg resulting in a gravimetric capacity of hydrogen to tank material mass of 13.3% and 55% volumetric efficiency, while energy density of the tank is 4.5 GJ/m^3 and specific energy is 15 MJ/kg. Thermodynamic modeling of the tank system indicates a mass flow rate of 1.05E-05 kg/s at steady state operating conditions. Initial comparisons between tank performance and modeling estimates are made. The resulting tank has improved performance for utilization in small portable power applications not previously amenable to cryogenic hydrogen.

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