Advancing Space Propulsion System Technology through Additive Manufactured Heat Pipe Structures

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Additive manufacturing offers the potential to enable affordable improved technologies for advanced space propulsion systems and related aerospace applications. In current work, a NASA Phase I SBIR program is being completed to demonstrate the use of additive manufacturing for producing titanium/water heat pipes with porous wick structures. The challenge is to use the additive manufacturing process to form integral porous structures with wick properties equivalent to those achievable with conventional fabrication approaches. Initial has been demonstrated with aluminum and titanium material systems. The target application is spacecraft radiator systems.

Also, work is underway to demonstrate additive manufacturing for fabrication of complex curvature leading edge heat pipes using Haynes 230 superalloy. Modules with up to six independent heat pipe envelopes have been produced. This work will verify the fabrication approach for application to spacecraft propulsion systems. Heat pipe modules with multiple heat pipes were successfully demonstrated in arc jet testing at NASA Ames Research Center. These modules were fabricated from niobium alloys, and contained six independent lithium heat pipes. The modules were completely coated with R512-E silicide and demonstrated long term operation in air at temperatures up to 1100C. Initial work is being done to develop the capability to produce structures with multiple heat pipe envelopes within nozzle-shaped thruster shapes. The combination of these technologies will make it possible to produce affordable advanced spacecraft propulsion components with multiple redundant heat pipes in refractory metal alloys. Such structures will be capable of continued operation with tolerance to single-point failures, which will enable a new generation of spacecraft propulsion systems to be developed.