IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Specialized Technologies, Including Nanotechnology (8)

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POLYMERS FOR IN-SPACE/ON-PLANET MANUFACTURING AND RECYCLING

Abstract

Studies performed both in the US and in Europe identified polymers as one of the main material groups to be used for in-space/on-planet construction due to their versatile applications both in habitable and exposed environments, low processing energy need, recyclability, and no need for additional agents‘. Developing in-space and on-planet manufacturing capability is the key for establishing infrastructure and supporting it over time. The in-space manufacturing environments are also not homogeneous and are susceptible to change from one extreme to another. For example, for LEO operations, variations in the thermal environment caused by going in and out of the eclipse need to be considered. These variations may negatively impact the manufacturing processes and their outcome. Additionally, support infrastructure would need to be implemented to make space-based manufacturing facilities possible. This paper provides an overview of factors and challenges influencing in-space manufacturing, such as: manufacturing under reduced gravity, detrimental effects of long-term exposure to the space environment (ATOX for LEO, UV), manufacturing of large parts, manufacturing under vacuum conditions, and using recycled feedstock. Several engineering polymers are selected and studied to evaluate the change of their properties under the extended influence of the space environment, recycling capability, and therefore overall suitability to be used for in-space manufacturing activities. Engineering polymer group is selected because with gradual degradation in properties they can be used in other applications, for example first for structural parts, and later for ones with less demanding mechanical properties. Long-term UV stability of recycled polymers is evaluated as well as recycling of aged polymers and process dependencies on the number of recycling cycles. Since the number of recycling cycles will be substantial to ensure closed-loop manufacturing, it is also investigated whether 3D printers are capable of processing recycled feedstock while ensuring satisfactory final part quality. To produce large structural parts, a major constraint that has to be overcome is the produced part needs to exceed the size of the printing chamber. In-space printing will take place under vacuum conditions, and various aspects of this manufacturing process need to be understood; 3D printing tests done with engineering polymers under vacuum conditions are presented and discussed. Since high-performance polymers are usually processed in closed chambers required for stable thermal conditions, open volume printing under space environment addresses new challenges, among others how to remove the part from the printer and how to perform maintenance in-between the prints. In the paper, the implementation of a verification plan to create a closed-loop system is discussed. The mechanical properties, thermal properties, dimensional accuracy, UV aging to evaluate suitability for in-space applications are presented using representative samples. Material properties that affect recycling process and quality of recycled filament are addressed and recommendations on material selection for in-space manufacturing and recycling are provided.