Additive Manufacturing for the Space Market

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Commercial and government space markets can benefit significantly from additive manufacturing (AM) using a wide range of materials. While the general advantages of AM are well understood, a number of factors must be considered to determine whether it is appropriate for a given application and select the process or processes that will yield the greatest benefits.

Qualification Costs

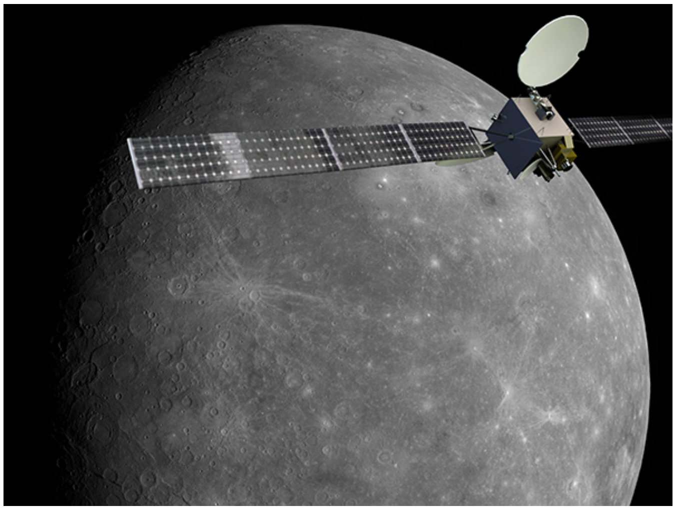
Process-qualification cost-benefit paradigms vary based on the application. This is especially true when comparing these costs for man-rated and non-man-rated applications. For EELVs (evolved expendable launch vehicles) and next-generation launch systems, components used during launch and booster stages have significantly different requirements than the components of the satellites they typically carry into space. These requirements include expectations for product lifetime as well as thermal and mechanical fatigue behavior.

Reducing Launch Costs

After meeting qualification requirements, a wide array of hardware can be built, ranging from brackets with little or no structural requirements to large components where substantially reduced production costs are the primary goal. While light weight and increased payloads are of paramount concern, overall launch costs must also be reduced by 30% to 50% to maintain competitiveness. Most existing AM applications in the space market represent a 50% cost reduction, provided that factors such as existing production routes, lead-time costs, forging costs, and buy-to-fly ratios are taken into consideration.

Component Consolidation

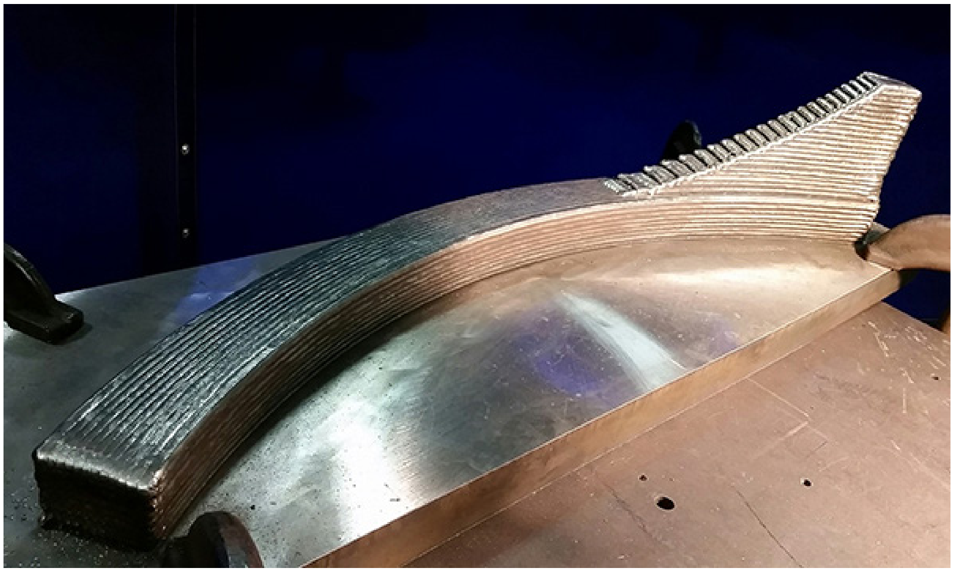
In many applications, AM can significantly reduce the number of individual parts required, eliminating their individual sourcing, production, joining, inspection, logistical, and inventory costs. It should be noted, however, that to meet design tolerances and performance requirements, metal AM parts must still be finish-machined and may require post-weld heat treatment, depending on the alloy.



Available Materials

Alloy systems of interest include 2XXX, 6XXX and 7XXX-series aluminum alloys, aluminum-lithium alloys, and titanium alloys. Copper alloys are also of interest for use in rocket nozzles, as is the use of AM to make thin high-strength stainless-steel components for propellant tanks.

Polymeric materials or material solutions with multi-functional capabilities can be developed with AM to integrate separate assemblies or subassemblies into a single component. Fiber-wound elements can be combined with fused deposition modeling (FDM) to create composite structures. AM also allows electronics to be embedded in parts to minimize the number of required components and save weight.



Demonstration part built by EWI to show typical appearance and process control achieved using arc-directed energy deposition (DED) for large parts.

Process Selection

Generally speaking, AM applications fall into two main groups: (1) those for small, complex parts that readily fit the powder-bed paradigm for laser-based and electron-beam-based (EB) machines, and (2) larger structural parts that do not fit within the build dimensions of available powder-bed systems. In the latter case, multiple directed energy deposition (DED) processes may be considered, including arc-based processes, laser-based processes, and EB. Solid-state welding processes such as linear friction welding, friction stir welding, and high-powered ultrasonic additive manufacturing should also be evaluated. Process selection depends on part size, required mechanical properties, and alloy weldability. The last is often the deciding factor between fusion-based processes, which require melting, and solid-state processes, which are better suited for so-called “unweldable” materials.

EWI Can Help

With AM experience in a wide range of applications addressing key market needs, EWI has the expertise and equipment capabilities required to serve the space market. If you’d like to learn more about how EWI’s innovative AM technologies can help you take advantage of these cutting-edge innovations, please contact us at info@ewi.org.

***Ian Harris** has more than 30 years of experience in applied research and business development for commercial and government clients. His primary expertise is in gas-shielded arc welding processes, with research resulting in more than 150 technical reports, papers, and book chapters. During his eight years as Arc Welding Technology Leader, Ian worked on many complex projects that involved multiple EWI technology teams. Through that experience, he developed a passion for introducing EWI’s full portfolio of capabilities to clients, particularly within the aerospace industry. In his new role as Technical Director, with primary focus on the Space market, Ian brings both his unique industry insight and his technical expertise to customers as they seek to improve their processes, productivity, and competitiveness.*