Additive Manufacturing Advances to Facilitate Novel Robot and Remote System Construction

Additive manufacturing (AM) in both polymer and metal has advanced to the point where it can substantially facilitate robot and remote system design and implementation. While AM is not a panacea to fix bad design concepts, properly used AM can create features and capabilities otherwise not possible in machined or cast products. AM design rules are still being developed and must be applied differently based on the process and purpose of the final component, but progress is being made in practical implementation.

Polymer-based AM has been available commercially for quite some time and is regularly used to facilitate prototyping and test fitting of parts later to be fabricated in metal or to produce low production quantity parts that do not require high structural strength. However Oak Ridge National Laboratory (ORNL) has pioneered large scale polymer additive manufacturing with sufficient strength to print a car and frame, a small house, a “wet” submarine, and tooling to mold wind generator blades. While polymer processes use a variety of materials, all polymer printers basically lay down a heated extruded bead of a certain width and height. Print resolution is based on the deposition rate of the printer. The larger the deposition rate, the lower the print resolution. Large scale polymer builds often rely on post processing (machining) to provide a smooth finish to the part surface.

Metal printing processes are much more diverse than polymer print processes. Electron beam (ebeam), laser, and binder jet are common methods to fuse metal powder-based systems. Metal powder spray can be done with laser or plasma. While metal powder systems produce high definition parts, part size is limited. Larger parts are currently done with wire feed systems based on laser or arc (metal inert gas (MIG) or tungsten inert gas (TIG)) processes. Part definition decreases, but part size can be on the order of tens of cubic feet and hundreds of pounds.

Two implementation examples are presented in this paper to illustrate the possibilities and to identify issues that remain. A dual arm hydraulic manipulator was printed in titanium using the ebeam process. All hydraulics and electrical cabling passageways were printed into the manipulator; there are no external hoses or cables. The distal link of an excavator arm was printed using a wire feed metal inert gas (MIG) process. The excavator was then used for digging as part of an equipment exposition validating the metallurgy of the printed part.