

TECH FRONT

Will We Use Welding Technology to Make RPs?

Processes under development at Southern Methodist University's RCAM (Research Center for Advanced Manufacturing) in Dallas employ a high-power laser and/or different welding processes (gas metal arc welding [GMAW], gas tungsten arc welding [GTAW], and variable polarity gas tungsten arc welding) for rapid manufacturing or solid free-form fabrication of metallic components.

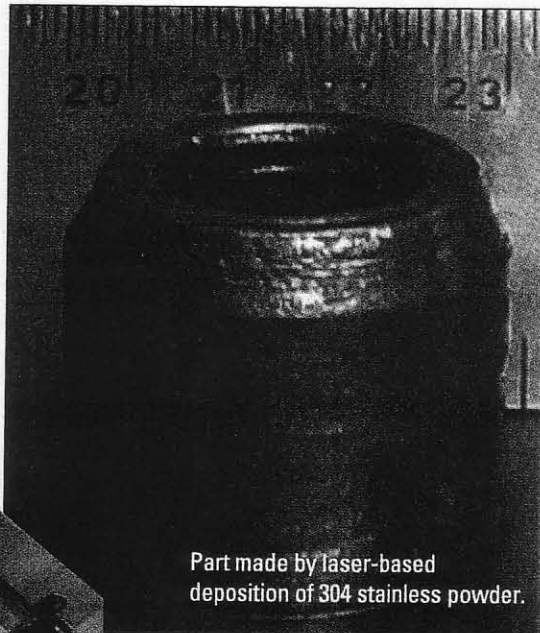
Led by Radovan Kovacevic, FSME, the RCAM research team is developing a solid free-form fabrication system that consists of a

prototyping welding processes for depth of penetration and heat buildup into the layer. Researchers say that part accuracy and surface finish must be improved, and the weld bead's microstructure,

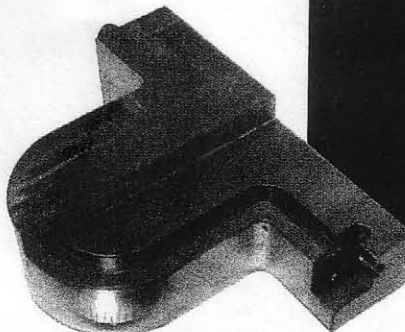
bead layer generated by GMAW. To decrease the cost of sensing and metal transfer control in GMAW, researchers recently eliminated the high-frame rate camera and replaced it with a simpler device that consists of a controller and a sensor based on a photodiode and a laser diode for backlighting.

Researchers also use gas tungsten arc welding (GTAW) instead of GMAW for deposition by welding. In GTAW, the wire-feeding rate does not depend on the welding current as it does with GMAW. It's possible to completely stop the metal deposition process with the arc on. Also, GTAW wire can be fed directly into the molten pool. Surface tension spreads the liquid metal evenly and thus avoids possible irregularities inherent to the droplet-based metal transfer. The weld bead in GTAW can be placed next to the previously deposited

bead. In GMAW, however, the previously deposited bead will affect arc stability, and an additional mechanism is necessary to ensure that the wire is always fed in front of the moving arc. In GTAW, to achieve a uniform cooling rate or uniform mechanical properties of the welded substrate, the molten pool volume is kept constant by adjusting heat input. Controlling the welding deposition process for GTAW requires controlling the shape and size of the molten pool. A machine vision system supplied by Weldware Inc. (Columbus, OH) co-axially installed with the torch acquires information on the size of the molten pool. A closed-loop control system now under development controls pool size by



Part made by laser-based deposition of 304 stainless powder.



Made by using a process that combines welding-based deposition and CNC milling, this part contains 3-D conformal cooling channels.

Nd:YAG laser, multiple-powder delivery unit, coaxial nozzle, three-axis CNC positioning system, and sensing units to monitor temperature, metal powder flow rate, and geometry of the clad bead. When perfected, this system will be used to make metal parts, to repair worn parts, dies and tools, and to build parts with functionally graded materials.

RCAM's effort may represent the first attempt to control rapid

residual stresses, and geometry must be controlled.

Existing methods for metal transfer control in GMAW have two major flaws: uncertain detachment time and inconsistent droplet size. To avoid these flaws, a new sensing and control method for metal transfer in GMAW uses a high-frame-rate digital camera assisted by a He-Ne laser and a real-time image-processing algorithm to monitor droplet formation. A PCI frame grabber and a Pentium III PC provide real-time droplet monitoring and control. This method of controlling the GMAW process reportedly is the first that can accurately control the height to width ratio of the

80m/mi

1.0

40 r/min

"Hog

0.9 sec.

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changing the heat input by altering the welding current in real time.

Another new deposition process uses aluminum alloys. To remove oxides from the top surface of the aluminum substrate

through so-called cathodic cleaning action, variable-polarity gas-tungsten arc welding is used. Switching between positive and negative polarity causes the periods of electrode positive to remove

the oxide and clean the surface. The experimental setup consists of a four-axis CNC positioning system, a variable-polarity welding power source, an arc-length sensor based on machine vision, an image processing system, a GTAW torch with a wire feeder, an infrared pyrometer, and a PC-based control system.

One workpiece made by this system, a cylinder 120-mm high and 100-mm in diam, was built by layering 300 weld beads, each 4-mm wide and 0.4-mm high. Another, a cone, consists of two segments: the first is 76 mm in diam and was built of 60 layers, 5-mm wide and 0.4-mm high. The second has a starting diameter of 76 mm and an ending diameter of 46 mm, and consists of 100 layers with the same dimensions as the layers from the first segment.

Surface quality of both samples is reportedly comparable to that obtained in precision investment casting. However, to directly fabricate metal parts and tools that are dense, metallurgically bonded, geometrically accurate, and exhibit good surface appearance, the researchers built a hybrid rapid prototyping machine that incorporates deposition by welding with 2½-axis CNC milling. This hybrid machine allows the production of metallic parts and tools with high dimensional accuracy and with complex external and internal geometrical features. The 2½-axis positioning system only permits fabrication of parts with vertical walls.

Kovacevic says the future hybrid rapid prototyping machine will consist of a six-axis robot, a five-axis CNC milling machine, a six-torch automatic changer, and six torches with corresponding wire feeders providing the ability to use different wire diameters and metals. It will have two welding power sources for different welding processes (GMAW, GTAW), with internal control and pulsing capabilities, and a number of sensors and controllers. ■

Workholding Solutions

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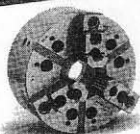
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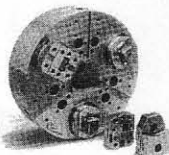
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