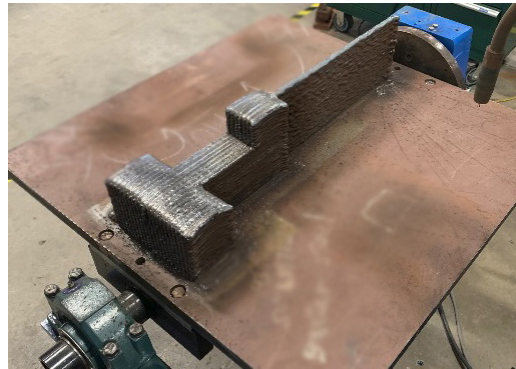


Qualification builds offer a standardized methodology to quantitatively evaluate arc DED material and product quality.

Production of standard qualification builds for integral single and double-sided build platform arc DED structures



Photographs depicting arc directed energy deposition standard qualification builds produced for (a) single sided nickel aluminum bronze alloy and (b) double sided high strength steel alloy with integral build platforms.

PROBLEM

Metal additive manufacturing technology is rapidly maturing. The impact on the U.S. Navy has been limited by the availability of standards and U.S. Navy Technical Publications. Arc-directed energy deposition (DED) processes present acceptable risk and offer great opportunities to leverage mature standards that include hundreds of codes, specifications, methods, and best practices given their similarity to gas metal arc welding.

OBJECTIVE

This project aimed to substantiate a relevant qualification procedure to accelerate the application of arc DED within the U.S. Navy for two important structural materials—HY80 steel and nickel aluminum bronze alloy C63200. Prior efforts focused on standard qualification builds, requirements, and process validation for single-sided non-integral build platform structures. This project extended qualification procedures and requirements to include integral build platform structures for single-sided and double-sided builds using nickel aluminum bronze and high-strength steel alloys, respectively.



**AMERICA MAKES
TECHNOLOGY
DEVELOPMENT
ROADMAP**

This project aligns to:



PROCESS

**ASTM PROCESS
CATEGORY**
Directed
Energy Deposition

EQUIPMENT
Pulsed Gas Metal
Arc Directed Energy
Deposition

MATERIAL
Nickel Aluminum
Bronze Alloy
C63200
HY-80 steel

TECHNICAL APPROACH

The team worked with NAVSEA to update the draft process requirements for the metal-directed energy deposition technical publication. Feedback and recommendations addressed necessary considerations for qualification and relevant mechanical testing for arc DED processes. The team developed the processes and procedure qualification requirements for integral build platform single and double-sided arc DED structures. Arc DED was completed for nickel aluminum bronze alloy and HY-80 high-strength steel. Process parameters and procedures were developed and validated from builds that consisted of sub-scale geometries representative of a full-scale standard qualification build. Metallographic evaluation of the build microstructures demonstrated the feasibility of producing acceptable material devoid of a lack of fusion, porosity, or cracking. Full-scale standard qualification builds were produced using the validated process parameters and procedures. A non-destructive test plan/procedure was developed and documented for the full-scale standard qualification build. Mechanical testing requirements were developed. Various mechanical test specimen designs, specimen extraction locations, and associated types of mechanical testing were reported including bend, tensile, and Charpy v-notch assessment.

ACCOMPLISHMENTS

Key accomplishments included the successful design and production of HY80 and C63200 standard qualification builds for integral single- and double-sided build platform arc DED structures. These novel qualification builds offer a standardized methodology to quantitatively evaluate arc DED material and product quality. The project team developed a process documentation and inspection framework which allows operators to capture key process information and outlines a method for inspection and qualification testing for a standard qualification build. Process parameters and procedures were developed which demonstrated the feasibility of producing acceptable material devoid of lack of fusion, porosity, or cracking. The materials and qualification build geometries investigated are relevant to a wide range of applications including pressure vessels, high-performance piping, valves, sonar equipment, seawater pump bodies, gears, weapons handling equipment, steam generation equipment, and desalination plants. The work provides a vital step in addressing qualification and certification criteria necessary for utilizing arc DED in a broad range of naval applications.

PROJECT END DATE

June 2020

DELIVERABLES

- Review of NAVSEA welding and casting specifications
- Review of the draft DED Technical Publication document to identify gaps in the document and provide recommendations to improve clarity of requirements for arc DED
- A presentation detailing two procedure (single and double-sided structure) qualification schemes
- CAD models and 2D drawings corresponding to both procedure qualification schemes
- Proposed AMPS and AM-PQR forms for both procedure qualification schemes
- DED qualification procedures report
- Final report

FUNDING

\$200,000 total project budget

PROJECT PARTICIPANTS

Project Principal: EWI

Public Participants:

U.S. Department of Defense
Naval Surface Warfare Center