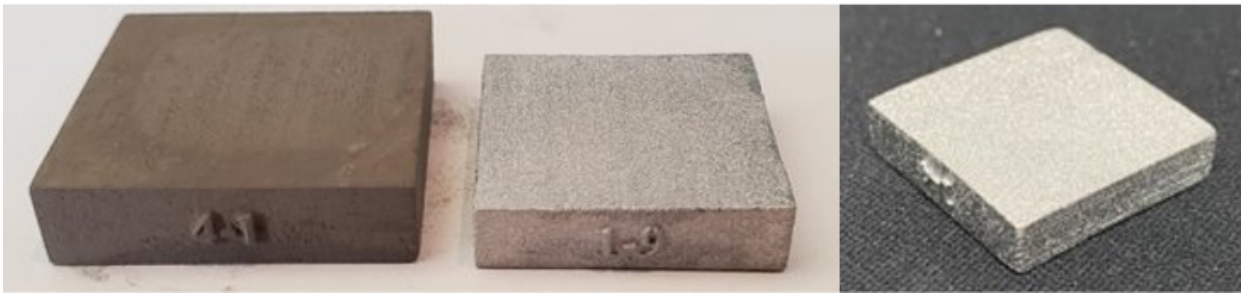
SUCCESS STORY 5503.001

Post processing of high strength steel reached densities of >98%

Collaboration leads to development and qualification of additively manufactured high-strength steel



AF 9628 steel virgin powder coupon sintered with a measured density of 99.17%.

PROBLEM

AF9628 is a high-strength low alloy steel developed at the Air Force Research Laboratory (AFRL). It is advantageous for its high strength and hardness without requiring expensive alloying elements such as tungsten or cobalt. AF 9628 has furthermore shown to have good outcomes when produced by laser additive manufacturing techniques, allowing for the fabrication of high-strength parts in an array of novel geometries.

OBJECTIVE

Increasing the AM production speed for AF9628 while reducing property anisotropy and residual stresses by developing process parameters for binder jetting this material was the objective of the project.

TECHNICAL APPROACH

The ExOne Company (ExOne) led the program which included AFRL, the National Science Foundation, America Makes, and the Department of Energy. Samples of AF 9628 steel powder were printed on the ExOne Innovent+ binder jetting system. The printed samples were sintered in an Elnik and CM tube furnace to prepare for density testing and microscopy. ExOne iterated the process until green densities of greater than 98% were reached to develop optimized print parameters. The optimized print parameters were used to print 50 tensile samples and 50 charpy bars. All of the printed samples were sent to Bodycote for heat treatment following an AFRL-provided schedule. The samples were then shipped to AFRL for tensile and impact testing.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

MATERIAL

ASTM PROCESS CATEGORY
Binder Jetting

EQUIPMENT
ExOne Innovent+

MATERIAL
AF 9628 Steel

ACCOMPLISHMENTS

ExOne successfully developed powder binding print parameters and the ability to post-process AF 9628 high-strength steel reaching sintered densities of >98%. After developing optimized print parameters, tensile and Charpy bars were produced, heat treated, and sent to the AFRL for tensile and impact testing. 100 test samples were printed, sintered, and heat treated for characterization. Testing results indicated that, unlike other materials, AF 9628 reached higher green densities when using a fast-spreading speed because it readily oxides. To keep the AF 9628 powder from oxidizing and causing lower green densities, all subsequent testing was conducted in a vacuum. Additionally, when sintering this material, it was critical that variations or hot zones in the furnace were eliminated. For all samples to reach the same density, the temperatures in the furnace had to be uniform. For each furnace, it was recommended to plot sintered density vs. sintered temperature to understand any variance between furnaces.

PROJECT END DATE

May 2021

DELIVERABLES

- Print parameters for AF 9628 Steel
- 40 tensile samples, 50 charpy samples shipped to AFRL
- Final report

FUNDING

$80,000 total project budget

PROJECT PARTICIPANTS

Project Principal:
ExOne Company

Other Project Participants:
NCDMM/America Makes
Air Force Research Laboratory (AFRL)

Public Participants:
U.S. Department of Defense