

# ADVANCED SPACE PROPULSION

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L-PBF GRCop-42 Fuel Injector



ADDITIVE MANUFACTURING ENGINEERING

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# L-PBF GRCop-42 FUEL INJECTOR

## About this part

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This injector head of an augmented spark-ignited torch brings together the gaseous propellants (oxygen and hydrogen or oxygen and methane) and electrical energy to generate a 3,000°F flame that is injected into the main combustion chamber to initiate combustion of the main stage propellants. The IN Space igniter is able to start and operate at high pressures making it ideal for rapidly starting up combustion devices used on launch vehicles. This particular torch burns about 0.1 lbm/s (pounds per second) of propellant flow to ignite 13 lbm/s of liquid oxygen and methane in a next-generation, 5,000 lbf thrust combustion chamber being tested at Purdue University.

Following assessment of the printed injector component, future plans for the igniter are to incorporate the igniter chamber and main chamber interface to reduce part count and eliminate the need for high temperature seals.

This part was printed on an EOS M400 machine by AME using laser powder bed technology (L-PBF). This L-PBF technology enables both the design optimization of the components flow channels as well as the fabrication of the novel copper alloy GRCop-42. GRCop-42 is Cu-Cr-Nb alloy developed by NASA Glenn Research and designed to possess excellent thermal conductivity, oxidation resistance, elevated temperature strength, creep resistance, and long low-cycle fatigue life. AME developed GRCop-42 printing capabilities to support the needs of NASA Marshall Space Flight Center (MSFC) and commercial space customers.

After printing, the part was thermally treated via hot isostatic pressing (HIP), and then polished via the Chemical Polishing (CP) process of REM's Extreme ISF® Process suite of technologies. The internal channels and exterior surfaces were CP'd to remove roughness, reduce surface waviness, remove potential foreign object debris (FOD), remove the HIP-oxide layer, and to reduce pressure drop caused by surface texture. Exterior surfaces for this application do not require ultra-low surface roughness, but if desired, REM's Chemical-Mechanical Polishing (CMP) process can be employed to produce roughness values <4 µin. REM developed their GRCop-42 polishing capability in conjunction with NASA MSFC and has applied this technology to injectors, combustion chambers, and nozzles for both NASA MSFC and commercial space customers.

# IN SPACE LLC

## About the Designer

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IN Space LLC is a research and development and engineering services firm providing solutions for the aerospace propulsion sector. The company's research focus is on increasing the performance and operability of propulsion systems while reducing system costs and program risks. Its decades of designing, building, testing, and analyzing parts, assemblies, and systems associated with aerospace vehicles have supported development efforts by other organizations creating the next generation of launch vehicles and spacecraft. Company customers include various branches and agencies of the U.S. Department of Defense, NASA, and companies ranging from legacy propulsion firms to New Space startups. IN Space LLC is located in West Lafayette, IN.



**ADDITIVE MANUFACTURING ENGINEERING**

## AME About the Printer

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Additive Manufacturing & Engineering, Inc. (AME) is a Small Disadvantaged Business (SDB) specializing in metal additive manufacturing. AME has assembled a team of engineers, technicians, and metallurgists with over 35 years combined experience in metal additive manufacturing, heat treatment, and design optimization for metal additive manufacturing with applications including aerospace and military components, new materials development and process optimization. Past and current customers include NASA, DoD, DoE, NIST, America Makes, and the National Center for Manufacturing Sciences. AME is ISO9001:2015, AS9100D Certified and ITAR registered, and is a member of America Makes. AME is located in Huntsville, AL and is a member of the NASA RAMPT project.

# REM SURFACE ENGINEERING



## About the Surface Finisher

REM Surface Engineering (REM) is a family owned, small business with over 60 years of continuous operation specializing in surface finishing and polishing of metal components. REM are the inventors of isotropic superfinishing and their Extreme ISF® Process is the leading metal additive surface finishing process for component performance benefits including increases to fatigue life, increases to corrosion resistance, improvements to part cleanliness, and improvements to fluid flow properties. Past and current customers include NASA, DoD, DoE, and numerous aerospace OEMs/commercial space launch companies. REM has received 6 SBIR grants in the past 4 years including currently active Phase 2 and Phase 3 SBIR's with NASA and the US Air Force. REM is ISO9001:2015, AS9100D Certified and ITAR registered, and is a member of America Makes. REM has business locations in Southington, CT; Merrillville, IN; and Brenham, TX; as well as a sister company located in St. Neots, UK. REM is a member of the NASA RAMPT project.



## America Makes