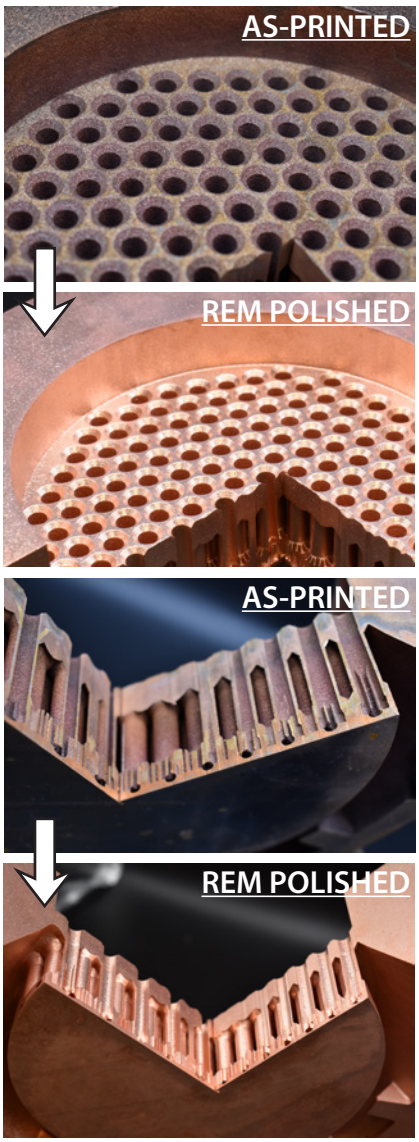
REM Surface Engineering

LAUNCHER

COPPER SURFACE FINISHING FOR SPACE APPLICATIONS

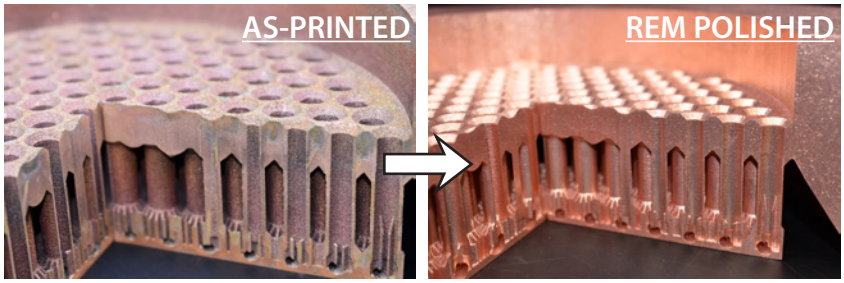


Copper is an important material to the rocket propulsion industry due to its high thermal conductivity. Thrust Chamber Assemblies (TCA's) and associated components such as fuel injectors and heat exchangers are excellent component applications for copper alloys.

While GRCop-42, a novel copper alloy developed by NASA Glenn Research Center, is showing strong potential in L-PBF rocket component applications, legacy alloys such as C18150 (CuCrZr) have and continue to demonstrate excellent performance in rocket engine applications with Launcher Space demonstrating multiple successful hot-fire tests of C18150 TCA's with both its E-1 and E-2 engines.

This heat exchanger is an example of both the additive manufacturing (AM) printability of C18150 for complex component applications as well as some of the surface finishing capabilities of REM's Extreme ISF® Process for this alloy. Heat exchangers, TCA's and other components where a high degree of heat transfer is desirable can benefit from having a high degree of surface roughness/texture. However, L-PBF and other powder-based AM processes suffer from significant amounts of granular roughness that can create problems in the form of particle shedding (cleanliness) and significant pressure drop.

REM's Chemical Polishing (CP) process is capable of eliminating the granular roughness from AM surfaces and either maintaining a high degree of surface texture or reducing surface texture and roughness as per the needs of the application/customer. On this heat exchanger component, REM is demonstrating our ability to reduce surface texture while removing granular roughness and oxide layers from the component's surface; final roughness values produced are in the 1.0 – 2.5 µm range.



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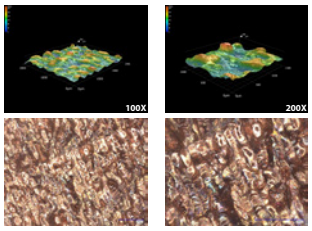
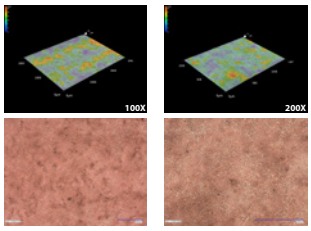
AS-PRINTED



REM POLISHED



REM's CP process (as shown here) has been proven reliable and repeatable across hundreds or rocket engine components and numerous successful hot-fire tests including Launcher's first successful E-2 engine hot fire demonstration. The CP process is capable of maintaining fine component features, maintaining or improving orifice shape, and maintaining tight material removal tolerances (+/- 25 um); additionally, the CP process can affect more significant material removal (>500 um) to produce desired wall thicknesses with robust material properties. Lastly, the CP process is capable of removing undesirable oxide layers such as those from thermal treatments (ex. HIP). REM CP processed combustion chamber and fuel injector components have displayed pressure drop reductions in excess of 70% as compared to as-printed surfaces.

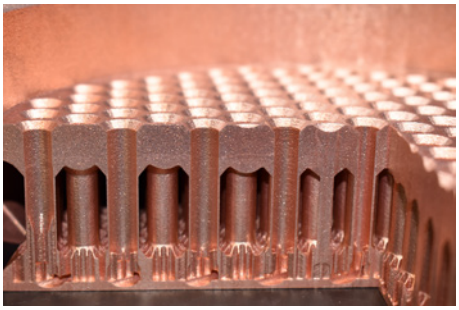
Launcher

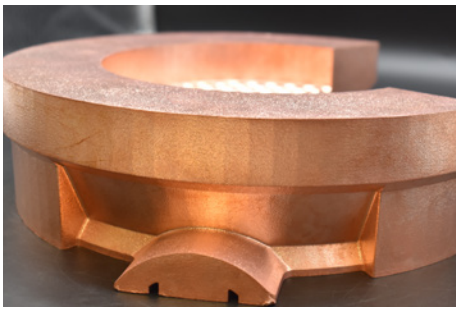
Launcher is an industry-leading commercial space launch company focused on providing low-cost access to space via its small launch vehicle, Light, as well as tailored satellite placement and payload hosting via its spacecraft, Orbiter. Launcher has multiple Air Force/Space Force awards including recent TACFI related to its E2 liquid rocket engine, and Orbital Prime to study the use of Orbiter for removing space debris.

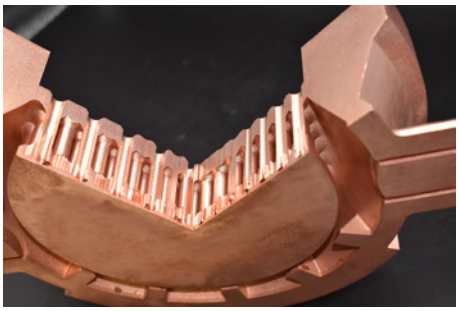
REM Surface Engineering

REM is a leading surface finishing/polishing technology supplier to both traditional and metal additive manufacturing markets. REM is a supplier to NASA MSFC, NASA JPL, the US Army, the US Air Force, the US Navy, and dozens of premier commercial customers who require the highest degree of surface finishing and quality control.

REM POLISHED







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