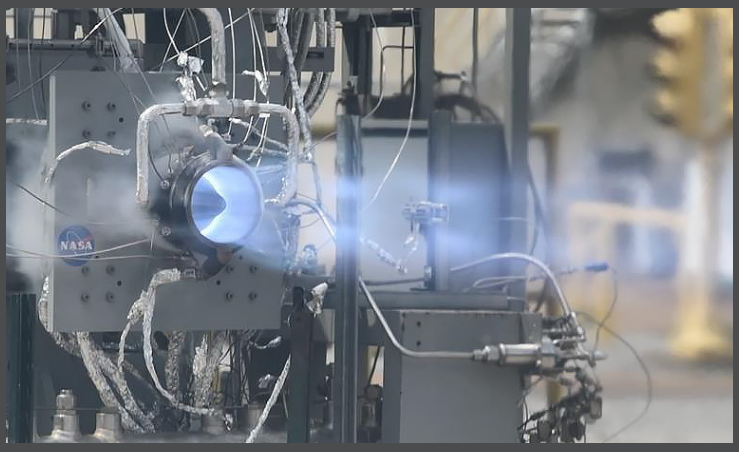
Internal Surface Finishing for Metal AM Components

Optimizing Internal Channels with REM's Extreme ISF® Process

Metal Additive Manufacturing offers unique opportunities to fabricate components with complex internal channel features in a single forming step. This fabrication capability can yield improved component and system performance as well as reduced production costs/lead times. However, powder-based AM components suffer from high levels of granular surface roughness which can result in poor flow properties and significant pressure drop; additionally, these granular surfaces commonly exhibit high levels of particle shedding, causing cleanliness and foreign object debris (FOD) issues.

REM Surface Engineering's Extreme ISF® Process includes REM's Chemical Polishing (CP) technology which is a controlled chemical dissolution process, optimized to controllably alter surface texture with a high degree of precision. REM's Chemical Polishing technology has demonstrated excellent applicability to internal channel applications due to its ability to remediate the aforementioned, AM-surface related challenges.



NASA's rotating detonation rocket engine (RDRE) hot fire test, Image courtesy of NASA.

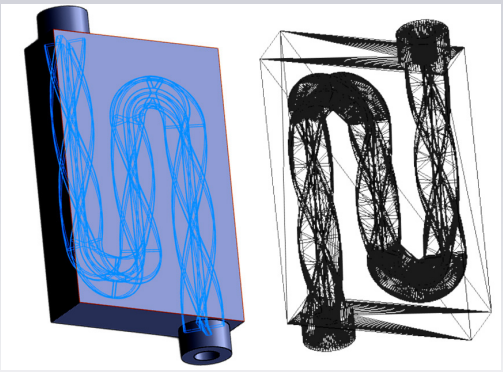
Internal Channel Process Benefits

PBF-LB/GRCop-42 components

- Reduction of pressure drop vs. as-printed surfaces (>70% per NASA Study[1])
- Improved cleanliness from greater than Class 6 to less than Class 2 per SAE AS4059
- Consistent surface material removal and texture generation throughout long and/or complex channels
- Complete removal of granular surface roughness

[1] Teasley, T., Gradl, P., Garcia, M., Williams, B., Protz, C. "Extreme Environment Hot Fire Durability of Post Processed Additively Manufactured GRCop-Alloy Combustion Chambers". AIAA Propulsion and Energy Forum (2021), https://doi.org/10.2514/6.2021-3233.

PBF/EB-Ti-6Al-4V Internal Channel Study

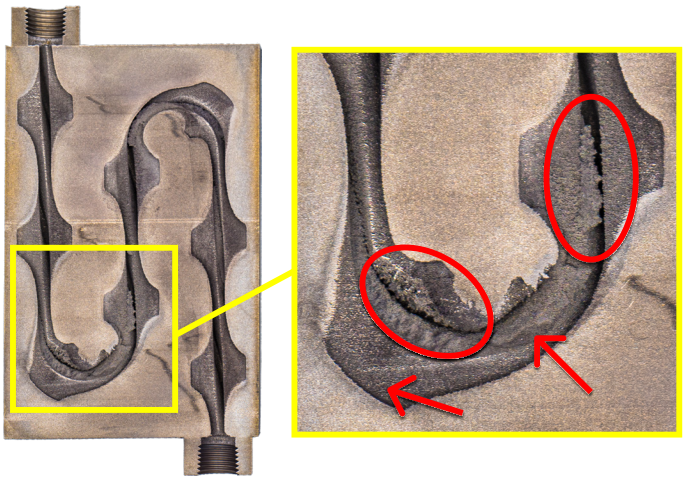


REM undertook an Air Force SBIR program to study some of the effects of its Chemical Polishing (CP) process on complex internal channels with varying degrees of powder occlusion. The study utilized PBF-EB components so as to ensure high levels of starting roughness and prevalent powder/powder-cake blockages.

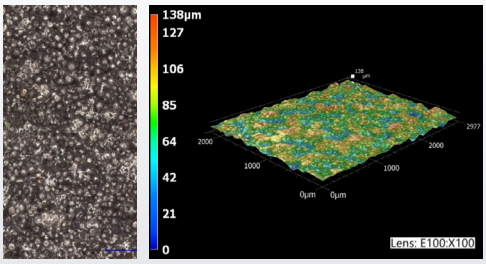
REM's CP process was able to uniformly clean and reduce the surface roughness of these moderately complex internal channels. Internal geometries were maintained and no variation of surface finish could be observed. The final surface produced exhibited a consistent residual texture devoid of any residual granular roughness or any sharp angled micro-features.

Subsequent cleanliness testing exceeded Class 2 levels per SAE AS4059.

Incoming Condition

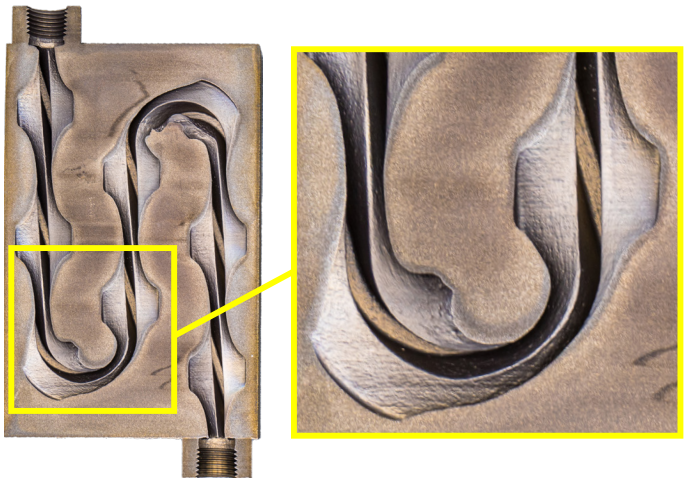


- Loose, partially-sintered powder blockages
- Highly granular surface
- High surface roughness/texture

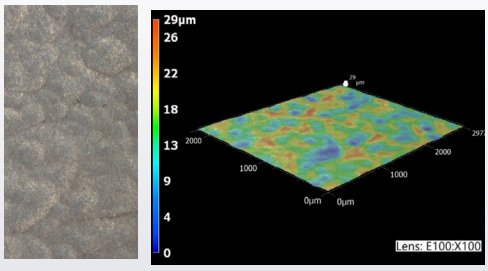


Parameter	Value (µm)
Ra	14 ± 4
Rq	17 ± 5
Rz	66 ± 17
Rp	32 ± 13
Rv	34 ± 5

After Processing



- All blockages and powder particles removed
- Gentle, slightly wavy surface remains
- Surface roughness/texture significantly reduced



Parameter	Value (µm)
Ra	2.4 ± 0.1
Rq	3.1 ± 0.1
Rz	10.9 ± 0.8
Rp	5.3 ± 0.2
R v	5.6 ± 0.7

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REM quality management system is certified to ISO 9001:2015 and AS9100:2016 Rev D
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