RESEARCH PARTNER

**Fraunhofer IFAM Dresden**

Material and process development for the joint R&D program

# INCONEL 713C

## MATERIAL DEVELOPMENT WITH MOLDJET

A difficult-to-print nickel superalloy qualified through paste formulation and sinter development - then validated on a real marine engine component.

713C

NICKEL-BASED SUPERALLOY

## KEY HIGHLIGHTS

### THE CHALLENGE

Inconel 713C is a high-gamma-prime nickel superalloy that is prone to cracking when processed by melt-based metal AM.

### THE SOLUTION

Fraunhofer IFAM developed a 63 vol.% water-based MoldJet paste and a tailored debinding/sintering route.

### THE RESULT

99.7% relative density, 1166 ± 73 MPa tensile strength and 12.5 ± 2.5% elongation - validated on a marine fuel-injection nozzle.

## THE CHALLENGE

Nickel-based superalloys are used in hot-gas-path and high-stress components because they retain strength and resist oxidation and corrosion at elevated temperatures. The same metallurgy makes Inconel 713C difficult to process with laser powder bed fusion: rapid localized melting and solidification can promote solidification cracking, microcracking and heat-treatment sensitivity.

Complex target geometries add another constraint. Fuel nozzles and similar parts can contain narrow internal channels that are difficult to clear of loose powder after a powder-bed build.

## THE MOLDJET APPROACH

MoldJet separates shaping from densification. A wax-like mold is inkjet-printed, filled with metal-powder paste, dried layer by layer, demolded, thermally debind and sintered. The metal is not melted during shaping, shifting material qualification from melt-pool parameter tuning to feedstock rheology, drying, green strength and sintering.

# MATERIAL DEVELOPMENT PLAYBOOK

Fraunhofer IFAM Dresden developed a MoldJet-processable paste from gas-atomized Inconel 713C powder and established a repeatable route from feedstock screening to real-part validation.

1. Select commercially available MIM-grade powder rather than a laser-specific narrow-spec powder.
2. Formulate and screen a water-based paste for rheology, drying, sedimentation resistance, wetting and green strength.
3. Transfer the qualified paste to a Tritone MoldJet system and print multi-geometry build jobs.
4. Establish thermal debinding and sintering, using in-situ FTIR gas analysis to identify critical temperature ranges and hold times.
5. Characterize green/sintered properties and validate the material on an end-use demonstrator.

### PASTE DEVELOPMENT

The water-based formulation reached 63 vol.% powder loading and was engineered to prevent sedimentation, deliver precise shear-thinning flow for cavity filling, and dry quickly after deposition without drying inside the print head.

# FRAUNHOFER IFAM R&D RESULTS

| Property | Target / Reference | Measured in joint R&D |
|---|---|---|
| Tensile strength (RT) | > 760 MPa (968 MPa MIM ref.) | 1166 ± 73 MPa |
| Yield strength (RT) | > 690 MPa (734 MPa MIM ref.) | 756 ± 20 MPa |
| Elongation at fracture | > 3% (7.16% MIM ref.) | 12.5 ± 2.5% |
| Relative sintered density | - | 99.7% |
| Carbon content | 0.08-0.20 wt.% (SAE AMS 5391) | 0.013 wt.% |
| Surface quality (sintered) | - | Ra 1.5-3.5 µm / Rz 7-15 µm |

In the reported R&D program, the measured mechanical properties met or exceeded the stated targets. The values above are shown against the cited MIM references.

## REAL-WORLD VALIDATION

The qualified paste was used to print a fuel-injection-valve nozzle for a WinGD large-bore two-stroke marine engine. The component must operate continuously above 300°C in a combustion environment affected by vanadium and sulphur in marine fuels.

| 47 mm | 0.4-2.0 mm | 50 µm |
|---|---|---|
| component height | internal channel diameters | layer thickness |

The intricate internal flow channels could not be produced by conventional machining, and MoldJet required no support structures inside the geometry.

## TRITONE PERSPECTIVE: PROCESS CONSIDERATIONS

The comparisons and commercial estimates below are Tritone's own assessment for this geometry. They are not conclusions or validation by Fraunhofer IFAM.

| | | |
|---|---|---|
| **BUILD RATE** | PBF-LB approx. 100-250 cm³/h | **Tritone spec.: up to 1600 cm³/h** |
| | Tritone estimate: approx. 6-10x productivity potential for this geometry. | |
| **SURFACE FINISH** | PBF-LB Ra > 10 µm | **R&D result: Ra 1.5-3.5 µm** |
| | The MoldJet value shown here is the measured result from the joint R&D program. | |
| **SUPPORTS** | PBF-LB: supports + removal | **MoldJet: no internal supports used** |
| | Tritone estimate: 10-20% total manufacturing cost savings from eliminating this step. | |

### ROLE OF FRAUNHOFER IFAM

Fraunhofer IFAM's contribution covered paste formulation, debinding and sintering development, material characterization and the demonstrator. Productivity, cost and broader technology-benefit statements in this case study are Tritone's own.

## CONCLUSION

The joint program demonstrated a route for processing Inconel 713C through paste formulation, debinding and sintering, and validated the resulting material on a complex marine demonstrator. Fraunhofer IFAM contributed the material and process R&D. Tritone's broader statements on MoldJet productivity, economics and technology positioning remain Tritone's own.

### ABOUT TRITONE TECHNOLOGIES

Tritone develops MoldJet® technology and additive manufacturing systems for scalable industrial production of high-quality metal and ceramic parts.

Tritone

Source: Teuber et al., “Production of Nickel-based Superalloy Parts by Using the MoldJet® Technology”.