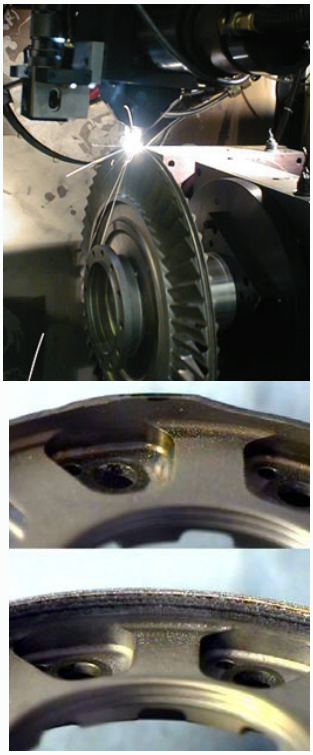
LENS® Superalloys

LENS® systems use state-of-the-art Additive Manufacturing Technology to restore the functionality of superalloy components.



Examples of superalloy components repaired with the LENS process.

Nickel-base superalloys offer outstanding strength and creep resistance at high temperatures, along with excellent oxidation and corrosion resistance. Superalloys can operate at temperatures up to 1100° C, and with the help of air cooling and thermal barrier coatings, superalloy turbine blades can operate in ambient temperatures that significantly exceed their melting point. Applications for superalloys include many components in gas turbine engines, such as blades, vanes and cases; rocket engines; and applications where the corrosion resistance is of value, such as chemical handling.

Many nickel base superalloys are difficult to weld. Without careful process controls, macroscopic defects such as cracks and porosity are relatively easily formed. Even if these defects are avoided, achieving high strength and ductility in the weld material is often difficult, due to the extreme requirements put on these types of materials, and the fact that they are typically optimized for forging or casting, rather than welding. The LENS process is able to repair a wide range of nickel-based superalloy components, because the laser and powder feed can be very carefully controlled.

FEATURES

- Complete Atmosphere Control – full protection for highest quality
- Closed-loop controls – precision process control
- Rapid solidification rates (>1000°C/s) – fine microstructures
- Low heat input – low distortion and heat-affected-zone
- Fiber Lasers – Reduced cost of ownership

APPLICATIONS

- Repair of worn components
- Rework of mis-machined components
- Modification of tooling for re-use
- Hybrid Manufacturing
- Advanced Product Development

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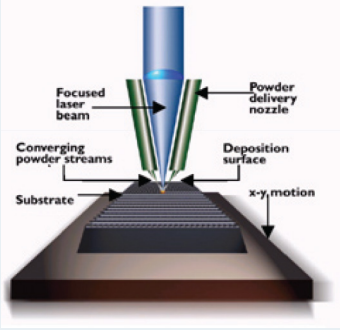
Laser Engineered Net Shaping



LENS® Deposition Head

Superalloy Metallurgy Using the LENS Process

Depending on the superalloy, the LENS process is usually operated at a slower cooling rate than with other materials, to mitigate stress build up. A pre-heat treatment is often employed to solution the Gamma prime phase. Post stress relief, and postaging are also commonly employed, to redevelop the microstructure.

Powder Specifications and Sourcing

Since LENS does not add, remove or alter the quantities of any chemical elements, the chemistry of the powder should match the chemical specification of the application. The buyer can specify the desired chemistry (for example, IN625, IN718 etc) to the powder manufacturer.

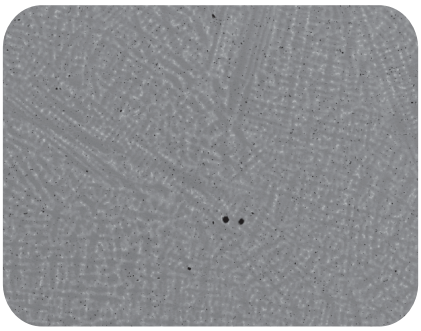
Users can choose any vendor to supply powder. ASM Powders, ATI, TLS, Praxair and Stellite are known worldwide suppliers of powder suitable for the LENS process. The typical powder size is 150 – 45 microns (-100/+325 mesh), although other sizes are acceptable. Optomec system owners can request the "LENS Powder Requirements" document for full details.

With appropriate care, most nickel base superalloys can be LENS-deposited. Commonly-processed materials are shown in the table below. Many other materials have been processed in specialized applications.

Inconels	Other Alloys
IN625	Hastelloy X
IN718	Waspalloy
IN713LC	MarM247
IN738	

Microstructure & Properties

The microstructure tends to have elongated grains running vertically through the part, with a dendritic structure usually visible.



Microstructure of LENS-deposited and heat-treated IN718, showing a dendritic microstructure.

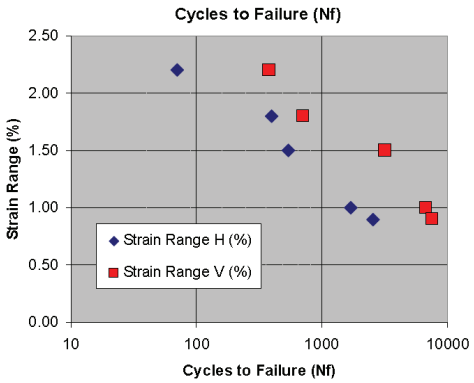
Macrostructure of LENS-deposited IN718, showing elongated grains in the Z-direction, and horizontal curved bands that indicate the layers of the build.

Tensile properties of IN625 and IN718 are shown in the table below. In general, the properties compare with wrought annealed products. Note that mechanical properties can vary with processing parameters, heat-treatment and precise chemistry.

	LENS IN625 Horizontal Direction	LENS IN625 Vertical Direction	LENS IN718 Horizontal Direction	LENS IN718 Vertical Direction
0.2% Yield Strength (MPa)	694	490	1097	1088
Ultimate Tensile Strength (MPa)	1052	829	1335	1247
Elongation (%)	33.0	43.0	16.6	21.7
Reduction of Area (%)	39.3	53.3	24.9	33

In general, LENS-deposited superalloys offers fatigue resistance between cast and wrought properties. The data below are for IN718.

Axial-axial LCF testing of IN718 under tensile loading at R=0.05, at 593C. Blue diamonds indicate samples tested along the growth direction, red squares indicate samples tested perpendicular to the growth direction.



ABOUT OPTOMEC

Optomec® is the world-leading provider of additive manufacturing solutions for high performance applications in the Electronics, Solar, Medical, and Aerospace & Defense markets. These systems utilize Optomec's patented Aerosol Jet Printed Electronics technology and LENS powder-metal fabrication technology. The company has a global customer base of more than 100 users that includes many industry-leading manufacturers.

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