Material Data Sheet
Wipro 3D – IN939

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Wipro 3D has successfully developed Nickel Alloy – IN939 known for its high tensile, fatigue, creep, and rupture strength at temperatures up to 850°C (1560°F). Parts built from IN939 can be hardened after manufacture by application of precipitation-hardening heat treatments.

The key highlight of the development is that Wipro 3D was able to develop this in 400W LPBF machine.

Characteristics of the Alloy

IN939 is known for its excellent performance in high-temperature environments. IN939 maintains high tensile, fatigue, creep, and rupture strength at temperatures up to 850°C (1560°F). The alloy exhibits excellent resistance to corrosion and oxidation, making it suitable for harsh environments. IN939 maintains good ductility even in the age-hardened condition, which is crucial for manufacturing and operational reliability. The alloy is resistant to strain-age cracking and remains crack-free in the as-built condition. IN939 can be hardened through precipitation-hardening heat treatments, which enhance its mechanical properties. These characteristics make IN939 an ideal material for applications in aerospace, turbine production, industrial gas turbines, microturbines, turbochargers, and various power industry parts.

Applications

1. **Aerospace Technologies**: IN939 is used in the manufacturing of components for aircraft engines and other aerospace systems. Its high-temperature strength and resistance to oxidation and corrosion make it ideal for parts that must endure extreme conditions, such as turbine blades and vanes.
2. **Turbine Production**: In both power generation and aviation, turbines operate at very high temperatures. IN939's ability to maintain mechanical properties at elevated temperatures makes it suitable for turbine disks, blades, and other critical components.
3. **Industrial Gas Turbines**: These turbines are used in power plants to generate electricity. IN939 is used in the hot sections of these turbines, where materials must withstand high temperatures and stresses over long periods.
4. **Microturbines**: Smaller turbines used for localized power generation or as auxiliary power units in various industries. IN939's durability and performance at high temperatures make it a good fit for these compact, high-efficiency systems.
5. **Turbochargers**: Turbochargers are used in automotive and industrial engines to increase efficiency and power output. IN939 is used in the turbine wheels and other high-temperature components of turbochargers, ensuring they can handle the intense heat and pressure.
6. **Power Industry Parts**: IN939 is used in various components of power plants, including those in nuclear, coal, and natural gas facilities. Its high-temperature capabilities and resistance to wear and corrosion help improve the reliability and lifespan of critical parts.

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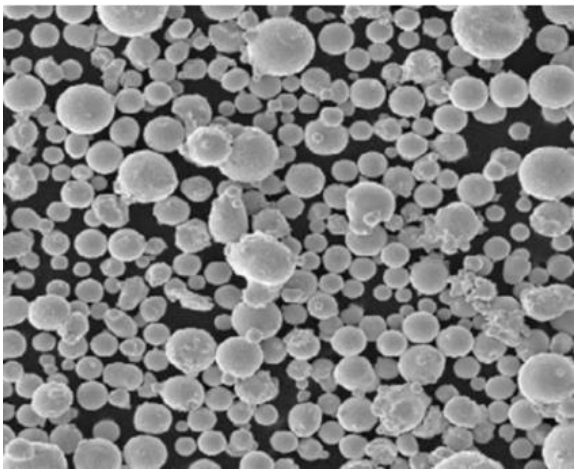
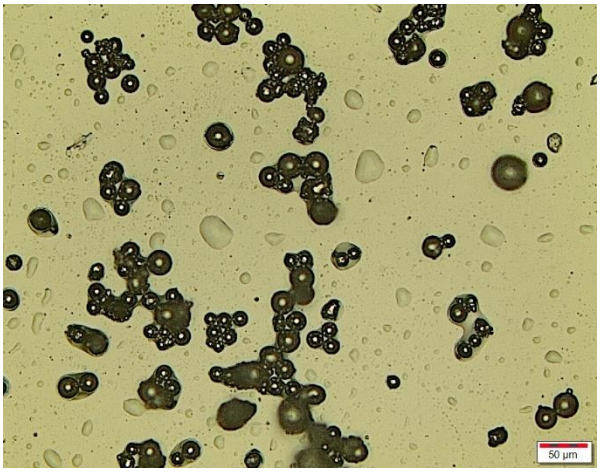
Chemical Composition

Chemical composition of raw material and built parts is compliant to table given below.

Chemical Composition (weight%)	
Element	**Limitations**
Cr	22.0-23.0
Co	18.0-20.0
Ti	3.0-4.5
W	1.0-3.0
Al	1.0-1.8
Ta	1.0-1.8
Nb	0.5-1.5
Zr	0.1-0.15
C	0.1-0.15
B	0.01

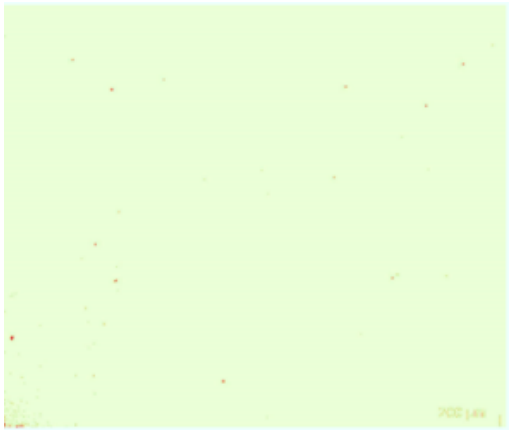
Powder Morphology

Powder morphology in SEM	Powder morphology in Optical microscope
	

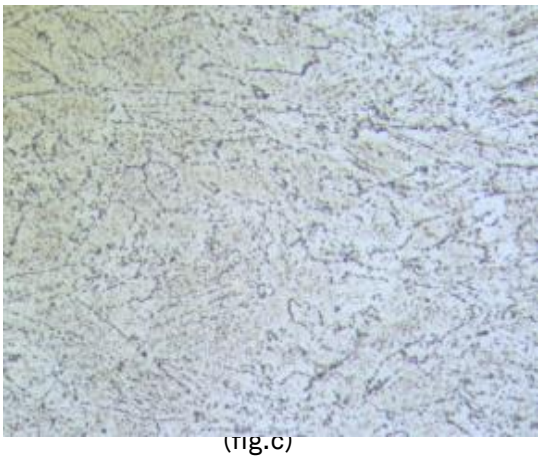
Microstructure & micro porosity

Microstructure of built parts showed >99.5% density on a well-polished surface:

(fig.a)



(fig.b)

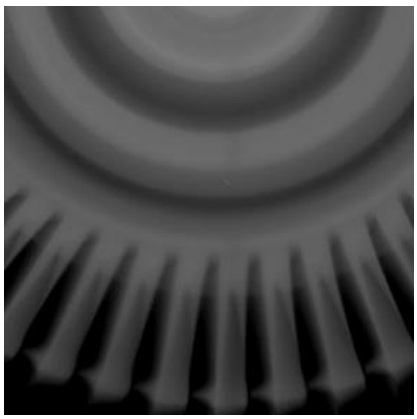


(fig.c)

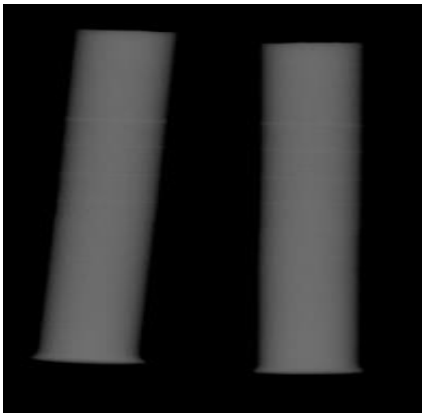
Figure (a) shows as printed-polished-unetched surface at 100X magnification, figure (b) shows Multiphase analysis to assess volume fraction of porosity, which is 0.2-0.4 across the surface and figure (c) shows as etched surface at 500x magnification showing columnar grains in the Heat-Treated condition.

Radiography & macro porosity

Radiography of sections of complex parts with internal channels (fig. d) & thick sections (fig. e) shows dense structures with excellent density.



(fig.d)



(fig.e)

Mechanical Properties

Mechanical properties of built parts confirm to below.

Room Temperature Tensile Data

Properties	HT condition values
Tensile Strength (MPa)	>1400
Yield Strength (MPa)	>1000
Elongation (%)	>8
Reduction in Area (%)	>8

There are various heat treatment methods for improving strength and/or elongation, hence if the user provides exact requirements, it can be discussed to achieve these properties.

High Temperature Tensile Data

Properties	850°C Tensile	950°C tensile
Tensile Strength (MPa)	>650	>350
Yield Strength (MPa)	>600	>290
Elongation (%)	>5	>10
Reduction in Area (%)	>5	>10

Stress Rupture Data

Properties	750°C	800°C	975°C
Yield Strength (MPa)	760	200	215
Rupture Time	11 mins	Unruptured for 65 hours	1.3 hrs

Low Cycle Fatigue Test Data

Properties	377°C	750°C
Cycles	>16000	>1700

High Cycle Fatigue Test Data

Properties	Room Temperature	750°C
Cycles	>10^6	>42000