Plastometrex

How NASA Revealed Hidden Property Variations with PIP Testing

CASE STUDY

Challenge

Mechanical properties can vary significantly across additively manufactured (AM) parts, driven by changes in local thermal history.

But traditional testing approaches force a compromise. Hardness can sample locally but does not provide a full stress-strain response, while tensile tests measure stress-strain but cannot practically map variation at small length scales.

In spaceflight applications, safety and lightweighting are paramount. But, with incomplete information, large safety factors are often built into designs to compensate, adding extra weight and inefficiency.

Objective

In collaboration with NASA, this case study used Profilometry-based Indentation Plastometry (PIP testing) to uncover property variations across a complex AM part as a means of enabling more efficient, informed design.

Testing

Sample: NASA HR-1 (Fe-Ni superalloy) C-ring, manufactured by Laser Powser Bed Fusion (LPBF).

Measurements: Mechanical properties were measured using the PLX-Benchtop, a compact indentation-based device, equipped with a standard 1 mm radius indenter.

Method: Using PIP testing, Plastometrex mapped the bottom surface of the C-ring to create yield stress (YS) and ultimate tensile strength (UTS) maps

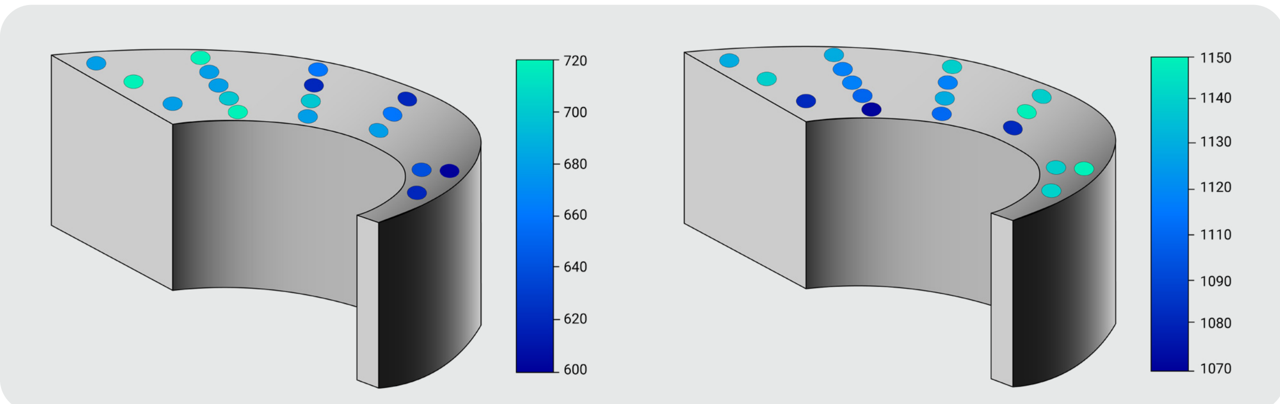

Figure 1: *Maps of a NASA HR-1 c-ring showing (left) yield stress and (right) UTS for the bottom of the sample.*

Results

Yield stress fell ~15% (~90 MPa) as wall thickness decreased from 50 mm to 10 mm, while ultimate tensile strength stayed largely constant.

Average PIP results showed strong agreement with NASA's independent tensile data: YS was within 2.6% and UTS was within 0.4%, confirming the accuracy of the test.

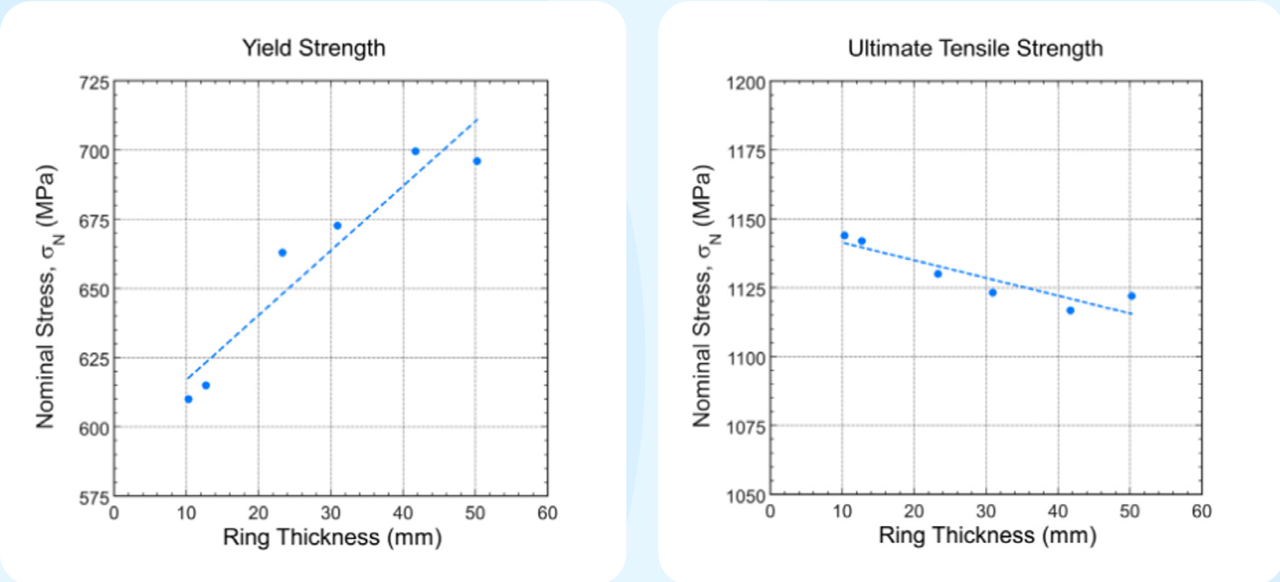

Figure 2: *Plot of (a) yield strength and (b) ultimate tensile strength as a function of c-ring thickness showing significant increases in yield strength and minor decreases in UTS as c-ring thickness increases.*

Conclusion

PIP testing revealed variations in strength that would have been missed with conventional methods, giving NASA the data to connect local performance to build conditions and geometry.

With this information, future manufacturing runs can incorporate **adjusted print parameters or tailored geometries** to maintain structural integrity without compromising safety.

EXPLORE PIP

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