PLASTOMETREX

PLX CASE STUDY

PIP Testing Small & Complex Parts:

Aluminium Bicycle Rim

In collaboration with

SPUR

Challenge

Small and complex components can be very difficult to characterise using conventional mechanical testing procedures such as uniaxial tensile testing. Conventional tensile testing requires the creation of a tensile coupon machined out of a larger section of material, which is impossible for many small and complex components. Furthermore, the production process of any part can significantly alter key material properties from the base material, so understanding the mechanical properties post-production is critical. A test which can easily obtain accurate mechanical testing data from small and complex parts would therefore be ideal for assisting in the development of these components.

Objectives

The objective of this case study was to obtain accurate mechanical testing data for a small, extruded aluminium part from a bike rim, provided by Spur, using PIP testing. If successful, it would demonstrate a practical way of obtaining key data for small and complex components with minimal processing and turnaround times.

Materials

A section of aluminium bicycle rim was provided by Spur [Figure 1]. The part was extruded and had intricate cross section designed to maximise the strength of the part and minimise its mass.

Figure 1: *A selection of aluminium bicycle rim provided by Spur.*

To demonstrate a practical way of obtaining key data for small and complex components with minimal processing and turnaround times.

Measurements

The mechanical properties (stress-strain relationships) were measured using an Indentation Plastometer, a compact indentation-based benchtop device. The technology uses the novel PIP method, developed by the former University of Cambridge materials scientists at Plastometrex. PIP uses an accelerated inverse finite element method to infer accurate stress-strain curves from indentation test data.

The PIP test takes only 3-minutes and requires minimal sample preparation (P1200). Sample sizes can be as small 3 x 3 x 1.5 mm, giving a 99% reduction in material volume needed when compared to tensile testing, which requires a full tensile coupon to be created.

Despite the small component size, three faces of the extruded part were thick enough to obtain full stress-strain behaviour, which is shown in Figure 2. This allowed for the comparison of the mechanical properties across different parts of the cross-section.

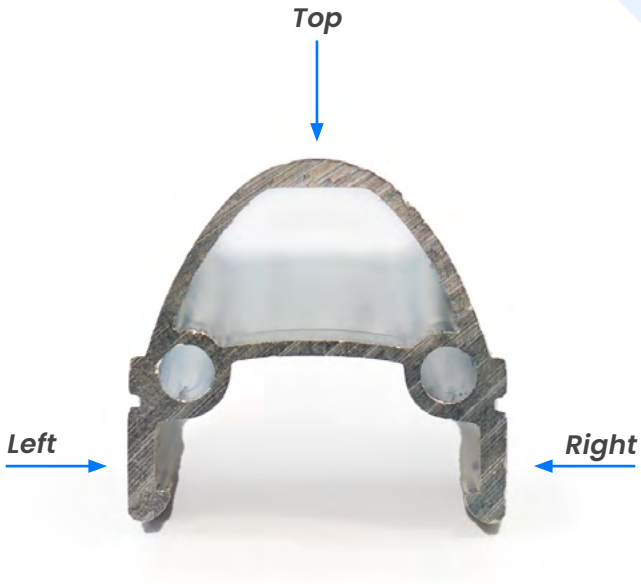

Figure 2: *Cross section of the bicycle rim showing where the PIP tests took place.*

Results

Indentation was successfully performed on all three faces to obtain full PIP-inferred stress-strain behaviour. Some anisotropy was detected, so multiple surface profile scans were taken in the extruded direction, the transverse direction and at 45° and 135° to obtain directionally averaged surface profiles. This can then be used by the PIP methodology to generate the stress-strain curves for the material.

The PIP derived stress strain data across the three indents showed similar behaviour - with the material yielding at about 270 - 280 MPa and then undergoing little work hardening until failure.

Test Location	Yield stress /MPa	UTS /MPa
Left	284 ± 7	293 (289 - 298)
Right	274 ± 8	284 (279 - 289)
Top	271 ± 9	281 (276 - 287)

Table 1: *PIP-inferred mechanical properties from the three indents*

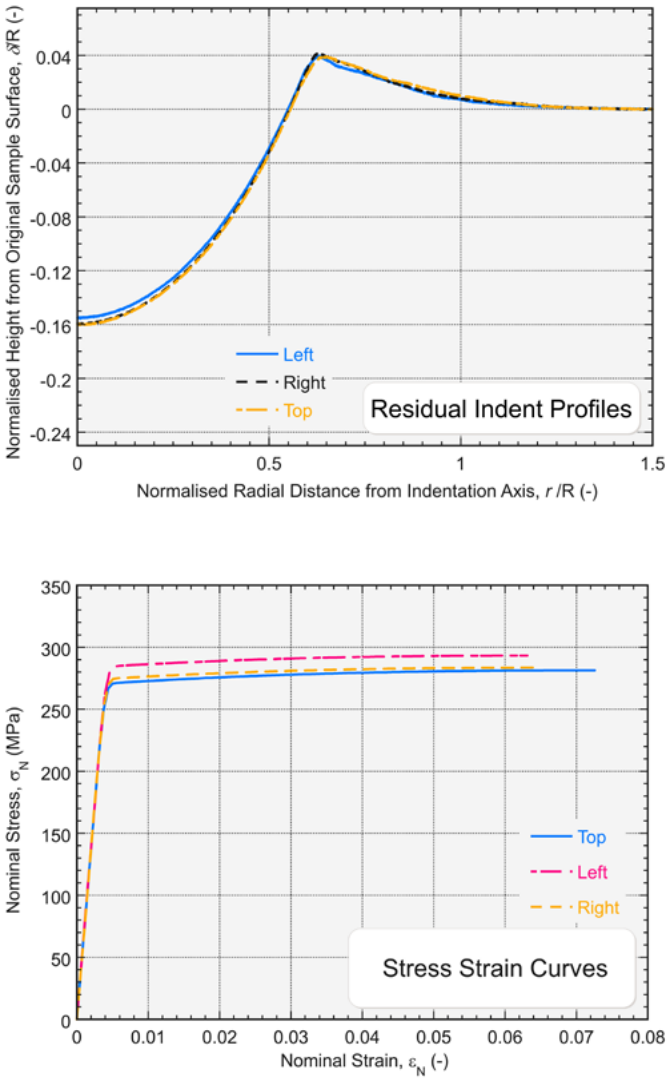

Figure 3: *The residual indent profiles of from the three indents, (b) The PIP-inferred stress-strain curves.*

Outcomes

PIP testing has successfully provided accurate data about the mechanical behaviour of a component that would have been difficult to obtain with conventional testing methods. Minimal sample volume and preparation was required enabling quick turnaround times and low material costs for such tests.

The utilization of PIP testing to obtain accurate mechanical information on small and complex parts opens up possibilities for small component manufacturers to streamline their development and production processes while obtaining vital testing data from their products.