

Profilometry-Based Indentation Plastometry for Rapid Mechanical Property Evaluation of 6xxx Aluminium Extruded Profiles with Increased Iron Content

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Introduction

Mechanical characterisation of aluminium extrusion products is commonly performed using tensile testing. While this method provides reliable measurements of strength and ductility, it requires extensive specimen machining, relatively large material volumes, and is inherently destructive. These limitations can be particularly restrictive when assessing local variations in mechanical properties within industrial extruded profiles.

Profilometry-Based Indentation Plastometry (PIP) [1] has emerged as a promising alternative for rapid mechanical characterisation [2, 3]. The technique combines instrumented indentation, high-resolution surface profilometry and inverse finite element analysis to derive constitutive material behaviour from a local indentation imprint [4, 5]. Although PIP has been successfully applied to a variety of metallic systems, its application to aluminium extrusion products remains relatively unexplored [Click or tap here to enter text.](#)

The present work evaluates the applicability of PIP for the characterisation of industrial 6xxx series aluminium extrusions. Particular attention is given to the correlation between PIP-derived mechanical properties and conventional tensile test results, while assessing the potential of the technique as a rapid and minimally invasive characterisation tool.

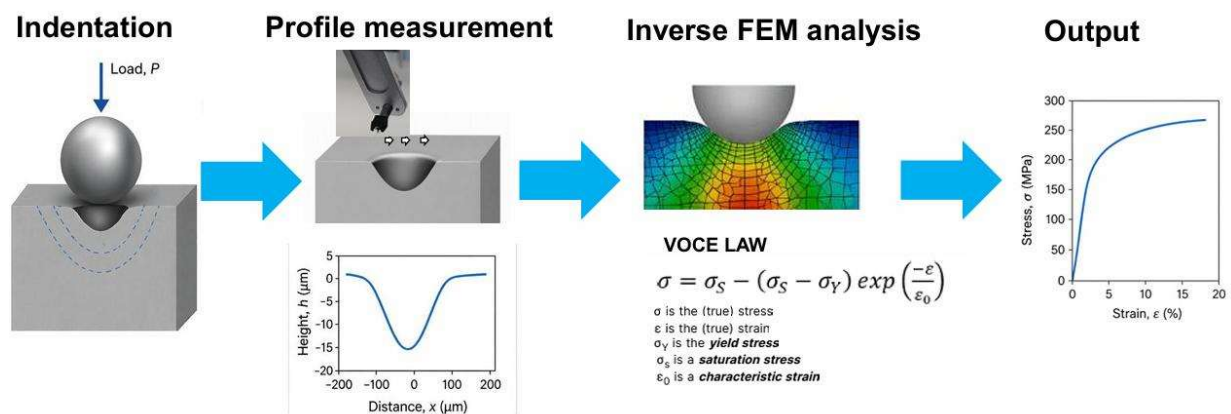


Figure 1. Schematic representation of the Profilometry-Based Indentation Plastometry process.

Figure 1 presents the overall workflow of the Profilometry-Based Indentation Plastometry methodology. Conventional uniaxial tensile testing was performed to provide a reference dataset for validation of the PIP-derived mechanical properties.

Experimental Procedure

Different 6xxx aluminium extrusion variants were investigated. The examined materials exhibited a fully recrystallised microstructure representative of commercial extrusion products. The PIP methodology consisted of four main stages: indentation testing, acquisition of the residual indentation profile through optical profilometry, inverse finite element modelling, and optimisation of the material constitutive parameters using a Voce hardening law. The resulting constitutive response was subsequently converted into an equivalent stress-strain curve for comparison with conventional tensile data.

Results and Discussion

The results demonstrate that PIP can successfully reproduce the overall tensile response of the investigated extruded aluminium alloys. Good agreement was observed between the stress-strain behaviour derived from indentation plastometry and that measured by conventional tensile testing.

Figure 2 shows a comparison between tensile and PIP-derived results. The agreement proves that the indentation-based methodology captures the key characteristics of the material deformation behaviour while requiring substantially smaller material volumes and minimal sample preparation.

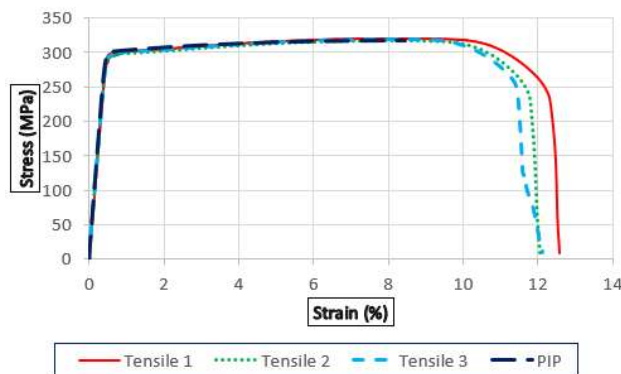


Figure 2. Comparison between stress-strain curves obtained from conventional tensile testing and Profilometry-Based Indentation Plastometry.

The findings support the use of PIP as a rapid mechanical characterisation technique for aluminium extrusion products and highlight its potential for applications where conventional tensile testing is impractical or undesirable. Further work is ongoing to extend the technique to additional aluminium alloy systems, processing conditions and microstructural states.

Conclusions

Profilometry-Based Indentation Plastometry has been evaluated as a rapid mechanical characterisation technique for different industrial 6xxx aluminium extrusions. The method successfully reproduced the overall tensile response obtained through conventional mechanical testing and demonstrated potential as a minimally invasive alternative for local mechanical property assessment. These results support further development of PIP as a practical tool for industrial quality control and materials evaluation.

References

- [1] T.W. Clyne et al., *Advanced Engineering Materials*, **2021**, 23, 9, 2100437.
- [2] T. J. F. Southern et al., *Mechanics of Materials*, **2023**, 187, 104846.
- [3] J. Dean et al., *Mechanics of Materials*, **2017**, 105, 112-122.
- [4] J. E. Campbell et al., *Acta Materialia*, **2019**, 168, 87-99.
- [5] M. Burley et al., *Advanced Engineering Materials*, **2021**, 23, 2001478