Experimental SHPB Characterisation of AISI 1045 Steel for Machining Applications

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Abstract. This study compared four specimen L/D ratios under identical SHPB testing and signal-processing conditions. Room-temperature tests were performed on 6 mm diameter AISI 1045 specimens under two loading conditions. Force equilibrium and repeatability were assessed before analysing the true stress–strain response. The results showed that specimen geometry affected the attainable strain rate and measured flow behaviour, providing validated data for future constitutive calibration in machining simulations.

Introduction

AISI 1045 experiences large strains and high strain rates during machining, making quasi-static data insufficient [1]. Because SHPB results depend on specimen geometry and force equilibrium [2,3], four L/D ratios were compared under identical processing to identify reliable data for calibration.

Experimental Method

Specimens of 6 mm diameter and four lengths were tested at two striker pressures, with three repeats per condition. Strain-gauge voltage signals were converted to elastic strain and processed using REL SURE-Pulse. One-dimensional wave analysis provided true stress, true strain and strain rate, using only stable force-equilibrium intervals [2].

Results and Discussion

A valid equilibrium region was defined where the force difference between the two specimen faces remained below 10% [4]. Figure 1 shows that shorter specimens produced higher force levels and strain rates. The L/D = 0.25 specimens reached 1442–2026 s^{-1}, whereas L/D = 1 reached 743–843 s^{-1}. Despite signal oscillations, increasing L/D consistently reduced the attainable strain-rate range. The L/D = 0.5 specimens exhibited the longest equilibrium interval and therefore appeared to provide the most suitable geometry among those tested.

Figure 2 shows gradual strain hardening, with the highest flow stresses, approximately 1.1–1.2 GPa, obtained for L/D = 0.25 and the lowest for L/D = 1. Specimen geometry had a more pronounced effect on the measured response than the change in striker pressure. However, the higher striker pressure increased the attainable strain and produced greater specimen deformation. Because geometry and strain rate varied together, the curves were interpreted as combined geometry–rate responses rather than as evidence of pure strain-rate sensitivity.

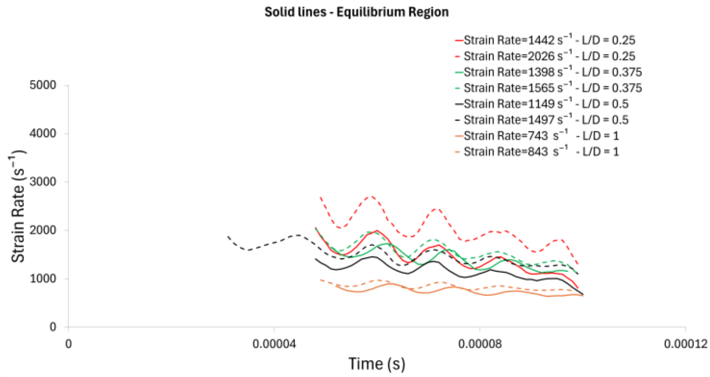

Fig 1. Processed force histories for four specimen L/D ratios under two loading conditions.

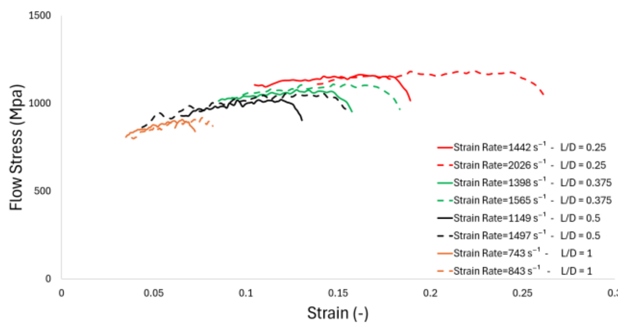

Fig 2. True stress–strain responses for four L/D ratios and eight strain-rate conditions.

Conclusion

- SHPB tests produced repeatable data for four L/D ratios.
- Shorter specimens reached higher strain rates, while L/D = 0.5 gave the longest equilibrium interval.
- Specimen geometry had a stronger effect than striker pressure.
- The results support future constitutive calibration for machining simulations.

References

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