Strain Rate Sensitivity Testing of Paliney® 7

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The rate at which a material is deformed can have a significant effect on mechanical properties such as yield strength, tensile strength, and tensile elongation. At the low end of the deformation rate spectrum are events like creep and stress relaxation, where materials deform very slightly in the days, weeks, or months following their initial loading. High deformation rate events, such as an impact, instead occur over millisecond timescales.

While the boundaries of strain rate sensitivity are difficult to test, rates between ~0.1 /s (10^{-1} /s) to 0.0001 /s (10^{-4} /s) are within the limits of commonly available tensile equipment. The strain rate sensitivity of 0.003 inch diameter Paliney® 7 wire within this range was evaluated for five commercially available tempers.

Results of the testing are presented in Figures 1 and 2. The yield strength increases consistently with higher rates of strain.The increase in yield strength over the full range of testing varied from 4% to 7% (5 ksi to 9 ksi) depending on the temper. The same trend was true of ultimate tensile strength, with observed increases of 2% to 3% (3 ksi to 5 ksi) over the full range of speeds tested depending on the temper. Trends for tensile elongation are more difficult to determine, as there is more variation between tests at the same strain rate. Variation within a strain rate are frequently as high as 2% strain or 10% of average. No strong elongation trends were observed in the annealed, heat treated, and semiconductor straight conditions. The ductile heat treatment and stress relieved conditions show some decrease in elongation at higher strain rates.

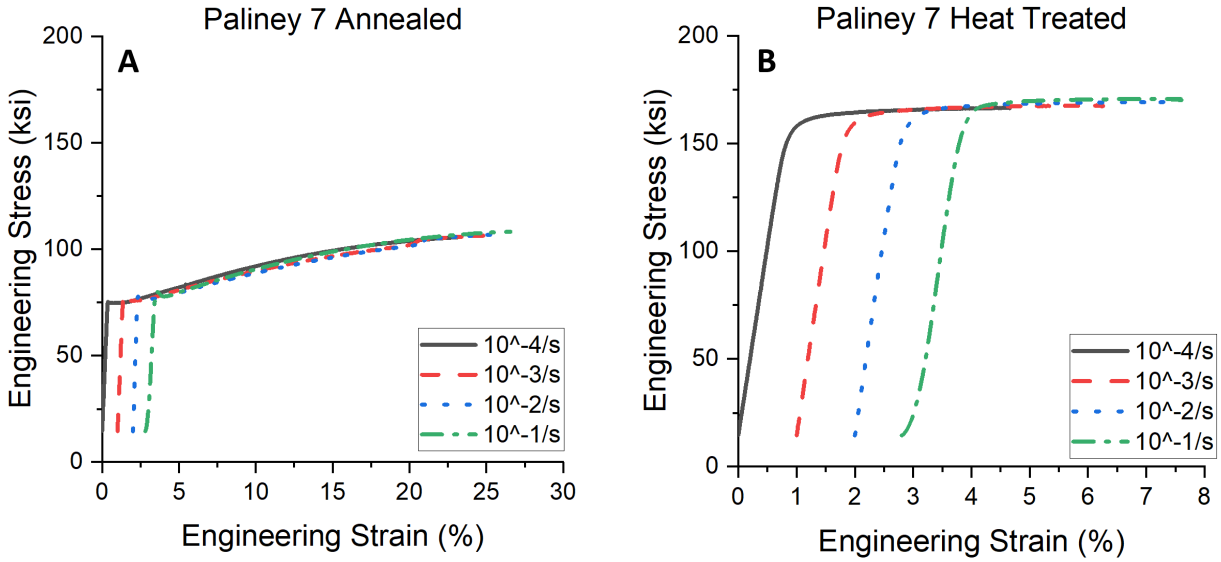

Figure 1: *Stress-strain curve comparisons of Paliney® 7 at different strain rates in the A) annealed and B) heat treated conditions. Curves are offset by 1% strain for clarity.*

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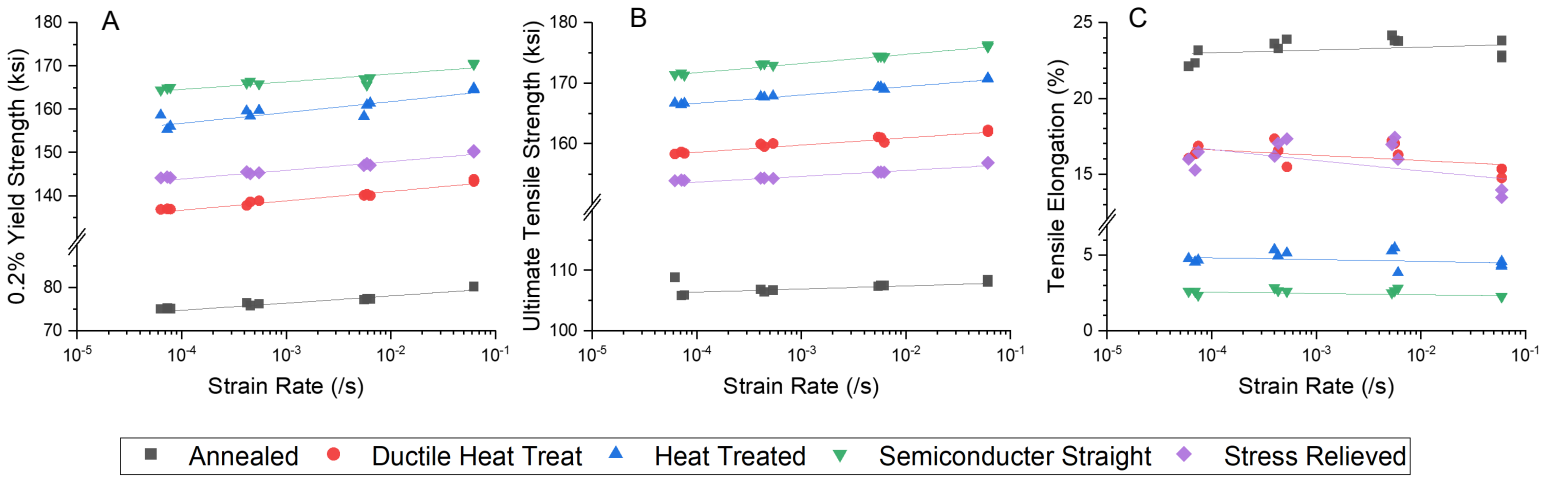

Figure 2: *Comparisons of A) yield strength, B) ultimate tensile strength, and C) tensile elongation vs strain rate for all five tempers of Paliney® 7*

Comparing with results from the literature, Pb-Sn solder at room temperature exhibited a ~66% increase in yield strength and tensile strength from 10^{-4} /s to 10^{-1} /s, thus exhibiting a pronounced strain rate dependency.[1] An example of high strength steel, on the other hand, was similar to Paliney® 7 over the same range of speeds. Yield strength was observed to increase ~4% between 10^{-4} /s and 10^{-1} /s, and the tensile strength increased ~2% over the same range.[2]

Consistency in properties and performance of Paliney® 7 over three orders of magnitude in strain rate is part of what makes it a versatile, robust precious metal alloy for critical engineering applications.

References:

1. Boyce, Brad & Brewer, Luke & Neilsen, Michael & Perricone, Matthew. (2011). On the Strain Rate- and Temperature-Dependent Behavior of Eutectic Sn-Pb Solder. Journal of Electronic Packaging. 133. 031009-1. https://doi.org/10.1115/1.4004846

2. Wang, W.; Ma, Y.; Yang, M.; Jiang, P.; Yuan, F.; Wu, X. Strain Rate Effect on Tensile Behavior for a High Specific Strength Steel: From Quasi-Static to Intermediate Strain Rates. Metals 2018, 8, 11. https://doi.org/10.3390/met8010011