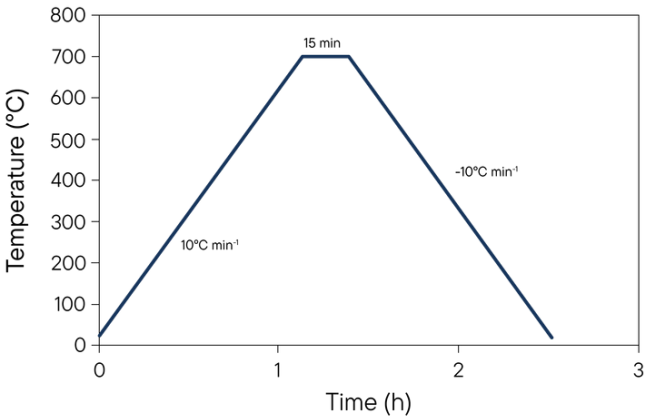
Thermal Expansion Behavior of Additively Manufactured Tool Steel

DIL L75 Vertical Characterization of Fe–Cr–Mo–V–Mn Tool Steel

The coefficient of thermal expansion (CTE) is a key material property for high-temperature tooling applications. Precise dilatometry enables the evaluation of dimensional stability, phase transformations and heat treatment effects, ensuring reliable performance of tool steels subjected to repeated thermal cycling. In this study, a LINSEIS DIL L75 Vertical was used to investigate the thermal expansion behavior of a laser metal deposited Fe–Cr–Mo–V–Mn tool steel before and after heat treatment.

Measurement Setup

- Instrument: LINSEIS DIL L75 Vertical
- Material: Laser Metal Deposited Fe–Cr–Mo–V–Mn Tool Steel
- Atmosphere: Argon
- Heating Rate: 10 °C/min
- Maximum Temperature: 700 °C
- Measurement: Dilatation and Coefficient of Thermal Expansion (CTE)
- Comparison: As-built vs. Heat-treated Material



The dilatometry measurements clearly reveal the influence of heat treatment on the thermal expansion behavior.
Key observations include:

- Stable thermal expansion over a wide temperature range
- Transformation effects visible in the as-built condition
- More uniform expansion after heat treatment
- CTE values comparable to conventional H13 tool steel

These results demonstrate the excellent thermal compatibility of the additively manufactured alloy with established hot-work tool steels.

Interpretation

The observed behavior can be attributed to:

- Stable thermal expansion behavior
- Heat treatment-induced microstructural changes
- Reduced retained austenite
- Material compatibility with H13 tool steel

This results in:

- Improved dimensional stability
- Reduced thermal stresses
- Reliable hybrid tool performance

Industrial Relevance

Dilatometry measurements support:

- Tool steel development
- Heat treatment optimization
- Additive manufacturing qualification
- Thermal expansion analysis
- Hybrid tool design
- High-temperature component development

Conclusion

The LINSEIS DIL L75 Vertical provides precise characterization of thermal expansion and CTE over a wide temperature range. The measurements confirm that the investigated Fe–Cr–Mo–V–Mn tool steel exhibits thermal expansion behavior comparable to conventional H13 steel after heat treatment, making it an excellent candidate for hybrid additive manufacturing and high-performance tooling applications.

Source:
Romano, T., Abdelwahed, M., Bengtsson, S., Bruzzo, F., Casati, R., Gedda, H., López, E., Ulfberg, P., Wilsnack, C., Vedani, M. Hybrid Laser Metal Deposition of a Fe–Cr–Mo–V–Mn Tool Steel for Hot Stamping Applications. Progress in Additive Manufacturing, 2023.
Adapted from thermal expansion measurements performed using a LINSEIS DIL L75 Vertical.