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Influence of Cooling Rate on the Microstructure and Mechanical Properties of the 25Cr-35Ni-15Co-5W-0.5C Alloy

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Introduction

- Ni–Cr-based alloys combine oxidation, corrosion, creep, and high-temperature resistance.
- Their as-cast performance strongly depends on solidification conditions.
- Cooling rate controls dendritic spacing, solute redistribution, and interdendritic carbide morphology.
- Faster cooling promotes refinement, whereas slower cooling favors coarse and continuous carbide networks.

Objectives

- Evaluate the effect of cooling rate on dendritic spacing and carbide morphology.
- Correlate microstructural refinement with compressive behavior.

Methodology

- **Alloy**: 25Cr-35Ni-15Co-5W-0.5C.
- **Processing**: induction melting and solidification in an AISI 1025 steel wedge-shaped mold.
- **Cooling rates**: 8.9–129.8 °C/s, calculated from thermal profiles recorded by type-K thermocouples.
- **Characterization**: optical microscopy and SEM-EDS.
- **Dendritic spacing**: linear intercept method.
- **Mechanical testing**: compression at room temperature, 10^{-3} s^{-1}, up to 0.30 strain.

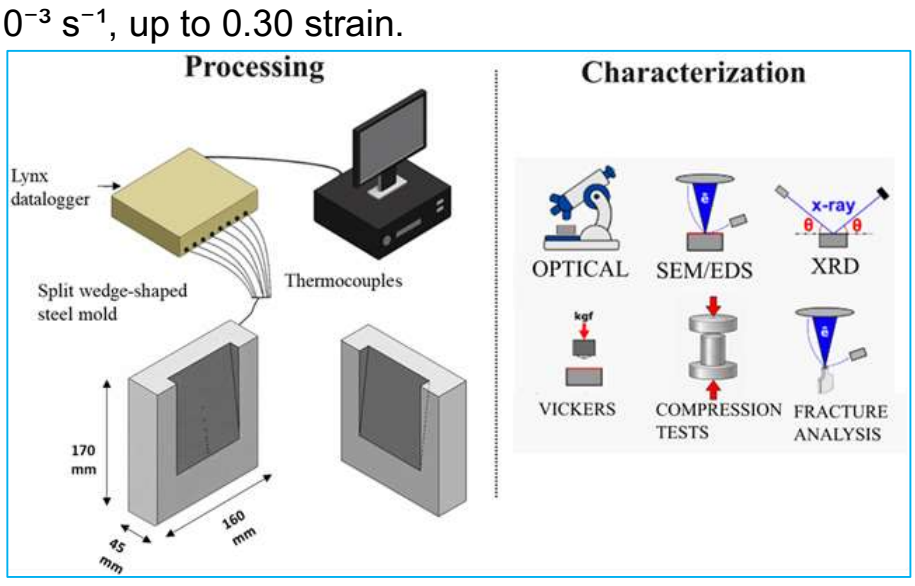


Figure 1. Experimental procedure used for alloy processing, thermal monitoring, microstructural characterization, and mechanical testing.

Results and Discussion

- All conditions exhibited a dendritic γ-FCC matrix surrounded by interdendritic carbides.
- Increasing cooling rate reduced dendritic spacing and promoted a finer carbide distribution.
- Slower cooling produced coarser dendrites and more continuous carbide networks.
- Refined microstructures exhibited higher hardness, maximum compressive stress, and strain-hardening capacity.
- Yield strength remained comparatively less sensitive to dendritic coarsening.

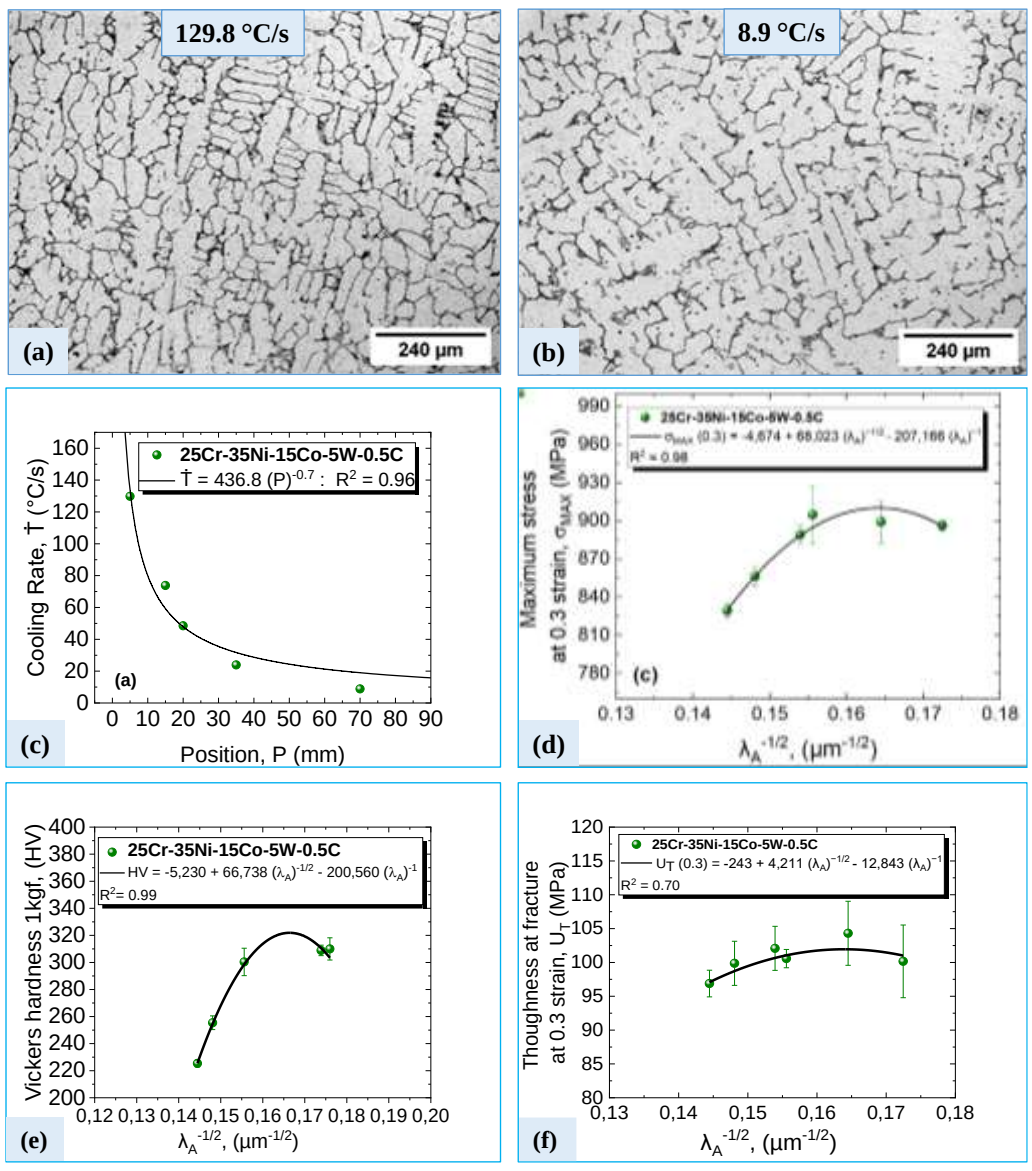


Figure 2. Effect of cooling rate on the microstructure and mechanical properties of the 25Cr-35Ni-15Co-5W-0.5C alloy: (a,b) dendritic microstructure; (c) cooling rate variation along the wedge; (d) maximum compressive stress; (e) Vickers hardness; and (f) toughness as a function of $\lambda_A^{-1/2}$.

Conclusions

- Cooling rates from 8.9 to 129.8 °C/s significantly modified the dendritic scale.
- Higher cooling rates promoted dendritic refinement and a finer carbide distribution.
- Refinement increased hardness, maximum compressive stress, and strain-hardening capacity.
- Cooling-rate control enables tailoring of the as-cast microstructure and mechanical performance.

References and Acknowledgments

- Pollock TM, Tin S (2006) Nickel-Based Superalloys for Advanced Turbine Engines Chemistry, Microstructure, and Properties. J Propuls Power 22:361–374.
- da Silva WA, Sousa SM de A, Spinelli JE (2024) Solidification Analysis of a High Cr-Ni Heat- Resistant Alloy: Microstructure and Hardness Evaluation. Mater Res. https://doi.org/10.1590/1980-5373-MR-2024-0299.
- Wu K, Liu G, Hu B, Li F, Zhang Y, Tao Y, Liu J (2012) Solidification characterization of a new rapidly solidified Ni-Cr-Co based superalloy. Mater Charact 73:68–76

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