cbecimat26
26° Congresso Brasileiro de Engenharia e Ciência dos Materiais
22 a 26 de novembro de 2026
Costão do Santinho
Florianópolis-SC

Behaviors of thermoelastic properties in NiTi-based shape memory wires deformed by cold rolling

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Introdução

Shape memory alloys from the NiTi system exhibit remarkable thermoelastic properties associated with reversible martensitic transformations induced by temperature variations or the application of mechanical stress. The present study evaluates the influence of chemical composition, heat treatment, and cold deformation on the thermoelastic and mechanical behavior of NiTi wires. Two samples were investigated, MSA with 49.8 at.% Ni (recrystallized at 600°C by 1h), and BCW, with 50.4 at.% Ni (annealing treatment at 400°C by 4h). Choi et. al. investigated mechanical properties and recovery stress of NiTi SMA wires prestrained by different degrees of cold rolling and categorized them into three deformation ranges: slight (reduction range is between 1-3%), moderate (reduction range is between 4-5%) and extensive (reduction range is between 7-10%). Zhang et. al. submitted superelastic NiTi-based alloys to severe cold rolling and observed that stress-induced reorientation of martensite (B19' phase) dominates the reaction.

Objetivos

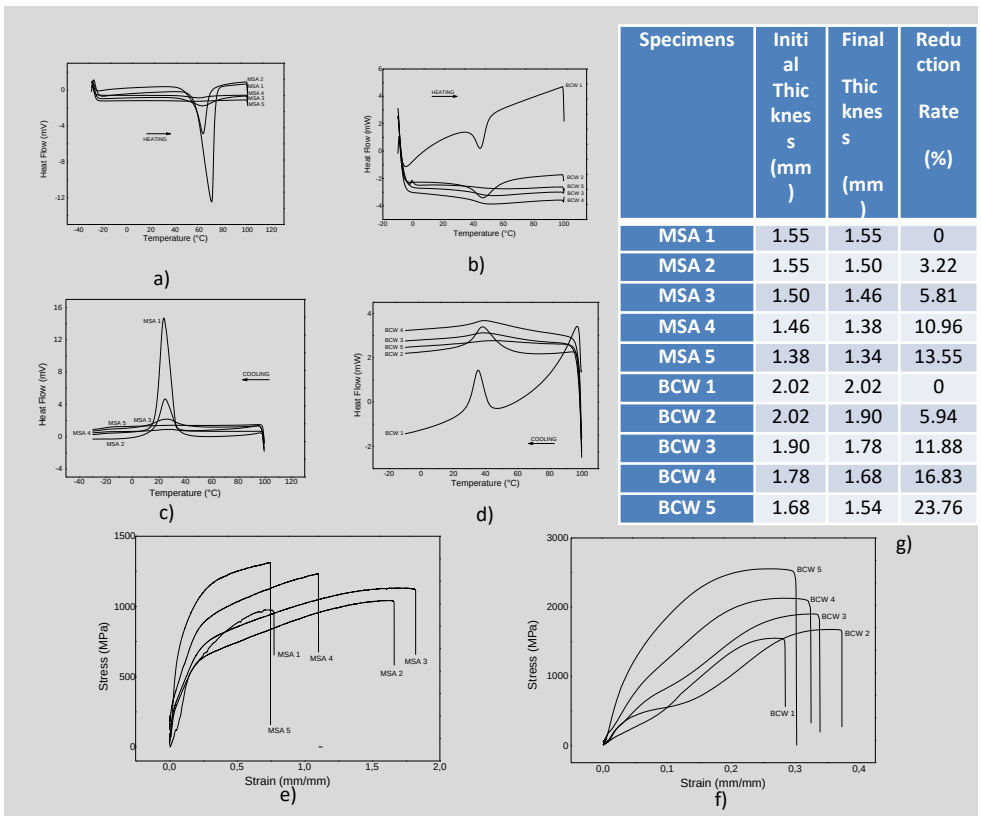
In this work, NiTi-based SMA wires were subjected to thermomechanical treatments by cold rolling followed by recovery. The main objectives of this study are to examine the behavior of the rolled martensite phase, observing the critical temperatures and the mechanical properties.

Metodologia

- The wires underwent cold rolling in a small electric rolling mill with an increment of 0.03 mm per tooth. Due to the characteristic of the martensite phase returning to it's initial shape when the load is removed, 10 roller cycles were required in the first thickness reduction, after those 1 or 2 cycles are enough.
- Stress-strain test for analyzes the mechanical properties.
- Calorimetric analyzes determine the critical temperatures, thermal hysteresis, and enthalpies of the martensitic transformations.

Resultados e Discussão

During deformation, the MSA sample (Fig. 1a) showed a reduction in As, while the Af behavior remained largely unchanged. Meanwhile, the BCW sample (Fig. 1b) exhibited no linear behavior. During cooling, neither sample showed linear behavior, as seen in Figs. 1d and 1e. In terms of thermal hysteresis, the BCW sample demonstrated superior behavior, with hysteresis remaining below 10 °C. In Fig. 1e and 1f, plastic deformation demonstrates strength gains with cold rolling. Fig.1g demonstrated that the BCW sample achieved a significantly greater reduction than the MSA sample, with values of 23.76% and 13.55%, respectively.



Specimens	Initial Thickness (mm)	Final Thickness (mm)	Reduction Rate (%)
MSA 1	1.55	1.55	0
MSA 2	1.55	1.50	3.22
MSA 3	1.50	1.46	5.81
MSA 4	1.46	1.38	10.96
MSA 5	1.38	1.34	13.55
BCW 1	2.02	2.02	0
BCW 2	2.02	1.90	5.94
BCW 3	1.90	1.78	11.88
BCW 4	1.78	1.68	16.83
BCW 5	1.68	1.54	23.76

Figura 1. DSC's Heating peaks: a) MSA, b) BCW. DSC's Cooling peaks: c) MSA, d) BCW. StressxStrain curves: e) MSA, f) BCW. g) Reduction rate.

Conclusões

The BCW sample exhibited the highest thickness reduction (~24%) and the highest yield stress (2555 MPa). In contrast, the MSA results—showing a lower thickness reduction (~14%) and lower yield stress (1313 MPa)—may explain the greater thickness reduction achieved in the BCW sample. DSC results for the MSA specimens showed moderate cold rolling leading to the completion of martensite formation, reorientation of temperature-induced martensite, and its subsequent plastic deformation. Conversely, the BCW specimens exhibited severe cold rolling, showing typical marforming behavior with deformation occurring below the martensite finish temperature (Mf), accompanied by pseudoplasticity due to martensite reorientation and subsequent plastic deformation.

Referências e Agradecimentos

- Choi E, Ostadrahimi A and Park J. On mechanical properties of NITI SMA wires prestrained by cold rolling. Smart Mater. Struct. 29 (2020) 065009 11pp.
- Treppmann D and Homdogen E. On the Influence of Thermomechanical Treatments on Shape Memory Alloys. Colloque C5, Supplément au Journal de Physique III. 1997, C5-211.
- Zhang J, Chen T, Li W, Bednarcik J and Dippel AC. High temperature superelasticity realized in equiatomic Ti-Ni conventional shape memory alloy by severe cold rolling. Materials and Design. 193 (2020) 1008875.