TiNi SMA - INVESTIGATION OF STRESS-INDUCED MARTENSITE REVERSE TRANSFORMATION, INDEPENDENT OF THERMAL INFLUENCES OF THE FORWARD ONE

E.A. Pieczyska, W.K. Nowacki, S.P. Gadaj and H. Tobushi*
Institute of Fundamental Technological Research, Warsaw, Poland
** Aichi Institute of Technology, Toyota-city, Japan*

Goal of the study was investigation of stress-induced reverse transformation behavior in shape memory alloy (SMA), independent of thermal influences of the martensite one**.** To this end, specimens of TiNi SMA were subjected to tension test performed on testing machine with stress rate 12.5 MPa/s to strain limit 8 %, followed by cooling the specimen to its initial temperature, and unloading with the same stress rate. Furthermore, an infrared camera was used in order to measure the infrared radiation from the specimen surface and to find the temperature changes, accompanying the phase transformation processes. The experiments have been carried out in room conditions.

The obtained results, namely the stress and the temperature changes vs. strain are presented in Fig.1, while the stress and the temperature changes vs. time in Fig. 2.

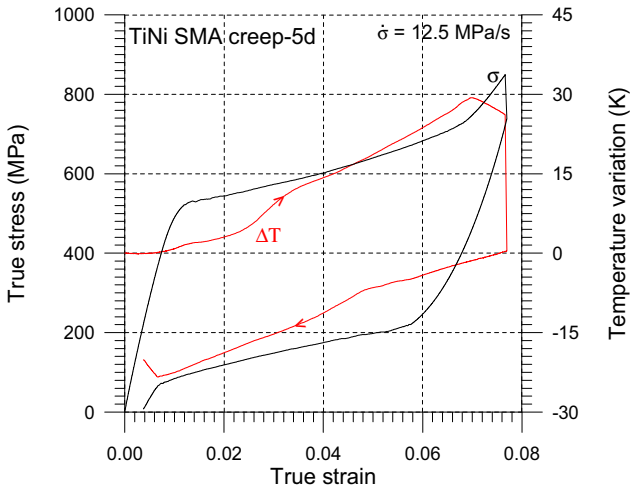

Fig. 1. Stress and temperature changes vs. strain during tension test of TiNi SMA with stress rate 12.5 MPa/s, followed by cooling the specimen to its initial temperature and unloading.

Looking at the figures one can notice that during the loading with such a stress rate, the stress increases up to 850 MPa which results in temperature increase up to 30K. Exothermic martensite transformation starts at of about 1% and develops with increasing stresses above 700 MPa till the strain limit 7%. At this strain value, the processes related to the heat flow to the surroundings are higher than the processes related to the heat production, so the specimen temperature drops. The drop in temperature, observed during the SMA loading manifests that at this level of deformation the exothermic main martensite transformation in the specimen is completed.

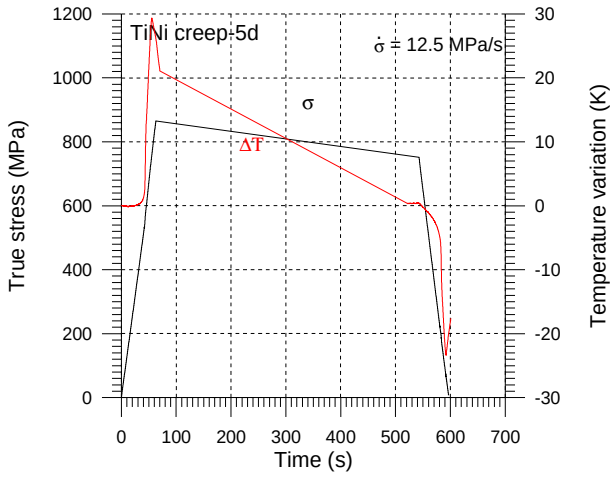

Fig. 2. Stress and temperature changes vs. time during tension test of TiNi SMA with stress rate 12.5 MPa/s, followed by cooling the specimen to its initial temperature and unloading.

During the subsequent cooling process, the temperature decreases to the initial room temperature due to the heat exchange with surroundings, while the stress decreases from 860 MPa to 740 MPa. It means that the stress relaxation under constant strain is induced due to the delayed martensite transformation when the specimen was under cooling process.

During the unloading, the main reverse transformation appears at stress of 220 MPa with strain of 6 % and finishes at stress of 80 MPa with strain of 0.6 %. The temperature drops due to the endothermic reverse transformation, up to –20K at the end of the process. However, one can notice that in this case the temperature drops from the same beginning of the unloading, which is probably caused by a "preceding" reverse transition.

Furthermore, there is not symmetry between the martensite forward and the reverse transformations. This is caused by the fact that the run of the martensite transformation is related to the instantaneous strain rate applied [1]. For the stress-controlled tension test the strain rate is not constant during the loading and the unloading processes [1-3].

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References

[1] E.A. Pieczyska, S.P. Gadaj, W.K. Nowacki and H. Tobushi (2006). Phase transformation front evolution for stress- and strain-controlled test in TiNi Shape Memory Alloy, *Experimental Mechanics*, Vol. 46, No 4, 531-542.
[2] Elżbieta A. Pieczyska, Hisaaki Tobushi, Wojciech K. Nowacki, Stefan P. Gadaj and Toshimi Sakuragi (2007). Subloop Deformation Behavior of TiNi Shape Memory Alloy Subjected to Stress-Controlled Loadings, *Materials Transactions*, Vol. 48, 2679-2686.
[3] E. Pieczyska, W. Nowacki, T. Sakuragi and H. Tobushi (2007). Superelastic deformation properties of SMA, *Key Engineering Materials*, Vols. 340-341, 1211-1216.