Orthodontic Film Composites—Superelastic Composite Material

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Cross-links:

NiTi Thin Film Technology

Orthodontic Film Composite—Superelastic Composites for Orthodontic Archwires

The Modeling group has continued simulations of composite orthodontic wires consisting of rectangular or round thin-wall NiTi tubes filled with polymers. Such wires have advantage over traditional full NiTi wires for which the superelastic effect during bending and torsion is only achieved by strong stresses that could be dangerous in orthodontic applications. The basic objective of simulations done in this year is to verify the stability of composite wires subjected to three-point bend tests and to determine in this context the critical polymer stiffness for a given wall thickness. Another simulation has been carried out to investigate the influence of the parameter A_f that defines the end temperature of the martensite-to-austenite phase transition in NiTi.

Fig. 1 illustrates the scheme of three-point bend tests and shows the simulation results. It should be pointed out that tree-point loading is more dangerous than pure bending caused by two moments applied to the ends of the sample because the stress concentration in the contact area causes instability.

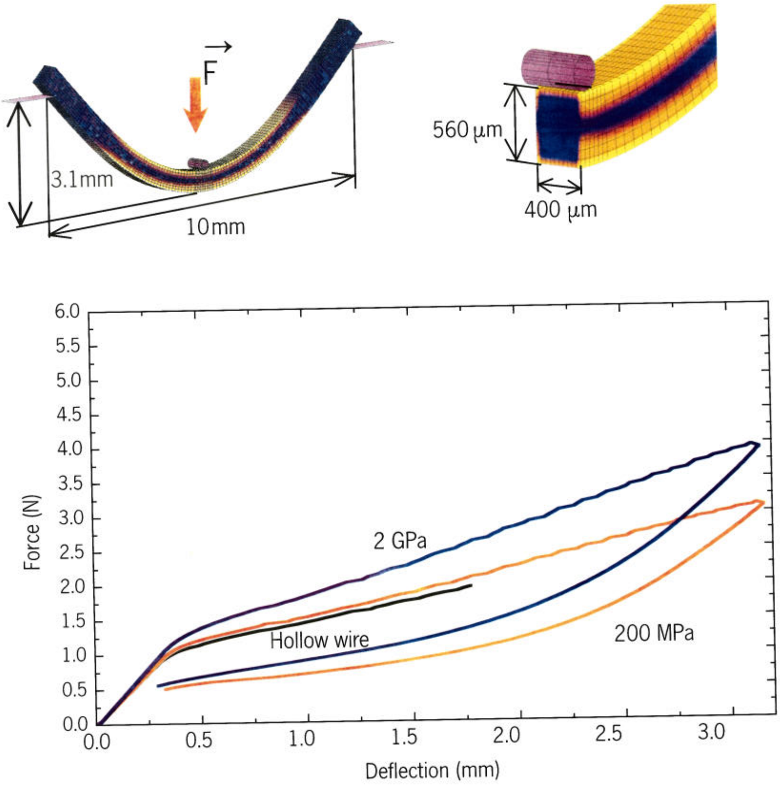

Figure 1: Three-point bend tests. The wall thickness of the wire is 35 µm as the E-modulus of the filling polymer varies through the set: 0 (hollow wire), 200 MPa, and 2 GPa. The loading is performed by a rigid cylinder of 130 µm radius.

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Fig. 2 shows the dependence of mechanical properties of the composite wire on the parameter A_f. The case where the thickness of the NiTi coating is equal 20 µm and the E-modulus of the filling plastic equals 400 MPa is presented. As it was expected, the stress value of the superelastic plateau goes down, if A_f increases. The simulation allows us to estimate this rate quantitatively and to formulate demands on the fabrication of the TiNi alloy.

Cooperation:

Clinic of Orthodontics, University of Bonn

Institute of Information Theory and Automation, Prague, Czechia

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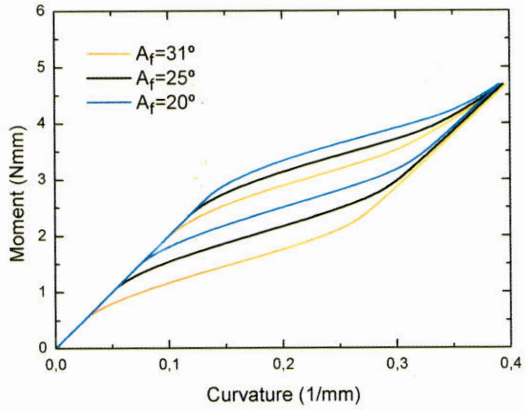

Figure 2: Loading/unloading curves at T=37 °C.

The simulation was done using a thermomechanical shape memory alloys model that contains a lot of parameters including E-modules for austenite and martensite as well as temperature dependent initialisation stresses σ^{s}_{AM} *(T)*, σ^{f}_{AM} *(T)*, σ^{s}_{MA} *(T)*, σ^{f}_{MA} *(T)*. These parameters were fitted using two tensile tests at two different temperatures (see Fig. 3).

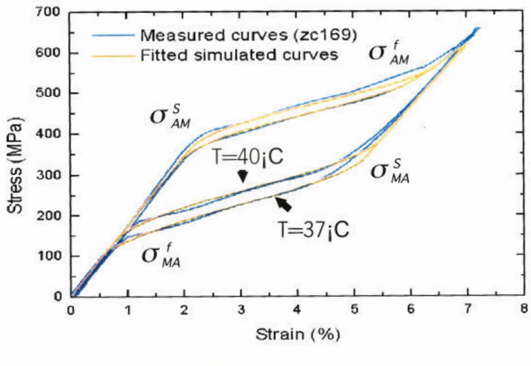

Figure 3: Fitting of the model parameters using two stretch tests at two different temperatures.

Reference: R. Hassdorf, J. Feydt, S. Thienhaus, L. Buforn, N. Conte, O. Pykhteev, M. Kruzík, N. Botkin, M. Moske: Spherical load indetation in submicron NiTiCu shape memory thin films. Proc. of the 2004 Mater. Res. Soc. Fall Meeting: Symp. on Fundamentals of Nanoindentation and Nanotribology III Boston, MA, (Eds. D.F. Bahr, et al.) Vol. 841 (2005), pp.R9.7.1–R9.7.6.