SUPERVISOR´S JUDGMENT OF THE PH.D. DISSERTATION

Author: **Antoine JURY**

Title: **Infrared calorimetry applied to thermomechanical characterization of NiTi alloys**

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Aim, methodology, and results of the thesis

The presented dissertation is a result of the cooperation between the University of Clermont Auvergne, France, Institute of Physics of the Czech Academy of Sciences in Prague, and the Czech Technical University in Prague. In compliance with the regulations in each country, an agreement for joint supervision of this thesis was signed by the rectors of both universities. The thesis objectives were to propose a novel approach to use infrared thermography and heat source reconstruction for calorific analysis of the martensitic transformation in NiTi shape memory wires.

In this work, the evolution of the thermal energy associated with localized deformation processes in cyclically loaded superelastic NiTi was examined by an original method of in-situ measurement of thermal fields by an infrared camera. The post-processing of recorded thermograms relies on a numerical inverse solution of the one-dimensional heat diffusion equation for unknown heat sources. The method was implemented in form of a programming script.

The obtained experimental results allowed to investigate spatio-temporal energetics of the stress-induced martensitic transformation in cyclically loaded superelastic NiTi. The analysis confirmed strong thermomechanical coupling that causes an apparent rate and cyclic dependency of the tensile response of NiTi wires. Furthermore, considerably higher dissipation energy was quantified for the nucleation sites of the stress-induced martensitic transformation compared to zones of the martensite shear-band fronts propagation. Previously reported fatigue cracks located preferentially at the nucleation sites were thus explained energetically. Simultaneous evaluation of the heat energy and mechanical work during superelastic cycling provided pieces of evidence for the spatial homogenization of the martensitic transformation and relatively low ratio between the heat and deformation energy, i.e. large stored deformation energy. The latter may provide an energetical argument for the low fatigue performance of NiTi wires subjected to superelastic cycling. Finally, an original thermography method for the identification of thermophysical parameters was developed thus ensuring the reliability of calorimetric analysis since the values of these parameters in the literature are largely scattered.

Assessment of the dissertation and the student´s work

The jointly supervised dissertation required a complex and flexible approach of the student. The candidate had also to fulfill all the requirements for Ph.D. studies at the Czech Technical University in Prague, i.e. to attend special and language courses for doctoral students. His curriculum involved Solid State Theory, Theory of Plasticity, Selected Topics from Physical Metallurgy, Neutron Scattering Applications in Materials Research, Nondestructive diagnostics, and English Language (Advanced), all finished by examinations. He also passed the state doctoral examination. These successfully passed exams in the English language in a foreign university prove that the candidate is strong-willed and persistent in his work. He showed this attitude also during his experimental work in the Institute of Physics of the Czech Academy of Sciences in Prague. Furthermore, he showed curiosity and initiative in proposing and setting up original experiments followed by thorough experimental data processing and analysis, which required algorithmic thinking and strong skills in programming. In addition, he kept asking about the physical interpretation of experimental data to answer persisting questions of deformation physics in shape memory alloys.

The dissertation has in total 123 pages. Part I provides a bibliographic review related to shape memory alloys, deformation calorimetry, thermodynamics of deformation processes, and heat source reconstruction. Part II deals with the analysis of heat sources related to localized deformation processes in a superelastically loaded NiTi wire. Fast characterization of functional fatigue in superelastic NiTi wires using infrared thermography and heat source reconstruction is described in Part III. Conclusions of the presented work are discussed in Part IV along with a further perspective of the presented research. The dissertation is complemented with Appendix A presenting the manuscript in Conference proceedings of the Society for Experimental Mechanics Series and with a list of publications of A. Jury and references.

The presented work satisfies, without any doubt, all the requirements laid on a Ph.D. thesis. It contains numerous original results. The graphical layout as well as the language level is excellent. All the aims were fulfilled. It is our pleasure to recommend this Ph.D. thesis to proceed for public defense.

Prague, April 5, 2021

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Luděk Heller   Miroslav Karlík