The application of NiTi alloys in polymer composite actuators and sensor systems.

Abstract

The research concerns the potential application of NiTi alloys in polymer composite sensor systems and actuators. A series of experiments were conducted on a proprietary test stand during the doctoral thesis, using NiTi alloy wires with a diameter of no more than 375 μm. The issues related to the use of NiTi alloys in sensor systems and actuators were addressed, as were issues connecting these two areas. The work was divided into three key stages. The first stage involved researching the impact of mechanical loading on the electrical properties of thin NiTi alloy wires with a diameter of less than 150 μm, both uncoated and embedded in a polymer matrix. The second part presents research on the impact of phase transformation on changes in the mechanical properties of thin NiTi alloy wires and composites based on them. The third stage focused on numerical research, including identifying and validating material model parameters. The first research examined how deformation and reorientation of structures affects the resistance of thin NiTi alloy wires. During cyclic stretching of NiTi alloy samples with constant displacement, a decrease in electrical resistance was observed after each successive cycle. Further research investigating the electrical properties of NiTi alloys focused on composite structures. For this purpose, samples were developed consisting of simple composites with a PLA matrix embedded with a NiTi alloy wire. Cyclic bending experiments on these composite samples confirmed that the NiTi alloy wire embedded in the PLA matrix also exhibited a decrease in resistance after each successive load cycle. A relationship was demonstrated between the contraction of the wire and the force it generates, the temperature of the wire and the current used to heat the wire by testing NiTi alloy actuators in a series arrangement with a spring. It was shown that, as the current intensity falls below the nominal value and the temperature decreases, the resulting shortening and generated force also decrease. A simple composite actuator was developed consisting of a NiTi alloy wire embedded in a matrix. A constant force was applied to the central part of the sample using a stamp. The deformation caused by the load was partially compensated for by activating the actuator, which caused changes in the NiTi alloy. To facilitate the design of actuators and sensors using NiTi alloys, the parameters of the NiTi alloy material model were determined. To this end, the tensile curve of the NiTi alloy was determined experimentally. The first simulations confirmed the model's good convergence with the experimental results.