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Effects of Permanent Loads on Mechanical Performance of Nitinol Tubes

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Introduction

Nitinol is frequently used as raw material for cardiovascular endoprosthesis, due to their high biocompatibility and properties such as psedoelasticity. Typically, the highest stress/strain that Nitinol based devices undergo occurs during crimping. These mechanical stresses can affect the functional fatigue behaviors [1,2]. Nitinol devices are crimped to small diameters to deliver to the anatomical location of interest. Thereby, the microstructural and mechanical changes in Nitinol tubes generated by mechanical load conditions are studied, to monitor the pseudoelastic properties as a function of load time. Consequently, a permanent load test is carried out by means of a fixture with parallel clamps, in order to generate deformation of the cross-sectional area of the tube. The procedure consists of deforming 5 mm long samples with 7 mm outer diameter tubes and a wall thickness of 0.5 mm in straight annealed condition at room temperature. For this test, o-shaped samples of single ingot were analyzed. The test was carried out with strains of 2 %, 4 %, 6 % and 8 % to simulate different device crimp strains. Parts were evaluated after time intervals up to six months under load. Afterwards the geometrical changes of the samples were measured. Additionally, the samples were characterized by DSC and XRD measurements.

Experimental Results

This study is focused on the comparison of pseudoplastic properties in different conditions of strain, with the purpose of observing the behavior in moderate and critical strain percentages as it is shown in Figure 1.

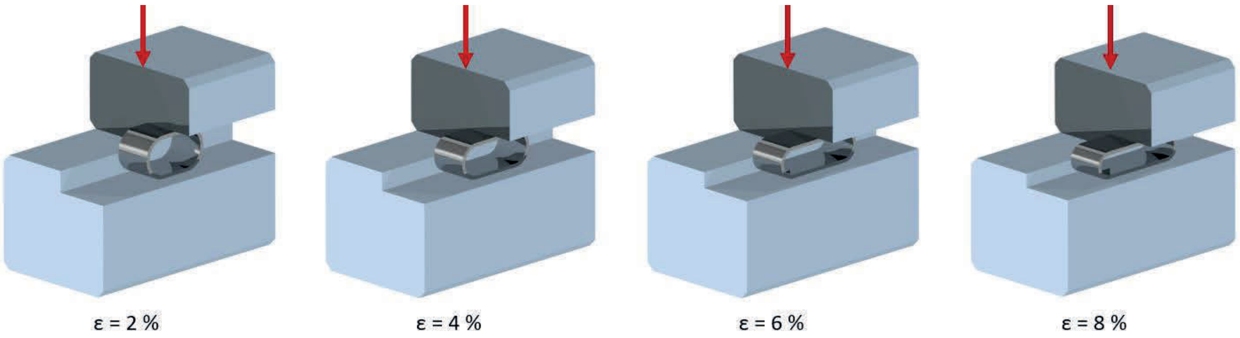

Figure 1: Test setup with various strain conditions for the 7 mm o-shaped samples under load.

Post-test geometric comparison is shown in Figure 2. The geometrical changes are increasing with strain and time. The maximum permanent strain is 0.22 % after six months at 8 % strain. The permanent strain of 6 months sample results in no additional significant geometrical changes in comparison with 3 months samples.

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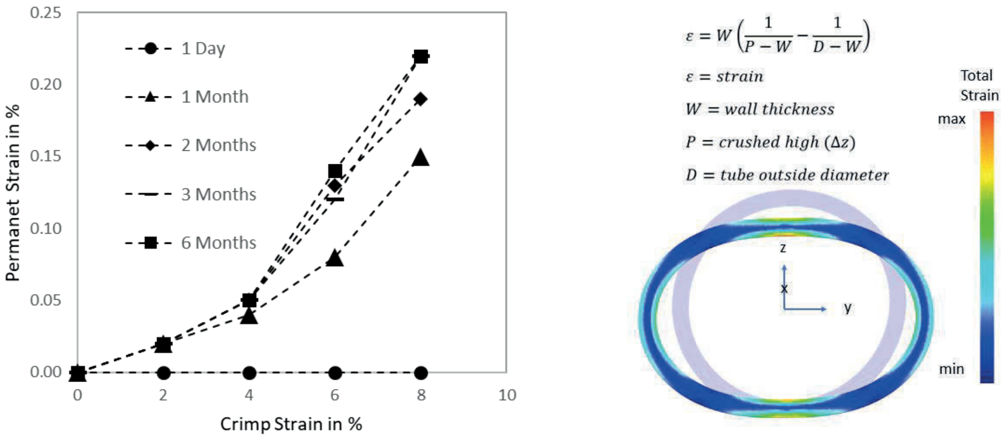

Figure 2: Permanent strain for each strain condition after six months under load on the left. Calculation method and schematic strain distribution (FEM) on the right.

XRD measurements show minor noticeable differences between the initial condition and post-test conditions. The signal intensity is decreasing, and the peak width is increasing after long term crimping for 40 °, 60 ° and 80 ° (2 theta). On the other hand, a significant change of M→R´ transformation in the DSC curves is visible. Although, there are no changes between initial condition and after six months under 2% crimp strain visible (Figure 3).

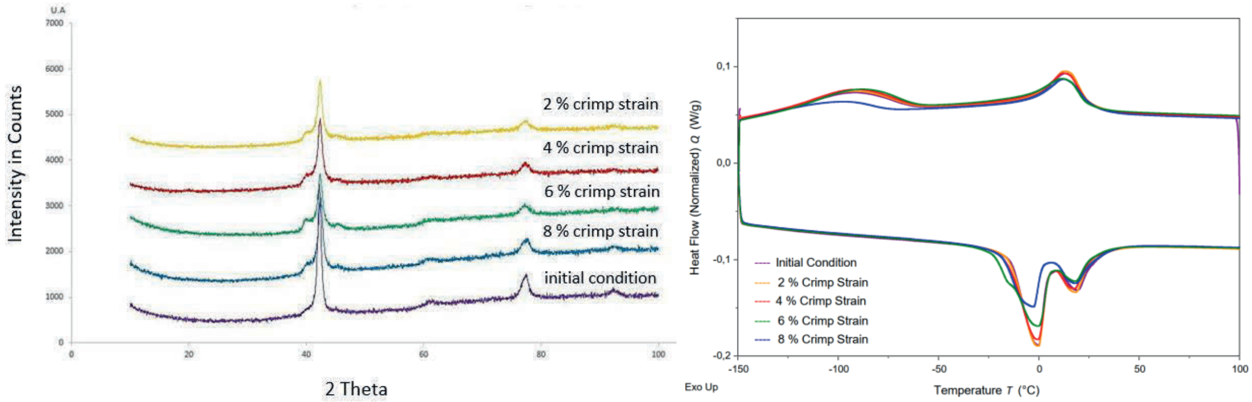

Figure 3: X-ray diffraction measurement (left) and DSC curves (right): initial condition and condition after six months under load with 2 %, 4 %, 6 %, and 8 % crimp strain.

Discussion and Conclusions

In this study effect of crimping of Nitinol under various strain conditions for different time intervals up to six months were analyzed. The permanent strain was increasing with the time and crimp strain. Primary results indicated that both strain and time affect the pseudoelastic properties, that appear as geometrical changes. It can be assumed that the permanent strain for 8 % crimp strain was saturated after six months under load. Moreover, changes in transformations properties were observed in DSC and XRD measurements. Further long-term crimping tests are ongoing.

References

[1] Pelton AR, Nitinol fatigue: a review of microstructures and mechanisms. J Mater Eng Perform, 2011, 20:613–617

[2] D. Stoeckel, A.R. Pelton, and T. Duerig, Self-expanding Nitinol Stents: Material and Design Considerations, Eur. Radiol., 2004, 14, p 296–301

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