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Tensile Testing of Nitinol Wire in Strain Control Using the AVE

Nitinol is a shape memory, superelastic alloy for which the biomedical industry has found extensive uses. A few examples of the numerous applications that use Nitinol include stents, dental wires, catheter guide wires, internal fracture fixation devices, biopsy forceps and others.

The major challenge in testing Nitinol is accurate strain measurements. The crosshead position or LVDT reading does not provide the accuracy necessary to achieve specific strain criteria specified in ASTM standards. A clip-on extensometer is often used but carries its own set of challenges to overcome. The weight of a clip-on extensometer may cause bending of the wire and the knife-edges may slip, damage the wire or lead to premature failure. Further, most clip-on extensometers have insufficient gauge lengths to accurately characterize the material.

The Instron® Advanced Video Extensometer (AVE) is a solution which allows for strain measurement of Nitinol wire in cyclic loading and to failure.

Test Configuration

A 5582 electromechanical test frame configured with a 1 kN load cell and 1 kN pneumatic cord and yarn grips were used for this test. The pneumatic cord and yarn grips allow for accurate specimen alignment and reduce the stress concentration at the grip faces which would otherwise lead to specimen failure. The AVE with a 500 mm Field of View (FOV) lens and 500 mm lighting array were also used to accurately track strain when small white adhesive dots are placed on the specimen to mark the gauge length. The complete test configuration is shown in Figure 1.

The most common test method for characterizing Nitinol, besides a basic tensile test to failure, requires that the material be loaded to 6% or 8% strain, unloaded back to zero percent strain and then pulled to failure. The Bluehill® software test profiler application allows the user to easily define each of these loading requirements and performs data analysis along specific sections of each curve. This test method was used to evaluate the tensile strength, strength at the upper and lower plateaus and the tensile set values for three Nitinol wire specimens of the same diameter.

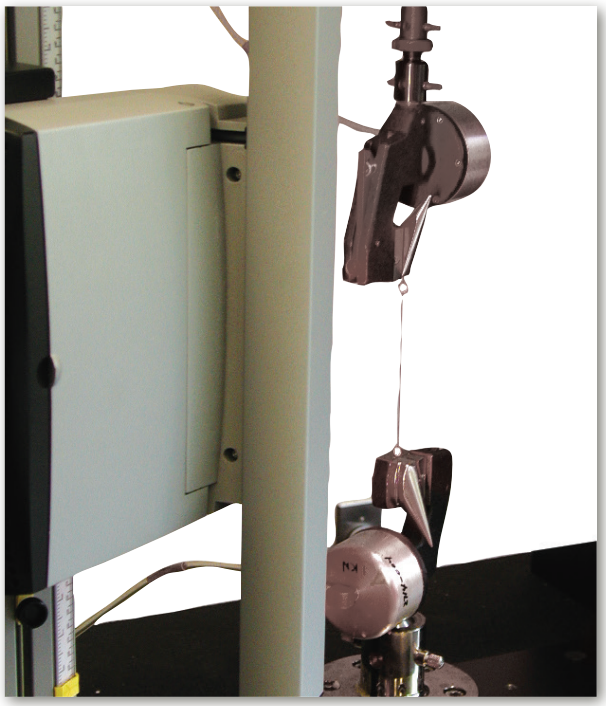

Figure 1:
A 5582 frame, 1 kN load cell, 1 kN pneumatic cord and yarn grips and the AVE were used to test Nitinol wire in tension.

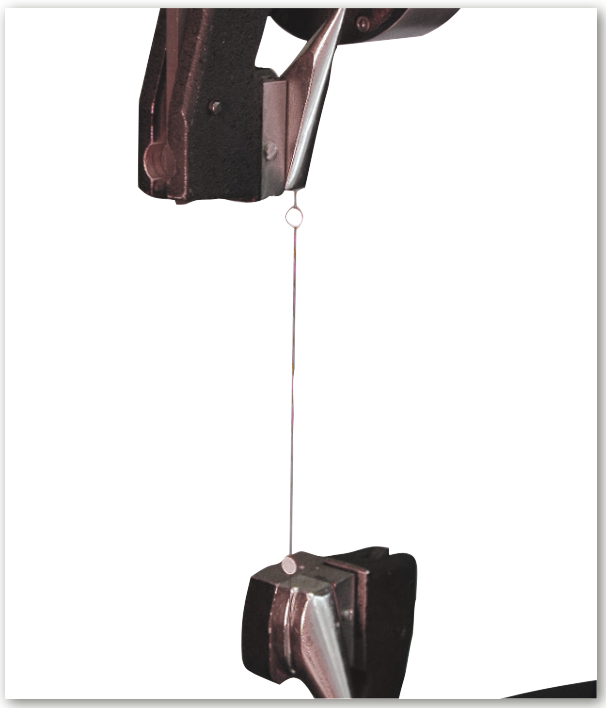

Figure 2:
Close-up of the Nitinol wire specimen with white marks for tracking tensile strain.

Results and Conclusions

These results show that the AVE was successful in tracking strain throughout the loading cycle and to failure. The accuracy at which the AVE was able to perform strain control at 0 % and 6 % strain should also be noted. In this test, tensile set was defined by finding the strain value at 10 N on both the loading curve and the unload curve and then finding the difference between those values, reported in % strain.

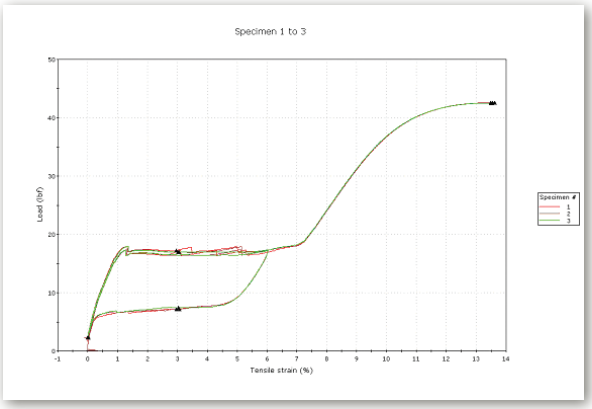

Figure 3:
Load vs. strain results for 3 Nitinol specimens tested. The specimens were loaded to 6% strain, unloaded back to 0% strain, and then pulled to failure.
NOTE: 0.016 inch diameter Nitinol wire - RR1

Configuration Table

Catalog Number	Configuration Options	Description
5582	Frame	Dual column test frame
2525-806	Load cell	1 kN capacity
2714-004	Grips	1 kN pnuematic cord and yarn grips
2663-821	Extensometer	AVE
2663-821J1	-	500 mm FOV kit
A565-21	-	BNC connector cable for strain control
2410-270U1	Software	Bluehill® Software with test profiler application

Specimen	Diameter	Max Load	Tensile Strength	Strain (Video) at Max Load	Stress at Upper Plateau	Stress at Lower Plateau	Tensile Set
#	in	lbf	ksi	%	3% ksi	3% ksi	%
1	0.016	42.562	209.063	13.525	84.553	35.227	0.021
2	0.016	42.575	209.130	13.421	83.406	35.352	0.044
3	0.016	42.514	208.831	13.478	83.319	36.569	0.005
Mean	0.016	42.550	209.008	13.475	83.759	35.716	0.023
S.D	0.000	0.032	0.157	0.052	0.689	0.741	0.019

Table 1:
Test results for three Nitinol specimens.

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