Testing Brief

Wire_test_V1, March 2003

Figure 1, Strain Controlled Wire Fatigue Experiment.

Testing Fine Wire

Introduction

Structural testing of fine wire for the purpose of obtaining static stress and strain data or cyclic fatigue data can be challenging. This brief will examine some of the difficulties encountered in wire testing and outline some techniques that may be successful in overcoming these difficulties.

Figure 2, Capstan Style Wire Grips

Gripping Wire

Unlike a classic ISO or ASTM tensile bar which has a wide section where the test specimen is gripped and a smaller gage section where most material straining and failure occurs, wire has the same cross sectional area throughout. As such, the highest strain and the most likely location for the wire to fail when stretched is the high stress area where the specimen is being gripped.

This may be acceptable when stress-strain information at low strains is of primary interest and the ultimate strength of the wire in unimportant. For example, some shape memory alloys experience complex transitions at relatively low strains (Figure 4). Physical testing of shape memory alloys is often performed at different temperatures but at low strains to examine these transitions. As such, a basic clamp or drill chuck may be sufficient to grip the wire (Figure 5).

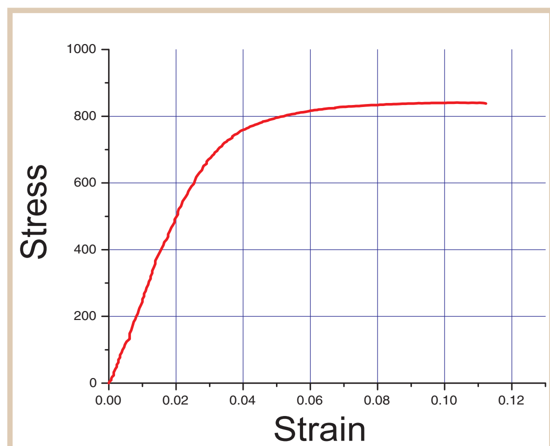

Figure 3, Wire Tensile Experiment to Failure

However, if the ultimate strength of the material is of interest (Figure 3), then a gripping system must be used which will gradually transition the high stress of the wire in tension into a gripping area where the wire is held stationary. A simple approach to this is to wrap the wire around a capstan such that the wire tightens onto the capstan as the wire is stretched. Because the wire in contact with the capstan transmits some of the tensile stress into the capstan, the wire doesn't strain as much as the wire experiencing the total tensile stress. Capstan gripping systems are commercially available from Instron Corporation (www.instron.com, Figure 2). Use of capstan gripping requires the wire to be sufficiently soft to wrap around the capstan and it also requires a long section of wire.

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Measuring the Strain in Wire

Measuring the force to stretch wire is straightforward and is accomplished using a strain gage style load cell mounted at the opposite end of a wire grip. Measuring the strain in the wire is more complex. Since the strain near the gripping of wire is indeterminate because of the complex stress condition, grip travel cannot be converted to strain in the wire. The strain must be measured directly and away from the gripping.

If the wire is sufficiently strong and can support the weight of a clip-on strain gage extensometer, this is a simple approach for many static experiments. If the wire is not able to support a direct contacting device, a laser extensometer which measures the movement of small lightweight tags adhesively bonded to the specimen may be used (www.e-i-r.com, Figure 5).

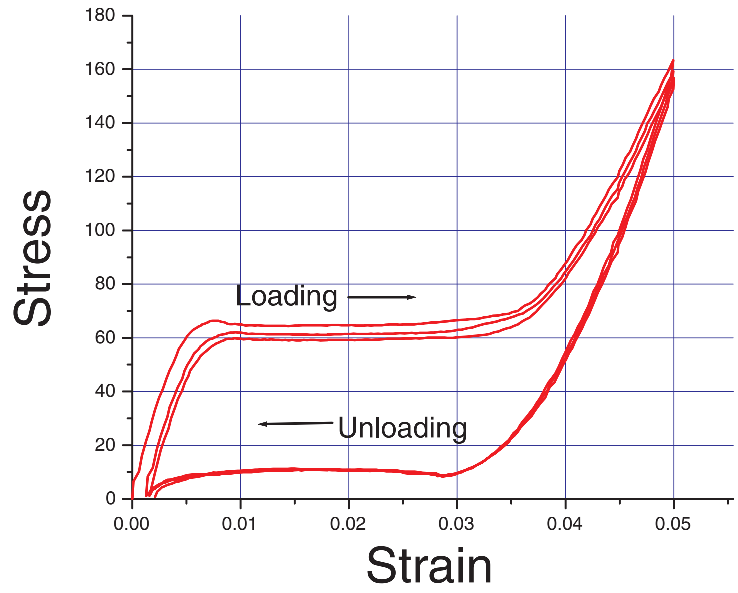

Figure 4, Loading and Unloading Experiment on a Wire Shape Memory Alloy.

Cyclic Fatigue of Wire

Measuring the cyclic fatigue life of wire under cyclic loading conditions may be performed on a servohydraulic test instrument. The cyclic waveshape may be defined with stress as the controlled variable or strain as the controlled variable. If stress is the controlled variable, the test instrument may be operated in load control using the load cell and the instrument will maintain the proper mean load and amplitudes. If strain is the controlled variable, then strain must be measured and used to control the test instrument. At frequencies above a few cycles per second, clip-on strain gage extensometers may vibrate and introduce control problems. Laser extensometers typically provide a low bandwidth signal that is suitable only for static testing.

At Axel Products, we couldn't find a suitable strain measuring system commercially so we developed a high bandwidth fiber optic based strain system that measures the movement of lightweight tags mounted to the wire. The system is complex to set-up for each experiment, however, strain controlled fatigue experiments have been successful at frequencies above 25 Hz. (Figure 1).

Summary

Testing fine wire involves difficult gripping and strain measuring challenges. Different solutions may be employed based on the objective of the testing.

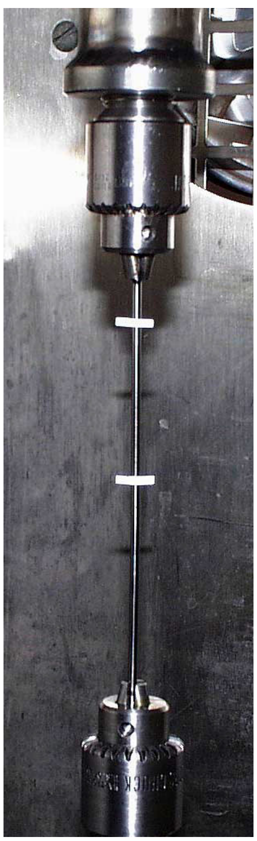

Figure 5, Wire Tensile Experiment with Simple Drill Chuck Grips and Laser Tags.

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Axel Products provides physical testing services for engineers and analysts. The focus is on the characterization of nonlinear materials such as elastomers and plastics.

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