Fatigue Testing of Thin Metallic Foils and Wires

The Challenge:

Predict the Fatigue Life of Products Made From Thin Metal Foil and Wire

Background

Metal foils and wires are used in a wide variety of applications such as radiators, Micro-Electro-Mechanical Systems (MEMS), electronics, optics, and food preparation. Knowing how long the foil and wire will survive the loading associated with the specific application is important in predicting the success of the product itself.

Knowing the fatigue life of the material in a traditional ASTM specimen geometry does not necessarily predict the fatigue life of the material as applied in the final product. Foils and wires may be only a few molecules thick which makes standard manufacturing defects a source of crack initiation and failure.

The process used to manufacture a thin foil or wire may alter the mechanical properties of the metal, and the chances of damage during normal handling and production are much higher than for thicker materials. These effects can make the foil and wire prone to fatigue damage at stress levels dramatically lower than the commonly accepted material fatigue life thresholds.

Meeting the Challenge

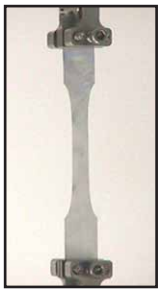
The ElectroForce® 3220 test instrument was chosen to test a thin 60 µm aluminum foil over a range of stress amplitudes that would cover a wide range of the fatigue life (S-N) curve at a stress ratio (minimum stress/maximum stress) of 0.1.

The maximum load range was;

L-max =24.50 N and L-min = 2.45 N

and the minimum load range was;

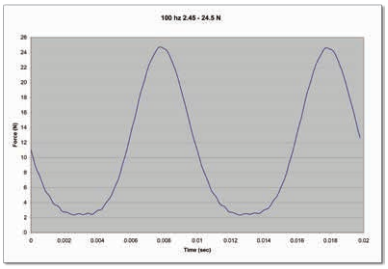
L-max = 0.098 N and L-min = 0.010 N



The sample, as shown in the photo to the right had a width of 10 mm and a reduced gage length 20 mm long.

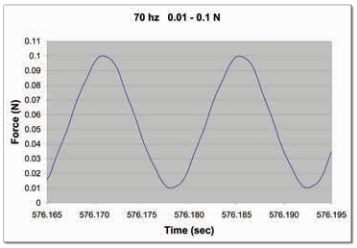
Fatigue life at the low stress levels is expected to exceed 10,000,000 cycles. At 15 Hz each test would last more than 7 days so the desire is to test at the highest frequency possible with accurate control of the force end-levels and a high fidelity waveform. As shown in the following data, the ElectroForce® 3200 system met all the required conditions.

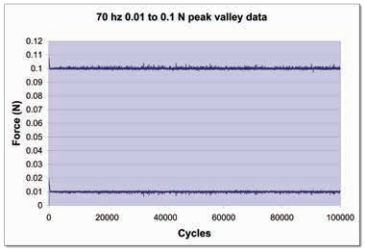
The graph to the right shows a standard 3200 instrument at the maximum load range running at 100 Hz.



The next two graphs show data from an ElectroForce 3200 system modified with a 250 g (2.5 N) capacity load cell at the minimum load range running a 70 Hz test on a 28 gage wire sample.

The first graph shows timed data from two cycles and the second shows the measured peak and valley of the controlled load at the minimum load range for the first 100,000 cycles.





This data demonstrates that the ElectroForce® 3200 test instrument, with optimized configurations, can obtain the data required for the complete fatigue life prediction of a thin foil or wire material.

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