CASE STUDY

Testing Molybdenum Wire

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When molybdenum wire is produced, internal defects in the makeup of the refractory metal can affect tensile strength. These defects can then affect performance during subsequent manufacturing processes, including the overall quality of the final product. This article is a case study showing how an Admet tabletop test frame with a programmable digital controller enabled Elmet Technologies to simply and reliably test its molybdenum wire products.

Molybdenum wire
Elmet Technologies Inc. of Lewiston, Maine, is a leading manufacturer of molybdenum and tungsten products, including molybdenum wire. Specifically, among its products are doped molybdenum wire, including K-Si doped HCT (High re-crystallization Temperature) and MoLa doped materials. Elmet wire products serve as mandrel wire in coil manufacturing and as filaments in lamps, in high temperature furnaces, and in equipment for semiconductor manufacturing. Tensile strength and ductility are primary concerns, because they have a great effect on product performance. Both HCT and MoLa exhibit better ductility after recrystallization for diameters below 0.090 in.

Tensile strength for molybdenum wire is generally measured in grams per milligram weight for a 200-millimeter length sample (g/mg/200 mm). Elmet produces wire within a normal range of 40 to 60 grams. In general, as tensile strength increases, percent elongation and straightness decrease. This means that both the upper and lower limits are important indicators of quality.

A large quantity of the molybdenum wire produced at the Lewiston plant serves as mandrel wire in the production of coiled tungsten filaments for light bulbs. The tungsten is wrapped around the molybdenum wire, which is then eventually dissolved out at the very end of the coil manufacturing operation.

Quality control
To ensure process control during manufacturing and to ensure product quality in lighting and other products, the moly wire is tested during and after processing.

“If the wire is not in spec, it can cause downstream processing problems such as wire breaking in the coiling machine,” says Vinay Desai, Elmet’s chief metallurgist. “We want to be sure we are in control.”

Before large runs, the first few meters of each draw are tested for tensile strength and/or elongation. Based on the test results, the production run continues or is adjusted, and the wire is retested. All finished wire products are also tested.

Universal testing machine
The molybdenum testing operation is a high-volume, repetitive process. The staff conducts between 25 and 50 tensile tests per shift. A few years ago, Mr. Desai and the operators noticed that the testing machine was showing signs of wear. Mr. Desai also knew that modern machines have more advanced digital controls that would add efficiency.

He replaced the worn machine with the Admet Expert 1000 tabletop single screw universal testing machine, which has a capacity of 1000 Newtons. The Expert line of testing machines ranges from 1 kN (225 lb) to 300 kN (67,000 lb). The unit includes a standalone user-programmable digital controller with a liquid crystal display that shows test parameters as well as date, time, specimen number, peak load, peak stress and total elongation.

The Expert 1000 is a single screw electromechanical machine that is run by a variable-speed electric motor and a gear reduction system. The moving crosshead rides up and down on a precision actuator that includes a ball screw and linear guide bearing for maximum stiffness. The crosshead motion loads the specimen in tension or compression. A range of crosshead speeds can be achieved by changing the speed of the motor.

The instrument is powered by a 32-bit microcontroller running at 16 MHz and a 20-bit A/D converter. The combination provides force and strain measurements that exceed ASTM E4 and ASTM E83 specifications, and powers a fast-acting closed loop servo system that accurately controls the speed of the crosshead.

Elmet worked directly with Admet to customize some of the software in the digital controller. In addition, Admet was asked to extend the column by six inches to allow for the testing of some wires with very high elongations.

The closed-loop unit tests wire samples to the breaking point, al-
though it can be set up to test to a user-defined load or position. The digital controller both controls and reports the crosshead position. It also controls the crosshead speed, ensuring that tensile strength results are consistent across different production runs, and that individual operators do not run tests at different speeds.

The unit is also available with MTestWindows, which is a personal computer-based controller and data collection system. However, because Elmet repeats the same tests, it did not require the more sophisticated testing system.

Calibration ranges

The Elmet machines are calibrated in three ranges: the first measures 0 to 1 kg; the second, 1 to 10 kg; and the third, >10 to 100 kg. The operators simply select the calibration range based on the wire diameter and the expected break load, and then record the calculated results. Tensile strength is noted from the digital display and transferred to the process tag. For some tests the operators record break load, peak load, and percent elongation.

The tensile test information also becomes part of the information base for the product lot. It is printed on the customer label and kept in a permanent database so that product specifications can be traced in the future.


### Wire products and applications

<table>
<thead>
<tr>
<th>Product</th>
<th>Thickness/diameter, in. (mm)</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire</td>
<td>0.001 to 0.250 (0.03 to 6.35)</td>
<td>Mandrel wires, leads and supports, furnace elements and windings, formed parts</td>
</tr>
<tr>
<td>Rod</td>
<td>0.020 to 1.750 (0.51 to 44.45)</td>
<td>Lighting, electronics and semiconductor industries, as well as heating elements, fasteners and structural components in high temperature HIP, vacuum and hydrogen atmosphere furnaces</td>
</tr>
<tr>
<td>Sheet</td>
<td>0.005 to 0.090 (0.13 to 2.29)</td>
<td>Sintering boats, high temperature furnace heating elements and heat shields</td>
</tr>
<tr>
<td>Plate</td>
<td>0.090 to &gt; 0.500 (2.29 to 12.70)</td>
<td>Furnace tooling and parts, and as a feed stock for the fabrication of parts for the electronics and semiconductor industries</td>
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</tbody>
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