**TESTING STRESS RELAXATION RESISTANCE**

This edition of Technical Tidbits continues last month’s discussion of stress relaxation. No discussion would be complete without a description of how test data are obtained.

To put it in the simplest terms possible, test specimens are placed in a fixture and loaded to a specific stress level (typically 75% of the 0.2% offset yield strength) in bending, tension, or torsion. The fixtures are put in an oven and held at temperature for a given amount of time, and are then removed. The stress relaxation is typically measured indirectly by monitoring the change in either strain or force/tension.

Stress relaxation data is typically presented in chart form. Isothermal curves show the relaxation vs. time for constant temperatures (left side of Figure 2). Isochronal curves show the relaxation vs. temperature for constant temperatures (right side of Figure 2). The isothermal curves are most frequently shown on material datasheets.

**Figure 1. Test Fixture Used to Measure Stress Relaxation in Bending.**
This specimen (per ASTM E328-13 Test Method C3) is a tapered cantilever beam, of near-constant section modulus down the length, designed to provide constant curvature down the length keep the stress fairly uniform on the top and bottom surfaces, instead of concentrating it at the fixed end. The set screw is used to deflect the beam until the outer fibers reach the desired stress level, and the whole fixture is placed in the test furnace. After the required amount of time, the fixture is removed and allowed to cool. The set screw is backed off, and an optical comparator is used to determine how far the beam tip is displaced from its initial position, which can be used to determine the percent drop in stress level, and thus the percent relaxation.

**Figure 2. Isothermal vs Isochronal Data.**
Both charts show data for the same material. The chart on the left displays isothermal curves, while that on the right shows isochronal curves.
Figure 3 above shows how a higher initial stress level leads to more rapid relaxation of stress. It also shows how isothermal stress relaxation resistance data may be better plotted with a logarithmic time scale, since stress relaxation is typically an exponential function of time with temperature as a constant in the exponent.

That is, it is governed by an Arrhenius-type equation. (There will be more on this in next Month’s issue of Technical Tidbits.) Figure 4 below shows how within a given alloy, higher strength tempers typically perform better than lower strength tempers. Next month we will show how to put all this data to good use.

**Figure 3. Effect of Initial Stress Level, and Linear vs. Logarithmic Scales.** These isothermal charts show how an increase in the initial stress level leads to faster relaxation of stress. The chart on the left has a linear time scale and that on the right has a logarithmic scale. The curves are straighter on the logarithmic scale, implying that stress relaxation is governed by an exponential function of time and temperature.

**Figure 4. Effect of Temper and Yield Strength (in Parentheses).** Higher strength tempers will typically, but not always, have more resistance to stress relaxation than softer tempers of the same alloy, regardless of temperature.

References:
Technical Tidbits Issue No. 12 – “Stress Relaxation and Creep.”

Technical Tidbits Issue No. 13 – “Factors Affecting Stress Relaxation and Creep.”

ASTM E328-13 Standard Test Methods for Stress Relaxation Tests for Materials and Structures

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