Issue No. 27 – March 2011 **Updated from Original September 2001 Publication**

Take the tension out of tensile testing – An overview of how to appropriately verify material properties using tensile tests.

- **Strain Rate Sensitivity**
- **Shape/Size Dependence**
- **Surface/Edge Condition**

The next issue of Technical Tidbits will discuss directionality of material properties.

Tensile Testing

The uniaxial tensile test is quite possibly the most useful test one can conduct on strip material. It generates a stress-strain curve, which characterizes a material's mechanical performance. The test is used to directly or indirectly measure the some of the most important material properties such as yield strength, tensile strength, elastic modulus, elongation, resilience, and toughness. When performed properly, the tensile test can be an invaluable tool for material characterization and verification. However, care must be taken to ensure that the test results are valid.

Figure 1 shows the standard configuration for tensile testing strip materials, according to ASTM E8. This shape is commonly referred to as a dogbone, with wide ends and a narrow middle. The allowable dimensions of each feature are governed by the ASTM specification. The grips of the testing apparatus hold the specimen firmly at the wide ends. The midsection of the sample has a narrower width than the grip section. This concentrates the stress in the test area, so that fracture and most of the strain occur here. Strain is measured in this section, and stress is calculated from the force load on the grips. If any strain or deformation occurs outside of the test area, the test results will be inaccurate. It takes time to machine a dogbone-style tensile sample, so straight sided samples are permitted by ASTM. However, if the fracture occurs outside of the area in which the strain is measured, the test results must be thrown out. It is therefore a good idea to prepare multiple samples if using straight-sided pieces.

Figure 2 shows a finite element analysis model of tensile samples of identical thickness and length, with varying widths, subjected to the same elongation. Note that in the dogbone sample, the stress is concentrated in the test area, while the stress is evenly distributed in the straight-sided sample. The stress magnitudes are approximately the same in all of the samples.

The results of the test depend on the rate at which the sample is elongated, or strained. This **strain rate sensitivity** shows up as higher stress at fast strain rates, and lower stress at slow strain rates. Therefore, two samples of the same piece of material that are tested on the same machine will show different strengths if they are tested at different rates!

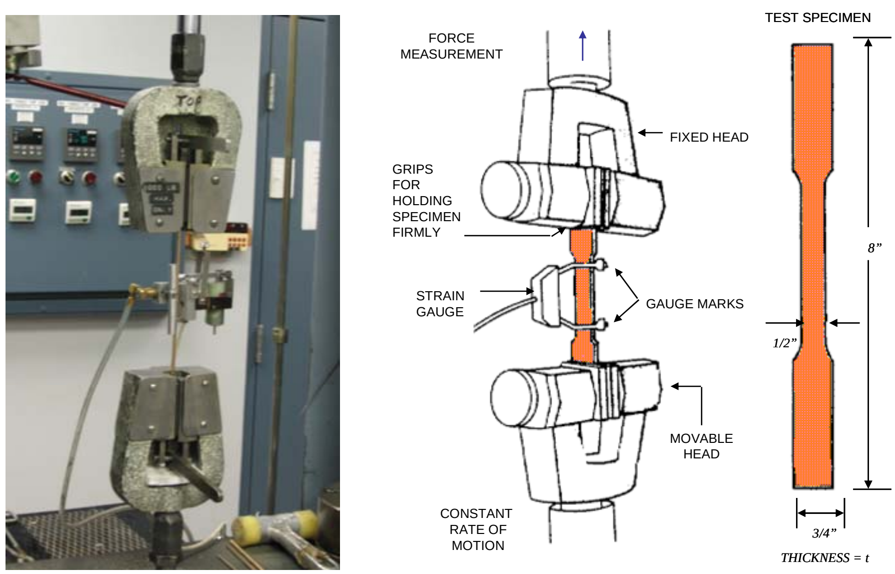

Figure 1. Standard Tensile Test Configuration

Tensile Testing (continued)

For the sake of consistency it is best to run tests on all material to be compared at the same strain rate. However, tensile tests on high elongation materials will take longer than low elongation materials.

In strip material, any nicks or burrs along the edge of the test piece will concentrate stress, which can cause the sample to yield and fracture prematurely. It is therefore a good idea to smooth the edges of the sample with a piece of sandpaper or an emery board before testing, especially if using a straight-edged sample slit from a wider strip. In rod and wire samples, a smooth surface finish after machining is imperative.

The size of the tensile sample is just as important as the shape in determining the results. Narrow strip with a width to thickness ratio of less than 8:1 will show lower stress (and therefore lower strength) than wider material. Additionally, samples of small cross section will show a small change in force for a given elongation. This decreases the accuracy of the force measurement, which in turn reduces the accuracy of the stress measurement.

If the material to be tested is plated, there is potential for inaccuracy as well. A soft, lubricious plating like tin may allow the grips to slip during the test. This will impact the strain and stress readings. Tightening the grips may compensate for any slippage, although this will increase the stress in that area. Any additional stress outside of the test section increases the likelihood of fracture occurring outside of the gauge length.

For samples with round cross sections, an additional problem may arise if the material to be tested is slightly curved. If the test piece is not aligned perfectly straight between the grips, there will be bending stress added to the tensile stress. This additional stress will not be taken into consideration when calculating the stress from the force load.

Given all of this potential variation, it becomes critical to ensure “apples to apples” comparisons of materials. To compare one material to another, it is best to use properly prepared, unplated tensile test specimens of identical size and shape, tested at the same strain rate. This will help ensure a more accurate test and comparison.

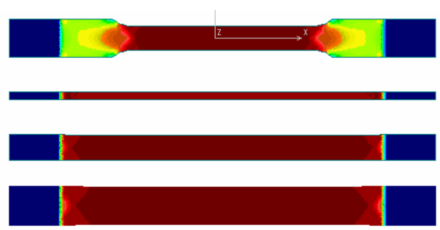

Figure2. Finite Element Model of Stress Distribution in Tensile Test Samples

Written by Mike Gedeon of Brush Performance Alloys Customer Technical Service Department. Mr. Gedeon’s primary focus is on electronic strip for the telecommunications and computer markets with emphasis on Finite Element Analysis (FEA) and material selection.

TECHNICAL TIDBITS

Brush Performance
6070 Parkland Blvd.
Mayfield Heights, OH 44124
(216) 486-4200
(216) 383-4005 Fax
(800) 375-4205 Technical Service

References:

ASTM E4

ASTM E8

ASTME E345

Please contact your local sales representative for further information on tensile testing or other questions pertaining to Brush Performance Alloys or our products.

Health and Safety

Handling copper beryllium in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on copper beryllium, contact Brush Performance Alloys