TECHNICAL TIDBITS

a publication by BRUSH WELLMAN ALLOY PRODUCTS

Issue No. 4 – May 2009 **Updated from Original October 1999 Publication**

Rubbing contacts the wrong way! - This discussion will explain how residual stresses can produce unexpected performance in contacts.

- **Residual Stress**
- **Bauschinger Effect**
- **Thermal Stress Relief**

The next issue of Technical Tidbits will include an informative discussion about reliability and end-of-life contact force.

Cumulative Stress & the Bauschinger Effect

In this age of miniaturization, the process of creating a robust connector design offers peculiar challenges. There are many operations necessary to turn coils of metal into contacts, including slitting, blanking, and forming. All of these processes leave their mark on the finished product. The **residual stresses** from these operations will combine in complex ways with the design stress produced during the operation of the contact. This may result in unexpected permanent set, stress relaxation, and loss of contact force, even when the design stress is well below the yield strength.

Finite element analysis (FEA) and other stress prediction techniques assume that the stress in a contact is only due to the operational contact deflection. However, in actual connector performance, the presence of residual stresses from forming operations in the material will affect the function of the contact. In particular, material properties will vary depending upon which way the contact is deflected. This induced directionality is known as the **Bauschinger Effect**. The main consequence is that contacts deflected back against the forming direction will experience a decrease in yield strength and less resistance to stress relaxation. This will result in a reduction in the contact force between a pin and contact that is critical for the passage of electrical signals. Figure 1 defines forward and backward deflection relative to the high stress 180° bend on the left side of the contact.

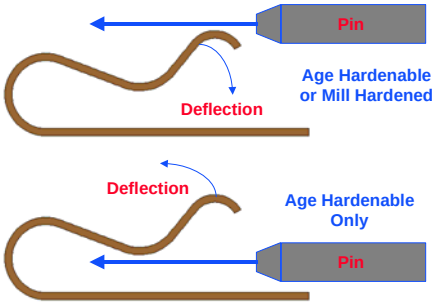

Figure 1. Preferred Bending Direction

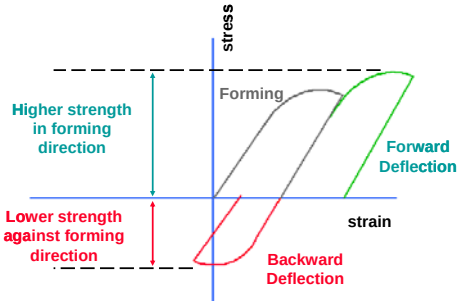

Figure 2. Stress-Strain Curves

Figure 2 shows the consequences of the Bauschinger Effect. In the forming step, the metal is deformed plastically into the desired shape. When the forming tools are removed, the metal springs back into a shape where all residual stresses in the contact balance. The yield strength may be slightly increased in the forward direction if the part has experienced strain hardening. However, the yield strength is substantially reduced below its original value in the reverse direction.

The Bauschinger Effect can be minimized through a combination of creative manufacturing and careful material selection. Since the Bauschinger Effect increases in bends with larger ratios of bend radius to material thickness and decreases with smaller ratios of bend radius to thickness,

Cumulative Stress & the Bauschinger Effect (continued)

use the smallest recommended bend radius for the given material. Here, materials with better formability have an advantage. In addition, materials with higher yield strengths tend to show more resistance to the Bauschinger Effect. Higher strength materials can absorb more residual stress and design stress without yielding, therefore they will perform better during both forward and backward deflections.

A second alternative is to use an age hardenable material, or to give the contact a **thermal stress relief** treatment. Sufficient heat treatments virtually eliminate residual stresses, meaning that standard stress-strain curves for these materials will once again apply. These stress-relieved contacts will then behave much more predictably. Unfortunately, heat treatments can be expensive, and the residual stresses may cause the parts to distort during the heat treatment process unless they are firmly fixtured.

Another method to control the effect is to design the connector so that contact deflection occurs in the forward direction. If a reverse deflection is unavoidable due to space constraints, other methods may be used to limit the consequences of the Bauschinger Effect. A two-step process may be used to form the bend, as shown in Figure 3. In the first step, the material is given a much sharper bend than required. In the second step, the contact is bent back into its final position. This process tends to balance the residual stresses on both sides of the bend. The balance of stresses will minimize the Bauschinger Effect and help to control heat treating distortion. However, this does not eliminate residual stress and adds several degrees of difficulty to the forming operation.

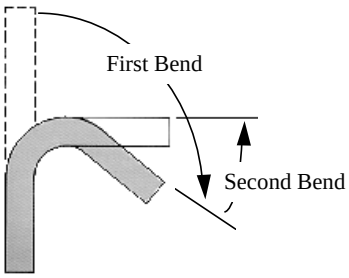

Figure 3. Two-step bend process

In summary, age hardening or stress relieving heat treatments are the most effective means to eliminate residual stress in electrical contacts. If it is cost-prohibitive to heat treat the part, design the contacts to deflect in the forming direction, not back against it. If a reverse deflection is unavoidable, stronger materials will allow for higher stresses without yielding. Finally, the original forming bends may be made tighter or made with a two-step process. By utilizing these techniques and minimizing the stress in the contact, design engineers can avoid the unpleasant experience of watching an otherwise good design fail.

Written by Mike Gedeon of Brush Wellman's Alloy 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 Wellman Inc.
6070 Parkland Blvd.
Mayfield Heights, OH 44124
(216) 486-4200
(216) 383-4005 Fax
(800) 375-4205 Technical Service

BRUSH WELLMAN ALLOY PRODUCTS

REFERENCE: The Influence of the Bauschinger Effect in the Performance of Connector Materials - John Ratka

Please contact your local sales representative for further information on residual stresses or other questions pertaining to Brush Wellman 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 Wellman Inc.