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TECHNICAL TIDBITS

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Bend there, done that! – A continued discussion on proper forming techniques of copper strip alloys with a focus on differentiating between theory and reality.

- **Forming Strains**

Bend Testing vs. Forming Reality

Last month's Technical Tidbits explored the notion of material formability. It explained how the R/t formability ratio is determined. This month's Technical Tidbits will explore why this number does not apply in every forming situation. The R/t ratio is a good indicator of relative formability, but is not an absolute measure.

One of the most common methods for forming automotive box terminals is to use a punch to score the base metal strip along the bend centerlines. The form will then be made in a press brake, with the score line functioning as a stress riser to initiate plastic flow. This method has the benefit of being quick and easy, with little springback. However, it has little in common with the V-block punch and die test used to measure formability. Figure 1 shows a cross section of a bend that failed in forming using the score and bend method. Figure 2 shows a cross section of a bend that was formed in a punch and die arrangement similar to theV-block test.

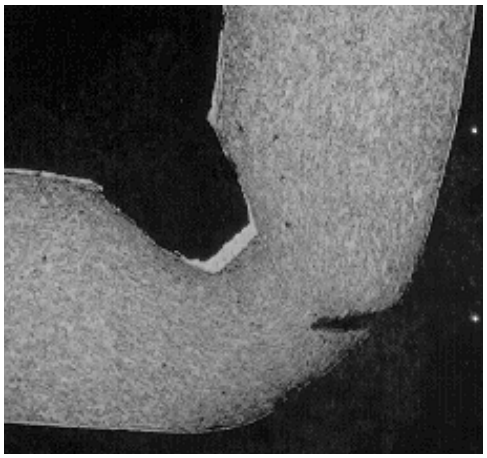

Figure 1. Failure of a Bend Created in a Press Using a Score Line to Locate the Bend

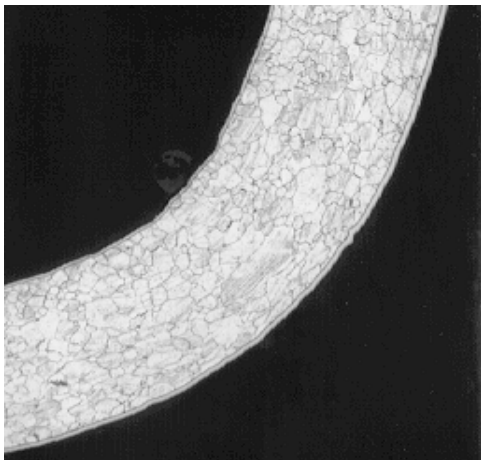

Figure 2. Bend Made with a Punch and Die Using a Generous Inside Radius

As one can see in the figures above, the score and bend method is a much more severe forming operation than the punch and die method. When a punch and die arrangement is used, the forming strains and stresses are distributed evenly around the entire arc of the bend. Evenly distributed stress minimizes the possibility of failure. When the strip material is scored prior to bending in the press brake, the score line becomes a localized area of very high strain. As the material is formed, all of the bending stresses and strains are concentrated in the area of the score line, increasing the probability of failure. (The relative amount of strain in the above photographs can be observed in the relative distortion of the grain boundaries.) Furthermore, this heavy strain also produces considerable cold work in the base metal, which effectively increases the temper of the metal. Quarter hard tempers may form like full hard tempers, half hard tempers may form like spring tempers, etc.

The next issue of Technical Tidbits will include an informative discussion on springback during forming operations.

Formability and Bend Testing (continued)

The reported R/t ratio of a material is generally an average of many test samples. Therefore, there is the potential for wide scatter in the test data. The same scatter in formability will generally show up in the field as well. Additionally, different material producers may define the R/t ratio in different ways. For example, they may use the mean or the median value, and may or may not take into account the standard deviation.

Formability is directly related to the ductility of the base metal. Different heats of the same material will generally tend to show variations in their mechanical properties. If a particular heat of material has a lower ductility than previous heats, it may show an increased tendency to fracture during bending. This may also occur if the thickness of the material is greater than previous material or if the grain size is different (larger grains will form better when there is stretching involved, smaller grains form better under even stress distribution).

If the material is stretched as well as bent when it is formed, the likelihood of failure increases. Any additional tensile stress placed on the material will be added to the tensile stress on the outside of the bend. This makes fracture on the outer radius much more likely.

The number of stages used to make the bend comes into play as well. Most bends can be made with one die stroke. However, if the bend is made in several progressive die strokes, the likelihood of fracture diminishes. The amount of strain required at each progressive step is much less than the amount required to form the bend in only one step. A multistage form will also allow for tighter control of springback.

When choosing a material, remember to look at the R/t ratio. However, this ratio should be considered a means of determining the relative formability of the material, and not as an absolute value. If the bend angles are 90º or less and if the stamping operation closely approximates the V-block test, then the R/t ratio should be fairly accurate. However, if the bending process is much more severe, it will be necessary to test the material before running it in order to determine whether or not the material can sustain extreme forming conditions.

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