Formability of Materion Brush Performance Alloys Strip Products

Formability refers to the ability of a material to be bent to a required geometry, without cracking or failure. The formability of copper strip is dependent upon a number of variables including alloy, temper, bending direction, strip thickness, width, and method of forming.

The heat treatable tempers (Alloys 25, 360, BrushForm® 96 and BrushForm® 158) are the easiest to form during fabrication. Following fabrication, parts can be heat treated to very high strength levels. As a result, these materials provide the optimum combination of excellent formability and the highest strength attainable. In applications not requiring severe forming, mill hardened strip (Brush Alloys 190, 290, 3, 174, Brush 60®, 390®, 390E, BrushForm® 47, and certain tempers of 360, BrushForm® 96 and BrushForm® 158) can be extremely cost effective. These materials are heat treated by Materion Brush Performance Alloys to deliver maximum formability at desired strength levels. Since mill-hardened strip requires no additional cleaning or heat treating after forming, manufacturing costs can be effectively reduced.

R/t RATIO

A material's formability rating (R/t) is expressed in terms of the ratio of the bend radius (R) to the strip thickness (t). This value defines the sharpest radius that can be formed without failure. Materion Brush Performance Alloys publishes forming limits in a 90° bend to which its strip products will form without failure. Larger R/t ratios indicate less form¬ability since a larger forming radius is required. Therefore, an R/t value of 0 means the material can be formed around a sharp corner (zero radius) without failure. An R/t of 1.5 would require a bend radius of at least 1.5 times material thickness. As in the case of a material's ductility, formability is heavily dependent upon an alloy's strength. As strength increases from cold rolling or mill hardening, formability decreases (increasing R/t ratio) and the formability becomes anisotropic (directional).

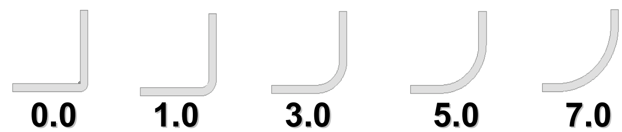

Figure 1. Various Forming Ratios

LONGITUDINAL VS. TRANSVERSE BENDING

As shown in Figure 2, bends are termed longitudinal or transverse depending upon their orientation to the rolling direction in the strip. The anisotropy or directionality of strip properties is the result of texture effects from cold rolling. When such anisotropy occurs, the formability in the longitudinal direction (good way bend) is typically better than that in the transverse direction (bad way bend).

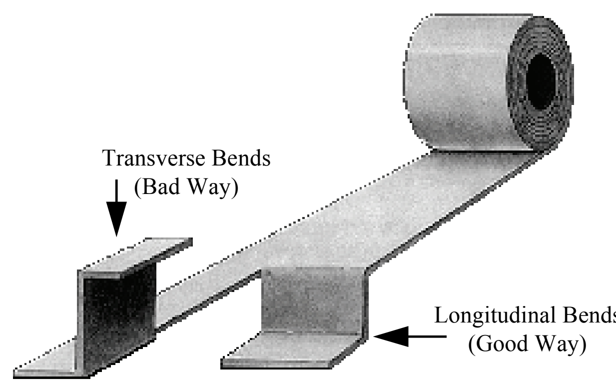

Figure 2. Longitudinal and Transverse Bend Orientation

TESTING METHOD

Materion Brush Performance Alloys tests strip formability with a semi guided bend test, similar to ASTM E 290. The test fixture consists of a 90° "vee" block and 90° punches with various radii ground into the into the block with the punch (see Figure 3). Following bending, the sample is viewed at 10 30X magnification. The surface is examined

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for cracks on the convex side of the radius. If no cracks are visible, the sample passes the test at that radius. The punch radius is then reduced and another strip sample is formed and examined. This process is repeated until cracks appear in the sample surface. Cracks need not penetrate the sample thickness to constitute a failure. The smallest radius not to cause visible cracking is divided by the strip thickness to determine the R/t ratio.

“Orange peel” is the texture on the bend surface as a result of bending and is sometimes viewed as a failure. In its milder forms it is not cracking, but only a surface change that results from deforming a straight piece of material. The presence of “orange peel” is influenced by many factors including cold reduction, grain size, and direction of bending. As a result, the presence of “orange peel” is not an accurate measure of formability. Evaluation of material using this method is very subjective.

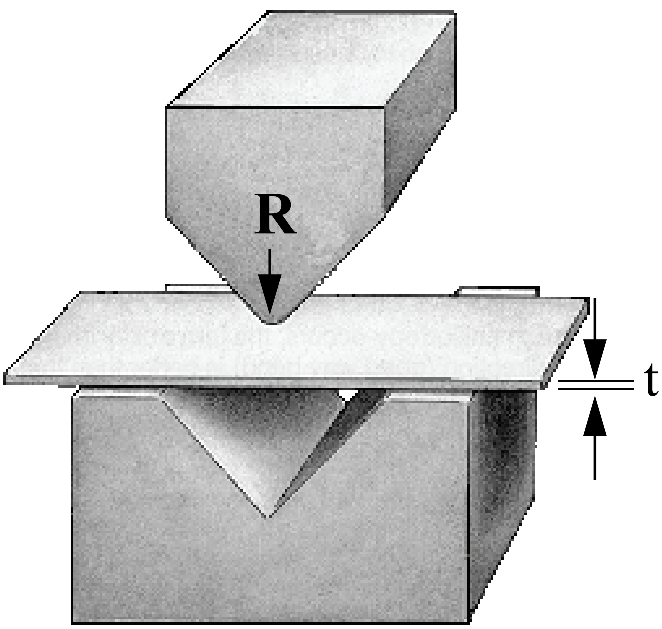

Figure 3. “Vee” Block Formability Die

Materion Brush Performance Alloys' published formability values in the accompanying chart are for strip at 0.010 inch (0.25 mm) thick. Strip less than 0.010 inch (0.25 mm) thick will be somewhat more formable than shown. **These numbers are published as a guide only and are not a specification. If your design requires that the material pass a particular R/t ratio, please specify when ordering the material.**

DESIGN FACTORS

In determining the optimum material for a given application, there are several factors that must be considered. As temper increases, strength and hardness generally increase, while ductility and formability decrease. The highest temper that will form the part without fracture is the one that should be specified. This will effectively ensure the reliability of the design with a temper that can be readily formed.

The directional nature of formability (good way vs. bad way bends) can provide additional design flexibility, as well as efficient material use.

APPLICATIONS

Materion Brush Performance Alloys formability information is intended to be used as a guide for selecting the appropriate temper for an application. If the inside angle of a bend is obtuse, a radius smaller than the recommended value can be used. If the angle is acute, a larger radius may be required. The quality of the bend can also be influenced by the form¬ing method used. For example, forming the bend in several steps, instead of just one, or rolling the material around the radius, will produce tighter bends than the R/t ratios would indicate. Also influencing the quality of a bend is strip width; very narrow strip will form better than wide strip. Strip with a width to thickness ratio less than about 10:1 will exhibit improved formability.

SAFE HANDLING OF COPPER BERYLLIUM

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 Materion Brush Performance Alloys, Technical Service Department at 1-800-375-4205.

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Guide to Strip Alloy Formability

Formability Rating	Specific Formability	Alloy and Heat-Treatable Temper	R/t Ratio for 90° Bend Direction of Bend		Alloy and Mill Hardened Temper	R/t Ratio for 90° Bend Direction of Bend	
			L	T		L	T
Excellent	Used for deep drawn and severley cupped or formed parts	25 A BrushForm® 96 A BrushForm® 158 A 360 A	0 0 0 0	0 0 0 0			
	As formable as the annealed temper but easier to blank	25 1/4 H BrushForm® 158 1/4 H 360 1/4 H	0 0 0	0 0 0	290 TM02 BrushForm® 158 TM00 BrushForm® 158 TM02 360 MH2	0 0 0 0	0 0 0 0
Very Good	Used for moderately drawn or cupped parts	BrushForm® 158 1/2 H 25 1/2 H 360 1/2 H BrushForm® 96 1/4 H	0 0.5 0.7 1.1	0.5 1 1.2 1.7	190 AM BrushForm® 96 TM00 174 1/2 HT 190 1/4 HM BrushForm® 96 TM02 290 TM03 360 MH4 Brush 60® 3/4 HT 290 TM04 190 1/2 HM 3 AT 390E® EHT ≤0.002" (0.05 mm)	0 0.2 0.5 0.5 0.5 0.5 0.5 0.7 0.7 0.5 1 1	0 0.2 0.5 0.5 0.5 0.5 0.5 0.7 0.7 1 1 1
Good	Formable to a 90° bend around a radius less than 3 times the stock thickness	360 H BrushForm® 96 1/2 H BrushForm® 96 H BrushForm® 158 H 25 H	1.2 1.5 1.5 0.5 1	2 2 2.5 3 3	BrushForm® 96 TM04 360 MH6 BrushForm® 158 TM04 Brush 60® HT 290 TM06 360 MH8 390® HT ≤0.004" (0.1mm) 3 HT 190 HM BrushForm® 158 TM06 360 MH10 390E® EHT ≤0.004" (0.10 mm) 360 MH12 BrushForm® 96 TM06	1 1 1 1.5 1.5 1.2 2 2 2 2 1.5 2 2 2.5	1 1.2 1.5 1.5 1.5 1.6 2 2 2 2 2.2 2.5 3 3
Moderate	Suitable for light drawing; used for springs				290 TM08 190 SHM 390E® EHT ≤0.006" (0.15 mm) 390E® EHT ≤0.010" (0.25 mm) 174 HT 390® HT >0.004" (0.1mm) 390E® EHT >0.010" (0.25 mm) 190 XHM	3.5 2.8 2.5 3.5 1.2 3.5 4 4	3 3.2 3.5 4 5 5 5 5
Limited	For essentially flat parts; forming requires very generous punch radius	BrushForm® 96 TD08	3	6	BrushForm® 96 TM08 BrushForm® 158 TM08 190 XHMS	5 5 5	7 8 10

Note: Formability ratios are valid for strip up to 0.050 inches (1.27 mm) thick. Strip less than 0.010 inches thick may form somewhat better than shown. Values reflect the smallest punch radius that forms a strip sample into a 90° "vee"-shaped die without fai

R = punch radius t = stock thickness

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