DECEMBER 2016 ISSUE #96

MATERION

TECHNICALTIDBITS

MATERION PERFORMANCE ALLOYS

PROPERTIES ARE USUALLY FUNCTIONS, **NOT CONSTANTS**

"It depends" is not a cop-out answer – A brief discussion on how material properties almost always depend on some other parameter.

▲ **Temperature Coefficient of Resistance**

The next issue of Technical Tidbits will discuss in-depth how certain material properties change with temperature.

Technical Tidbits Issue #91 alluded to the fact that material properties are almost never constant. Usually, they are functions of some other environmental parameter. This issue will discuss this concept in more detail, focusing primarily on the effect of temperature.

When comparing properties among multiple materials, it is important to ensure that you are doing an accurate comparison based on data collected by similar test methods. Furthermore, those test conditions should be similar to what the application will experience in service. For example, if your part will be run at elevated temperature, then you need to know what its material properties will be at that particular temperature. Otherwise, you will have no guarantee that your part will work as intended.

Temperature will most likely have the biggest influence on mechanical properties. Material data sheets and specification sheets will usually show properties measured at room temperature (typically within a few degrees of 20°C) unless otherwise stated. Some properties will increase with temperature, and others will decrease, as shown below in Figure 1.

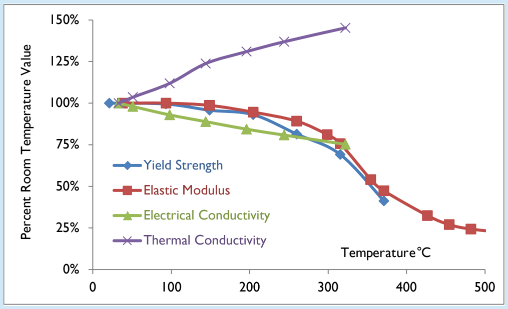

Figure 1. How Key Properties of C17200 (Alloy 25) CuBe Change with Temperature.
Yield strength, elastic modulus, and electrical conductivity all decrease with temperature, while thermal conductivity increases. Note that this is instantaneous change with respect to temperature, and does not include the effects of any metallurgical changes that might happen when the material is exposed to elevated temperature for a long time.

Sometimes, you can define a material property that does nothing but describe how another particular property varies with a given parameter such as temperature. The **temperature coefficient of resistance** is one example. It describes how electrical resistance (or resistivity) changes with temperature. It is used in the following equation:

$$R = R_{reference} [1 + \alpha \cdot (T - T_{reference})]$$

Here, $R_{reference}$ is the electrical resistance at a reference temperature ($T_{reference}$), R is the electrical resistance at the temperature of interest (T), and α is the temperature coefficient of resistance. Since electrical resistance is only a function of geometry and resistivity (at least under DC and low frequency AC currents), resistivity may be substituted for resistance in the above equation. The temperature coefficient of resistance (relative to 20°C) is about 4% °C-1 for pure Cu, and is about 1% °C-1 for C17200 CuBe.

PROPERTIES ARE USUALLY FUNCTIONS, **NOT CONSTANTS** (CONTINUED)

Figure 2 illustrates a couple of important points. Some materials have higher initial strength levels than others, while some retain a greater percentage of their initial strength at high temperatures. Sometimes, a material that has lower strength at room temperature will have higher strength at elevated temperature relative to another material under consideration. This illustrates the importance of choosing materials based on their properties under conditions close to the expected field conditions, as opposed to choosing based on data sheet values taken at room temperature under ideal conditions.

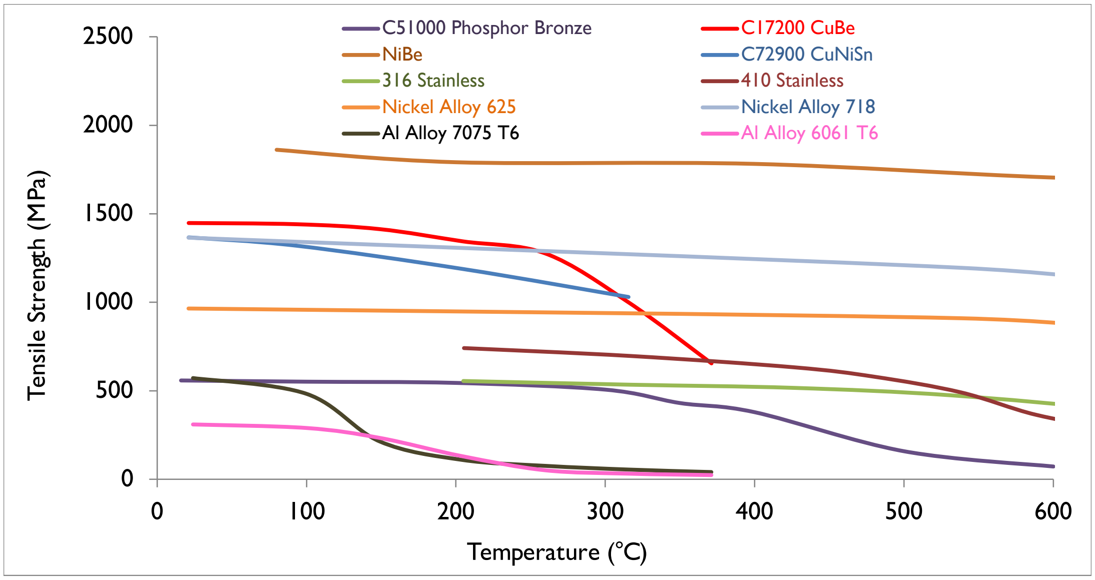

Figure 2. Tensile Strength as a Function of Temperature.
Most copper alloys will maintain a tensile strength close to their room temperature values through about 200 to 300°C. Aluminum alloys drop off in strength at about 100 to 150°C, while nickel and steel alloys can withstand much higher temperatures.

While Figure 2 shows tensile strength as a function of temperature, yield strength and the elastic modulus will show similar decreases with temperature (as previously shown in Figure 1). Thus, it is also helpful to think about the percentage of the room temperature value retained at elevated temperature. For example, as discussed in prior editions of Technical Tidbits, you can estimate the elevated temperature fatigue strength of a material by multiplying the room temperature fatigue strength by the percentage of the tensile strength retained at elevated temperature.

It should be emphasized that the data shown above are for instantaneous changes in properties vs. temperature, and do not include time-dependent changes such as creep or metallurgical (phase) changes. Those will be discussed in next month's edition.

TECHNICALTIDBITS

Materion Performance Alloys
6070 Parkland Blvd.
Mayfield Heights, OH 44124

MATERION

Sales
+1.216.383.6800
800.321.2076
BrushAlloys@Materion.com

Technical Service
+1.216.692.3108
800.375.4205
BrushAlloys-Info@Materion.com

Written by Mike Gedeon of Materion Performance Alloys Marketing Department. Mr. Gedeon's primary focus is on electronic strip for the automotive, telecom, and computer markets with emphasis on application development.

Please contact your local sales representative for further information on material hardness or other questions pertaining to Materion 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 Materion Performance Alloys or your local representative.