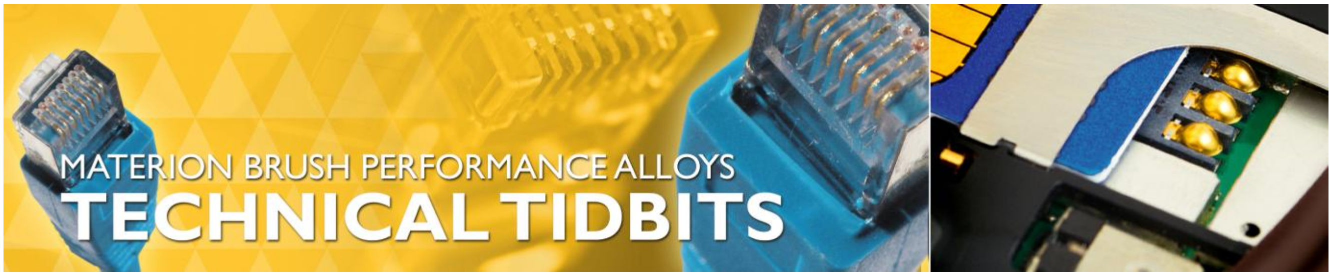

Issue No. 58 – October 2013 **New Publication**

Even metal fatigues more quickly in the heat – Continuation of the discussion on how to modify the calculated fatigue strength value to account for real-world conditions.

- **Modification Factor**
- **Temperature Factor**

The next issue of Technical Tidbits will continue the discussion on fatigue strength modification factors

Fatigue Strength Modifying Factors - Part 2

(This issue of Technical Tidbits continues the materials science refresher series on basic concepts of material properties.) Last month's edition of Technical Tidbits discussed how to modify the fatigue strength of a material to account for surface condition. This month we discuss how to estimate elevated temperature fatigue performance of materials.

The modification factor for temperature may be unique in that it can be greater than 1. There are certain steel alloys that show improved fatigue performance at elevated temperatures, and others such as copper alloys that show improved performance at cryogenic temperatures. Some alloys may even show decreased fatigue strength at elevated temperatures as well as transition to brittle at cryogenic temperatures. However, there will always be a large range of temperatures at which any metal will show reduced life relative to room temperature testing.

The best way to ensure that your device will have adequate life at elevated temperature would be to conduct the appropriate fatigue testing at the temperature of interest. Since this is not always practical, there are ways to estimate the modification factor based on tensile test data. A simple method to do so is presented below.

Figure 1 shows an estimated modification factor for 3 high performance copper alloy spring materials in strip form. This is not data that was generated in fatigue - it was actually estimated from tensile testing. The factor is calculated by dividing the elevated temperature tensile strength by the room temperature tensile strength. Since fatigue strength is generally proportional to tensile strength (in high strength alloys such as these), the same factor could be used to modify the estimated fatigue strength at the desired number of cycles. Note that this approach is useful for the high cycle (>1000 cycles) regime only.

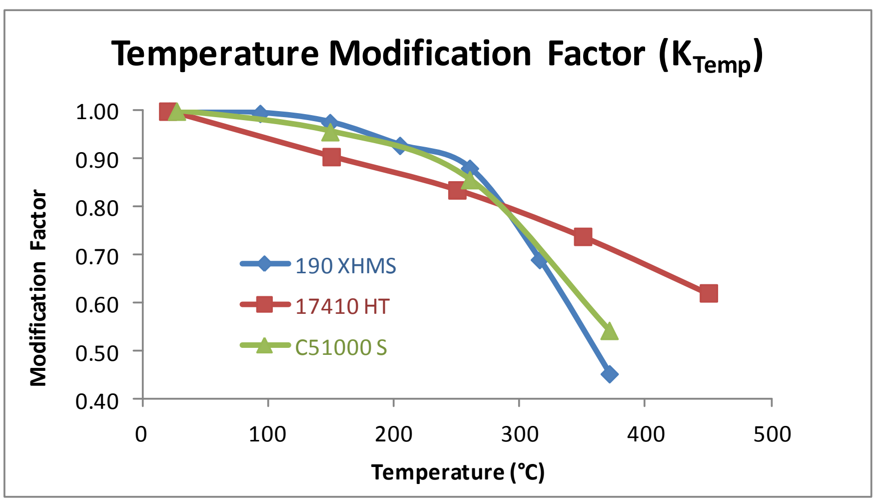

Figure 1. Effect of Temperature on Tensile and Fatigue Strength of Various High Strength Copper Alloys. As the temperature increases, the tensile strength drops to a fraction of its room temperature value. Since fatigue strength is proportional to tensile strength, the same modification factors may be used to estimate the fatigue strength at a given number of cycles at elevated temperature, when the corresponding room temperature fatigue strength is known.

Fatigue Strength Modifying Factors - Part 2 (continued)

Note that this is a modification factor only, it is not a measure of absolute performance. All 3 materials have similar modification factors at temperature, but if you use this to estimate the 10^8 cycle fatigue performance, you can see a large difference in performance. Generally speaking, materials with higher tensile strengths will have higher fatigue strength, as illustrated in the following table:

	190 XHMS	17410 HT	C51000 S
Tensile Strength (MPa)	1448	819	483
10^8 Cycle R=-1 Bending Fatigue Strength (MPa)	379	328	207

If you multiply the room temperature fatigue strength by the modification factor shown in Figure 1, you obtain the chart shown in Figure 2. The performance difference, based on tensile strength, is apparent.

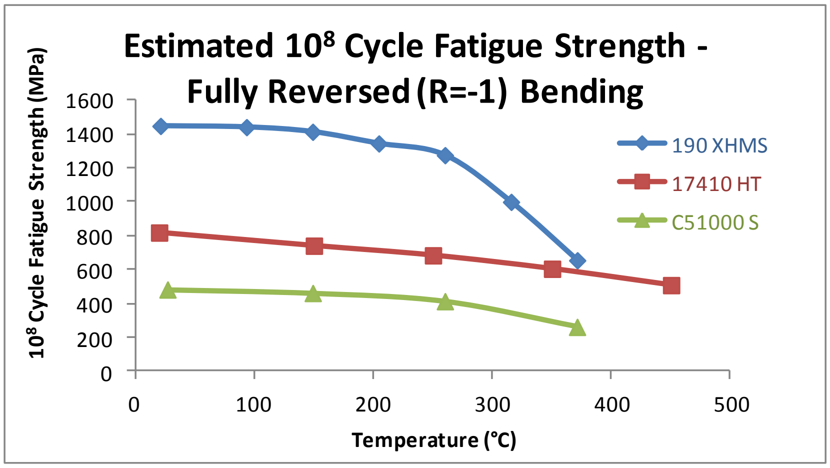

Figure 2. Effect of Temperature on Fatigue Strength. As the temperature increases, the maximum permissible stress level for 10^8 cycle survival drops. For clarity, the 50% failure rate at 10^8 cycles is used as the room temperature value, which is multiplied by the percentage decrease in temperature in tensile strength to obtain the estimated curves. Note that this is not actual fatigue test data or design data, and is used for illustrative purposes only.

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