MATERION BRUSH PERFORMANCE ALLOYS
TECHNICAL TIDBITS

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What's your stress ratio? – An in-depth discussion on the various stress states that influence fatigue behavior.

- **S-N Diagram**
- **Stress Ratio (R Ratio)**
- **Unidirectional (R=0) Testing**
- **Fully Reversed (R=-1) Testing**

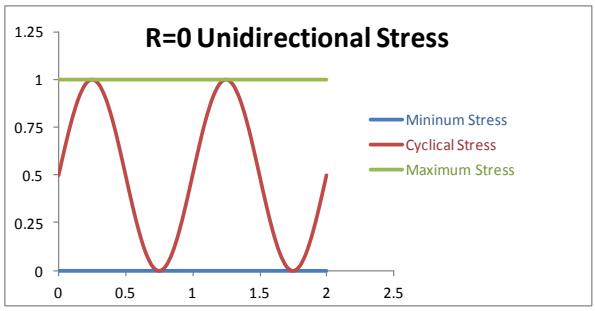
The next issue of Technical Tidbits will continue the discussion on Fatigue.

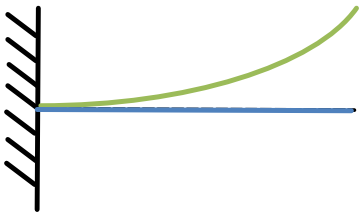
Fatigue and Stress Ratios

(This issue of Technical Tidbits continues the materials science refresher series on basic concepts of material properties.) Last month's edition of Technical Tidbits introduced the concepts of fatigue, the three stages of fatigue failures, and the S-N curve of a material. This month, we will discuss the various ways that parts undergoing fatigue may be loaded.

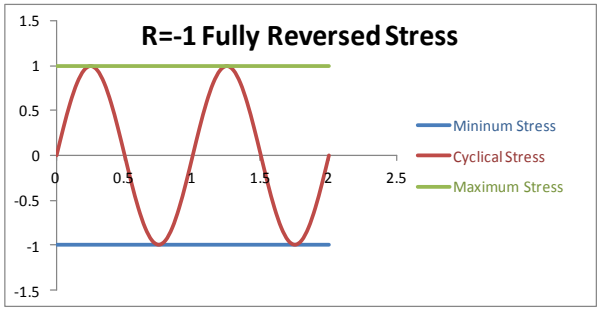
For proper fatigue characterization of a material for a given application, it is necessary to obtain data in a test whose loading mimics the expected cyclical loading that will be experienced by the material in the application. This means that if the part will experience cyclical uniaxial tension, then the test data should be generated in uniaxial tension. For expected bending or torsional stresses, the test data should be generated in bending or torsion, respectively.

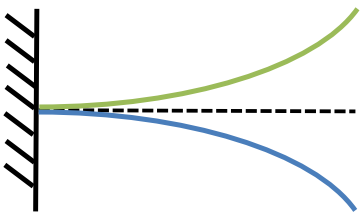
Next, the **stress ratio**, or **R ratio**, of the test must be determined. This is simply the ratio of the minimum stress experienced during a cycle to the maximum stress experienced during a cycle. It is important to note that the stress values can be positive (tensile stress) or negative (compressive stress). In the easiest case to visualize, the test specimen starts out unloaded (zero stress), is loaded to the required maximum positive stress level, and then unloaded to start the next cycle. In this case, the R ratio would be exactly zero. This is called **unidirectional (R=0) testing**. A spring contact in a modular jack would be an example of this loading condition (assuming that the contact is not preloaded in any way.)



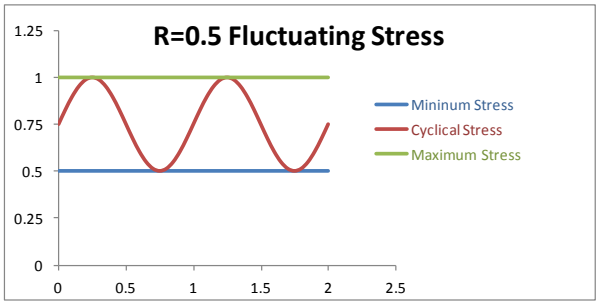


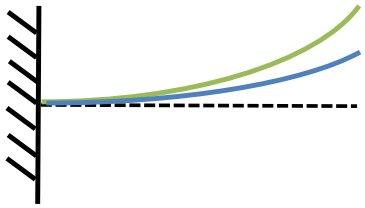
The most extreme case would be if each cycle consisted of loading the test specimen to a given stress level (in bending or torsion), and then loading to an equal and opposite stress level in the other direction. In this case, the minimum stress would be the negative of the maximum stress, and the R ratio would be exactly equal to -1. This is known as **fully reversed (R=-1) testing**. A rotating axle or shaft subjected to a constant bending stress would be an example of this condition, as each point on the circumference of the shaft would alternately experience tension and compression as it rotates around the center.

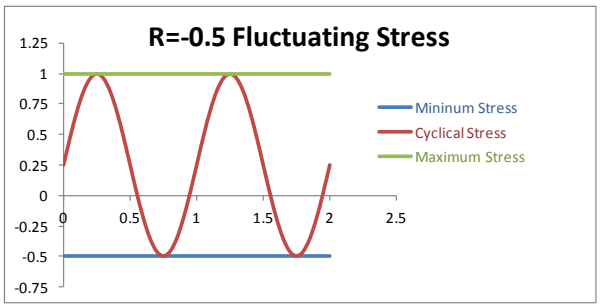


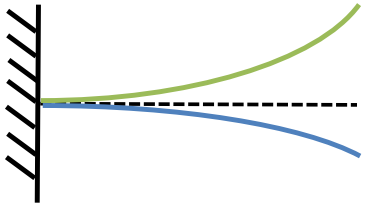


Fatigue and Stress Ratios (continued) At other times, a part such as an electro-mechanical relay may be preloaded to a certain stress level that is never removed during the life of the part. The part may then be loaded to the maximum stress level and then released back to the preload. In this case, the minimum stress would be some small positive value associated with the preload, and the maximum stress would be a larger positive value. In this case, the R ratio would be greater than 0 and less than 1. Another possibility is to have a minimum compressive stress of lower magnitude than the maximum stress. This would result in an R ratio between -1 and 0. This could be the case in some switch and relay contacts.









One important point to note is that the all sources of stress will factor into the fatigue performance of a component. This includes the design stress from mechanical sources (applied forces, pressures, or deflections), thermal stresses (elevated environmental temperatures or internally generated by joule heating), vibration, impact, and even residual stresses from forming or machining operations. Many of these sources are highly variable and unpredictable. This is why it is important to include safety factors in fatigue analysis.

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TECHNICAL TIDBITS

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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 Brush Performance Alloys