SOLAR ATMOSPHERES

Whether or Not to Use Cryogenic Treatment

Claims for the benefits of cryogenic treatment abound. Research also abounds, but with differing conclusions. Yet, applications have proven helpful, even dramatic, for the wear life of metal parts, dies and tooling applications after cryogenic treatment.

The applicability of cryogenic treatment for improved wear life is dependent on part application. Several successful applications include H13 dies, cemented carbides, 440 tooling and consumer parts where improved performance is desired (see list below).

Below is a summary of information and criteria compiled by Don Jordan, Solar Atmospheres Corporate Metallurgist and Vice President of Heat Treating at the Souderton, PA plant. This information is criteria to help make a decision on whether or not to use cryogenic treatment for a particular application.

FACTS

1. Cryogenic treatment transforms retained austenite to martensite, which increases hardness.
   - This may or may not increase wear resistance depending on the application. Retained austenite adds toughness to the structure, which enhances impact and fatigue resistance, both of which are important properties in many types of wear applications. Tough / ductile austenite inhibits crack initiation and blunts crack propagation. But increased hardness or "deformation resistance" resulting from cryogenic treatment often does result in increased abrasive wear resistance for many applications.

2. Retained austenite can transform to martensite under strain-induced conditions.
   - This can lead to dimensional instability in processing or service because there is a volume increase associated with the phase change of austenite to martensite. The problem is particularly acute with grinding, where retained austenite and its propensity to result in grinding cracks is a major concern in the gear industry. Thus, cryogenic treatment to eliminate retained austenite is highly desirable to avoid strain-induced distortion of parts.

3. Cryogenic treatment will amplify distortion.
   - If distortion is present after quenching, cryogenic treatment will make it worse. This means that from a “cryogenic standpoint” marquenching or vacuum gas quenching are desirable because both tend to minimize quench distortion.

Metallurgical Thoughts-To-Be Truths

4. The martensite that transforms from retained austenite during cryogenic treatment is structurally different than the “bulk martensite.”
   - Tempering after cryogenic treatment initiates the preferential precipitation of fine eta carbides only in the martensite formed from retained austenite transformation. Only epsilon carbides are precipitated within the bulk martensite.

- Eta carbides enhance wear resistance by adding strength and toughness to the martensitic matrix. Note the use of the word toughness; this is an important attribute used to describe retained austenite and its contribution to wear resistance in certain specific applications.

5. Interrupted cooling before complete transformation can "stabilize" retained austenite.
   - Stabilization reduces the ability of austenite to transform to martensite. Therefore, it is highly desirable to perform cryogenic treatment of steel as in integral part of the heat treatment cycle.

6. Carbide wear improvement due to changes at microvoids.
   - The results of one study showed that only abrasive wear resistance (not hardness or other typically measured mechanical property) was improved by cryogenic treatment. With cryogenically treated carbide, "plastic flow may take place at defects (microvoids-points of stress concentration) due to shrinkage on cooling which results in residual compressive stresses on the surface of the voids on return to room temperature. Such stress reduces the effectiveness of the defects in lowering the localized strength of the material and this situation should result in the reduction of abrasive wear".

Most "Marketed" Benefit

7. Improved dimensional stability and service performance.
   - Gun barrels, automotive racing parts (including engine blocks and heads), intricate parts to be EDM and numerous others, including golf balls, report very satisfying results on dimensional stability and enhanced performance.
   - Musical instruments purport improved sound quality.
   - Try it…you may like it.

Overview Comment

Cryogenic treatment is primarily performed for dimensional stability and improved wear resistance in specific applications. The above criteria are helpful to sort out the possibilities for success. However, processing parts, tooling and dies is done with numerous factors playing a role. Consequently, with metallurgical analysis some experimentation may be necessary to discover the possible benefits of cryogenics for a new application.