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CRYOGENIC SERVICES

Cryogenic Treatment for Motor Sports

Robin Alan Rhodes
Cryogenic Institute of New England, Inc., Worcester, Massachusetts

Many people have heard about using deep cryogenic treatment for enhancing the performance properties of their critical racing components. This technology has been widely adopted across many motor sports applications, including automotive racing, motor cross, tractor pulls, kart, boat and skimobile, to name a few. So exactly what is this technology and why are so many racers using it?

First, Deep Cryogenic Treatment is an extended process that very gradually "freezes" or removes heat from the items being treated. It is not a replacement for heat treatment, but rather an extension of the heat-treating process that produces further refinement in the metal. Typically, the parts are brought down to 300 degrees below zero (F) in a very slow ramp and then held at that temperature for an extended dwell (24 hours), before being returned to ambient temperature. The last step is a post temper to +300/ +350 degrees F. The entire process takes about 72 hours.

The technology has its roots in research conducted by NASA in the 60's as early space engineers tried to understand what happened to metals subject to the extreme temperatures of space.

Having said that, Swiss watchmakers and German machinists recognized from experience that metal properties were enhanced when allowed to "season" over a cold winter - sometimes packed in snow and placed in caves. The metals were stabilized and less prone to distortion when machined, enabling the critical tolerances in precision components (e.g. watch gears) to be held more closely.

Today's cryogenic treatment is a further advancement of this metals aging "secret" practiced by these old craftsman.

Based on before and after analysis, we know that deep cryogenic treatment provides for three documented transformations in metals. First, in heat-treated steels, we know that retained austenite is transformed to martensite, creating a more uniform grain structure and homogenous steel. This provides for a tougher and more durable material as the voids and weaknesses of an irregular grain (or crystal) structure are eliminated. This mechanism also provides for better thermal properties -- better heat dissipation -- in cryogenically treated steels. Additionally, it is this mechanism that leads to friction reducing qualities in metals, especially when final machining, polishing, grinding or honing are done AFTER deep cryogenic treatment. It is also why cryogenically treated steels show more uniform hardness than non-treated steels.

(It is technically inaccurate to say that cryogenic treatment increases hardness. Testing before and after shows little - if any - change to hardness. What has been documented, though, is that hardness is more uniform or consistent across the part.)

The second mechanism relates to modification in the carbon microstructure of cryogenically treated steels. Before and after micrographs show the formation of carbides within the steels. The technical description of this is called "the precipitation of eta-carbides". At the National meeting of the Heat Treating Society of ASM held in Pittsburgh this fall, some new dramatic SEM images were presented by Zbigiew Zurecki, a metallurgist from Air Products showing the vast increase in such carbides after cryogenic treatment. This follows on earlier work documenting the mechanism by Dr. Randall Barron of Louisiana Tech and a team of Japanese researchers who published a paper for ISIJ in the mid 1990's.

This mechanism contributes to the dramatic increase in wear resistance of cryogenically treated steels. Steel is, at its most basic formulation, iron (Fe), a metal, and carbon (C), a non-metal. The carbon is dissolved chemically into the iron and is what provides wear resistance. In other words, high carbon content equates to high wear resistance. (The maximum amount of carbon that can be dissolved chemically is about 6% and “high carbon” tool steel like A2 has about 1% carbon.) So just a little bit of carbon (diamond) goes a long way in promoting wear resistance.

Hence, this tweaking to the carbon microstructure, through the precipitation of eta-carbides, has dramatic impact on the wear resistance of cryogenically treated steels and cast irons (brake rotors, for instance). (Note that cast irons - rotors - are even higher in carbon content, 2% to 3%, for instance). That's why rotors that are cryogenically treated typically last 2X to 3X longer than untreated steels.

The third mechanism relates to stress relief. It is based on Einstein's (and the German physicist Bose’s) observation that matter is at its most relaxed state when it has the least amount of molecular activity or kinetic energy. When we freeze the components, we are actually removing heat, or reducing the molecular activity in the metal. This “relaxes” the metal and reduces residual stresses in it. These hidden stresses propagate when the part is placed into service and cause failures due to fatigue. Hence, by reducing residual stresses, you greatly reduce or eliminate failures due to cracking or what people term "metal fatigue".

These myriads of mechanisms bring practical benefit to a variety of engine components and other automotive parts. With better thermal properties and reduced stresses, distortion of parts is greatly reduced or eliminated. Therefore, "blow by" associated with the distortion of pistons and cylinder walls is greatly reduced. In addition, blocks that are honed after cryogenic treatment will enjoy the benefit of "micro-smoothing" from the more uniform grain structure. This means less drag and a reduced coefficient of friction. So by treating the pistons and block BEFORE final machining, (hone, grind and/or polish,) you will generate more horsepower and higher torque (as measured on a DYNO) with a cryo treated engine than a non-treated engine. (Typically up to 5% more).

After cryogenic treatment, brake rotors do not distort (warp or twist) and therefore brake fade and chatter are eliminated. In addition, rotors typically perform in service at least twice as long and more typically, three times longer.

All components, including cranks and pistons can be machined after treatment to a more accurate dimension because part "walk" or "creep" is greatly reduced or eliminated. This is because the residual stresses that are present in the part before machining are often removed along with the metal cutting. Theses hidden stresses can be holding the part in flat or round, and when they are removed with the metal, the part is free to move to its unstressed dimension. This is why parts move during or after the machining process. By relieving the stresses prior to final machining with cryogenic treatment, this dimensional change is eliminated. In addition, they will wear much better and hold their desired tolerance much longer due to the enhanced wear resistance properties.

Likewise, gears, drive shafts, cranks and cams benefit because of their unique fabrication. These components are subject to great torque stress requiring ductility (flex) internally, and high wear demands on the surface due to the steel on steel meshing of the components. Add to that their complex geometry and you have a sophisticated - and complex- metallurgical environment. Many gears are case hardened to provide a high carbon content on the skin to promote wear resistance, while not inducing brittleness (a result of higher carbon content) in their interior. Their shape, coupled with the associated machining, produces a stress rich environment that is easily exploited by the action of the gearbox. So you can see how cryogenic treatment is beneficial to gears. Stresses are relieved, reducing failures associated with their propagation into cracks, while carbon microstructure is enhanced to provide a more wear resistance outer layer. A real win-win application!

Aluminum parts benefit also, certainly from stress relief, as well as other enhancements from the mechanical compression they see from the extended freeze at -300 F.

Cryogenic treatment is also affordable and protects your investment in expensive racing components. At the Cryogenic Institute of New England, our individual component prices for our Nitrofreeze ® Cryogenic Treatment ranges from $2.50 per spark plug, $10 for a connecting rod or piston w/ rings, to $600 for an entire V8 engine (including block). When they break their engines down, our customers are amazed to see how their engine components are almost like new, even after a season of racing!

And, of course, all racers recognize that component failure in the midst of a race has the potential for disaster. Hence the old adage, "Before one can finish first, one must first <u>finish</u>!"

Cryogenic treatment of brake rotors, engines and transmission parts is perfectly legal and almost universally applied on top-level race circuits like Formula One and NASCAR. It is now available for motor sports enthusiasts of all levels through the Nitrofreeze® Cryogenic Treatment Services offered by the Cryogenic Institute of New England, Inc. of Worcester, Massachusetts.