CryoTemp
Deep Cryogenic Tempering

Cryogenic Thermal Cycling

Increasing the life of components, perishable tooling and wear parts

Powerkote
Hi Tech Ceramic Coatings

Cryogenic Thermal Cycling Process Chamber

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Glossary of terms:

- **Cryogen** ⇨ a substance for obtaining low temperatures. I.e., a refrigerant. In our case, LN2 or liquid nitrogen.
- **Cryo** = **Kryos** from the Greek, meaning **cold, freezing**.
- **Cryogenic** ⇨ of or relating to the production of very low temperatures.
- **Cryogenics** ⇨ A branch of physics that deals with the production and effects of very low temperatures.
- **Cryonics** ⇨ The practice of freezing humans who are not curable by current medical technology, in the hope that ways may be found to bring them back to life at some future time when ways of repairing the damage caused by the **freezing** process have been developed, as well as cures for the diseases or other causes of death which necessitated their **cryonics** suspension. See www.alcor.org.
- **Tempering** ⇨ In heat treatment, to reheat hardened steel or hardened cast iron to some temperature below the eutectoid temperature for the purpose of decreasing hardness and increasing toughness. I.e. "to soften".

Definitions from Webster's New Collegiate Dictionary, ASM Metals Handbook and Alcor.

What is Cryogenic Thermal Cycling?

Cryogenic Thermal Cycling process is capable of dramatically **improving the performance characteristics** of a wide variety of materials, such as ferrous and non-ferrous metal, alloys' carbides, super-plastics (including Teflon and Nylon) and ceramics

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What is Cryogenic Thermal Cycling? Continued…

- The entire process takes between **36 to 74 hours** depending on the weight & type of material being treated.
- The CTC Process is **not a surface treatment** it affects the entire mass of the component being treated making it stronger throughout and dramatically reducing wear.
- This means the process keeps working for the life of the component rather than ceasing to be effective after surface is worn and otherwise damaged.
- Because during treatment these mechanisms are operating cyclically and in temperature ranges previously not visited, Cryogenic Thermal Cycling is continuing to provide new applications for optimizing the performance properties of materials and metals.
- The hardness of the material treated is unaffected so there is actually less tendency to crack or chip while its strength and durability is actually increased.

The Process of Cryogenic Thermal Cycling:

- Our state of the art CTC Systems uses a computer that duplicates the optimum thermal curve.
- It precisely regulates the temperature change and brings an absolute consistency not available in any other tempering process.
- After having loaded the chamber with product the lid of the chamber is closed and the computer is programmed with the appropriate information.

cryogenic treatment system interface control panel

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The Process of Cryogenic Thermal Cycling: Continued...

- The temperature in the chamber is slowly and precisely lowered from ambient to - 320°F.
- This may take as long as 8 to 14 hours, which is always far less than a degree per minute.
- In certain applications our ramp down rate could be as slow as a half of a degree per minute.
- This may lengthen the process, making it that much more costly but experience has proved that it is well worth the time and expense.

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The Process of Cryogenic Thermal Cycling: Continued...

- We now allow the nitrogen to enter the chamber through a phase separator for safety, and very importantly to purge the chamber of air and moisture.
- Within this inert nitrogen atmosphere condensation will not accumulate.
- The soak phase of the process maintains - 320°F for at least 24 hours, and usually more.
- This is important because molecular motion slows dramatically at very cold temperatures. To ensure complete transformation one must maintain these low temperatures for period longer than 20 hours.

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The Process of Cryogenic Thermal Cycling: Continued...

- The system then warms the chamber and contents to ambient temperature over a period of 12 to 24 hours, sometimes longer depending on the load.
- This precise control and long time duration ensures that there will never be a large difference in temperature from the outside of a part to the core of the part.
- This is how it is possible to safely process items with very dissimilar material and construction.

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The Science of How and why?:

- **Deep cryogenics** is the ultra low temperature processing of materials to enhance their desired metallurgical and structural properties. In our case, this is a temperature about -320°F, -196°C, or 77°K. These ultra cold temperatures are achieved using computer controls, a well-insulated treatment chamber and liquid nitrogen (LN2). Nitrogen is the gas that constitutes 78.03% of the air we breathe here on planet Earth.

- The liquid form, is the product of air separation, compression and liquefaction. What this boils down to is that our **deep cryogenic systems** are completely environmentally friendly and actually help reduce waste.

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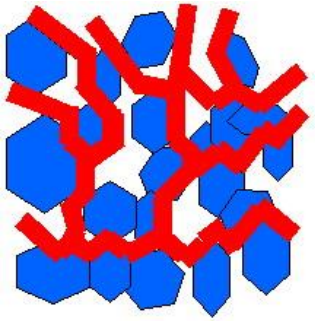
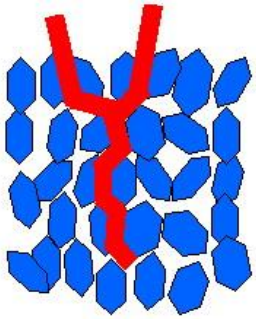
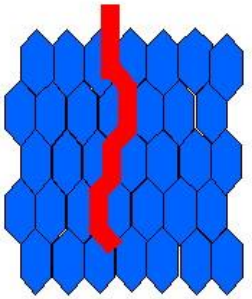
The Science of How and why?:







Energy Path	Re-Alignment	Energy Transfer
Through untreated molecular structure. Dissipation of energy causes vibration which results in metal fatigue.	During the Thermal Cycling process, the micro- structure begins to particulate into smaller, regular micro-structures	Thermal Cycling processed metal allows the passage of energy is direct, eliminating vibration - the main cause of metal fatigue.

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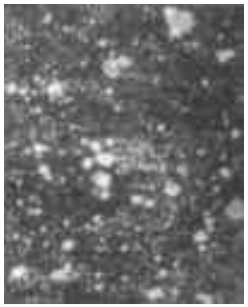
The Benefits of Cryogenic Thermal Cycling:

These ultra-cold temperatures, below -310°F, will greatly **increase the strength and wear life** of all types of vehicle components, castings and cutting tools. In addition, other benefits include reduced maintenance, repairs and replacement of tools and components, reduced vibrations, rapid and more uniform heat dissipation, and improved conductivity.

This process is like an insurance policy for your tools and components.

Before CI Processing



After CI Processing

Comparative microphotographs (1000x) of steel samples show the change in microstructure produced by the controlled deep cryogenic process. Uniform, more completely transformed microstructure and less retained austenite at right, is related to improvements in strength, stability and resistance to wear.

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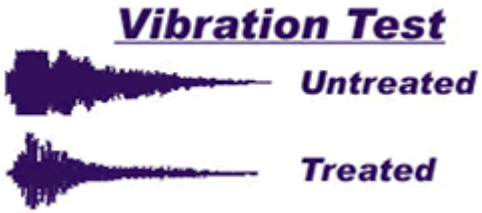
The Benefits of Cryogenic Thermal Cycling:

- Decrease abrasive wear
- Decreases erosive wear
- Decreases corrosive wear
- Reduces distortion
- Relieve residual stresses
- Improves machineability
- Reduces sharpening time
- Reduces materials lost during sharpening
- More sharpening / grindings before replacement of parts
- Withstand higher temperatures
- Allows tighter machining tolerances in metals and plastics
- Does not damage component parts
- Environmentally clean process
- Treats the entire component, not just surface
- Yield better performance with sports equipment
- Smoother action and cleaner sounds from musical instruments
- Increased component strength and durability
- Improves electrical and thermal conductivity
- Improved conductor resistiveity
- One time process
- Improved availability, reliability, yield and productivity
- Less down time
- Reduces maintenance expenses
- Reduces tooling costs
- Lowers production costs
- Improves profitability

Tests:



Dissipation of energy causes vibration, which results to metal fatigue, wear and ultimately component failure. During the Thermal Cycling Process, the micro-structure begins to particulate into smaller, regular micro-structures. The Thermal Processed metal allows the passage of energy to be direct, eliminating vibration, the main cause of metal fatigue. The ultra-cold temperatures below -200°C(-330°F) will increase strength and wear life of all types of vehicle components, machine components, cutting tools, medical equipment and electronic devices to a 300% life expectancy increase over non treated components. Thus leading to reduced maintenance, repairs and replacement of tools and components.	The Molecule is inverted from a concave form to a convex form. This fills lots of voids and gaps on a microscopic level making the part more dense without changing it's weight or hardness. A more dense formation allows sound waves or vibration to pass through the metal creating less vibration in it's state of matter, Less vibration creates less damaging micro cracking which increases wear life.

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Tests:

Material Improvement Results

Chart Below Represents Comparison Between
-120°F Shallow Quenching Vs.-310°F Deep Cryogenic Tempering

AISI #	Description of steel	(-120°F)	(-310°F)
D-2	High carbon / chromium die steel	316%	817%
A-2	Chromium cold work die steel	204%	560%
S-7	Silicon tool steel	241%	503%
52100	Bearing Steel	195%	420%
O-1	Oil hardening cold work steel	221%	418%
A-10	Graphite tool steel	230%	264%
M-1	Molybdenum high speed steel	145%	225%
H-13	Chromium / moly hot die steel	164%	209%
M-2	Tungsten / moly high speed steel	117%	203%
T-1	Tungsten high speed steel	141%	176%
CPM-10V	Alloy steel	94%	131%
P-20	Mold steel	123%	130%
440	Marstensitic stainless	128%	121%
430	Ferritic stainless	116%	119%
303	Austentic stainless	105%	110%
8620	Nickel-chromium-moly steel	112%	104%
C1020	Carbon steel	97%	98%
AQS	Graphitic cast iron	96%	97%
A-6	Manganese air work cold die steel	73%	97%
T-2	Tungsten high speed steel	72%	92%

Source: Dr. R. F. Barron, Louisiana Tech University

Tests:

Tool Durability Analysis

Tool Type	Company	Tool Material	Results
Broach	Auto Manufacturer	Hi Nickel & Carbide	250%
Chipper	Box Manufacturer	Carbide	500%
Corrosion	Lab Studies	S2, M2, 4142, 316	Less Corrosion
Deburring	Lab Studies	Inconel	400%
Dies	Injection Molding, Extrusion	Mild Steel, Hi Ni Alloy	400%
Drills	Aircraft Manufacturer	M42, M7, C2	30%
Electrodes	Steel Fabrication	Copper	600%
End Mills	Aerospace	M42	450%
Face Mill	Aerospace	C2 Carbide	400%
Gear Cutter	Auto Manufacturer	Ti-n Coated	350%
Hob	Turbine Manufacturer	M2, M7	250%
Key Cutter	Aircraft Manufacturer	M2, M7	250%
Logging	Paper Manufacturer	Saw Chain	400%
Machinability	Machine Shop	Thin Wall Aluminum Casting	50%Lless Time
Milling	Machine Shop	347 SS M7	350%
Punching	Metal Fabrication	M7	600%
Slicer	Plastics Plant	M7	600%
Stamping Dies	Steel Fabrication	D2	600%
Shredder	Paper Manufacturer	M7	400%
Tap	Tool Manufacturer	C2 Carbide	600%
Wood Cutting	Wood Shop	High Speed Steel	500%

Applications:

- Gears
- Crankshafts
- Aircraft components
- Moulds
- Lathe inserts
- Motor vehicle engines
- Water pump impellers
- Knives and blades
- Gun barrels for single or rapid firing applications
- Gearboxes
- Bearings
- Cutters
- Hobs
- Press dies
- Drill bits
- Saw blades
- Shear blades
- Break disc and pads
- Most metal tooling
- Golf clubs
- Aluminium bats
- Musical instruments
- Sound equipment
- Fishhooks
- Electric motors
- Copper conductors
- Commutators
- Carbon brushes
- Shafts
- Railway wheels
- Tennis racket strings
- Propellers
- Castings
- Conveyor rollers
- CDs And DVDs
- Sock knitting machine components.
- Processing plants
- Earthmoving equipment
- Off- highway trucks
- Mechanical component parts
- Electronic equipment
- Medical equipment

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Achievement:

- The results of CTC transformation create improved mechanical properties throughout the entire part as opposed to the limited effect of surface treatment.
- Cryogenic Thermal Cycling is continuing to provide new applications for optimizing the performance properties of materials.
- The performances through CTC processes of desirable properties (such as wear resistance) tell a powerful story of tools being treated and showing through scientific measurement that there is increased durability, or “wear Life” of 200% to 300%.
- Our advanced thermal processing technology enhances the performance of steel and other materials by transforming their molecular structure. This transformation accomplishes several very important things:
- The extreme cold temperatures during cryogenic processing also slow movement at the atomic level, increasing internal molecular bonding energy and promoting a pure structural balance throughout the material. The end result is a material with an extremely uniform, refined and dense microstructure with vastly improved properties.

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Achievement:

- **Austenite to marten site conversion** - Normal hardening transforms austenite, with its unstable crystalline structure, into marten site, which is much stronger and more durable. But normal hardening doesn't convert all of a steel's austenite to marten site. For that to occur, cooling technology is required. Cryogenic processing results in a nearly complete transformation of retained austenite to marten site.

- **Carbide particle formation** - Normal hardening creates carbide deposits that disturb the alloy's crystalline structure. During the cryogenic phase of thermal processing, small carbide particles precipitate out of the crystalline lattice and are evenly distributed throughout the material. This reduces residual stresses and creates a very hard, fine carbide lattice structure with improved wear resistance.

- **Grain structure is refined** - All of the individual particles that make up an alloy are placed into their most stable state. These particles then are aligned optimally with surrounding particles. Also, molecular bonds are strengthened by the process.

- **Internal stress is relieved** - Particle alignment and grain refinement combine to relieve internal stresses, which can contribute to part failure. This results in material that is optimised for durability.

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Achievement:

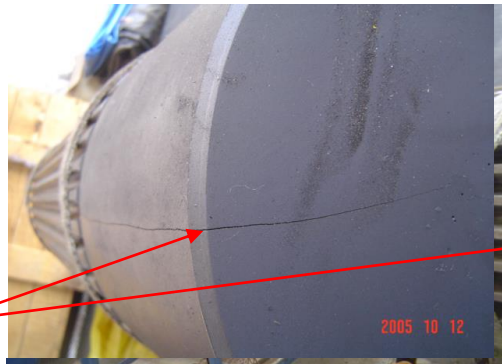
Improved electrical and thermal conductivity:

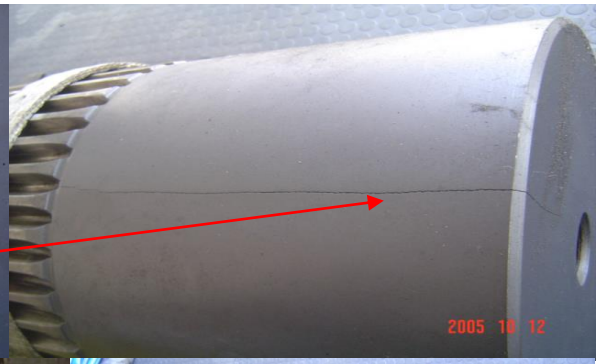
- Deap cryogenic processing will promote stress relief, improved conductivity and lower the resistance in electrode material.
- Copper, silver or other electrical conductors and connectors will have a freer flow of electrons.
- Solder or brazed zones are stress relieved, which allows the current to flow less encumbered from the conductor to the connectors.
- Dielectric material is also improved in uniformity and performance, making it a better insulator.
- Essentially, deep cryogenic processing is all about removing the BTUs or heat energy out of the material being processed.
- Kinetic energy is the energy of motion and this energy keeps the molecular structure of materials in an irregular state.
- By removing much of this energy with deep cryogenic temperatures, the molecules are allowed to align themselves in a more uniform pattern.
- This uniformity will remain once the material is returned to working temperatures.
- It has been proven through the use of very accurate ohm – meters that the measured resistance of a conductor before and after processing, and others showed a gain in efficiency (and reduced heat).
- The IR temperature detectors showed anywhere from 30 – 40% reduction in heat in materials. This benefit is just one reason why racers in all motor sports utilise the process so extensively.

Proof:

2300 P&H Shovel Main Shaft and Bull Gear

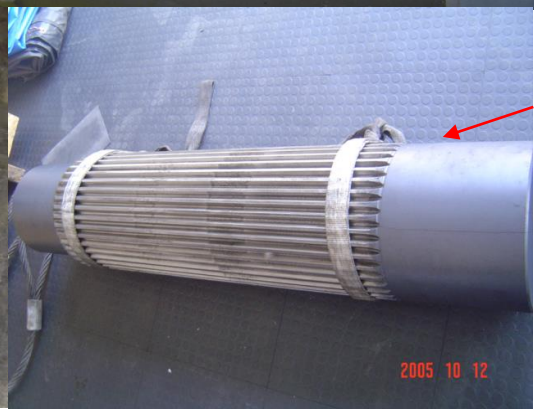
Through Cryogenic Thermal Cycling, a previously repaired micro-welded main shaft, showed that the process in the repair was flawed, hence the crack shown here





The processed steel used in the Bull Gear proved to be flawless, hence the perfect Cryogenic Thermal Treatment Process. The Bull Gear was also then CermaLube Dry Film Lubricant Coated.

Ref: Powerkote



The processed steel used in this main shaft proved to be flawless, hence the perfect Cryogenic Thermal Treatment Process. The Main Shaft was also then CermaLube Dry Film Lubricant Coated.

Ref: Powerkote

The Bull gear and main shaft have been in use since the date shown on the photographs – 10/12/2005, and are still currently in use in a P&H 2300 Shovel at Exxaro

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Legal

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