Cold Facts
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Cryotreatment: Panacea or Black Magic?

Two coincidental events brought the subject of cryotreatment to top of mind: CSA's Midwest Chapter hosted a meeting on the subject, featuring principals of American Cryogenics (a corporate sustaining member), Waukesha WI, and a six-minute segment on the Discovery Channel featuring cryotreater 300 Below, Inc., Decatur IL, brought many phone calls to the CSA national office seeking information on the process.

The following article incorporates information from various companies, from our academic contacts and from materials gathered over the years. We welcome reader response.

The Tough Questions: Does It Work? How?

There is a lot of material available extolling the effects of cryogenic treatment on a whole range of materials, from tool steel to nylon stockings. Testimonials abound. Yet there is also a scepticism and even a feeling that the whole thing is "black magic." As an article in the June 1987 issue of *Popular Science* asks, "If cryogenic treatment is so good--and relatively cheap--why isn't it universally applied?" The magazine answered, "For one thing, it doesn't always work; and when it will work [it] is not always predictable."

We watched the videotape of the segment of "The Next Step," on the Discovery Channel, that brought 300 Below to national attention. The program began on shaky ground (at least to this writer who is dedicated to changing the public equation of cryogenics with cryonics which cheapens us and puts us "on the fringe" in the minds of the uninformed) by telling the audience that cryogenics is the science of low-temperature phenomena. "One application you're probably familiar with is people who have their bodies frozen after they've passed away, in the hopes of being brought back to life in the future." Starting with that wrong turn, the program hosts then did explain that cryogenics also (!) applies to the more practical freezing of objects. They showed 300 Below President Pete Paulin (a CSA member) demonstrating that the process makes metals and plastics a lot stronger and more durable. "Cryo-processing creates a denser, more coherent structure," he said, "abrasive resistance is increased, so the object lasts longer. Precise temperature regulation is critical, and by marrying the computer to our cryo-processors, we're accurate within one-tenth of one degree."

Company customers were interviewed, including a brass quintet from Millikin University who have had their instruments treated and find that slides and valves are much smoother to operate and tonal quality improved noticeably. The firm calls the treatment "Cool Note," "cryogenic processing to make your horn come to life!"

John Koucky, 300 Below Vice President, reports that the company got almost 6,000 inquiries since the story, the highest response ever to a segment of "The Next Step!"

As a result, 300 Below is establishing regional "service centers," much like franchises, for those who want to get into the business and be affiliated with the company. The company has

also developed a specialty they call "cryo-accurizing" for treating hunting weapons, which other treaters also report is a very popular use of cryotreatment just now.

Edging into the Japanese Knife Market

A column by John Husar, "On the Outdoors," in the Sunday, May 28, 1995, *Chicago Tribune*, quotes Mike Stewart of BlackJack Knives, Effingham IL, who has gotten a foothold into the Japanese specialty knife market by using cryotreatment to produce edges that hold their sharpness longer. Stewart also works with shotgun and rifle barrels.

He gave an excellent layman's explanation of what happens in cryotreatment: "Supercooling refines the carbide in steel, expanding the carbon structure to fill any voids in the metal. Then, as higher temperatures return, `everything relaxes into where it wants to be.'" He noted that when the Japanese knife companies sent groups over to study his procedure, he kept some of the "crucial steps" to himself, kind of proprietary secrets, because "if every step isn't carefully controlled, those temperature extremes will shock steel into delaminating."

At the January 16 meeting of the CSA Midwest Chapter, Charles Wiberg, Technical Advisor, and Steven Wiberg, PE, President, American Cryogenics, Inc., Waukesha WI, gave a talk on cold treatment of tool steels and other highly alloyed materials. Charles Wiberg is a veteran commercial heat treater, having founded Midland Metal Treating Corp., Franklin WI, and then Therm-Tech, parent company of American Cryogenics. Steven Wiberg has a degree in metallurgy from the University of Wisconsin-Madison. C. Wiberg began by stating that cryotreatment is a discipline in search of some legitimacy. It is not accepted very well by the metallurgical industry, yet cold treatment is capable of producing some dramatic results. The technique has recently been improved by the availability of liquid nitrogen, the development of high tech insulation and the use of a microprocessor which allows computerized control of the somewhat risky situation of dealing with hardened tool metals, he said.

He credited Dr. Helmut Trucks, PE, ("the grandfather of cryo in the US"), who encouraged Wiberg and expressed a firm belief that cryogenics should proceed into metalworking to be accepted as a discipline. Dr. Trucks, who died a few years ago, was a senior research engineer and design specialist at General Dynamics Corporation before he became a private consultant engineer. He was affiliated with Cryogenics International, Scottsdale AZ. Among his writings is, "Improving Die Casting Productivity by Increasing Die Life," for *Die Casting Engineer*, Sept./Oct. 1988. Another article is entitled "How Cryogenics is Used for the Treatment of Metals." He also wrote, "Stresses in Aluminum Castings, How to Avoid Them, and How to Relieve Them before Machining."

Dr. Randall Barron, Academic Authority

The most noted academic authority on the subject of cryotreatment today is Dr. Randall Barron (a long-time CSA member), who holds both master's and doctorate degrees in ME from the Ohio State University. His area of expertise is in heat transfer, and he is Professor in the Mechanical and Industrial Engineering Department at Louisiana Tech University, Ruston LA. His dissertation was on "Heat and Mass Transfer to a Cryosurface in Natural Convection." Dr. Barron is cited by many of the cryotreatment companies for studies of the effects of cryotreatment. For example, an article that appeared in the August 1982 issue of *Cryogenics,* "Cryogenic treatment of metals to improve wear resistance," studied nineteen metals, including 12 tool steels, 3 stainless steels and 4 other steels, subjected to cryogenic

treatments to determine the difference between a 189K soak and a 77K soak in improving the abrasive wear resistance. The tool steels exhibited a significant increase in wear resistance after the 77K soak and a less dramatic increase after the 189K soak. There was an increase in wear resistance after the cryotreatment for the stainless steels, but the difference between the two treatments was less than 10%. The plain carbon steel and the cast iron showed no improvement after either cryotreatment.

An article in the January 1992 issue of *Modern Machine Shop* summarizes Dr. Barron's explanations of what happens and why: "Researchers are not certain about what happens to materials at 320 degrees below zero (so-called deep cryogenic treatment). Alloy tool steels used to make end mills, twist drills, reamers and other cutting tools have been the object of the most study in this area. Results vary, but a two- to sevenfold improvement over the normal life of these tools is typical.

"One of the best explanations was put forth by Dr. Randall Barron, one of the foremost researchers in cryogenic treatment of metal. Two primary mechanisms are at work, he wrote. First, super-cold treatment apparently converts any retained austenite into martensite, and the martensite is tempered as the metal returns to room temperature.

"The martensite structure resists plastic deformation much better than the austenite structure, because the small carbon atoms in the martensite lattice `lock together' the iron atoms more effectively than in the more open-centered cubic austenite lattice. Tempering the martensite makes it tougher and better able to resist impact than untempered martensite.

"Second, the cryogenic treatment of high-alloy steels, such as tool steels, results in the formation of very small carbide particles dispersed in the martensite structure between the larger carbide particles present in the steel. This strengthening mechanism is analogous to the fact that concrete made of cement and large rocks is not as strong as a concrete made of cement, large rocks, and very small rocks (coarse sand). The small, hard carbide particles within the martensite matrix help support the matrix and resist penetration by foreign particles in abrasive wear."

The *Popular Science* article says that published research had not confirmed Dr. Barron's latter observations. Further, what about improvements claimed in such materials as copper electrodes and golf balls? Stress relief is the theoretical answer.

Wiberg Talk

A summary of the Wiberg talk follows:

"The use of deep cryogenics in the treatment of materials is a science seeking legitimacy. Over the past 10 to 15 years, many in the field have been freezing anything from pantyhose to golf balls claiming increased wear properties. Unfortunately, these applications have taken away from the practical usefulness of this technology, especially in the perishable tool market. Little scientific research exists that confirms why improvements occur. In fact, the only significant piece of wear study research has been done by Dr. Randall Barron. His study is widely cited by cryogenists across the country. His results are often mis-applied, and conclusions are drawn from his results that are really `leaps of faith' rather than scientific facts.

"In order to improve our legitimacy and image as provider of a beneficial service, it is important to be very factual in representing the potential benefits of deep cryogenic treatment. There are several issues on which cryogenists need to focus. First, and maybe most important, is that no all-inclusive claims can be made regarding how a certain material will respond to deep cryogenic treatment. In many instances, the preconditions, or how the material was heat treated before it is received for cryotreatment, will dictate the amount of improvement that occurs, if any. In the case of most tool steels, if proper heat treatment has not taken place, the effects of cryogenic treatment are greatly minimized. Therefore, one cannot make a claim, for instance, that D-2 will always improve by a certain percentage. It is very important to establish an early "technical partnership" with the customer and educate them as to what deep cryogenic processing can and cannot do in their particular application. The technical partnership also allows the metallurgist to make suggestions in material selection, tool design and heat treatment, so that maximum wear results can be achieved from deep cryogenic treatment.

"Another issue that those in the field need to address is the generation of good scientific research, based on results. In-depth wear studies on various materials before and after treatment should be performed. Dr. Barron's study should be replicated. This would strengthen its legitimacy. Research should be performed to examine material selection, design, heat treatment and cryogenic treatment, toward the creation of better quality tools. Scientists in the areas of metallurgy and physics need to study the phenomena that occur at deep cryogenic temperatures in order to allow us to fully understand what exactly happens to the material.

"The actual process of deep cryogenic treatment is not complex. However, the process of customer education is. Therefore, it is difficult for a person to really understand and explain deep cryo processing without some background in material science, or direct access to someone in the material science field. With current technology, we feel that processors can be built that are easy to use and highly effective.

"The deep cryogenic treatment of materials as a service and a science is in its infancy. There is great promise that it has a vital place in the material improvement field. However, much research and study needs to be done before hard and fast claims can be made. Each potential application has to be carefully evaluated with the customer so that the best results are achieved. It is our responsibility to educate our clients with factual information on what is known about cryogenic processing, and what has yet to be discovered."

Danish Study Confirms Barron's Findings

In late February, Dr. Barron told *COLD FACTS* that a group from Denmark is involved in a research study of the cryogenic treatment process. "They have made some SEM studies, and they have identified two mechanisms responsible for the wear improvement brought about by the cryogenic treatment (slow cooldown ~2 hrs. from room temperature to LN2 temperature; long soak ~16 to 20 hours at -300 degF to -320 degF; warm to room temperature, then temper at +200 degF to +300 degF for about an hour). The mechanisms are:

- Complete transformation of retained austenite to martensite. Martensite is a harder, more wear-resistant structure.

- Formation of small carbide particles within the martensite matrix. This strengthens the material without appreciably changing the hardness (macro-hardness).

Cryotreatment Pioneer Busch

Laura J. Barber, Vice President of Cryo-Tech, Inc., Hazel Park MI, reports that her father, Ed Busch, was a pioneer in the cryotreatment industry 30 years ago, a time when no one had heard of cryogenics. "It was referred to as `Black Magic,' and he was considered a con artist. Needless to say, it was a hard sell, but he believed in it so much he never gave up. He went door to door, not taking no for an answer and traveled the states and Canada giving speeches at seminars. He knew steel better than anyone. He owned several large heat treating companies for over 20 years before he stumbled upon this. Of course, cryogenics was used in the aerospace industry, but it was never heard of on the open market. Ed is now 77 years old," she reports, "I came to the company six years ago so he could retire, although he still comes in to smoke a cigar!"

Formerly known as Materials Improvement, Inc., Cryo-Tech has been featured in several magazines, such as *Popular Science*, *National Dragster*, various industrial magazines and most recently *Crain's Detroit Business*. Barber reports she has seen articles in *Guns & Ammo* magazine regarding freezing gun barrels to stabilize them; *Power Transmission Design* featured an article about freezing gears for transmissions. "All of a sudden, cryogenics is the current buzz word. But I have yet to read anything new that we haven't already done. Although every once in a while we discover something new and that is very exciting, especially for the customer who wanted to try it!" she says.

300 Below distributes reprints of articles on cryotreatment that include: "Cryogenics: The newest secret for Performance & Durability?" from *The Puller*, February 1996; "Cryogenics: Racing Secret?" from *Race & Rally, Winter 1995-96; "Can Freezing Parts Make Them Stronger?' from Short Track Racing, October 1994; "Cryo-Rifles, Deep Cryogenic Stress Relief," "Stress Relief," from Precision Shooting, March 1995; and "Cold Cuts," from Cutting Tool Engineering, August 1992.*

Marko Malen, Sales Manager, Cryogenic Tempering/-300, Seville OH, was interviewed in the May 1995 MetalForming magazine article, "Cryogenic Treatment Can Boost Tool Life."

Barber says that Cryo-Tech's guarantee helps convince new customers to try this unknown process. It states: "If your production records clearly indicate that the processed tools showed no cost advantage over your unprocessed tools, we will gladly refund the cost of the Cryo-Tech processing." The company stands behind this promise. Other companies offer similar agreements for first-time users, although we saw none that was spelled out quite so clearly.

Cryo-Tech's success stories are fairly representative of what was reported by the various companies contacted for this story. Barber says, "We have 30- years' worth of success stories. Just this week so far a plastic company in Fraser MI has reported that the set of granulator blades we treated for them are still running after 28 days; normally the blades last 7-10 days before they are removed for resharpening. Last year we froze a set of slitter blades for AC Rochester in Flint and, good news, the blades are still running. We have had a lot of success with carbide inserts, which are very costly; we can sometimes double and triple their life. I just shipped out a go-cart engine for a local customer. The process not only extends the wear

life, it also stabilizes the component. Last week, we did a camera mount that will be sent into outer space. One of our biggest accounts is Markley guitar strings. We get parts in from precision grinding shops. Sometimes while grinding a close tolerance, the part will move on them. If we freeze it, the movement will stop. This of course, enables them to get a tight tolerance on their finished grind. Gun barrels are now a `hot' item. We do several a month for local sharpshooters. Engine blocks, heads, pistons, etc., for race cars come in regularly. The list is endless."

Cryogenics International (CI) provides fact sheets from several industrial and university studies on the use of controlled deep cryogenic treatment. These include increase of useful life of copper resistance welding electrodes for a semiconductor manufacturer from 5 to 22 days; Northrup Corporation elected to use cryotreated M7 drills, because they produced 102% more holes than plain M7, for all general drilling; HSS taps for a pump manufacturer and a railroad equipment manufacturer showed increased strength and wear life, fewer changeovers, reduced need for inventory; treatment of 8% cobalt end mills increased milling cuts per resharpening from 3 to 78, and resharpening required only 1/3 the amount of stock removal to restore the tool geometry.

University studies reported by CI found that cryotreatment extended the life of carbide deburring tools - performance increased 400%, wear resistance increased; 27% fewer twist drills were required to do the same job, resharpening removal amount was cut by 1/2.

CI President Charles Beresford said his prices have just been reduced, so that a company producing automotive parts, for example, could purchase a unit for under $20,000 that could easily save them as much as $250,000 per year - paying for itself in a very short time.