From Fleets to Flutes:

Cryogenic Treatment Offers *Cool* Applications; Metallurgists Remain Unimpressed

By Sarah A. O'Brien

"You caught me on a boat," admitted Frederick J. Diekman, President of Controlled Thermal Processing, Inc., upon realizing that my questions on cryogenic processing would take more than a few minutes to answer. "The boys wanted me to go fishing — can I call you back?"

In their 2001 *Heat Treating Progress* article, "Cryogenics: The Racer's Edge," Diekman and Controlled Thermal's Racing Specialist, Roger Schiradelly, wrote, "Cryogenic processing is destined to become part of the standard production process, as opposed to being an add-on process as it now exists." Today, however, the process still appears to exist as an add-on, and only in few cases is it known to be standard for parts post-production. Many in the metallurgical field are reluctant to accept the science behind cryogenic processing, while those in some industries are against the use of a treatment that will decrease overall sales, as the treatments make parts more durable and therefore less likely to need frequent replacement.

Diekman stated, "The process has not been well received in the general metallurgical community. Part of the reason for this is that it is not taught in many colleges to metallurgy students."

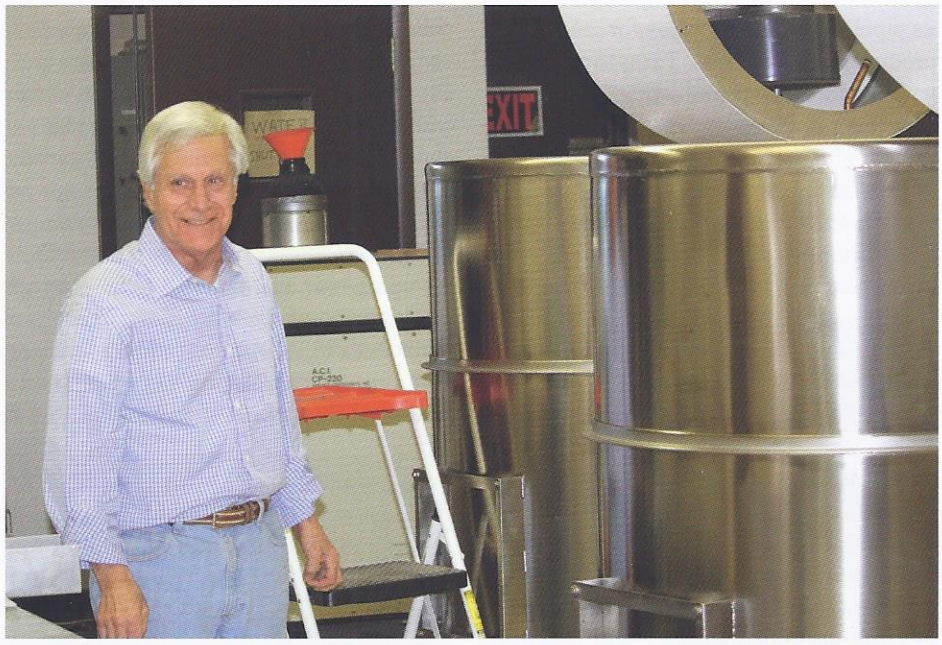
Dr. Jeff Levine, Founder and President of Applied Cryogenics, Inc., noted this skepticism on part of many company metallurgists as well, stating, "They tell me that if it was really so good, they would have been doing it a long time ago. It's not in their textbooks, and they didn't learn about it in school. If it doesn't work, they're liable to get fired, so they're not willing to take the risk."

In one instance, a pompous "Dr. So-and-So" insisted to Levine that there was no change in the material's properties after the company's knives had been cryogenically treated following manufacturing. However, when asked if there was any difference in how long the treated knives lasted versus the non-treated knives, his answer was telling: "They got three times the life."

"You've got to know what you're looking for, and people don't know what to look for," said Levine, who is used to dealing with clients wary of a process that is largely based in practical rather than theoretical experimentation.

Of course, some metallurgists, such as Air Liquide's ALTEC Business Development Specialist, Rozalia Papp, are helping manufacturing companies improve material quality through use of cryogenic treatment: "Air Liquide embraced this process and it is one of our offers," said Papp. Air Liquide currently boasts a cryogenic processor with a vacuum-insulated chamber, produced by Controlled Thermal Processing, which treats components in order to increase wear resistance, increase fatigue life, and decrease residual stresses, among other benefits.

Papp credits the hesitancy on part of metallurgists to an incomplete scientific study of the process; the field of cryogenics is still somewhat of a mystery: "The absence of a complete understanding of the science and mechanism(s) by which cryogenic treatment improves performance hampers its widespread acceptance by metallurgists."



When Dr. Jeff Levine founded Applied Cryogenics, Inc. in 1981, there were no cryogenic treatment machines on the market, so he decided to build his own. Here, he stands in front of machines in the process of being assembled. Photo by Michael McCormick

How it Works

Cryogenic processing involves the use of temperatures as low as -184°C to modify parts. Rather than acting as a coating, cryogenic processing impacts the entirety of the treated material, creating permanent changes. Deep cryogenic treatment (DCT) is not to be confused with cryogenic tempering, which Papp describes as a "misnomer," since, "DCT is not a substitute for heat treating and encompasses more than stress relief. It is usually applied after conventional

heat treatment to alter certain properties of heat-treated components [such as by way of retained austenite to martensite transformation]."

During the cryogenic cycle, a piece is gradually brought down to cryogenic temperatures, which is broadly recognized as any temperature below -150°C. The temperature is then held for a set amount of time, determined by the material and size of the part. After what typically ranges from 6 to 40 hours, the temperature is slowly ramped back up to room temperature.

A solid grasp of how various types of metals will react to the treatment is necessary, according to Robin Rhodes, President of the Cryogenic Institute of New England, Inc., which offers Nitrofreeze Cryogenic Services. "The oversimplification embraced by many laypeople that cryogenic treatment is a magic wand that cures ills in all metals is an inaccurate portrayal," emphasized Rhodes. "It's a misconception that cryogenic treatment will make any metal a super-performer. The reality is that you need to understand the failure mechanism you're trying to prevent and understand the material you're working with before deciding whether [cryogenic processing] is appropriate. Cryogenic treatment does offer many solutions to many problems, but you also need to understand its limitations."

Behind-the-Wheel Perspective

Faster, stronger, and longer lasting — these are just a few of the improvements that competitive racers have noticed about their vehicles after using cryogenic processing on brake rotors, engines, and other parts. In fact, "many, if not all, of the top racing teams have their own cryogenic treatment capabilities," said Rhodes. "It's just not widely talked about, since they don't want to lose their competitive edge."

In automotive shops that Rhodes claims "are cleaner than an operating room," mechanics and technicians ensure that a car is at optimum performance, especially with drivers pushing the vehicle to its absolute limits during each race. "The irony is that the difference between first and second place is usually fractions of seconds. Every edge in terms of how the car performs is critical to them," said Rhodes.

Cryofab's dewars have impressed Levine: "Cryofab makes the best dewars I've bought. They are cosmetically and functionally the best." Photo by Michael McCormick

Diekman of Controlled Thermal Processing added, "We've worked with a top fuel drag racing team who used to change their valve springs in the engine every run. After cryogenic treatment, they can go six runs without changing the springs. This was not a casual decision because if the springs break, they could kill the driver."

The Founder and President of Victor Aviation, Victor Sloan, has worked with six-time World Champion drag racer Brendan Murry to improve the performance of his engine components through cryogenic treatment. In his 2014 article for *Cold Facts*, Sloan wrote, "Certain metals, after being Cryogenically Non-Destructive Tested (NDT) and treated, have shown large increases in their fatigue life. Similarly, improved life of components used in aerospace, vehicle, wind energy, turbine power plants and transmissions has also been documented and can reduce the cost of ownership" (See "LN_2 Testing and Cleaning at NASA Ames' Transonic Wind Tunnel," February 2014).

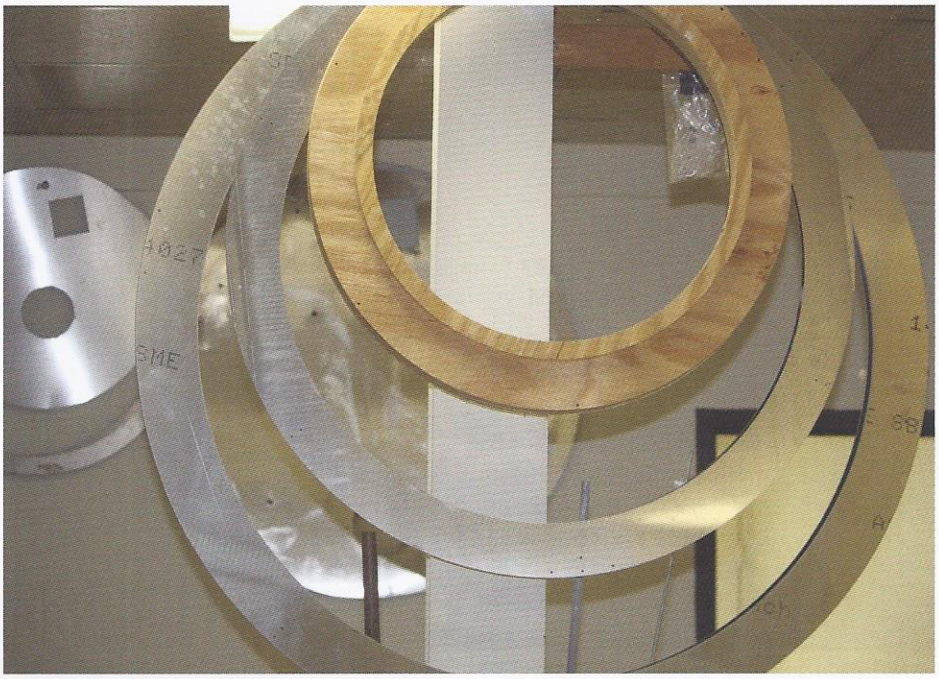
Another large application of cryogenic treatment is fleet vehicle components. "There's a perfect storm of stress and wear in an engine," said Rhodes of such vehicles. "All of the benefits of cryogenic treatments—wear resistance, stabilization, better thermal properties—come to help the performance."

Levine has worked with the US Postal Service to treat the fleet vehicles' brake rotors, and many police departments take advantage of cryogenic treatments as well. Lenny Burnham of the Department of Public Works in Woburn, Massachusetts, has noticed a difference in cryogenically-treated brake rotors, which the Woburn Police Department uses as replacement rotors after the factory-made rotors wear down: "I know the treated brake rotors do last longer. Unless they're driving metal on metal, and then [the brakes] are junk no matter what."

Music to a Manufacturer's Ear

Although cryogenic treating of material is not always advertised, many companies employ this process in order to enhance their products. "The treatment has been adopted as standard by a number of industries. Many of its applications are used routinely," stated Rhodes.

One unique application has been improving the musical capabilities of certain instruments. According to Diekman, cryogenic processing is used by the Chicago Symphony Orchestra, as well as by Yamaha Flutes. Dean Markley is another company that utilizes this treatment, boasting "Blue Steel" acoustic



While many are still skeptical about cryogenic processing, Levine, whose machines come in the three sizes pictured here, said, "It's catching on. I have been getting more and more business and more competitors." Photo by Michael McCormick

guitar strings that are cryogenically frozen: "By freezing our strings down to -320°F, we tighten the molecules, minimizing microscopic gaps," its website states, "This process removes transient frequencies that produce harsh highs and muddy lows, creating a more consistent string, with true tone and longer life."

Levine has done business with Osmun Music himself, and offered, "I could give [customers] a hand-waving explanation about how [the instrument] changed for the better, but just use it!" In an experiment with Powell Flutes, Levine had a professional musician test three to four head joints "to listen to the nuances of sound," and the flutist chose the cryogenically-treated head joint in double-blind tests every time except one. However, Levine explains, "They called me later and told me that they had gotten the numbering wrong, and that he had yet again chosen the treated flute." Although Levine had feared that the stress relief on the material after freezing would change the acoustic properties, it seemed to have done so in a way that pleased those whom Levine refers to as having "the golden ear."

Diekman said, "It's a very fine process. I recommend cryogenic processing for any company that wants to make their products the best."

Overcoming Skepticism

Diekman is optimistic about the future of cryogenic treatments, remarking that research on the subject has advanced over the years: "Research has progressed from 'Does it work?' to 'How does it work?' to examining what you would specifically do with a certain metal." The Cryogenic Society of America has compiled a database of articles written on the subject, hoping to encourage further study into cryogenic treatment (www.cryogenictreatmentdatabase.org).

Those in the industry predict that cryogenic treatments will become increasingly relevant in coming years. As Papp reminded, "I'm a metallurgical engineer, and I'm not a skeptic of DCT. On the contrary, I believe there is a hidden universe to be discovered in the structural changes of metals and other crystalline materials at very low temperatures. When DCT is scientifically mastered, it will completely revolutionize the heat treatment of metals."

While countries such as India are researching and publishing studies on cryogenic treatments, American scientists are slowed in their research by rigid safety regulations and industry protocol. "Scientific researchers must concede time away from creativity to comply with standards and regulations, so it is not easy to discover something new," said Papp.

Levine, who is "one of the pioneers" in the field according to Rhodes, finds this regrettable, as cryogenic processing originated in America. "A lot of research is being done in India, China, and Eastern Europe, but it started here in the '60s with Ed Busch," said Levine, referring to the first commercial cryogenic processor, developed by Busch in 1966. Levine continued, "In my travels, when I used to do sales calls, I spoke with an old timer — I was a new-timer then — and found out that cryogenic treatments had been used during World War II at the Watertown Arsenal [in Watertown, MA] by Clarence Zener."

Richard N. Wurzbach and William DeFelice of Maintenance Reliability Group wrote on the subject, "At that time there were no computer controls so the steel tooling would be immersed in liquid nitrogen for a brief period of time, allowed to warm up, then placed into service. This method was crude and uncontrolled. [...] But the tools that would not break would experience a greatly enhanced service life" (See Maintenance Reliability Group's "Improving component wear performance through cryogenic treatment").

While cryogenic treatments await more attention by American researchers, companies that offer the process are able to retain not only their austenite (to transform into martensite), but also their sense of humor: "We're in the growing stage. It's not a process that we understand 100 percent. I don't understand gravity 100 percent, but I still use it," said Diekman.

Levine takes a lighthearted view as well, saying that he knows the treatments are producing real results for his customers because, after all, "They keep coming back for more!" ■

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