Deep Cryogenic Treatment of Cone Crusher Parts

By Jack Cahn, Deep Cryogenics International

ATLANTIC MINING IS A profitable gold mine operating in Nova Scotia, Canada. Owned by the Australian firm St. Barbara, they constantly work to improve miner safety, increase environmental stewardship, and lower operating cost. One method they chose to achieve these goals embraces an innovative technology called deep cryogenic treatment (DCT).

DCT is a cold thermal process that increases the abrasive wear life of metal items such as ground engagement tools, conveyers, and gears. The process is similar to heat treating, but in the opposite thermal direction. Items are placed in a highly insulated tank and slowly cooled to the optimal temperature – near -196°C – using alloy-specific recipes. Following a return to ambient, items are tempered to increase fracture toughness and eliminate hydrogen embrittlement.

DCT is low cost, permanent, carbon neutral, and very effective. It is normally done after heat treating but it can also be performed after an item has been manufactured and shipped to an end customer. In production, it costs about 10 to15 per cent of the original item to increase wear life by 20 to 40 per cent.

Challenges to adoption

In prior years, obstacles to commercializing DCT were small-sized equipment, few service providers, and no testing or research support. No one knew how to certify DC-treated parts since, unlike heat treating, the process doesn't increase part hardness, leave visible high temp colour bands, or change an item's dimensional size. As a result, mining equipment original equipment manufacturers (OEMs) often made improvements based on material alloy, heat treat protocols, or surface treatments. Without DCT, only the 'hot side' of thermal processing was being employed – leaving much of the potential benefit still on the table.

Technology advancements

In 2018, Deep Cryogenics International (DCI) opened the world's only DCT research lab, quietly tucked into a small oceanfront town in eastern Canada. As demand grew, they added more treatment capacity. Atlantic Mining was an early technology adopter when they discovered that DC-treated core saw blades yielded two times the wear life of untreated saw blades. Other mining customers began to use the process on gears and slurry pump seal plates.

Saw blades, gears, and tooling are relatively small, low-cost items made of martensitic steel, which is easily improved by both heat treating and DCT. The bigger question is how can we improve

The CP-36K is the largest cryogenic processor built to date.

the wear life of higher cost and much larger parts that are at the heart of critical, non-redundant platforms such as cone crushers?

Cone crushers rely on impact force and abrasive wear to crush rock, which are also the key failure modes associated with the short life of the two primary components – the mantle and bowl liner. Unlike ground engagement tools, ball media or mill liners made from carbon steel, cast iron, or chrome moly, cone crusher wear parts are cast from manganese austenitic steel. Usually supplied as 13 to 22 per cent manganese castings, this material exhibits a unique wear property called ***work hardening*** – the ability to harden under compressive load. This phenomena, also known as TRIP or TWIP, is the result of:

- The chemical/physical percentage of manganese, carbon, and chromium;
- The temperature and method of heat treating;
- The final grain structure of the casting; and
- Precise control over the size, quantity, and location of carbides within the matrix.

The breakthrough

Beginning in 2019, DCI conducted several mechanical property tests on DC-treated manganese steel. After demonstrating significant wear improvement in crushing granite using their ASTM G81-97(a) Gouging Abrasion Wear Tester, DCI developed a proprietary thermal formula that controls material grain growth and carbide distribution while maximizing the TWIP effect.

DCI generated a prediction model that compared baseline-supplied items against DC-treated items and then against DC-treated and surface modified items, using a special process (SP). When they shared the results with Atlantic Gold, the first purchase order to DC-treat full-size mantles and liners was generated.

Houston, we have a problem… and a solution!

Unfortunately, no existing DC tanks are large enough to process mantles or liners of this size. Scaling the technology from DCI's round tanks (seven cubic feet and 42 cubic feet capacity) to work in a large rectangular unit 30 times bigger (1,280 cubic feet) is a complex scientific, engineering, and manufacturing problem.

Undeterred, and with a generous grant by Canada's NGEN and additional funding by the Atlantic Canada Opportunities Agency (ACOA), DCI set out to build the largest and only industrial-sized deep cryogenic tank in the world. Cryogenics scientist Dr. Jeff Levine has been hired to assist in thermo-kinetic design and tank construction is taking place at CTS in Nova Scotia.

The complex platform control requires multiple cryogenic valves, blowers, and thermocouples to sample part temperature and an ability to precisely meter the flow of liquid nitrogen before expansion into gaseous state at -196°C. Future Designs is supplying controls and Chart Industries is building a large storage dewar for liquid nitrogen. Third-party independent testing will take place at Red Deer Polytechnic by Dr. Tonya Wolfe and her CIM team. Lloyd's Register will qualify both the deep cryogenic process and the equipment for international registration and approval. DCI will use a variety of methods to certify parts that have been DC treated.

At 8' x 8' x 20' and with a 30,000 lb DCT capacity, the CP-36K is the largest cryogenic processor built to date and will be operational this fall. Induspec, a new DCT production facility in North Bay, Ontario, may add this capacity to support the mining and forestry communities.

Made in Canada and launched first for mining use in Canada, the CP-36K will serve DCI's charter of "making things last longer" – no matter how large they may be. M

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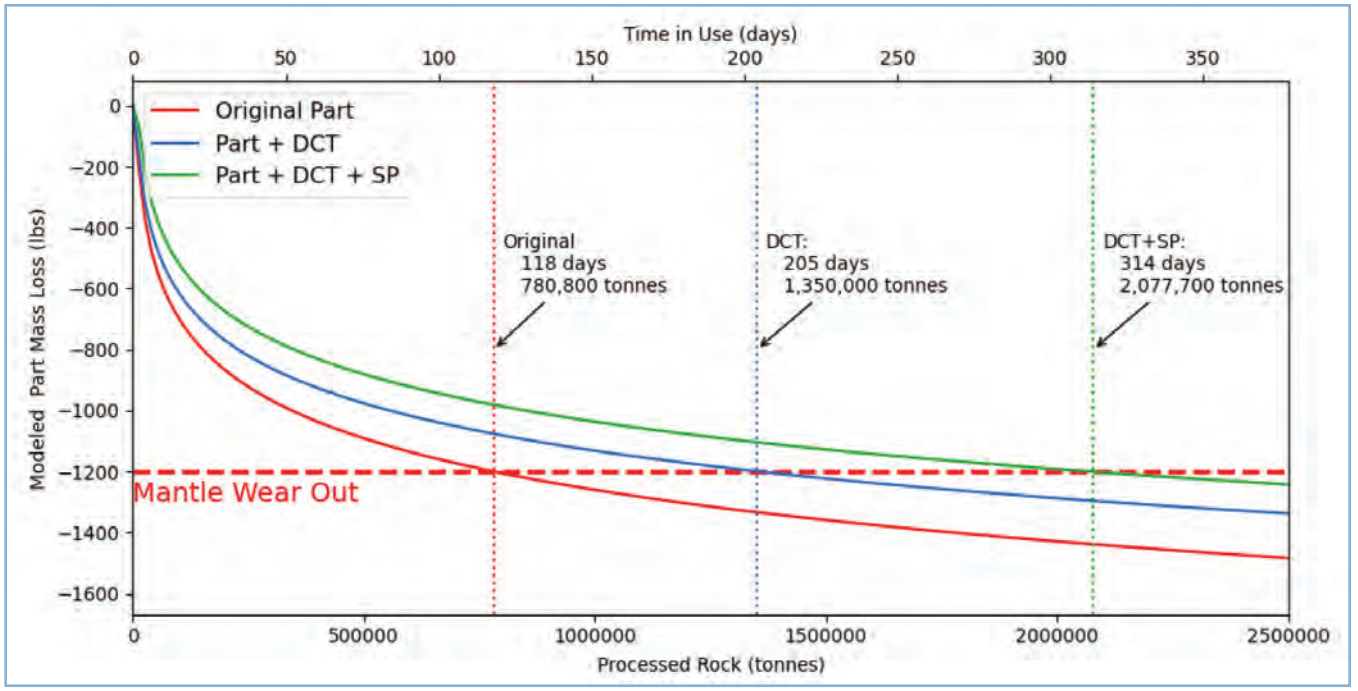

Prediction for wear improvement on Atlantic Gold's Mantle Liner, using the model generated from the G81 wear tester data.