Cryogenic Treatment

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Abstract :
In today's competitive marketplace, the necessity for sophisticated cryogenic treating has become a reality. In addition to stress relief, today's companies are finding that controlled cryogenic treatment dramatically increases the useful life of component, perishable tooling and wear parts. Cryogenic is the ultra low temperature processing of materials to enhance their desired metallurgical and structural properties. This ultra cold temperature, below -310 °F or 119 K, is 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.

1. Introduction :

Thermal treatment of metals certainly is regarded as one of the most important developments of the industrial age. After more than a century, research continues into making metallic components stronger and more were resistance. One of the most modern processes being used to treat metal is cryogenic tempering, which uses liquid nitrogen. While the science of heat treatment is well known and widely understood, the principle of cryogenic tempering remains a mystery to most people in industry. Until recently, cryogenic tempering was viewed as having little value, due to the often-brittle nature of the finished product.

The purpose of this work is a condensation of much of the information available concerning the effect of cryogenic treatment has no metal structure, as well as an overview of the actual process involved in treating parts. This work also includes a conceptual design of cryogenic process.

2. The Concepts of Cryogenic Process :

Cryogenics, a product of aerospace research, refers to temperatures below –310 °F. The material is frozen through a thermodynamic refrigeration cycle. In this process the material is cooled slowly and held there for a prolonged period of time, often 20 – 60 hours, then slowly allowed to return to room temperature.

The treated materials maintain its original size and shape through out the cryogenic process. What does change most significantly is an increase in the material toughness, stability and wear resistance. The treated material becomes less brittle but without losing hardness. The cryogenic treatment is a one-time process only and affects the material through to the core not just the surface. Resharpening or redressing of worn tools does not destroy the effects of the treatment.

3. The Working Process of Cryogenic Treatment :

Two changes in the microstructure of steel occur as a result of cryogenic treatment. These changes are the principal reasons for the dramatic improvement in wear resistance.

Firstly retained austenite – (a softer grain structure always present after heat treatment) is transformed into the harder, more durable grain structure, martensite. The range of retained austenite after initial heat treating may be as high as 50% or as low as 3% depending on the heat treating operator and accuracy of the heat-treating equipment. Cryogenic treatment simply continues the conversion initiated by heat treatment, where by almost 100% of the retained austenite is converted to martensite. As greater amounts of retained austenite are transformed, and wear resistant martensite is increased, the material obtains a more uniform hardness.

Secondly fine (eta) carbide particles are precipitated during the long cryogenic soak. These are in addition to the larger carbide particles present before cryogenic treatment. These fine particles or "fillers", along with the larger particle,

form a denser, more coherent and tougher matrix in the material. The surface energy of the martensite is higher than the surface energy of austenite due to the differences in their atomic structure. In adhesive wear situations, the martensite is less likely to tear out than its austenite. The adhesive wear co-efficient is decreased, and the wear rate is decreased. Both the martensite formation and the fine carbide formation work together to reduce wear. The additional fine carbide particles help support the martensite matrix, making it more difficult to dig out lumps of material.

4. Property Changes due to Cryogenic Process :

- ***Wear Resistance*** - increases between 25% and 400%.
- ***Hardness*** - often increases from 1 to 3 HRC, depends on the amount of retained austenite.
- ***Toughness*** - increases or remains the same on steels and increase much in others materials.
- ***Residual stresses*** - completely relieved.
- ***Dimensional Stability*** - this was the original purpose of cryogenic treatment, complete dimensional stability is achieved with cryogenics due to the formation of a 100% martensitic structure.
- ***Intergranular corrosion resistance*** - increases between 5% and 50%.

These changes are given to the whole structure; any regrinding or resharpening process does not affect the benefits of cryogenic treatment.

5. Benefits of Cryogenic Treatment

Cryogenically treated materials show a marked increase in wear resistance without any discernable change in dimensional or volumetric integrity. Treated material is easier and cleaner for machining process. Redressing treated tools removes less stock material resulting in longer tool life. Although the material is stronger this treatment, it shows little or no change in yield or tensile strength. The treated material becomes less brittle, without a change is the increased toughness, stability and wear resistance. The process also used extensively to relieve residual and tensile stresses.

6. Cryogenic Applications :

- **Industrial Applications:**

  Cryogenic treatment works on reamers (carbide or HSS), tool bits, tool punches (carbide or HSS), carbide drills, carbide cutter, milling cutters, files, shaping equipment, saw blades, band saw blades, reciprocating blades, cutting tools and dies etc. In all the cases, this treatment is a stronger and more wear resistance metal.

- **Automotive Applications:**

  Cryogenics works with almost all metal engine parts. Pistons, rings, rockers, push rods, connecting rods, valves, the crank and camshafts and even the block itself. Together, a treated engine can last substantially longer in terms of wear than any other process could achieve. Even parts like brake rotors, drums, and brake pads can benefits from cryogenic treatment.

- **Medical Applications:**

  Cryogenics has also been used by the medical industry. Surgical tools used by doctors, surgeons, dentists, and other specialist can all benefit from the increased wear resistance of the treatment. Surgical tools, like many other industrial tools, are expensive to replace, so cryogenic treatment can really pay off. In addition, many surgical implants are also treated. This helps prevent the part from wearing; it increases the tensile and bending strength of the part, as well as reducing the likelihood of micro fracturing. Cryogenics really is a healthy choice for the medical field.

- **Sports Applications:**

  Cryogenics is used to treat many types of sports equipment, the most common being golf clubs. Because cryogenics increases the molecular density of treated materials, it improves the distribution of energy through the objects. The treatment also increases the rigidity of the metal, which in this case might affect the shaft of the golf club. This type treatment can be used on

many other types of sports equipment where the same energy and rigidity characteristics would benefit the user.

- **Musical Applications:**

Cryogenics is also used to treat many types of musical instruments. Because treated materials are denser, the surface area of an object is affected. Inside the instrument, the surface is smoother than an untreated instrument. This change in surface characteristics changes the quality of sound that the instruments can produce. In most cases, a crisper, clearer sound is achieved, especially amongst the brass section of instruments. The same type of effect can also be useful in strain ged instruments by treating the strings themselves. There really is no end to the numerous ways cryogenics can assist, both at work and at play.

7. Conclusions

Cryogenics is an exciting and important frontier that already has led to major discoveries and holds much future promise. Relatively undiscovered industry has also developed its service side to provide cryogenic processing in response to specific regional niches. As in the case with many scientific discoveries, the cost factor limits the usefulness of this process in the production phase of the material industry.