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A Review on Cryotreated Engine Part

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***Abstract*: Cryogenic treatment is an add-on process to conventional heat treatment process in material processing technology. It is a one-time permanent treatment which affects the whole section of the component. It is not like the coatings of superior materials over other metal surfaces that only affects the surface of components. Cryogenic treatments are proved to be a good way to reduce the retained austenite content and improve the performance of materials by improving its marten site structure. Objectives of cryogenic treatments are to increase material's strength, hardness, wear resistance, ductility, & toughness, to obtain fine grain size, to remove internal stresses, to improve machinability, cutting properties of tools, to improve surface properties, electrical properties & magnetic properties.**

***Keywords*: cryogenic treatment, objectives of cryogenic treatments.**

1. Introduction

A. *What is a cryogenic system?*

Cryogenics is the branch of physics that deals with the production and effects of very low temperatures. The Large Hadron Collider (LHC) is the largest cryogenic system in the world and one of the coldest places on Earth.

B. *Cryogenic treatment*

A cryogenic treatment is the process of treating work pieces to cryogenic temperatures (i.e. below −190 °C (−310 °F)) in order to remove residual stresses and improve wear resistance on steels. In addition to seeking enhanced stress relief and stabilization, or wear resistance, cryogenic treatment is also sought for its ability to improve corrosion resistance by precipitating micro-fine eta carbides, which can be measured before and after in a part using a quantimet.

The process has a wide range of applications from industrial tooling to the improvement of musical signal transmission. Some of the benefits of cryogenic treatment include longer part life, less failure due to cracking, improved thermal properties, better electrical properties including less electrical resistance, reduced coefficient of friction, less creep and walk, improved flatness, and easier machining.

2. Literature review

K. Prudhvi & Venkata Vara Lakshmi: They studied about the normal high-speed steel tool for machining. But it is not possible to machine the hardened materials. So they apply cryogenic treatment for a certain time. Hardness is tested for the tool before and after treatment. Hardness for the untreated tool was 64.06 HRC and for a treated tool was 65.83 HRC. Therefore, hardness is increased by 1.73 HRC than the untreated tool. They have concluded from the experiments that there are 34.17 seconds decreases in machining time & there is no tool wear when machining EN8 and when machining EN 19 there are 22.04 seconds decrease in machining time & 0.03g increase in tool wear resistance. Deep cryogenic treatment has a significant effect on increment in the wear resistance and correspondingly reduces machining time of steels such as EN8 and EN19.

Podgornik, I. Paulin, B. Zajec, S. Jacobson, V. Leskovsek: Material used in this study was a high fatigue strength cold work steel with lower C and high W and Co content. In order to examine the effectiveness of DTC on fracture toughness and load carrying capacity, two more tool steels were used namely high C and V content cold work tool steel and one high-speed steel. After specimens were machined, they were vacuum heat treated using nitrogen gas at a pressure of 5 bar.

1) In case of low carbon cold-work tool steel (A1), DCT results in greatly improved fracture toughness while maintaining high hardness. On the other hand, for high C cold-work tool steel DCT has a negative effect, while for high-speed steel, DCT has practically no effect.

D. Das, K. K. Ray, A. K. Dutta: Their study examined the effect of the temperature of the treatment on the wear behavior of AISI D2 steel. Samples were subjected to conventional treatment (CONT), Cold Treatment (CT), Shallow Cryogenic Treatment (SCT) and Deep Cryogenic Processing (DCT) in separate batches. CONT consists of hardening and tempering; while in CT, SCT and DCT, an additional step of controlled sub-zero treatment with the lowest quenching temperature under 198, 148 and 77 K respectively, was incorporated into the curing and quenching treatments. Microstructural examinations were performed using optics and SEM.

They concluded that:

1) All types of sub-zero treatments appreciably improve the wear resistance of the die steels compared to the CONT ones. Improvement in wear resistance by SCT and DCT is significantly higher than that achieved by CT, and the maximum improvement is obtained by DCT.
2) The obtained results lead to the conclusion that lower the temperature of sub-zero treatment higher is the improvement in wear resistance.

3. How is cryogenics used today?

There are several applications of cryogenics. It is used to produce cryogenic fuels for rockets, including liquid hydrogen and liquid oxygen (LOX). Magnetic resonance imaging (MRI) is an application of NMR that uses liquid helium. Infrared cameras frequently require cryogenic cooling.

Cryogenic freezing of food is used to transport or store large quantities of food. Liquid nitrogen is used to produce fog for special effects and even specialty cocktails and food.

Cryogenic temperatures are used to store tissue and blood specimens and to preserve experimental samples.

Cryogenic processing is used as part of some alloy treatments and to facilitate low temperature chemical reactions

Cryomilling is used to mill materials that may be too soft or elastic to be milled at ordinary temperatures.

A. Cryogenic Disciplines

Cryogenics is a broad field that encompasses several disciplines, including:

- Cryonics: Cryonics is the cryopreservation of animals and humans with the goal of reviving them in the future.
- Cryosurgery: This is a branch of surgery in which cryogenic temperatures are used to kill unwanted or malignant tissues, such as cancer cells or moles.
- Cryoelectronics: This is the study of superconductivity, variable-range hopping, and other electronic phenomena at low temperature. The practical application of cryoelectronics is called cryotronics.
- Cryobiology: This is the study of the effects of low temperatures on organisms, including the preservation of organisms, tissue, and genetic material using cryopreservation.

Table 1
Cryogenic Fluids: The following fluids are most often used in cryogenics

Fluids	Boiling Points
Helium-3	3.19
Helium-4	4.214
Hydrogen	20.27
Neon	27.09
Nitrogen	77.36
Air	78.8
Argon	87.24
Methane	111.7

4. Definition of 'Cryogenic Engine'

Definition: A cryogenic engine/ cryogenic stage is the last stage of space launch vehicles which makes use of Cryogenics. Cryogenics is the study of the production and behaviour of materials at extremely low temperatures (below -150 degree Centigrade) to lift and place the heavier objects in space.

Cryogenic stage is technically a much more complexed system with respect to solid or liquid propellant (stored on earth) stages due to the usage of propellants at extremely low temperatures. A cryogenic engine provides more force with each kilogram of cryogenic propellant it uses compared to other propellants, such as solid and liquid propellant rocket engines and is more efficient.

Cryogenic Process Consist four stages, that involves:

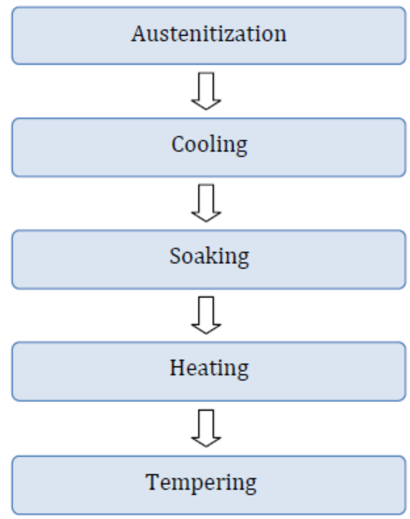

Fig. 1. Cryogenic Process

1) *Austenitization:* Heating from room temperature to its austenitizing temperature (around 1100 °C), at an extremely slow rate ranging from 0.5 to 1.5°C /min
2) *Cooling:* Direct cooling from austenitizing temperature to -196 °C at the rate of 1.5 to 2 °C. It is also called as quenching.
3) *Soaking:* For a period of time ranging from 24 to 36 hours depends upon which material is to be treated
4) Heating: From -196 °C to room temperature at the rate of 0.5 to 1°C /min.
5) *Tempering:* Reheating the metal at predetermined temperatures which are lower than the transformational temperature (around 150°C to obtain different combinations of mechanical properties in the material.

A. Merit's

There are several merits of cryogenic process:

1) The problem of grain coarsening at high temp treatment can easily be taken care during the cryogenic treatment/process.
2) Cryogenic treatment contributes in reducation or elimination of retained austenite. This will lead to a complete transformation to marten site which will in turn improve the mechanical properties of the steel.
3) Increases resistance to abrasive wear.
4) Improves the microstructure of the metal, not just the surface Parts may be subsequently reground or machined without affecting the results of the cryogenic process.
5) Decreases residual stresses, while increasing toughness and dimensional stability Improves resistance to impact Request Information.

5. Conclusion

This paper presented an overview on Cryotreated Engine Part.

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