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Cryogenic Treatment of Brake Rotors to Improve Wear Resistance

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Cryogenic treatment utilizes temperatures below 123K to modify the micro-structure of metals and other materials. Cryo-treatment has been widely adopted as a tool of cost reduction and performance enhancing technology. This paper highlights benefits of cryogenic treatment for brake rotors. In practice while driving under emergency conditions safety and braking response are always major concerns. Also you already have a lot on your mind either move ahead or apply brake. It is emphasized on cryo-treatment of brake rotors.

1. INTRODUCTION

NASA engineers were the first to notice the effects of cold temperatures on materials. They noticed that many of the metal parts in the aircraft that had returned from the cold vacuum of space came back stronger than they were before flight. Since then sub-zero treatment (-80° C) has been used for many years, but with inconsistent results. Many of the inconsistencies were reduced by longer soaking periods and with deep cryogenic treatment (-185° C). Cryogenic processing can be applied to both brake rotors and pads. The result observed is two to three time increase in life of components even under severe racing conditions. As a side benefit, the rotors also observed less prone to crack or warp. It is interesting that drivers report better braking action and feel.

2. CRYOGENIC TREATMENT

The cryogenic treatment cycle has following steps

• Ramp down or Cooling Phase. In most cycles, the temperature is ramped down to 89K (-300°F, or -184°C) from ambient temperature in four to ten hours. This slow decent in temperature helps reduce the temperature gradient within the component and keeps stresses to a minimum.

• Hold. The temperature is held at 89K for a period of time, typically from six to forty hours.

• Ramp up or Warming Phase. The temperature is brought back to ambient over a period of four to ten hours.

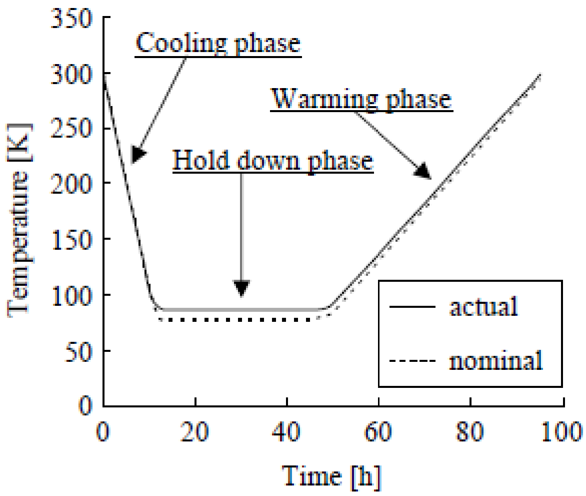

Figure 1 Cryogenic Treatment Cycle

3. ADVANTAGES OF CRYOGENIC TREATMENT

- Increase resistance to abrasive wear
- Requires only one permanent treatment
- Changes the entire grain structure of the metal, not just the surfaces
- Refinishing or regrinds do not affect permanent improvements
- Eliminates thermal shock through a dry, computer controlled process
- Transforms most retained austenite to hard martensite
- Forms micro-fine carbide fillers to enhance carbide structures
- Increases durability and wear life
- Decreases residual stresses in tool steels
- Decreases brittleness
- Increases tensile strength, toughness and stability
- Relaxes internal stresses
- Works on new or used tools

- Reduced down time, less maintenance and higher productivity
- Deep cryo processing is compatible with other treatments (TiN, Chrome, Teflon etc.)
- High alloy steel cutting tools stay sharper longer, fewer micro-cracks, less chipping
- Results in the orderly arrangement of crystals, increases internal bonding energy, and achieves a structural balance throughout the mass of the material

Cryo-treament can make a major contribution to solving these problems:

1. High abrasive wear in cutting tools, moulds, dies, brake rotors, gears, engine components, etc.
2. High corrosive wear in chemical, food, and oil equipment applications.
3. High erosive wear from, water, slurries and other abrasive grit carriers.
4. Distortions induced by design, forming, machining or environment.
5. Stress relief in complex tools, components, and welds.
6. Stress relief cracking of weld zones.
7. Surface finishing in any application where long life is needed.
8. Stabilization in parts and components as a result of stresses.
9. Machinability in aluminium and copper parts.
10. Electrode life in copper resistance welding electrodes .

4. METALLURGICAL CHANGES BY CRYO-TREATMENT

Cryogenic Treatment and processing promotes three transformations in heat-treated steels and cast irons.

(1) Crystal structure becomes consistent or homogenous through the conversion of austenite to the desired martensitic crystal . After heat-treating, nearly all steels have a certain percentage of austenite that was not fully transformed into martensite.

(2) The carbon structure of steels is modified through a mechanism that is technically described as “the precipitation of eta-carbides”.

(3) All metals – not just steel, but also aluminium, copper, cast alloys, etc. – benefit from the residual stress relief that deep cryogenic treatment promotes.

5. EXPERIMENTAL WORK

To find out effect of improvement in wear resistance of brake rotors designed a methodology. Similar types of brake rotors and liners are purchased and given them treatment at -80 deg. C and -185 deg. C. Untreated and treated rotors are used in motorcycle for equal manual braking on road condition. Wear of any part causes material removal which results in loss of weight. So these are sufficient parameters to measure the wear.

Assumptions during experimental work.

1. Road conditions are unchanged.
2. Braking effort is same. (Same person applies the brake.)

Figure 2 Brake Rotor ready for Cryogenic Treatment

6. RESULT AND ANALYSIS

TABLE 1. WEIGHT ANALYSIS AFTER 2000 BRAKING FOR BRAKE ROTORS

	ROTOR WITHOUT TREATMENT	ROTOR -80 ^{O}C TREATMENT	ROTOR -185^{O}C TREATMENT
INITIAL WEIGHT (A)	1232.5gm	1245.0gm	1244.5gm
WEIGHT AFTER 2000 BRAKING (B)	1229.5gm	1242.5gm	1243.5gm
WEIGHT LOSS FOR USE (A-B)	3.0gm	2.5gm	1.0gm
FOR EXAMPLE LIFE IN YEARS	03 YEARS	3.75 YEARS	09 YEARS

7. CONCLUSION

Cryogenic treatment improves the wear resistance of brake rotors by three times. Deep cryogenic treatment is more effective than subzero treatment. As the braking cycle increases after use the effort for braking increase.

8. FUTURE SCOPE

During the study brake rotor used is drum and expanding shoes type, instead DISC type rotor can be used and same way analysis for effect of cryo-treatment may carried out.

9. REFERENCES

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