TECHNICAL DATA ARTICLE

Ordered Growth in CarTech Hiperco® 50 Alloys

Minimizing Net Size Change for Tight Tolerance Applications

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INTRODUCTION

There is increasing demand in the soft magnetics industry for tighter tolerance laminations to meet challenging design criteria. Carpenter Technology Corporation and its customers have long been aware of a net dimensional change in CarTech Hiperco® 50 alloys (Fe49 – Co49 – V2) after post fabrication annealing. In order to better serve its clientele, Carpenter has evaluated the root cause and designed a special process to improve the dimensional change characteristics of CarTech Hiperco 50 alloys.

CAUSE OF NET SIZE CHANGE

The net size change or "growth" of these alloys is due to a phase change experienced during heat treating. Traditionally these alloys are supplied in the cold finished – unannealed condition, which means that they are "disordered." After heat treating, when cooling below the ordering temperature (TORDER) the alloys transition from the "disordered" phase to the "ordered" phase. What this means on an atomic scale is that the atoms are randomly arranged in the "disordered" phase and preferentially arranged in the "ordered" phase. The "disordered" phase has a larger coefficient of thermal expansion (CTE) than the "ordered" phase. This intrinsic difference manifests itself as a net size change after heat treating because the material grows more as it is heated than it shrinks as it cools (Figure 1).

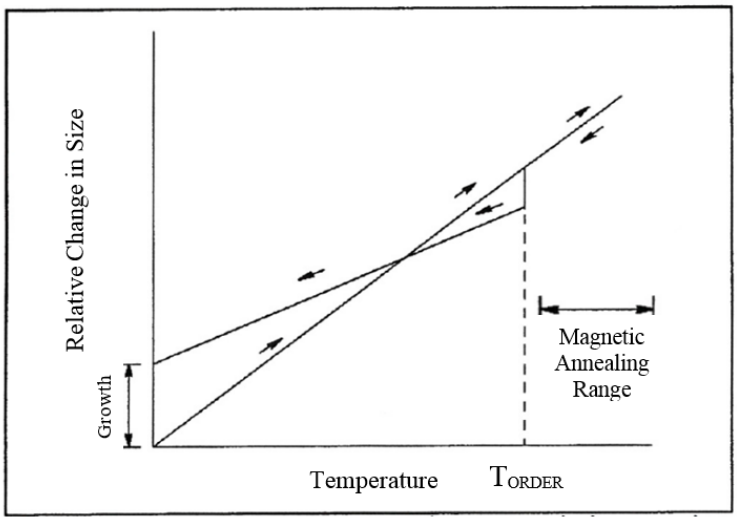

Figure 1.

Schematic representation of the disorder-order phase change effect on CTE in CarTech Hiperco 50 alloys.

ANALYSIS

Electromagnetic motors, generators, and bearings are a few of the applications utilizing CarTech Hiperco 50 alloys today and all require tight control of size tolerances. The net size change that these

alloys experience can be difficult to account for. Carpenter has done extensive analysis of the CarTech Hiperco 50 alloys and has determined that the typical size change after conventional heat treating of cold rolled-unannealed material is ~.0008" per inch of material in the rolling direction and ~.00055" per inch 90° to the rolling direction (Figure 2). Any net change in thickness of the material is negligible for strip product. All analysis performed was on symmetrical and whole pieces of strip.

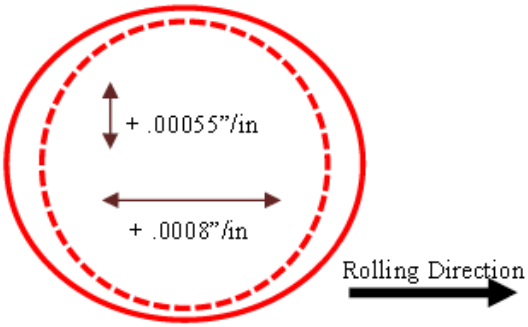

Figure 2.

Schematic of conventionally processed growth in CarTech Hiperco 50 alloys post annealing.

MINIMIZING NET SIZE CHANGE

The industry today has a few techniques to try and account for this size change, however due to the complex shapes being fabricated from CarTech Hiperco 50 alloys, the thermal stresses from heat treating and the mechanical stresses from stamping, the growth is not always uniform or consistent. Carpenter has developed a special process for CarTech Hiperco 50 alloys to minimize the net size change realized. As discussed previously, size change is an intrinsic behavior due to a change in CTE and other factors that influence the final distortions associated with post fabrication annealing. Carpenter's analysis of our "specially processed" CarTech Hiperco 50 alloys after a conventional post heat treatment have a net size change of ~ .0003" per inch or less in both the rolling direction and 90° to the rolling direction (Figure 3).

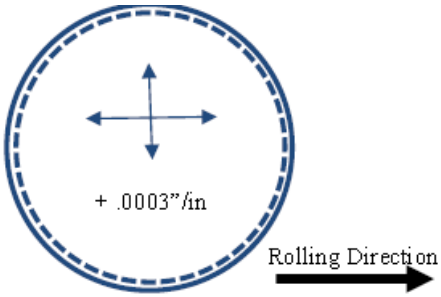

Figure 3.

Schematic of "Specially processed" growth in CarTech Hiperco 50 alloys post annealing.

CONCLUSION

"Specially processed" CarTech Hiperco 50 alloys see a 63% reduction in size change in the rolling direction and a 55% reduction in size change perpendicular to the rolling direction. It should also be noted that the size change becomes symmetrical. Thermal and mechanical stresses that affect the net size change of laminations were not evaluated by Carpenter. This "special process" does not alter the post annealed magnetic performance of the material.

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