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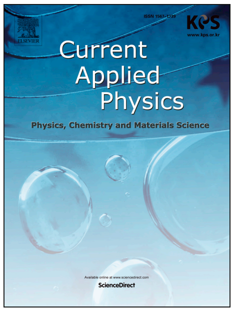

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Daudi R. Waryoba, Winston Roberts

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Application of Electromagnetic Processing for Development of High-Performance Sintered Powder Metal Parts

Daudi R. Waryoba[a,*],Winston Roberts[b,†]
[a]Division of Engineering, Penn State University, 1 College Place, DuBois, PA 15801
[b]Department of Physics, Florida State University, Tallahassee, FL 32306

ABSTRACT: Electromagnetic processing was used to study the effects of electro-magneto forming on the dimensional control and thermal stability of sintered powder metal (PM) parts. The investigation was carried out on sinter-hardened, low chromium- molybdenum bainitic steel. The results show an increase in the microhardness of about 14% for the electromagnetic processed parts compared to the as-sintered parts. This was attributed to the 2% increase in the density, 17% and 29% reduction in the volume fraction of porosity and width of the bainitic lath, respectively, due to the electromagnetic processing. Dimensional characterization was carried out using a vertically aligned push-rod dilatometer. After four thermal cycles of heating and cooling, at a controlled rate of 5^{o}C/min to 1000^{o}C, the electromagnetic processed parts exhibited reduced dimensional change of about 44% lower than for the as-sintered parts. This is significantly important for applications that demand high dimensional tolerance and performance, especially at elevated temperatures.

Keywords: Powder metallurgy; Bainitic steel; Sintering; Electromagnetic forming; Dilatometry

1. Introduction

Electromagnetic processing of materials (EPM) is a phenomenon that has been recognized for over two decades. In EPM, the interaction of the electromagnetic fields with the media occurs by means of various forces such as Lorentz, Kelvin, and diamagnetic forces [1]. This enables materials to be controlled, processed and manipulated thereby affecting their microstructure, texture, and material properties [2,3]. For example, Ludtka *et al*. [3,4] studied the effects of the magnetic field on the phase transformation kinetics in a medium carbon steel and noted a shift in the onset of austenite decomposition due to the magnetic field. This shift was attributed to the thermal recalescence associated with the release of latent heat, and showed a 70^{o} –90^{o}C increase in transformation temperature. The quantitative microstructural analysis indicated a 25–30% increase in ferrite volume fraction due to the magnetic field. Esling *et al*. [5] used electromagnetic processing of materials to show how this process can be used for tailoring the texture and the grain boundary characteristics of materials. In their study of the phase transformation processes of a proeutectoid steel under a magnetic field, they observed an increase in the frequency of low angle boundaries, and lattice distortion caused by the solubility of carbon atoms in specially orientated ferrite grains through the dipolar interaction between magnetic moments of iron atoms. Li *et al*. [6,7], used electromagnetic bulging process to study the microstructure, texture and mechanical properties of annealed 5A02 Al alloy tubes, and reported a significant increase in the yield strength and fracture strength of the post-bulged samples. This enhancement was attributed to the formation of dense dislocation bands and dislocation walls in the bulged samples due to the effect of high strain rate of this process and to

* drw29@psu.edu; corresponding author.
† wroberts@fsu.edu