Additive Manufacturing of Fe-Si Soft Magnetic Materials

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ABSTRACT

3D printing, additive manufacturing, has attracted significant attention recently as a technology that allows three dimensional shapes to be formed. Binder jet printing is a popular process that can compete favorably with injection molding and polymer bonding. Lasers provide a unique opportunity to heat small areas of powder, typically 20 to 50 microns, and the melt cools rapidly, with the cooling rate is fast enough to form fine grained microstructure. Binder jetting process allows faster fabrication of 3D printing. We compare binder jetting and laser printing of soft magnetic materials like Fe-3Si powders from the same feed stock. Also, of interest is to compare the results to that reported for injection molded parts.

INTRODUCTION

Soft magnetic materials play an important role in the conversion of electrical energy in transformers and inductors in alternating current (AC) applications and provide good path for magnetic flux in direct current (DC) applications. Hoeganaes has developed a variety of soft magnetic materials for use in press and sinter and press and cure applications [1-6].The advancements in 3D printing have reached a commercial stage and we wanted to understand better the technology applicability of 3D printing to Fe-Si soft magnetic materials. Traditional laminations of Fe-Si have been in use for over several decades. Due to demand in improving motor efficiency, recently motor lamination topology is changing due to advancements in FEA and better understanding of torque and torque ripples in motors. This has led to complex geometries with channels in the rotors and other features. These are difficult to machine and results in significant loss of material. 3D printing offers an opportunity to make these complex geometries. For DC and lower frequency applications, Fe-3Si is used extensively. The main function of the soft magnetic material is to convert electrical energy to mechanical power. For example, DC motors and generators, electromechanical relays and switches, armatures, and pole pieces for opening and closing electrical circuits such as doorbells and buzzers and variety of switches, antilock braking systems, wheel sensors, EGR valve bodies.

For AC applications such as transformers and motors, resistivity of the material must be high so rolled laminations are used. Currently, there is desire to make the final part by 3D printing, in which case Fe-3Si is integrated into the devices during the printing process.

To satisfy the future and current requirements, it is important to understand the effect of processing methods on the magnetic properties. This presentation compares the binder jetting and laser printing on identical materials and post processing them to maximize the magnetic properties. Results are compared with properties of injection molded parts via the MPIF standard.