Magnetic properties of oxalate coated iron powders based soft magnetic composites

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Abstract

The transition to electric vehicles necessitates more efficient motor designs, with three-dimensional flux motors utilizing high-strength soft magnetic composites (SMC) emerging as a promising alternative. This study explores modifying iron powders with hydrated oxalate, producing a soft magnetic composite. We report two different types of oxalate coating on iron that include deposition of mixed copper/iron oxalate and manganese/zinc oxalate coating on iron, respectively. AC and DC magnetic measurement of SMC made using copper/iron oxalate revealed that increasing treatment temperature enhances DC permeability. Furthermore, the contribution to the core losses as a function of heat treatment and AC frequency were also studied. These findings provide insights into optimizing soft magnetic composites for high-performance electric motor applications.

Introduction

Soft magnetic composites are ferromagnetic iron particles that are coated with an electrical insulating film that allows for 3D magnetic flux paths. This provides a unique advantage over traditional laminated electrical steel, commonly used in motors, that only allow 2D magnetic flux paths. Hence, soft magnetic composites are ideal for designing complex electromagnetic components that have higher permeability with enhanced saturation density, lower eddy current losses, provide excellent high temperature resistance and can be used in high frequency applications. However, they suffer from poorer mechanical strength and higher costs relative to electrical steel[1-3].

The higher costs relative to powdered iron or silicon steel can be attributed to the complexity of producing uniformly coated iron powder with good insulation characteristics. Good magnetic properties necessitate the need to consolidate these powders to higher densities (~7.5 g/cc) and this requires the use of expensive binders with good thermal stability as well as high compaction pressure (~900 MPa). Soft magnetic composites also require heat treatment to relieve residual stresses for minimizing coercivity. Such a heat treatment is usually limited to ~550°C under controlled atmosphere and hence soft magnetic composites are not fully sintered compacts and have poorer mechanical strength. There is usually a tradeoff between the magnetic properties and mechanical strength.