DEVELOPMENT OF POLYMER-BONDED MAGNETIC COMPOSITE USING MAGNETIC-ASSISTED ADDITIVE MANUFACTURING (MFAAM)

by

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ABSTRACT

The incorporation of a magnetic field into a 3D printer facilitates the production of a durable anisotropic magnet by utilizing extruded magnetic filaments. This capability is of interest to both researchers and individuals passionate about 3D printing. The utilization of bonded polymer magnets in electronics presents a potential avenue for cost reduction and weight reduction, as well as environmental benefits. This is due to the recyclable nature of the matrix and additive employed in the fabrication process, which would contribute to a more sustainable approach. The composite material investigated in this thesis research is a PA12/SrFe12O19 polymer bonded magnet. Polyamide 12 (PA12), also known as Nylon12, and Strontium Ferrite (SrFe12O19) composites have been identified as promising manufactured composites suitable for applications in magnetic devices. The utilization of Magnetic Field-Assisted Additive Manufacturing (MFAAM) enables the attainment of anisotropy in magnetic characteristics with the application of a print magnetic field. This technique proves beneficial for various magnetic applications, including but not limited to transformer cores, electric motors, and magnetic gears. The incorporation of strontium ferrite has been found to have a positive impact on the mechanical characteristics of Polyamide 12, which is a thermoplastic material commonly utilized in Fused Filament Fabrication (FFF) processes. Enhancing the magnetic properties of magnetic composites

necessitates the concurrent improvement or preservation of the structural integrity exhibited by the binding material (PA12). Therefore, it is crucial to achieve a harmonious equilibrium between these two factors to optimize the performance of magnetic devices in various applications. Therefore, this thesis study aims to evaluate the morphological, mechanical, magnetic, and thermal properties of the PA12/$SrFe_{12}O_{19}$ magnetic composites made using the MFAAM technique. In this thesis study, a co-rotating twin screw extrusion technique is employed to fabricate filaments consisting of PA12/$SrFe_{12}O_{19}$ composite material. The filaments are produced with varying concentrations of magnetic particles, specifically 10wt%, 35wt%, and 54wt%. The MFAAM process is employed to produce test samples, wherein a modified open-source LulzBot Taz 3D printer is utilized to house a magnetic field source. The mechanical properties are investigated through the utilization of a United Testing System (UTS) and Material Testing System (MTS Exceed), while the magnetic properties are examined utilizing a Biaxial Vibrating Sample Magnetometer. Furthermore, the morphological and thermal properties of the sample were investigated by the utilization of scanning electron microscopy (SEM) and an SDT-650 instrument. The incorporation of strontium ferrites into PA12 resulted in improved or retained mechanical properties across all three packing fractions, with only a little reduction observed in the tensile value for the 54wt% fraction. The magnetic characteristics of the samples were enhanced when helped by MFAAM at 10wt%, 35wt%, and to a lesser extent, 54wt%. The scanning electron microscopy (SEM) images revealed that there was effective dispersion of particles observed at all loading levels, with little agglomeration observed specifically in the samples with 54wt% of MFAAM assistance. The magnetic composites demonstrated favorable thermal stability at elevated temperatures (100°C) across all packing fractions.