

Advanced additively manufactured permanent Magnets for New Energy and MObility Applications

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Introduction

The first year of the MagNEO project has marked substantial progress across both technical and strategic fronts, with all work packages (WPs) advancing toward the project's main goal: developing robust, rare-earth-free permanent magnets for green energy and mobility applications. This coordinated effort includes significant research on alloy design, additive manufacturing, simulation, sustainability assessments, and application-specific validation.

WP1 – Alloy Design and Material Characterisation

WP1 focused on identifying promising AlNiCo alloy compositions and optimising processing conditions to enhance magnetic properties via shape anisotropy. Over 60 compositions were synthesised and underwent thermomagnetic treatments and magnetic characterisation. Microscopy and micromagnetic modelling revealed nanostructural features that are potentially beneficial to performance. Additionally, machine learning and atomistic simulations were explored to accelerate the compositional screening process. Notably, CONIFY conducted additive manufacturing trials using AlNiCo5 in PBF-LB mode to identify optimal print parameters.

WP2 – Simulation and Optimisation of Powder Production and Magnet Design

WP2 achieved coordinated progress across three tasks. CFD simulations advanced the design of powder atomisation nozzles and optimised gas parameters to improve particle size distribution. In microstructure modelling, steady-state and transient simulations were validated using experimental data, enabling the establishment of correlations between numerical and real-world parameters. Topology optimisation also progressed with the development of finite element models for two industrial components: a marine generator and a headlight motor, facilitating evaluation of material substitutions and shape parameters.

WP3 – Additive Manufacturing and Recycling Innovations

WP3 addressed both additive manufacturing and recycling. CEIT and VTT produced AlNiCo5 and AlNiCo8 powders, used by VTT and CONIFY in PBF-LB trials. AlNiCo5 prints showed promising density with minor cracking, whereas AlNiCo8 encountered challenges in spreadability and delamination, which are now under investigation. On the recycling side, BioG3D and AIMEN are utilizing and refining crushed end-of-life (EoL) magnets to develop Fused Filament Fabrication (FFF) and Fused Granulate Fabrication (FGF) printable materials with high magnetic filler content and optimized magnetic performance.

WP4 – Sustainability and Innovation System Analysis

Although WP4 officially commenced in month 12, preparatory efforts were initiated. IRES began designing the Life Cycle Assessment (LCA) and Life Cycle Costing Analysis (LCCA) frameworks, defining system boundaries and necessary input data. Concurrently, SINTEF introduced the Technological Innovation System (TIS) framework to map the institutional and stakeholder landscape influencing MagNEO innovations. This groundwork is essential for evaluating the environmental, economic, and social impacts of the project's outcomes.

WP5 – Application-Driven Validation and Specification

WP5 analysed the magnet requirements for two real-world applications: a marine MW-class shaft generator and a high-speed solid-rotor motor for industrial use. Specifications were collected and compared, and representative models were developed to simulate magnet behaviour under real operating conditions. These validated models will guide future experimental tests and ensure the relevance of research outputs to industrial end-users.

Consortium Coordination and Outreach

The M12 project meeting, held in Nicosia and hosted by RTD Talos, provided an important platform for knowledge exchange and future planning. The project is also actively preparing for representation at major events, including ICEAF 2025 in Greece, Euro PM 2025 in Scotland, and FisMat 2025 in Italy, where MagNEO partners will present their results and promote sustainable magnet technology.

MagNEO's first year laid a strong multidisciplinary foundation by integrating materials science, simulation, sustainability, and industry-focused validation, paving the way for Europe's transition to rare-earth-free magnet technologies.

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