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INTEGRATED RECYCLING TECHNOLOGY FOR $R_2Fe_{14}B$-TYPE MAGNETIC ALLOYS

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The growing consumption of rare-earth metals (REMs) in high-tech sectors – including electric vehicle production, wind turbine manufacturing, and electronics – has made the recycling of magnetic alloys an increasingly critical priority. While modern recycling methods (extractive, pyrochemical, powder metallurgy) demonstrate operational efficiency, they remain cost-prohibitive, technically challenging to implement and pose significant environmental risks.

A 'magnet-to-magnet' recycling method is under development at the Seversk Technological Institute of NRNU MEPhI. The process involves:
hydride dissolution in sulfuric acid;

– co-crystallization of rare-earth metal (REM) and iron sulfates;
– thermal conversion to oxide compounds;
– electrochemical reduction to pure metals.

The recycling process critical phase involves precisely managed crystallization, progressing through three distinct stages such as nucleation – initial crystal formation, growth – controlled particle enlargement, ripening – final crystal maturation.

Current research evaluates three industrial crystallizer configurations:

– cooling, which induce crystallization through temperature reduction;

– evaporative, which increase solution concentration through solvent removal;

– agitated, which ensure homogeneous substance distribution, promoting formation of uniform crystals.

The development process incorporates critical operational parameters: thermal profile, solution concentration, process duration, mechanical inputs. Key crystallization efficiency determinants were confirmed by solvent selection, temperature gradient, evaporation surface area.