Optimization Principles of Eddy Current Separator for Mixtures with Different Particle Sizes

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Abstract: The study of the electrodynamic behavior of non-ferrous particles in time-varying magnetic fields is a promising area of research with wide applications, including recycling of non-ferrous metals, mechanical transmission, and space debris [1]. The key technology for recovering non-ferrous metals is eddy current separation (ECS), which utilizes the eddy current force and torque to separate non-ferrous metals. ECS has several advantages, such as low energy consumption, large processing capacity, and no secondary pollution, making it suitable for processing various mixtures like electronic scrap, auto shredder residue, aluminum scrap, and incineration bottom ash [2].

Improving the separation efficiency of mixtures with different particle sizes in ECS can create significant social and economic benefits. Our previous study [3] investigated the influence of particle size on separation efficiency by combining numerical simulations and separation experiments. A strong correlation between the eddy current force in simulations and the repulsion distance in experiments was found by Pearson correlation analysis, which confirmed the effectiveness of our simulation model. The interaction effects between particle size and material type, rotational speed, and magnetic pole arrangement were examined, which offered some optimization criteria for eddy current separators. The mechanism behind the effect of particle size on separation efficiency was discovered by analyzing eddy current and field gradient. The results showed that the magnitude and distribution heterogeneity of eddy current and magnetic field gradient increased with particle size in eddy current separation. We have further found that increasing the curvature of magnetic field lines within particles can also increase the eddy current force, providing an optimized method to improve the separation efficiency of fine particles.

Based on the results of the above-mentioned studies, a more systematic and comprehensive set of optimization guidelines can be proposed for mixtures with different particle size ranges. The separation efficiency of fine particles could be improved by increasing the rotational speed, curvature of magnetic field lines, and electrical conductivity/density of materials, as well as utilizing the eddy current torque. When designing an ECS, the particle size range of the target mixture should be investigated in advance, and the suitable parameters for separating the mixture can be fixed accordingly. The results can guide the design and optimization of ECS, and also expand the application areas for ECS.

Keywords: Eddy current separation, Metal recovery, Numerical simulation, Particle size.

References

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