Optimizing Truck Fleet Selection and Sizing in Open-Pit Mining Using Simulation: Analyzing Sustainability Impacts of Fleet Configuration and Truck Failures

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# ABSTRACT

This study introduces a simulation-based model designed to optimize truck fleet type and size configurations in open-pit mining operations, focusing on sustainability and emissions reduction. The model evaluates both homogeneous and heterogeneous fleet setups to identify optimal strategies that enhance operational efficiency, productivity, and environmental performance. Through comparative analysis, we find that heterogeneous fleets outperform homogeneous configurations by achieving production targets with reduced fuel consumption, supporting an effective balance between productivity and emissions reduction. The simulation results also indicate that, when factoring in potential truck failures, smaller trucks within a homogeneous fleet offer higher flexibility in ore transfer and experience lower average downtimes, thus maintaining operational flow more effectively than heterogeneous fleets under failure scenarios. This insight highlights the advantages of homogeneous fleets with smaller trucks in conditions where truck reliability is variable. Conversely, heterogeneous fleets show higher fuel efficiency in non-failure scenarios, achieving lower fuel consumption per ton moved. The study underscores the critical role of fleet selection, sizing, truck reliability, and emissions in optimizing fuel consumption, production rates, and material flow in mining operations. These findings offer practical insights into configuring fleet operations that meet production demands while minimizing costs and environmental impacts, contributing to more sustainable mining practices.