Optimizing In-Pit Crushing and Conveying Systems for Cost-Effective Open-Pit Mine Scheduling: A Sensitivity Analysis on Material Throughput and Haulage Costs

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# ABSTRACT

In open-pit mining, in-pit crushing and conveying (IPCC) systems offer significant advantages over traditional truck-shovel (TS) methods, particularly as haul distances grow with increased mine depth. IPCC reduces the need for extensive truck haulage, cutting down on fuel consumption, maintenance, and carbon emissions by transporting material via conveyors. Placing crushers within the pit streamlines material handling and stabilizes haulage costs over time, providing a more cost-effective and sustainable operation. This study develops a model to optimize IPCC placement and relocation to minimize haulage costs and maximize Net Present Value (NPV) in long-term mine scheduling. To examine the sensitivity of our model, we vary two key parameters: the tonnage of material processed while the crusher remains in the optimal panel and the dollar-per-ton-kilometer cost of haulage. By adjusting the processed tonnage, we evaluate how throughput levels influence haulage requirements and crusher relocation strategies. Altering the haulage cost, meanwhile, offers insight into how changing market conditions impact the economic viability of crusher relocations and the overall robustness of the model. The methodology utilizes a two-stage clustering approach, combining k-medoids and hierarchical algorithms, to define crusher panels and mining cuts precisely, integrating road and conveyor networks. Tested on real mine data, this approach shows significant NPV gains across analyzing the scenarios, consistently outperforming traditional TS methods. Our findings highlight that optimal IPCC configurations depend heavily on both material tonnage and haulage costs, underscoring the importance of these factors in sustainable and cost-efficient mining practices. This scalable model provides a flexible solution for modern mine planning, advancing IPCC as a practical alternative to traditional haulage methods.