The International Journal of Advanced Manufacturing Technology, Vol 143, March 2026

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A review of failure mechanisms and advanced remanufacturing technologies for gears and sprockets in mining machinery

Abstract

This review systematically identifies, quantifies, and synthesizes the failure modes of heavy-duty gears and sprockets in mining equipment, examines their underlying causes or contributing factors, and evaluates remanufacturing strategies to enhance component durability. Despite the critical role of these drivetrain components, the number of mining-specific studies is limited, making this synthesis essential for understanding trends, informing practical interventions, and proposing further research areas. Analysis of the literature indicates that tooth fracture dominates gear failures, representing approximately 75% of reported cases in open-pit mines, primarily due to extreme shock loads, and 50% in underground mines, driven by fatigue and contamination. In contrast, abrasive wear is the primary mode of sprocket degradation (> 60% in both mining environments), resulting from continuous exposure to abrasive particulates, moisture, and high-humidity conditions. Manufacturing-induced defects, particularly quenching micro-cracks and unfavorable residual tensile stresses from conventional heat treatments, emerge as a primary contributor to premature failures, independent of operational conditions. Advanced remanufacturing techniques provide targeted solutions for these recurring failures. Laser cladding using wear-resistant iron-based matrix metal composites (IMMCs) enables precision restoration of gear teeth, while wire-arc additive manufacturing (WAAM) is well-suited for repairing extensively fractured components. By integrating insights on failure mechanisms, operational environments, and remanufacturing effectiveness, this review bridges critical gaps in mining-specific knowledge of component degradation and restoration. The synthesis offers actionable guidance for extending the service life and improving the operational reliability of heavy-duty mining drivetrain components.