



Selection of a suitable wear-resistant metal matrix composite for remanufacturing continuous miner cutter (CMC) sleeves via a two-step laser-based technique

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ABSTRACT

The premature failure of continuous miner cutter (CMC) sleeves in underground coal mining necessitates remanufacturing to enable a closed-loop system and enhanced sustainable mining operations. However, a techno-economic analysis conducted revealed that exclusively using laser cladding (LC) to remanufacture failed sleeves is not economically viable. Thus, this research aims to explore a two-step laser-based remanufacturing technique that incorporates gas metal arc welding (GMAW) and LC, as well as identify suitable wear-resistant metal matrix composites (MMCs) for restoring damaged sleeves. Consequently, an LC process was used to deposit three MMC materials onto optimised GMAW overlays. A comparative analysis of the manufactured MMC coatings revealed that WC/TiC/AISI4340 coating exhibited a well-consolidated, crack- and pore-free microstructure and a superior microhardness of 931 HV0.5 compared to WC- and TiC-reinforced composites, which had average hardness values of 670 HV0.5 and 744 HV0.5, respectively. Additionally, the WC/TiC/AISI4340 coating demonstrated an excellent low wear rate (0.0007 g/s) comparable to TiC-reinforced coating, and a propensity to extend the sleeve's lifespan by a factor of four. These enhancements are attributed to the formation of an umbrella-like network of TiC, predominantly distributed in the coating top region and solid solution strengthening [(Ti, W)C] caused by the partial dissolution of WC/TiC carbides and their precipitation into the eutectic carbide network within the interdendritic grain regions. Hence, combining GMAW and LC processes with WC/TiC/AISI4340 presents a promising remanufacturing strategy for restoring mining equipment, offering improved performance, longer lifespan, and economically viable and sustainable mining operations.

Abbreviations: LC, laser cladding; CMC, continuous miner cutter; SAW, submerged arc welding; FCAW, flux-cored arc welding; GTAW, gas tungsten arc welding; MMAW, manual metal arc welding; GMAW, gas metal arc welding; WFR, wire feed rate; CE, cladding efficiency; ACPS, average carbide particle size; AMFP, average mean free path.

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