The International Journal of Advanced Manufacturing Technology, volume 139, July 2025

Optimised consolidation and characterisation of TiC-SiC-reinforced AISI-4340 composite coatings for conical pick remanufacture

Akintunde, IB; Lindsay, EE; Olakanmi, EO; Prasad, RVS; Botes, A; Pityana, Sisa L; Skhosane, Besabakhe S

Abstract
TiC-SiC-reinforced AISI-4340 composite clads have been identified as a suitable material to remanufacture worn conical picks. However, the inherent defects in the clad produced, the industrial requirement to improve clad microhardness, and abrasive wear resistance necessitate the need for optimising laser processing and material parameters. Therefore, this research is conducted to investigate the effects of the powder feed rate, the scanning speed, the angle of inclination of the nozzle, and the yttria addition on the quality characteristics of the coating. The results show that as the feed rate increases from 6 to 8 g/min, the clad height increases, and the width decreases due to the reduced spreadability of the viscous melt pool. Clad height and width decrease as scanning speed increases from 0.4 to 0.5 m/min, attributed to reduced laser energy-powder interaction (LEPI) time. Furthermore, as the nozzle is inclined 2° and 4° away from the vertical, this results in an increased width and a reduced height due to the reduction of the beam deflection (increasing heat input) and loss of powder particles before reaching the focal point. Thus, the carbide melts (carbide dissolution) and reduces the reinforcing effect, leading to a decrease in wear resistance. Moreover, the addition of yttria lowers the dissolution temperature of the carbides, with a consequent increase in width and a lesser height of the clad. The geometric analysis of optimised clad established coatings with 2.3 mm height, minimal weld penetration (0.4 mm), and small HAZ of less than 1.4 mm produced. Furthermore, the microstructure revealed a homogenous dispersion of retained TiC particles in the morphology of the lath martensite, with minimal (2.6%) porosity. Additionally, the coating has the highest amount of TiC particles retained in the AISI-4340 matrix with an average microhardness of 1743 HV0.5 and 26.24 mm3 volume of material loss. The use of optimised clads for remanufacturing worn CM picks to be as new will adequately withstand the hardness of engrained quartz (1100-HV0.05) in the coal seam during underground cutting of the coal mass, thus mitigating the premature failure of the picks.