Abstract

The need for productivity improvement of mining sectors by excavating harder rocks through mechanical excavators leads to advancements in design and development of cutting tools. Layer depositions on conical rock cutting bits are one of the important approaches in improving wear resistance properties for hard rock cutting applications. The selection of coated bits with proper deposition method is of prime concern to overcome the challenges of rock cutting processes. This thesis deals with the speculative investigation to measure the efficiency of rock cutting and identify the wear behavior of coated conical rock cutting bits. Newly designed and customized shaping machine were employed with a triaxial force dynamometer to cut the rock samples linearly and to calculate their associated powers. AlTiN and TiAlSiN were deposited in the conical cutting bits through sputtering technique. The micro hardness, presence of coated elements and morphological characterization were determined. TiAlSiN coated bits possesses high hardness than AlTiN and uncoated bit, which is due to the presence of hard carbo nitride, hence it was deposited as first layer on cutting bit. Two rock samples of fine grained sandstone with UCS of 83.77 MPa and 97.00 MPa was used in this study. Various cutting ranges i.e., cutting speed of 100 mm/sec, 150 mm/sec and 200 mm/sec and cutting depth of 2 mm, 4 mm and 6 mm were investigated and the best compromises were identified between the variables such as cutting forces and extracted volume of rock, cutting effectiveness, specific energy required for cutting and bit wear. The worn surfaces have been significantly investigated through scanning electron microscopy and energy dispersive x-ray analysis. Also from the obtained experimental results, it is evident that TiAlSiN coated bit with cutting speed of 200 mm/sec and cutting depth of 6 mm displays better performance for both the rock samples and is desirable for hard rock cutting applications.

This study also presents the influence of different cutting parameters such as cutting speed, depth of cut and coating material on the output responses through grey-fuzzy combined Taguchi technique and DEAR-Taguchi approach. Resultant cutting forces, specific energy, wear rate, quantity of material removed and angle of resultant reaction forces were considered as primary concern of hard rock cutting process. ANOVA has been applied to determine the critical influence of cutting parameters. Taguchi orthogonal test design had been employed to optimize the process parameters affecting the output responses. Two types of optimization technique were carried out to predict the influence of rock cutting parameters on output responses. L9 orthogonal array was considered for analysis. It was also observed that the TiAlSiN coated bit had significant influence in determining the output parameters at cutting speed of 200 mm/sec and cutting depth of 6 mm for both the rock samples. The output of this study helps in extending the application of surface miner for excavating harder rocks in mines with optimized parameters for better efficiency.

Keywords: Lab-scale linear rock cutting; Cutting parameters; Rock cutting bits; Wear; Taguchi; ANOVA; Grey relational analysis; Multi-response optimization.