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Dominant rock properties affecting the performance of conical picks and the comparison of some experimental and theoretical results

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Abstract

Conical picks are the essential cutting tools used especially on roadheaders, continuous miners and shearers and their cutting performance affects directly the efficiency and the cost of rock/mineral excavation. In this study, in order to better understand the effects of dominant rock properties on cutter performance, 22 different rock specimens having compressive strength values varying from 10 to 170 MPa are first subjected to a wide range of mechanical tests. Then, laboratory full-scale linear cutting tests with different depth of cut and cutter spacing values are realized on large blocks of rock specimens using one type of conical pick. Specific energy, cutting and normal force values for relieved and unrelieved cutting modes are recorded using a triaxial force dynamometer with capacity of 50 tonnes and a data acquisition system. Cutter force and specific energy values are correlated with rock properties and theoretical force and specific energy values obtained from widely used theoretical approaches.

The results indicate that uniaxial compressive strength among the rock properties investigated is best correlated with the measured cutter performance values, which is in good agreement with previous studies. However, it is also emphasized in this study that Brazilian tensile strength, Schmidt hammer rebound values, static and dynamic elasticity modulus are also dominant rock properties affecting cutter performance.

Theoretical specific energy defined by different researchers has a meaningful relationship with the experimental specific energy, which is an essential parameter for predicting the instantaneous cutting rates of mechanical excavation systems. It is also demonstrated that the experimental cutter forces obtained for 5 mm depth of cut are in good agreement with theoretical force values, if the friction angle between rock and cutting tool is included in the theoretical formulation. It is emphasized that, to some extend, laboratory tests can help to minimize high cost of a trial–error approach in the field.

1. Introduction

Application of excavation machines for hard rock excavation in both civil and mining engineering fields has increased significantly in recent years and a full-scale laboratory cutting test has emerged as a necessity to provide basic data for machine selection, design and performance prediction for a given rock formation [1–5].

The ability of excavation machines to operate and cut effectively in hard rock is limited by the system stiffness and the ability of cutting tools to withstand high forces. Mean and peak cutter forces, which are obtained with high reliability from the full-scale linear cutting tests, are of vital importance for a given rock formation. The force acting on a cutting tool changes constantly in magnitude during a cutting process due to chipping and brittle nature of the rock. Averages of all the force changes during the course of cutting action gives mean cutter forces and mean peak forces are average of the peak forces for a given cutting condition. High forces may result in gross fracture damage to the tungsten

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