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Estimation of Rock Strength from Diamond Drilling

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Abstract : The mining industry relies on an estimate of rock strength at several stages of a mine life cycle: mining (excavating, blasting, tunnelling) and processing (crushing and grinding), both very energy-intensive activities. An effective comminution design that can yield significant dividends often requires a reliable estimate of the material rock strength. Common laboratory tests such as rod, ball mill, and uniaxial compressive strength share common shortcomings such as time, sample preparation, bias in plug selection cost, repeatability, and sample amount to ensure reliable estimates. In this paper, the authors present a methodology to derive an estimate of the rock strength from drilling data recorded while coring with a diamond core head. The work presented in this paper builds on a phenomenological model of the bit-rock interface proposed by Franca et al. (2015) and is inspired by the now well-established use of the scratch test with PDC (Polycrystalline Diamond Compact) cutter to derive the rock uniaxial compressive strength. The first part of the paper introduces the phenomenological model of the bit-rock interface for a diamond core head that relates the forces acting on the drill bit (torque, axial thrust) to the bit kinematic variables (rate of penetration and angular velocity) and introduces the intrinsic specific energy or the energy required to drill a unit volume of rock for an ideally sharp drilling tool (meaning ideally sharp diamonds and no contact between the bit matrix and rock debris) that is found well correlated to the rock uniaxial compressive strength for PDC and roller cone bits. The second part describes the laboratory drill rig, the experimental procedure that is tailored to minimize the effect of diamond polishing over the duration of the experiments, and the step-by-step methodology to derive the intrinsic specific energy from the recorded data. The third section presents the results and shows that the intrinsic specific energy correlates well to the uniaxial compressive strength for the 11 tested rock materials (7 sedimentary and 4 igneous rocks). The last section discusses best drilling practices and a method to estimate the rock strength from field drilling data considering the compliance of the drill string and frictional losses along the borehole. The approach is illustrated with a case study from drilling data recorded while drilling an exploration well in Australia.

Keywords : bit-rock interaction, drilling experiment, impregnated diamond drilling, uniaxial compressive strength
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