World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:17, No:11, 2023

Experimental Study of Impregnated Diamond Bit Wear During Sharpening

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Abstract : The lifetime of impregnated diamond bits and their drilling efficiency are in part governed by the bit wear conditions, not only the extent of the diamonds' wear but also their exposure or protrusion out of the matrix bonding. As much as individual diamonds wear, the bonding matrix does also wear through two-body abrasion (direct matrix-rock contact) and three-body erosion (cuttings trapped in the space between rock and matrix). Although there is some work dedicated to the study of diamond bit wear, there is still a lack of understanding on how matrix erosion and diamond exposure relate to the bit drilling response and drilling efficiency, as well as no literature on the process that governs bit sharpening a procedure commonly implemented by drillers when the extent of diamond polishing yield extremely low rate of penetration. The aim of this research is (i) to derive a correlation between the wear state of the bit and the drilling performance but also (ii) to gain a better understanding of the process associated with tool sharpening. The research effort combines specific drilling experiments and precise mapping of the tool-cutting face (impregnated diamond bits and segments). Bit wear is produced by drilling through a rock sample at a fixed rate of penetration for a given period of time. Before and after each wear test, the bit drilling response and thus efficiency is mapped out using a tailored design experimental protocol. After each drilling test, the bit or segment cutting face is scanned with an optical microscope. The test results show that, under the fixed rate of penetration, diamond exposure increases with drilling distance but at a decreasing rate, up to a threshold exposure that corresponds to the optimum drilling condition for this feed rate. The data further shows that the threshold exposure scale with the rate of penetration up to a point where exposure reaches a maximum beyond which no more matrix can be eroded under normal drilling conditions. The second phase of this research focuses on the wear process referred as bit sharpening. Drillers rely on different approaches (increase feed rate or decrease flow rate) with the aim of tearing worn diamonds away from the bit matrix, wearing out some of the matrix, and thus exposing fresh sharp diamonds and recovering a higher rate of penetration. Although a common procedure, there is no rigorous methodology to sharpen the bit and avoid excessive wear or bit damage. This paper aims to gain some insight into the mechanisms that accompany bit sharpening by carefully tracking diamond fracturing, matrix wear, and erosion and how they relate to drilling parameters recorded while sharpening the tool. The results show that there exist optimal conditions (operating parameters and duration of the procedure) for sharpening that minimize overall bit wear and that the extent of bit sharpening can be monitored in real-time.

Keywords : bit sharpening, diamond exposure, drilling response, impregnated diamond bit, matrix erosion, wear rate
Conference Title : ICMME 2023 : International Conference on Mining and Minerals Engineering
Conference Location : Dubai, United Arab Emirates
Conference Dates : November 13-14, 2023