

Understanding of rock cutting mechanism under confinement

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Abstract:

Since the income of PDC (Polycrystalline Diamond Compact) drill bits, understanding the cutting mechanism of rocks has always been an important issue for optimizing drilling performances. However, while the depths reached by wells get deeper and deeper, it appears that the understanding of this destruction mechanism with high-depth conditions is not yet fully mastered.

Research in this field is mainly based on experimental and numerical methods. Among numerical ones, the Discrete Element Method has already shown promising results. Therefore, this numerical method has been implemented in this thesis to address the problem of the evolution of the cutting mechanism in high-depth conditions with a focus on the effects of confinement.

To address this issue, this thesis addressed firstly the calibration of a numerical model representing as accurately as possible the behavior of the Vosges Sandstone, chosen as the reference rock. For this purpose, a calibration protocol based on uniaxial and polyaxial tests has been developed. Then, the effects of confinement and cutting parameters were studied. The objective was twofold: on the one hand, to better understand the evolution of the cutting mechanism under confinement and, on the other hand, to ensure the accuracy of the numerical results compared to the experimental ones.

The results of this thesis are interesting for several reasons. Firstly, the new calibration procedure allowed to determine numerical parameters reproducing the evolution of the Vosges Sandstone behavior. Secondly, the comparative analysis of the numerical results with the experimental ones highlighted their qualitative and quantitative consistency. Thirdly, this thesis highlighted the evolution of the cutting mechanism as a function of the two essential parameters, the confinement and the depth of cut. While the mechanism is generally considered to be composed of two regimes, the existence of three distinct regimes is demonstrated, namely: friction, brittle, and ductile regimes. The boundaries of these regimes are governed by rock behavior, confinement, and cutting parameters

Finally, an analytical model that estimates the Optimal Specific Energy of cutting according to the confinement is proposed. This model is based on rock properties and a parameter characterizing the rock-tool interaction.