Experimental and Theoretical Evaluation of Solid Particle Erosion in an Internal Flow Passage within a Drilling Bit

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Abstract

Recently, the particle impact drilling (PID) technology has attracted numerous interests as it can greatly increase the rate of penetration (ROP) in a cost-effective manner. So far, no attempts have been made to evaluate solid particle erosion and optimize the drilling bit structure together with operational parameters since the steel particles can increase the erosion of its internal flow passage resulted from the liquid-solid flow with a high velocity. In this study, a pragmatic and robust technique has been developed to experimentally and numerically evaluate solid particle erosion in an internal flow passage within a drilling bit under various conditions. Experimentally, a field-scaled three-dimensional (3D) experimental setup is developed to perform erosion experiments under various conditions, during which operating pressure, particle size, and velocity are changed, while the erosion rate of the internal flow passage within the drilling bit is continuously monitored and measured. Numerically, a two-way coupled Eulerian-Lagrangian approach is employed to solve the liquid-solid flow in the internal flow passage. The liquid is described as a continuous phase that can be solved by using the Navier-Stokes equations, while the solid particles are described as a discrete phase that can be solved with Newton's second law. A commonly used erosion model is then utilized to quantify solid particle erosion behaviour in such an internal flow passage during two phase liquid-solid flow. The good agreements between experimental measurements and theoretical calculation results indicate that such integrated techniques can be used to accurately evaluate the complicated erosion behaviour. The erosion is found to be mainly distributed on the contraction surface, while, at the inlet velocity greater than 8.0 m/s, the average erosion rate is dramatically increased. The maximum erosion rate is increased quickly as the particle concentration is smaller than 5.0 vol% and the inlet angle is increased when it is smaller than 23°. At a low erosion rate, the optimal particle diameter is found to be 2.0 mm.

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