Accepted Manuscript

Title: Transient and Steady State Analysis of Drill Cuttings Transport Phenomena under Turbulent Conditions

Authors: Emmanuel I. Epelle, Dimitrios I. Gerogiorgis

PII: S0263-8762(17)30641-X
DOI: https://doi.org/10.1016/j.cherd.2017.11.023
Reference: CHERD 2902

To appear in:

Received date: 21-8-2017
Revised date: 10-11-2017
Accepted date: 14-11-2017

Transient and Steady State Analysis of Drill Cuttings Transport Phenomena under Turbulent Conditions

Emmanuel I. Epelle and Dimitrios I. Gerogiorgis*

Institute for Materials and Processes (IMP), School of Engineering, University of Edinburgh, The King's Buildings, Edinburgh, EH9 3FB, United Kingdom

**Corresponding author: D.Gerogiorgis@ed.ac.uk (+44 131 6517072)*

HIGHLIGHTS

- Cuttings flow visualisations provide novel insight in oil and gas drilling transport phenomena
- The Discrete Element Method (DEM) is used to study interparticle and particle-wall collisions
- Large cuttings can increase turbulence by inducing high-frequency eddies in certain regions
- Smaller cuttings tend to spread more evenly in the annulus, affecting effective fluid properties
- Streak-like fluid ejections from the walls facilitate particle lifting into the bulk flow region

ABSTRACT

Understanding the intricacies of multiphase flows is paramount to any drilling operation, and this has been under continuing and intensive development for the past decades. A major complexity associated with this operation is the uncertainty in the transport phenomena of generated cuttings as drilling progresses under different attainable configurations and fluid rheological conditions. Increased transport efficiency of drill cuttings in most drilling operations is usually characterised by an increased mud circulation velocity; this creates complex turbulent interactions between the solid and liquid phases. The study of the dispersion of these cuttings, in relation to their axial, tangential and slip velocity profiles in the annulus is carefully investigated in this work under steady and transient conditions. Computational Fluid Dynamics models (Eulerian-Eulerian, Lagrangian-Eulerian/Discrete Element Method) are utilised for this purpose. The implementation of the Eulerian-Eulerian model provides a macroscopic description of the distribution of fundamental flow properties such as pressure, volume fractions and velocities of each phase. Furthermore, a direct description of the particulate flow, inherent transient motion, interparticle and particle-wall collisions are obtained with the particle tracking functionality of the Lagrangian-Eulerian/DEM technique. The results obtained using the Eulerian-Eulerian model reveal that particle slip velocities are lowest at the central regions of the annulus with the effect of asymmetry due to inner pipe rotation being more pronounced along the longitudinal plane. Particle diameter has tremendous effects on the alteration of turbulence properties of the continuous phase with very distinct velocity profiles. Cuttings trajectory analysis show some extra phenomena which have been physically observed in available experimental studies; one of which is the occurrence of ejections of coherent structures at the walls of the flow domain. The difficulty of carrying out transient and steady state experimental measurements of particle velocities is an area where CFD shows great potential. The few available data in literature are well predicted with errors less than 11%. Similarly, fluid axial and tangential velocity predictions carried out, yield reasonably accurate results, thus further validating the CFD approach employed in this work.

Keywords: Oil and gas engineering; oil well; cuttings; multiphase flow;Eulerian-Eulerian model; Lagrangian-Eulerian model; Discrete Element, Method (DEM)