Theory Analysis and CFD Simulation of Pressure Wave Generator

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Abstract

Pressure wave with high propagation speed and energy concentration properties can be applied in leakage detection and vibration cementing in drilling industry; another significant application of pressure wave is transmission signal in measurement while drilling system during drilling process. Transient flow has evident effects on particle migration in pipe flow, which may be affected by the pressure wave in fluids motion. Although it can be noticed that pressure wave has been extensively applied in drilling industry and other areas, a little of research has been done on generating controllable pressure wave, and the generating mechanisms of pressure wave were lack of a systematic study.

In this paper, firstly, theory analysis of pressure wave generated in water hammer principle was conducted. And a pressure wave generator which is consist of a stator and rotor with four valve slices was designed. When the generator works, the rotor is rotating with constant speed and the stator remains static. The pressure wave was generated by the continuous shear perturbation of fluids. Then a simplified CFD model of pressure wave generator connecting the upstream and downstream pipes was established, and the grid and the time step independence were carried out. Generating process of controllable pressure wave in pipe flows was simulated, and the frequency and amplitude characteristics were obtained. The results suggest that amplitude characteristics can be regulated by changing the rotor speed, profiles of rotor and stator, and the gap between the rotor and the stator. The frequency characteristics can be adjusted by using different valve slice number and the frequency of rotor. The relation between pressure wave and the velocity of fluids in x-direction are obtained. The pressure wave amplitude at a certain position in pipes varies with the 1st derivative of fluids velocity in x-direction, which can be described by a linear formula. In addition, the waveform distortion may be induced by the short pipes with low rotor speed, so there exists a critical frequency for a certain length pipe. And the critical frequency can be estimated by the 1st characteristics time of pressure wave to avoid the distortion.