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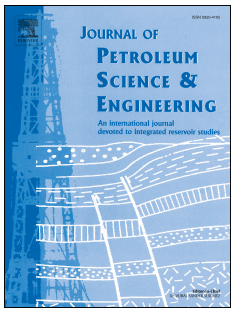

Well trajectory effect on slug flow development

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Well Trajectory Effect on Slug Flow Development

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1 ABSTRACT

The effect of horizontal well trajectory on slug flow development was experimentally studied using a 2.0 in. ID flow loop to mimic different well trajectories. Inclination angle in the lateral section was varied ± 1° from the horizontal to simulate three well configurations, namely, toe-down, one-undulation with a sump, and one-undulation with a hump. Slug length and frequency along the well were measured using fourteen conductivity probes located along the test section. Experimental results indicated that slug length in the vertical and lateral sections of a well present values up to four and two times, respectively, larger than typical dimensionless slug length reported in the literature. Furthermore, slug flow development along the vertical section is affected by the lateral section deviation angle and length. At the same time, lateral section slug flow development is affected by liquid fall back from the vertical section and lateral section length. Slug characterization along the well is critical to properly design and operate downhole and surface equipment and properly predict pressure gradient and liquid holdup along the well.

2 INTRODUCTION

Shales reservoirs ordinarily have insufficient permeability to allow a significant amount of fluid flow from the reservoir to the wellbore. Therefore, in order to commercially produce from shale reservoirs, horizontal or deviated wells are drilled, and multi-stage hydraulic fracturing is performed to increase the formation conductivity. Moreover, typically, geologists and reservoir engineers design well trajectories based on gas rate while drilling. They "surf" up and down to find a good permeability streak (Jackson *et al.* 2011). Consequently, wells result in complex trajectories such as toe-up, toe-down or undulated.

Slug characterization is critical to properly design the artificial lift (AL) systems (i.e. separator or shroud design for pumping systems) and AL system operation (i.e. plunger lift cycle setting, electric submergible pump frequency variation, rock pump stroke stetting) and surface equipment sizing (i.e. well test separator and slug catcher). Furthermore, slug characterization along the well is critical to properly predict pressure gradient and liquid holdup along the well.

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3 LITERATURE REVIEW

As gas production decreases and liquid accumulates along the lateral and vertical sections of a horizontal well, slug formation is promoted. This condition can cause different operational problems such as back pressure increase against the formation and reduction of the well production, faster mechanical fatigue along the well completion or surface equipment, shorter run life of the artificial lift system, casing/tubing corrosion or scale precipitation among others. The following paragraphs summarize different experimental and modeling studies to characterize the slugging phenomena and its effects in the production system.