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Study on oil–water two-phase flow in horizontal pipelines

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Abstract

The simultaneous flow of oil and water in pipelines is a common occurrence in the petroleum industry. Water fractions in the output stream increase materially during the producing life of a well and many wells exist from which economic production can still persist with water volume fractions in the liquid phase in excess of 90%. The presence of water must be properly accounted for when designing and predicting the flow behavior in both wells and pipelines. This paper is aimed at giving a brief review on the research of oil–water pipe flows in the past decade. The contents are divided into three sections: (1) flow pattern identification and its transition; (2) phase inversion mode ling; (3) pressure drop prediction. It is obvious that oil–water flow patterns, phase inversion prediction and pressure drop have played a great role in the design and running of oil–water flow systems. This paper critically reviews research achievement and presents the current trend in order to offer a guide in future research of the oil–water pipe flows.

Keywords: Oil–water flow; Flow pattern; Phase inversion; Pressure drop; Liquid–liquid; Two-phase flow

Contents

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1. Introduction

The simultaneous flow of oil and water in pipelines is a common occurrence in the petroleum industry. Increased offshore oil and gas exploration and production have resulted in transportation of well fluids in pipelines over relatively long distance. Often, the fluid delivered by the well contains water, which is already present within the stratum. Water fractions often increase during the producing life of a well. Furthermore, with water flooding of the reservoirs, the fractions of water in the output stream increase materially and many wells exist from which economic production can still persist with water volume fractions in the liquid phase (i.e. water-cut) in excess of 90% (Hewitt, 1997). The presence of water must be properly accounted for when designing and predicting the flow behavior in both wells and pipelines. Numerous studies have been published in recent years in oil–water flow through pipes. This paper reviews research achievement and current trend in order to offer a guide in future research of the oil–water pipe flows.

2. Oil–water flow pattern identification

2.1. Flow pattern classification

Determination of the flow patterns is a central problem in two-phase flow analysis. Previous work in this area has been reviewed extensively by Valle (1998). For the specific case of oil–water systems, oil properties can be quite diverse, and the oil–water viscosity ratio can vary from more than a million to less than one, and its rheological behavior can be Newtonian or non-Newtonian, so it is quite difficult to determine oil–water flow patterns. In early experimental research, Oglesby (1979) reported there were 14 flow patterns, while others described only three to four (Russel et al., 1959; Malinowsky, 1975). Since the 1990s, with the advanced instruments and techniques, different flow pattern parameters have been measured more accurately, and flow patterns of oil–water flow have been analyzed objectively (Trallero, 1995; Trallero and Brill, 1996; Nädler and Mewes, 1997; Angeli and Hewitt, 1998; Shi and Jepson, 1999; Shi, 2001).

Significant progress has been made in understanding the flow patterns of the oil–water flow in recent years. New and more comprehensive flow patterns based on published and acquired data were proposed by Trallero (1995) and can be summarized in Fig. 1.

(1) Segregated flow
- Stratified flow (ST)
- Stratified flow with mixing at the interface (ST&MI)

(2) Dispersed flow
- Water dominated
  - Dispersion of oil in water and water (Do/w & w)
  - Oil in water emulsion (Do/w)
- Oil dominated