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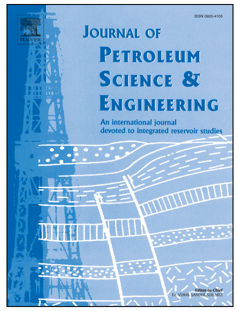

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Modelling Mist Flow for Investigating Liquid Loading in Gas Wells.

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Abstract

This paper presents a dynamic simulation approach to investigating liquid loading in gas wells for a fluid flowing in the mist flow regime. Two-component gas-liquid two-phase flow is considered, using coupled thermodynamic and hydrodynamic models as well as constitutive equations that incorporate the Peng-Robinson equation of state and the convex hull algorithm. The behaviour of the flow properties is investigated as phase change occur during flow. The accumulation of liquids is explored by investigating the distribution of the liquid density in the tubing, which is explicitly determined from the flow variables. The calculated phase densities are validated using data obtained from NIST RefProp and the results show good agreement. This procedure can provide substantial benefits in investigating the phenomena of liquid loading in gas wells compared to critical velocity predicting models that determine the stagnation velocity under isothermal conditions.

Keywords: Liquid loading, mist flow, phase change, Peng-Robinson EOS, Convex hull, gas well

1. Introduction

At discovery, the fluid in a typical gas reservoir exists as a single-phase gas [1, 2, 3]. However, depending on the reservoir conditions, composition of the gas and the depletion method, gas condensates and water may also be produced. While the reservoir pressure and the gas flow rate remain high, any liquids produced are carried by the gas to the surface. However, hydrocarbon production is synonymous with reservoir energy depletion; and hence a reduction in the gas flow rate and the liquid carrying capacity of the gas. This results in the gradual accumulation of produced liquids at the bottom of the wellbore, known as liquid loading, due to the inability of the gas phase to lift and ensure continuous removal to the surface of the produced liquids.

The problem of liquid loading is encountered during production from all gas wells. It causes production downtime, makes prospects less promising, decreases gas production and can eventually kill a well if adequate measures are not taken to mitigate its deterioration. Liquid loading is peculiar to gas wells and is most prevalent in ageing fields and wells producing from wet-gas reservoirs. Nevertheless, it can also occur in wells producing from dry gas reservoirs due to direct water incursion from an adjacent aquifer into the wellbore; and in new wells that have poor completion designs.

Liquid loading is inevitable during the productive life of a gas well. Its occurrence is an indication of the existence of gas-liquid two-phase flow. Unfortunately, modelling gas-liquid two-phase flows is more complicated than single-phase gas flow because of the presence of a liquid phase and different multiphase flow regimes. Figure 1 shows flow regimes that can occur in a typical gas well in order of decreasing gas velocity. The gas flow rate is typically greatest at the onset of production and so a gas well will first experience the mist flow regime. If liquids are directly produced in the

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