DEPARTMENT OF PETROLEUM ENGINEERING

COVENANT UNIVERSITY

OTA, OGUN STATE, NIGERIA

# A NEW MODEL FOR PREDICTING LIQUID LOADING IN MULTIPHASE GAS WELLS

A MASTER OF ENGINEERING DISSERTATION

BY

BOLUJO, OPEYEMI ENIOLA

14PCN00720

FEBRUARY, 2017.

# A NEW MODEL FOR PREDICTING LIQUID LOADING IN MULTIPHASE GAS WELLS

**A MASTER OF ENGINEERING DISSERTATION**

**Presented to**


**College of Engineering**

**The Department of Petroleum Engineering**

**BY**

**BOLUJO, OPEYEMI ENIOLA**

**14PCN00720**


***In Partial Fulfillment of the requirements for the Degree of Master of Engineering***

***In petroleum Engineering***


**COVENANT UNIVERSITY, OTA**


**FEBRUARY, 2017.**

## CERTIFICATION

This is to certify that the contained research project titled *A NEW MODEL FOR PREDICTING LIQUID LOADING IN MULTIPHASE GAS WELLS* was researched, and the results thoroughly analyzed under the supervision of the project supervisor and approved having satisfied the partial requirement for the award of Master of Engineering Degree in Petroleum Engineering (M. Eng.), Covenant University, Ota.

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External Examiner

# DEDICATION

I dedicate this work to God almighty, the most gracious and merciful for his faithfulness and loving kindness. Glory be to your holy name.

## ACKNOWLEDGEMENT

All the glory and honour be to God, for his mercies endureth forever. For the strength, wisdom and grace that he made available throughout the period of this work. I say thank you Lord.

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To my parents, Mr. and Mrs. Joseph Akinshola Bolujo, I say big thank you for always being there for me.

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# ABSTRACT

Liquid column that accumulates in the wellbore leading to the reduction or completely preventing the production of gas well is called liquid loading. This is one phenomenon that is essential because in other to optimize the recovery of hydrocarbon from the gas reservoir and to prevent the occurrence of liquid loading, pressure differential as a function of flow rate across the valves must not be neglected. Several options have been employed in well completions to predict liquid loading and how it can be mitigated but the results have shown varying degrees of discrepancies and hence cannot be easily used because of the challenges involved in predicting the bottomhole pressure in a multiphase flow. In the last decades, different techniques and correlations have been offered by many authors for determination of critical liquid loading rate. This new model considered the pressure drop at the bottomhole and along the functional nodes (valves). The model is an improvement on Fadiro model with the introduction of valve equation to the fundamental momentum equation. It described a systematic approach for estimating liquid loading in a gas well by numerical integration method. None of the previously described models considered pressure drop along the functional node. It is therefore, evidently effective when compared analytically with Turner, Guo and Fadairo models. The result shows that the flow rate during the transient stage is faster than that of Fadairo and it became stable at a certain time during production. It was also observed that the minimum energy required to lift liquid out of the wellbore is higher than that at the initial production stage. The numbers of incorrectly predicted wells as calculated by the new model are far lower than all the previously described models. This model is essential for field operators so as to equip them on how to tackle the risk of liquid loading during natural gas production.

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# NOMENCLATURE

| | |
|---|---|
| A | cross sectional area of conduit, $ft^2$ |
| Ai | cross sectional area of conduit, $in^2$ |
| $C_d$ | drag coefficient. |
| DH | Hydraulic diameter of the conduit, ft |
| $E_K$ | gas specific kinetic energy, ibf-ft /$ft^3$ |
| Eksl | minimum kinetic energy required to keep liquid droplet from falling, ibf-ft/$ft^3$ |
| Ekm | minimum kinetic energy required to transport liquid droplet, ibf-ft/$ft^3$ |
| f | Moody friction factor, dimensionless. |
| $g_c$ | 32.2 $ft.s^2$ |
| L | conduit length, ft |
| $P_{wf}$ | wellhead flowing pressure, psia |
| P | pressure, lb/$ft^3$ |
| Qg | insitu gas volumetric flow rate $ft^3$/s |
| Qoil | Oil volumetric flow rate, $ft^3$/s |
| Qs | Solid particle volumetric flow rate, $ft^3$/s |
| Qw | Water volumetric flow rate, $ft^3$/s |
| $\mathbf{S_g}$ | Gas specific gravity, air = 1 |
| $\mathbf{S_o}$ | Specific gravity of produced oil, fresh water = 1 |
| $\mathbf{S_S}$ | Solid specific gravity, fresh water = 1 |
| $\mathbf{S_w}$ | Specific gravity of produced water, fresh water = 1 |

Vmx mixture velocity, ft/s

Wo Oil weight flow rate, lb/s

Wg Gas weight flow rate, lb/s

Ws Solid particle weight flow rate, lb/s

Ww Water weight flow rate, lb/s

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