Modelling of Sand Entrainment and Deposits in Horizontal Oil Transport

Some oil and gas reservoirs in Nigeria are often weakly consolidated, making them liable to sand production. During upstream petroleum production operations, light oil and sand mix from the reservoirs are produced through wells dug into formation zones and transported through horizontal pipes between well heads and flow stations. The residual sand transported through the pipes pose serious problems such as, blockage and, reduction of pipe efficiency and integrity. A mathematical simulation of the transport process of crude oil and sand in a horizontal pipe is discussed in this book. The model used is a modified form of the Doan et al (1996 and 2000) models. The effect of eddies in three regions was incorporated in the mass and momentum equations of the model and a third equation for solid phase was also developed. Difference formulae were generated for the conservation equations by applying Fick's equation for diffusion as a basis for the origin of the finite difference formula. The diffusion equation was modified and applied to the momentum phase equations so as to make the model have a clear solution. The method adopted in this book, rather than the usual method of solving models

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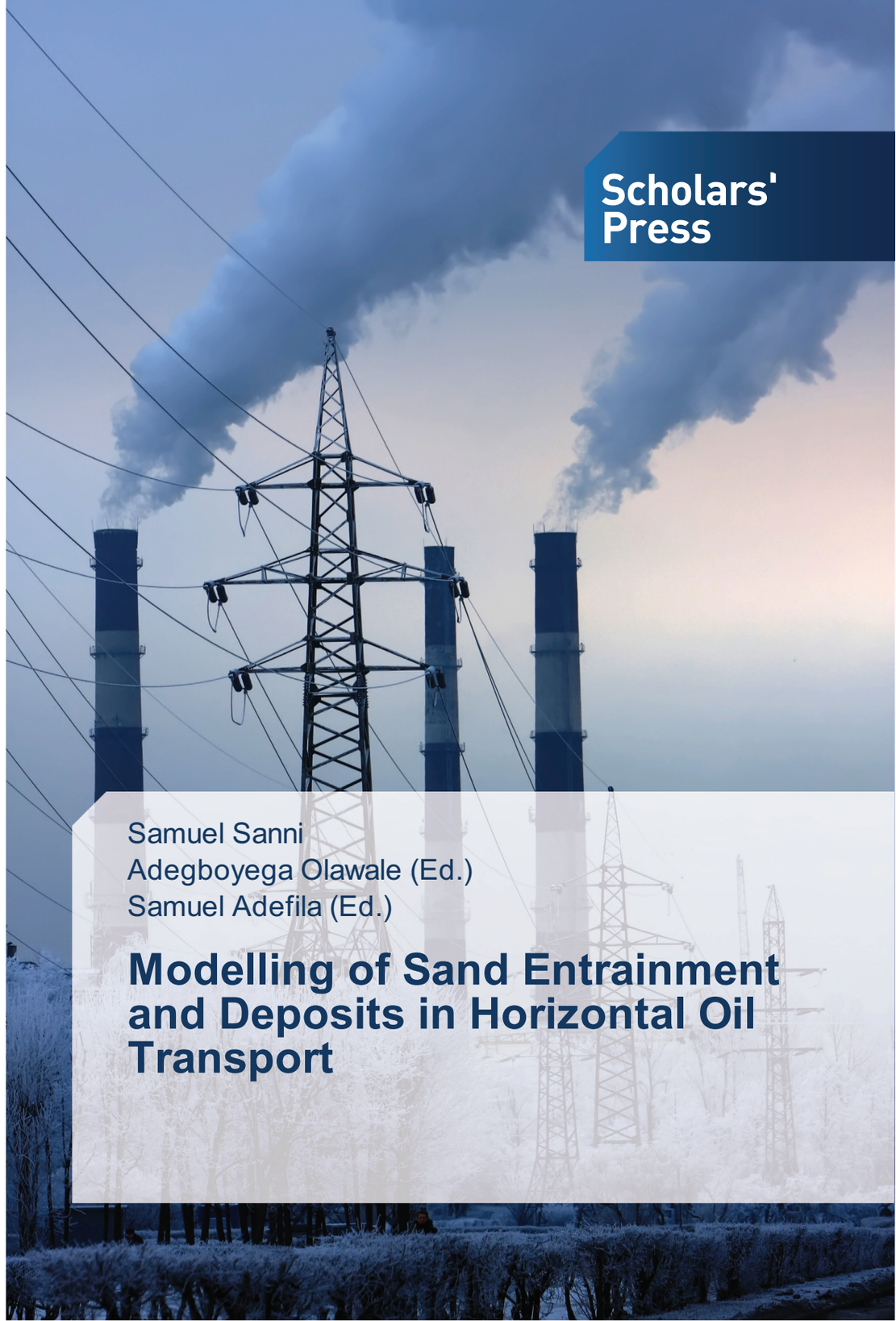

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ABOUT THIS BOOK

This book is a product of the modeling and simulation studies of upstream sand crude oil transport. It seeks to bring to the mind of the reader, the current practices and the need for viable alternatives in order to curb losses accruing from conventional practices and work over operations. Its knowledge base includes the application of Mathematics, Physics, Computer Science and Chemical Engineering to resolve sand transport or deposition problems. This book is a compilation of the author's M.Sc Thesis in the Department of Chemical Engineering, Ahmadu Bello University Nigeria, 2009.

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NOMENCLATURE

Symbol	Designation	Unit
A	Cross-sectional area	m^2
g	Gravitational acceleration	ms^{-2}
P_f	Fluid phase pressure	$kgm^{-1}s^{-2}$
P_k	Kinematic pressure	$kgm^{-1}s^{-2}$
P_s	Solid phase pressure	$kgm^{-1}s^{-2}$
q_f	Volume flow rate of oil	m^3s^{-1}
q_s	Volume flow rate of sand	m^3s^{-1}
t	Time	hrs or s
V_m	Volume of mixture	m^3
V	Volume	m^3
w_f	Oil velocity	ms^{-1}
w_s	Sand velocity	ms^{-1}
z	Axial distance	m
β	Fluid-particle interaction coefficient	kgm^3s^{-1}
Δz	Change in length	m
ε	Oil concentration (volume fraction)	-
ϕ	Suspended sand concentration (volume fraction)	-

ρ_f	Oil density	kg/m^3
ρ_s	Sand density	kg/m^3
σ	Sand deposit concentration	-

PREFACE

Some oil and gas reservoirs in Nigeria are often weakly consolidated, making them liable to sand production. During upstream petroleum production operations, light oil and sand mix from the reservoirs are produced through wells dug into formation zones and transported through horizontal pipes between well heads and flow stations. The residual sand transported through the pipes pose serious problems such as, blockage and, reduction of pipe efficiency and integrity. A mathematical simulation of the transport process of crude oil and sand in a horizontal pipe is discussed in this book. The model used is a modified form of the Doan *et al* (1996 and 2000) models. The effect of eddies in three regions was incorporated in the mass and momentum equations of the model and a third equation for solid phase was also developed. Difference formulae were generated for the conservation equations by applying Fick's equation for diffusion as a basis for the origin of the finite difference formula. The diffusion equation was modified and applied to the momentum phase equations so as to make the model have a clear solution. The method adopted in this book, rather than the usual method of solving models of this type simultaneously, solves the model equations directly. The sand deposit points, oil distribution, velocities of oil and sand, forces (gravity, inertia, interaction, solid and fluid phase pressure forces) and most importantly, oil volume flow were simulated on hourly basis. Chapters one through to four explains how transport principles were adopted in controlling sand deposition problems.