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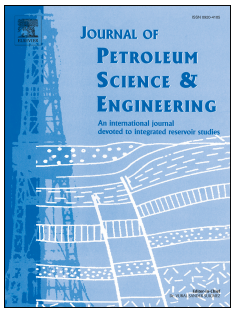

Analytical models for sand onset under field conditions

E. Papamichos, K. Furui

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ACCEPTED MANUSCRIPT

Analytical models for sand onset under field conditions

E. Papamichos

Department of Civil Engineering, Aristotle University of Thessaloniki
GR-54124 Thessaloniki, Greece, epapamic@civil.auth.gr , and
SINTEF Industry, N-7465 Trondheim, Norway, euripides.papamichos@sintef.no

K. Furui
Department of Resources and Environmental Engineering, Waseda University
3-4-1 Okubo Shinjuku-Ku, Tokyo 169-8555, Japan, furui@waseda.jp

Abstract

Analytical sand onset models consider the tangential stress at the hole (wellbore or perforation) to compare with the strength of the formation. This simplified criterion does not consider the effect of axial and shear stress at the hole which in experiments have been shown to play a role. This paper presents the formulation of three analytical failure criteria for wellbore or perforation failure and sand onset under field conditions. The resulting analytical expressions are suitable for implementation in programs for sand onset and sand mass analyses. Expressions for critical formation strength, critical drawdown or critical depletion for sand onset are derived. The models can be calibrated on hollow cylinder hole failure strength data or eventually on the uniaxial compressive strength. The analytical model results are compared and validated on numerical simulations using a finite element program developed for sand production studies. The comparisons show that analytical models can reproduce satisfactory sand failure diagrams under various stress anisotropy and production conditions in the field. Finally, the effect of the wellbore on the perforation stresses is analyzed by comparing finite element and analytical results.

Keywords: Sand production; Anisotropic stresses; Hole failure models; Finite element method; Field applications

1 Introduction

Sand production in often encountered in hydrocarbon producing sandstone reservoirs due to the failure of the formation around perforations or open hole completions. These openings are stressed by the in situ stresses to a degree that can exceed the formation strength. The effective stress that these openings are experiencing increases with the applied drawdown and depletion. For safe and economical production, the critical drawdown for sand onset as a function of formation strength and depletion and/or the critical depletion as a function of strength and drawdown are sought. Both numerical and analytical models have been developed to calculate sand onset. Rahmati et al. (2013) present an extensive review of both numerical and analytical sand production prediction models.

Analytical sand onset prediction models use the near wellbore or perforation stresses to predict formation failure. For shear stress failure, which is most often the case in sand

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