Petroleum Research

Petroleum Research 2018 (August-September), Vol. 28, No. 99. 8-11

DOI: 10.22078/pr.2018.2475.2146

Study of the Temporal-Spatial Distribution of Surface Subsidence due to Production from Kupal Oil Field

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DOI: 10.22078/pr.2018.3051.2414

Received: December/20/2017 Accepted: May/15/2018

Abstract

Measurement of temporal-spatial distribution of surface subsidence as a result of production from hydrocarbon reservoirs is a relatively common practice worldwide; however, it is set aside in Iran, although it seems that prediction of subsidence trend at the beginning of the reservoir life can be beneficial in future production estimates. In this paper, the accuracy of the numerical modeling for calculating subsidence process is evaluated by comparison with the in-situ measurements recordings, as well as those designated from analytical solutions for two hydrocarbon reservoirs in the USA, and the Netherlands. It was observed that the numerical simulations can well trace the subsidence trend in spite of elastic behavior assumption, and other simplifications considered. Although, the real mechanism of subsidence is inelastic, and parameters variations are possible. Afterwards, the distribution of temporal-spatial surface subsidence in a specified zone of Kupal oil field, Iran, was predicted. Moreover, unlike the verification examples, in which pressure changes in the whole reservoir had been considered to determine settlements, the "production history" of some wells was used in the simulations. It was concluded that production from the selected area in the Kupal oil field has resulted in surface subsidence in the range of 26 to 32 cm in the period between years of 1372-1396.

Keywords: Kupal Oil Field, Production, Subsidence, Temporal – Spatial Distribution, Numerical simulation.

INTRODUCTION

The process of oil production results in reservoir compaction. Accordingly, the compaction of the reservoir can induce surface subsidence [1]. Numerous studies in various parts of the world have been conducted in this regard, considering the negative consequences it may cause [2, 3, and 4]. These cases confirm that it is convenient to estimate the trend of surface subsidence at the start of the reservoir life to be able to design the casing more appropriately. Although measuring the surface subsidence is nearly common in numerous hydrocarbon fields worldwide, it has not been considered so much in the oil industry of Iran. In this paper, the efficiency of numerical simulation to specify the variations of subsidence over time is verified at first, through comparison of the results with the field measured data and also, based on the analytical relationship for two case studies in USA and Netherlands. Then, the temporal-spatial distribution of surface subsidence due to the production from a number of oil wells in Kupal oil field located in the southwest of Iran is determined based on the previously verified numerical modeling.

VERIFICATION EXAMPLE NO. 1

LOST HILLS FILED, CALIFORNIA, USA

In this part, the surface subsidence of the giant Lost Hills reservoir located in the west area of California, USA, was assessed. Some parts of this reservoir settled more than 3m from 1989 to 2011. The accumulative trend of subsidence has been determined in this filed using Insar (Interferograms Synthetic Aperture Radar) system [5]. The measured data were compared with the corresponding results based on the two different methods of analytical solution and numerical simulation. It must be noted that for the analytical part, the relationship proposed by Geertsma has been used [6]. Variations of surface subsidence over time according to the different ways of filed data, analytical solution, and numerical simulation show that there is a good agreement between the corresponding results. Meanwhile, the numerical simulation can predict the subsidence process more carefully.

Verification Example No. 2

Groningen Filed, Netherlands

In another study, the Groningen field as the biggest gas filed in Western Europe was considered. Measurement of surface subsidence conducting from the start of the production since 1960s show that the subsidence values in different parts of the field are between 17 and 28 cm [6]. Both analytical solution based on Geertsma's relationship and numerical simulation were used again to predict the subsidence values and also to specify how they conformed to the in-situ measured data. The results show that both methods have suitable adaptations with the field measurements and can simulate the real conditions well.

NUMERICAL SIMULATION OF SURFACE SUBSIDENCE (KUPAL OIL FIELD)

According to the two previous verification examples, the numerical simulation is used in this part to specify the temporal-spatial distribution of surface subsidence in the specified area including 9 wells of Kupal oil field in the south-west of Iran. In view of that, a three-dimensional numerical model with the finite element method was performed with the commercial code ABAQUS, covering the boundary between the ground surface and the two reservoirs of Asmari and Bangestan at depths of 3175 m, and 3960 m, respectively.

Figure 1 shows the variations of pressure drawdown for the considered wells. These data were introduced in the model for each well individually. Figure 2 shows the temporal trend of subsidence for each of these 9 wells. As depicted, the similar trends of subsidence are observed for all wells. The results showed that the surface subsidence ranges between 26 and 32 cm in the years between 1372 and 1396. Also, it is concluded that the numerical simulation is capable to estimate the distribution of the surface subsidence effectively, provided that the mechanical properties in the simulated area are well-defined.

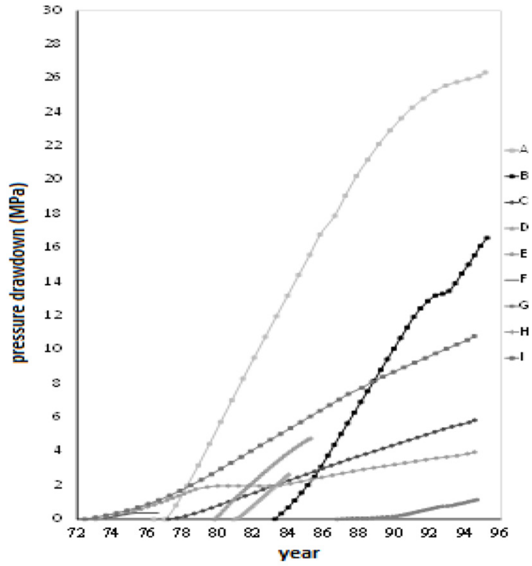

Figure 1: The variations of pressure drawdown for each well introduced in the simulation model.

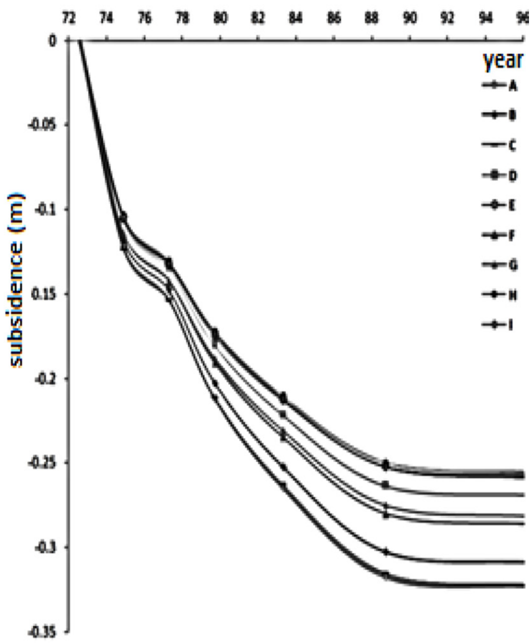

Figure 2: Estimation of surface subsidence over time for each well between years of 1372-1396.

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