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New Technology Applications for Improved Attic Oil Recovery: The World's First Slim Smart Completions

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Abstract

Smart completions, passive inflow control devices (ICD) and maximum reservoir contact wells (MRC) are some of the more recent technology advancements employed to enhance recovery and extend the life of mature oil fields in Saudi Arabia.

This paper illustrates a progression of technology in the most mature field operated by Saudi Aramco. In this field, one of the challenges is to maximize production from the inadequately swept attic oil zone resulting from a significant permeability contrast with the underlying high-permeability zone. Since 1995, a progression of new technology deployment has taken place to improve oil recovery from this thin attic oil zone. The technology deployments included among others: recompletion with short-radius horizontal sidetracks, single lateral re-entry sidetracks equipped with passive ICDs and new multilateral MRC wells equipped with intelligent completions.

Until 2007, smart completions, which are critical for water production control in multilateral producers in this thin zone, could only be deployed in new producers due to tubular and completion equipment size restrictions. Hence, dead wells could not be re-entered and completed with smart completions. In 2007, the first slim smart completion (SSC) in the world was run in a multilateral sidetrack; thus, successfully converting a dead well to a smart MRC enabling production optimization and control of individual laterals. Later in 2007, the first segmented SSC was deployed, providing a technology with more control than a passive ICD completion to delay water production in a single lateral application.

The paper will focus on the SSC technology since this is the latest well type introduced for production optimization purposes for this challenging attic oil development project.

Introduction

The field was the first giant field developed in Saudi Arabia. It was discovered in the early 1940s. The field was initially produced in a primary depletion mode. A pressure support program was started after 8 years of primary depletion. During a 24 year period, the produced solution gas was re-injected as part of the reservoir pressure support program. The gas injection was carried out in the primary reservoir at the crest of a high relief dome feature. A flank water injection program was started in the mid 1950s, and it became gradually the main field pressure support mechanism.

After more than 60 years of production, approximately 57% of the oil initially in place in the primary reservoir has been produced[1]. At this mature production stage, it is exceptional that the field watercut has remained as low as less than 35%. This latter fact is chiefly a result of favorable geology and prudent reservoir management practices. The absence of vertical barriers, relatively long distance from injector to first row producers and managed production offtake are all factors that have allowed gravity to play the primary role in the recovery process. The low volumetric throughput (managed production offtake) is illustrated by the fact that the average annual production over the production period has been as low as 0.7% of total original oil in place per year.

An added advantage has been that the main reservoir permeability distribution (higher permeability towards the top, excluding the top 25 ft) has allowed oil production from the top section while water gravity drainage was taking part in the lower poorer reservoir section. As a result, very limited well water production has been observed during the field life. In fact, wet crude handling facilities were first commissioned 34 years after production start-up. The normal production practice during these early years was that any producer showing well crude samples with salt content would be shut-in.

Figure 1 shows a typical present day (2007) saturation log run in a vertical well across the full section of the main reservoir. The red intervals on the logs indicate oil saturation while the blue colored sections indicate water bearing intervals.