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Sand on Demand: An Approach to Improving Productivity in Horizontal Wells Under Heavy Oil Primary Production

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Abstract

The cold production recovery process, as it is practiced in Western Canada, is successful for vertical wells. Applications of cold production technology with aggressive sand production in horizontal wells, however, have been much less successful.

This paper presents the results of experiments performed to assess the feasibility of applying cold heavy oil production with horizontal wells using less aggressive (i.e., controlled) sand production strategies. Specifically, the effects of slot size, confining stress, fluid velocity and sand grain sorting on sand production have been investigated.

Preliminary results indicate that slot size selection is critical for establishing "sand on demand". For proper slot size selection, it is essential to know the grain size distribution of the sand; in particular, attributes such as the size of the coarsest fraction of the sand and the sorting (uniformity coefficient) of the sand. For example, it was observed in the sand production experiments that the critical pressure gradient for maintaining continuous sand production is much lower for well sorted sands than for poorly sorted sands. Ultimately, poorly sorted sands may require different criteria than well sorted sands for slot size selection.

Flow rates are also crucial for managing sand production since a critical pressure gradient is required for initiating sand production and maintaining continuous sand production. The critical pressure gradient decreases as the slot width or confining pressure increases. Large permeability increases were observed in the sand production region. Persistent sand production led to the growth of a channel and/or the presence of a dilated zone which had an elliptic shape.

Introduction

Heavy oil production is becoming more important in Canada due to the depletion of conventional oil reserves. Western Canadian crude oil production is approximately 370,000 m^3/d. Of this amount, nearly 75 % is composed of heavy crude and bitumen (including bitumen produced at mining plants). In situ heavy oil and bitumen production has more than doubled from 56,000 m^3/d to over 165,000 m^3/d in the last 25 years (Chugh et al. 1997; National Energy Board (NEB) 2008).

Historically, recovery factors for conventional heavy oil primary production have fallen in the range of 1-5 % of the original oil in place (OOIP). However, the implementation of an enhanced primary production technique in the mid to late 1980s has raised recovery factors to between 5-20%. The new operating technique has been named "cold production" by Canadian producers. In the cold production process, sand is produced aggressively along with the heavy oil. This process has been successfully implemented in vertical (or slant or deviated) wells equipped with specialized pumping equipment (progressive cavity pumps). Nearly 50% (~ 37,000 m^3/d) of western Canadian conventional heavy oil production comes from cold production areas in eastern Alberta and western Saskatchewan (Sawatzky et al. 2002).

Horizontal drilling is a cost effective means of increasing output while unlocking reserves previously considered unrecoverable using conventional drilling technology. Applications of cold production technology in horizontal wells, however, have not been very successful. Horizontal wells produced under aggressive sanding conditions have required frequent sand cleanouts, which significantly increased the cost of the operations.

A limited amount of sand production into horizontal wells, small enough to avoid plugging of the wells, may help to increase the permeability of the formation around the wells and lead to increased production rates. Therefore, a controlled sand production strategy aimed at enhancing the permeability of the surrounding formation could be an important factor in optimizing cold production in horizontal wells from unconsolidated heavy oil reservoirs.

Many studies have been performed in the past on different aspects of sand production. However, they have mainly concentrated on finding effective methods to avoid sand production due to the high operating costs involved in handling and