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Lab Testing and Field Application of a Large-Scale Acetic Acid-Based Treatment in a Newly Developed Carbonate Reservoir

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Abstract

A large-scale acetic acid-based stimulation treatment was developed to remove drilling mud filter cake in vertical wells in a newly developed carbonate reservoir. The wellbore stability of this weakly consolidated carbonate formation can easily be reduced by contact with HCl-based acids. Extensive lab testing had indicated that the formation is mechanically weak, becomes brittle upon contact with acids and produces large amounts of fine particles that can cause severe damage. Furthermore, a chloride-free acid formula was required to minimize interference with the pulsed-neutron logs (PNL). A special acid treatment was needed to remove the damage while maintaining the integrity of the formation.

Several tests were conducted in the laboratory to evaluate both regular and emulsified acetic acid and non-acid formulae (mainly EDTA). Initially, two acid formulae were selected for field application. The first used 10 wt% acetic acid in an emulsified form, while the second formula was based on 10 wt% regular acetic acid in combination with additives. Further lab and field-testing indicated that the emulsified form might pose a problem in the presence of fine inter-matrix dolomite particles. Therefore, the treatment performed in the field focused on the use of 10 wt% acetic acid with several water-wetting agents (mainly surfactants and mutual solvent).

The acetic acid treatment was applied in five vertical wells in this field using a coiled tubing unit. Pressure build-up tests after the treatment indicated that the acid was successful in removing the filter cake in all cases. Neither fine particles, nor any type of emulsion was noted in the well flowback samples. However, well productivity after the treatment was found to be a strong function of the lithofacies of the formation (*e.g.,* chalk versus packstone). Wells with high reservoir quality rock (*i.e.*, packstones with a permeability of 20-30 mD), demonstrated excellent pressure response after the treatment. Flowing wellhead pressures were increased significantly. Wells with low reservoir quality showed a moderate increase following the treatment.

Introduction

The field has been developed to produce oil from the Shu'aiba reservoir and is located in the Eastern Rub'Al-Khali (The "Empty Quarter") of Saudi Arabia. The formation consists of reef, lagoonal, and deep-water carbonate accumulations. The oil column is overlain by a large gas cap, and underlain by an active aquifer. The temperature range of the formation is 180-195°F. The produced crude has an °API stock gravity of 41 and a dynamic viscosity of 2.83 mPa.s at 70°F. Wells and production facilities are situated on the interdune subkhahs. The associated gas, representing an average gas oil ratio (GOR) of 750 SCF/STB, is separated, compressed to 3500 psig, and re-injected into the gas cap.

Reservoir Mineralogy. In terms of mineralogy, the formation is dominated by calcite (90-100 weight percent). The remaining minerals are minor dolomite (0-8 percent, occasionally reaching 13 percent in isolated intervals and trace amounts (usually less than 0.5 weight percent) of ankerite, quartz, pyrite, siderite and gypsum. XRD analysis has also indicated the presence of minor amounts of halite, sylvite and barite. These three minerals are not naturally occurring in the formation, and are probably the result of drilling fluid contamination.

Mineralogical Texture of Lagoonal Facies. Texture was found to play a very important role in determining the outcome of acid treatments in this field. To illustrate this point, thin sections were taken from core plugs obtained from a horizontal well in this field. **Plates 1 - 6** show a typical range of lithofacies and textures exhibited in the lagoonal facies. The

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