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Society of Petroleum Engineers

Reduced Operating Costs and Wellbore Stimulation Using Facultative Microorganisms to Control and Remediate Existing Paraffin Accumulations

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This paper was prepared for presentation at the SPE Environmental Issues in the Oilfield held in Lansing, Michigan, March 16-17, 1992.

Abstract

This paper will explain and demonstrate a method to reduce operating costs and increase production in individual wells or fields with skin damage due to paraffin accumulations and corrosion utilizing an individual treatment design from a library of facultative anaerobic microorganisms. The case studies shown are from the Norwich Unit in Central Michigan.

These neutrally charged marine organisms, in a saline solution of nutrients, are naturally occurring, non-pathogenic, non-toxic, non-carcinogenic, non-combustible and require no permits from the Environmental Protection Agency for storage, transportation or disposal. Environmentally, these microorganisms are as safe an any product in our industry to control and reduce skin damage.

Paraffin formation and corrosion has resulted in significant economic losses and reduced profitability for Michigan producers and operators. The resulting skin damage can be controlled and reduced through proper treatment by locating microorganisms in the immediate formation, perforations, and in the case of most problem wells, in the lifting mechanism or surface equipment. Traditional control methods for treatment involve implementing techniques such as hot oiling with paraffin solvents, corrosion inhibitors and condensate treatments. These techniques have been marginally successful, economically prohibitive and temporary at best. Many of these traditional methods are dangerous from a safety standpoint and often have caused serious long-term damage to the productive life of the well (especially in the case of hot oiling).

References and illustrations at end of paper.

Introduction

Paraffin and corrosion in the Norwich field has always been a tremendous drain on operating expenses. The Norwich field has 120 producing wells from the Richfield formation located in Missaukee and Roscommon counties, Michigan. (See Figure 1) The Richfield formation is a Brown Niagara, Reef Structure, at a depth of approximately 7000'. Plugging of pumps and subsurface with salt has been controlled by injecting down the backside with fresh water on most of the producing wells. The fresh water source is a shallow formation with a temperature of 48° F, enhancing the paraffin and corrosion problems in the wellbore.

The paraffin problems in the field were being treated by hot oiling the backside and the flowlines with solvents, and corrosion inhibitors for the associated corrosion caused by the dissolved oxygen in the fresh water treatment for salts. Rig work due to paraffin and/or corrosion was substantial. The average monthly costs associated with hot oiling were $20,000.00, $31,000.00 for rig work and $3,800.00 for corrosion inhibitors to maintain protection for the production system. The average cost per well per month was $457.00.

Bio Tech, Inc. was given (12) twelve wells to treat to control paraffin and inhibit corrosion in Central Michigan. The information from these 12 wells have been collected and a few case studies have been selected to show the advantages of microbial treatments to degrade existing paraffin, extend productivity, and increase profitability by reducing operating expenses.

Monitored Treatment Results

The 12 wells that were treated with facultative anaerobic microorganisms were treated at an average cost of $815.00 per well for the initial month treatment to establish a colony of microorganisms in the wellbore. The monthly cost to maintain a proper colony of the microorganisms with supplemental treatments was $378.00 per well. The costs were determined for each well after initial samples were collected and tested in the lab for dosage and treatability. The dosage determines which strains of microorganisms need to be treated with to optimally control the identified problems. The treatability determines the compatibility of the microorganisms to the fluids sampled.

The average production for the twelve wells treated was 17 BOPD, 38 BWPD and 16.5 MCFD. The production rates were taken from field tests recorded on the average of once a month, before the treatment started and after. Individual decline curves were not provided. Therefore, it was difficult to determine the exact increase in production due to the control and degradation of existing paraffin. However, a possible increase of between 30-51 BOPD and 20 MCFD was noticed.

Prior to treatments with microorganisms on these twelve wells, approximately (24) twenty-four rig jobs and (42) forty-two hot oiling treatments were being performed yearly. Since the microbial treatment had started, only two wells had been pulled without having to hot oil to unseat the pump, a reduction of 87.6%. One well was pulled to change out a pump while the other was pulled for a tubing leak. The hot oiling had been reduced to only two flowlines and the one well with a tubing leak before the pump was seated, a reduction of 89.4%.

Slight increases in production were noticed just by avoiding the downtime associated with well problems due to chemical circulation times or rig work. However, many wells have seen a dramatic increase in production due to the bioremediation of wellbore restrictions, plugged perforations, formation damage and extending the pump life due to the reduction of wear-and-tear caused by paraffin accumulations.

Preliminary Testing and Design

Once the twelve problem wells were identified, all pertinent well data, history, and wellhead fluid samples were sent to the lab and evaluated for "treatability" and any negative influences that may be naturally occurring or induced in the fluids. A treatability or compatibility rating (1+, 2+ or 3+) and a dosage of which microorganisms is established to optimally control the identified problem on every well. Together with the well data and the history, an appropriate treatment was designed for each well to achieve the discussed goals of the project. The parameters that must be met for a microbial project are listed in Table 1 below.

TABLE 1

1. The survival temperature range is between 34° F - 208° F. The microbes are dormant between 34° F - 40° F.
2. The optimum temperature range is between 90° F -150° F. The microbes can multiply every 20-120 minutes at this temperature range.
3. The chloride content by volume needs to be less than 15%.
4. The pH needs to be greater than 3.
5. The H_2S content in a fluid needs to be less than 5000 ppm.
6. The formation must produce at least a trace of water or water must be added to provide the microorganisms with an adequate means of transportation throughout the entire system in the water phase.

Objective

Increase profitability by reducing rig activity caused by paraffin and corrosion failures. Remediate the existing paraffin damage and restrictions within the production system and control future accumulations of paraffin and control corrosion. This will stabilize production, and ultimately increase production and extend the wells economic life if existing paraffin damage at the perforations or back in the formation are removed.

Treatment Procedure

Initially, each well was batch treated and shut-in for 24 hours to allow the water level and the microorganisms the opportunity to establish a colony over the perforated intervals. Then, the wells were shut-in between two and four hours after each supplemental monthly treatment to allow the microorganisms to gravity feed into the wellbore annulus. In most cases, little or no modification of wellhead plumbing is required to accommodate the associated treatment equipment. Daily production is not affected, as opposed to hot oiling, because lengthy recirculation times are not required and produced fluid from the stock tanks is not used as a transport media.

Selected Case Studies

Norwich 6-14

The Norwich 6-14 was being hot oiled four times a year before microbial treatment started. Photos of the rods and paraffins were taken before the treatment, 62 days into the treatment, and 153 days into the microbial treatment. (See Figure 2) A photo was also taken of a flowline sample prior treatment and 30 days into the microbial treatment. (See

Figure 3) The pour point of these two samples are 105° F prior and 45° F 30 days into the treatment.

The treatability of the fluids sampled was determined to be a 1+. The dosage was determined to be 50% Para-Bac X and 50% Para-Bac XXX. Table 2 shows the recorded information since microbial treatment started on- this well.

Norwich 4-9

The Norwich 4-9 was being hot oiled twice a year and well serviced with a rig monthly before microbial treatment started. Photos of the rods and paraffins were taken before the treatment and 153 days into the microbial treatment. (See Figure 4)

The treatability of the fluids sampled was determined to be a 2+. The dosage was determined to be 25% Para-Bac X, 25% Para-Bac XX and 50% Para-Bac XXX. Table 3 shows the recorded information since microbial treatment started on this well.

Norwich 2-2

The Norwich 2-2 was being hot oiled down the backside and flowline monthly in the winter and occasionally during the warmer months.

The treatability of the fluids sampled was determined to be a 1+. The dosage was determined to be 50% Para-Bac, 25% Para-Bac X and 25% Para-Bac XXX. Table 4 shows the recorded information since microbial treatment started on this well.

Discussions for Optimum Wellbore Treatments

Wellbore treatments using facultative anaerobic microorganisms to control and reduce paraffin formation and control corrosion are extremely cost-effective. Controlling these identified problems and dramatically reducing the well rig service will ultimately increase the productive economic life. Individual well treatments require less investment capital than previous techniques and the return on your investment is relatively short-term. The procedure recommended for optimal wellbore treatments utilizing facultative microorganisms include:

1. Sampling of wellbore fluids to determine the treatability with microorganisms to establish compatibility.
2. Treatment dosages must be designed specifically for individual well samples. Initial and continued sampling of each well before and during treatment is required to maintain a proper colony of the microorganisms.
3. Well monitoring by the service company and the operator for effective communication of any changes in well operations. The service company must monitor the presence of the microorganism to accurately adjust dosage amounts and note production changes, yielding optimum productivity with minimum down-time and maximizing cost efficiency. The operator must provide accurate production rates. Complete and detailed well charting by the service company is integral for effective system monitoring.

Conclusions

1. The production increase or stabilization due to control of the restrictions within the wellbore, perforations and formation face was between 30 - 51 BOPD and 20 MCFD. Economically, an increase revenues by $18,300.00 per month for oil ($146,400 in 8 months) ad $1,372.50 per month for gas ($10,980 in 8 months).
2. Operating costs have been reduced by 20.9% by reducing the hot oiling treatments by 89.4% and well rig service jobs by 87.6%. The time saved by field personnel by allowing them to mechanically repair surface equipment and free them of the responsibilities of following hot oilers, replacing drums of chemicals or supervising well servicing is not included in the revenue figure above.
3. The average revenues per month by utilizing facultative anaerobic microorganisms has been $19,648.12 for the twelve wells treated.

Nomenclature

P = Para-Bac:
Biodegrades Carbon Chain $C_{16}H_{34} \rightarrow C_{22}H_{46}$

Px = Para-Bac x:
Biodegrades Carbon Chain $C_{16}H_{34} \rightarrow C_{40}H_{82}$

Pxx = Para-Bac xx:
Biodegrades Carbon Chain $C_{40}H_{82} \rightarrow C_{60}H_{122}$

Pxxx = Para-Bac xxx:
Biodegrades Carbon Chain $C_{45}H_{92} \rightarrow C_{60}H_{122}$+

Ps = Para-Bac Super:
Biodegrades Carbon Chain $C_{16}H_{34} \rightarrow C_{70}H_{142}$+

The above microorganisms degrade the carbon chain two carbons at a time, enhancing the paraffin carrying capacity.

TT = Treatability (compatibility of microbes to fluids treated.)

Presence - Colonies per milliliter (optimum range: 800,000 - 1,200,000)