EVALUATION OF CYCLIC STEAM STIMULATION OF WELLS IN THE NEEDHAM-BLOEMER LEASE KERN BLUFF FIELD

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The purpose of this report is to summarize the work done to estimate the remaining reserves on three leases of the Kern Bluff Field: Needham-Bloemer, Wells-McGregor and Vedder-Parkford. An important factor in the estimate was to evaluate the historical performance of the wells under cyclic steam stimulation (CSS).

It should be noted at the outset that a few data issues were encountered:

1. Needham-Bloemer well #1 had duplicated dates, but not duplicated data. This made it difficult to evaluate and therefore the data from this well was not used. See Appendix 1.
2. Wells McGregor and Vedder-Parkford did not have any wells cyclic steamed after 1972. However, their performance was similar to the performance of the wells in Needham-Bloemer for the same time period.

Conclusions:

1) The wells responded to cyclic steam with increased oil production.
2) Overall, the Kern Bluff field responds to cyclic steam like a typical California heavy oil field, e.g., Kern River, Coalinga and Midway Sunset.
   a) The first CSS jobs were very successful and were followed by gradually decreasing production rates as additional jobs were performed.
   b) The field has additional potential for cyclic steam, both in existing wells and in new wells.
3) Based on the full cyclic life of a new well, 50,000 barrels of oil is estimated to be the cumulative production potential for a new well.
4) Using the same methodology, 20,000 barrels of oil is estimated to be the cumulative production potential for an RTP well.
5) Twenty separate wells were analyzed; 137 separate cyclic steam stimulations were analyzed:
   a) The CSS jobs were basically in two groups – late 1960’s/early 1970’s and late 1970’s/early 1980’s
   b) A period of approximately 15 years broken into two 7 year periods was all the time spent on cyclic steaming in this field.
Procedure:

1) Collect the production and injection data by well.
2) Graph the data by month on a per day basis, e.g., barrels of oil per day (BOPD) and barrels of steam per day (BSPD).
3) Note the peak production.
4) Add up the cumulative production from the cyclic steam stimulation.
5) Average the peak production and cumulative production by year for all the wells by year.
6) Graph the production response to obtain an average forecast curve.

Review of Cyclic Steam Jobs by Year

Three leases were reviewed: Needham-Bloemer, Wells-McGregor and Vedder-Parkford. The latter two leases had cyclic steam stimulations performed only in the late sixties and early seventies; the leases were not steamed in the late seventies and early eighties. Only the Needham-Bloemer lease had CSS jobs in the late seventies and early eighties.

The chart above illustrates the production response of the wells that were cyclic steamed on Needham-Bloemer from 1965 to 1984, when the last cyclic steam job was performed.

This historical production profile is typical of California reservoirs that contain heavy oil and that are under cyclic steam stimulation. Further the graphs below illustrate the changes over time in the significant variables that measure the effect of cyclic steaming: steam oil ratio (SOR), peak production,
cumulative production, volume of steam injected per job, and time of thermal effect on a well, which was capped at 18 months.

MHA proposes that this graph be used to estimate the production from any future new wells that may be drilled in the field. For RTP wells, only the performance of the CSS jobs beginning in the late 1970’s and early 1980’s should be used to take into account that these wells are not new.

Caveats: the last two years had few cyclic jobs and the averaged data may not be indicative of any future trends. This was also true of a few of the years in the mid-1970’s.

**Peak Production** - At first, the cyclic steam jobs were extremely successful, with peak production averaging 60 bopd. Later on, during the mid-1970’s, very few jobs were performed and those jobs performed poorly. In the late 1970’s and early 1980’s the production response rebounded higher again.

This may have been a function of the price controls (tiered oil pricing) that was in effect at the time, which would have forced the operators into very low cost operations at the expense of proper steam quality and rates. Once those prices were lifted, an aggressive cyclic program could be initiated again and the results were significantly better. The last cyclic job was in 1984, which coincides with the purchase of Gulf (the Kern Bluff operator) by Chevron.

**Cumulative Production** – The graph basically follows the pattern of peak production. Though in the early 1980’s there was a boost in cumulative production indicating that the cyclic jobs were still effected, even though the peak production was not as high as it was initially. This is a good indicator of future economic success, if a new cyclic steam program is initiated.
Cumulative Steam Injected – The graph shows that most jobs averaged approximately 10,000 barrels of steam, except for the ones done in 1976.

Cumulative SOR – The graph shows a gradually increasing steam-oil ratio, which indicates that less oil was recovered for the same volume of steam injected. This is typical for a given field over time.

Time (Days) – This graph illustrates the length of time a CSS job was effective. This variable was measured by assuming that any production above the previous baseline was due to the effect of the cyclic job. However, since this was not measured by temperature in the field, the value was cutoff after 18 months.

Number of CSS jobs – This graph illustrates the number of CSS jobs by year. There is a large fluctuation from a high of over 20 to less than 5. It is important to compare the performance data (peak, cumulative production, etc.) against the number of jobs performed because a small number of jobs will tend to skew the averages, one way or the other, and in this particular study, usually downward.
In total there were 137 cyclic steam jobs performed. Actually there were more cyclic steam stimulations performed, but unfortunately the data was missing from them, so they were not included in the tally.

Based on the data analyzed, the following two graphs given below are the recommended forecasts to use to evaluate the production response to cyclic steam stimulation in the Kern Bluff Field, and subsequently to estimate the potential reserves. These graphs are essentially idealized and averaged production responses based on the historical performance of the wells on the Needham-Bloemer lease.

It should be noted that the graphs assume the following:

1. That the wells are cyclic steamed once a year.
2. That the steam quality is in the range of 60 – 80 percent steam quality.
3. That the steam rate is approximately 500 barrels of steam per day.
4. And that the steam injection volume is at least 8,000 barrels.

Below is the recommended production response forecast for a new well over 120 months.
Below is the recommended production response forecast for an RTP well over 120 months.

Appendix 1: Data corruption issue with NB well #1.

Note that the dates are duplicated, but the data is not. This was difficult to analyze, therefore the data from this well was not used to evaluate cyclic steam stimulation, even though it was obvious this well had been cyclic steamed.