Scale Inhibition Through Formation Squeeze Techniques

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INTRODUCTION

Calcium sulfate scale in San Andres wells in West Texas is one of the most serious production problems we face today. The scale problem in these wells ranges from minor to extremely severe and, in many cases, can mean the difference between a profitable and an unprofitable well. This problem has received the serious attention of a number of operators and chemical suppliers and a great deal has been learned about the problem. It will be the purpose of this paper to discuss some of the remedial techniques currently employed with particular emphasis on formation squeeze techniques.

DISCUSSION

The West Welch Field has been one of the worst offenders that we have encountered in our operations. Calcium sulfate scale was a problem in this portion of the Welch Field during primary production and continues to be a problem during secondary recovery operations. Due to the severity of the problem and the different remedial measures used over the years, a brief resume of this work will serve as a good background for this subject.

The West Welch Field wells are open-hole completions with from 100 ft to 150 ft of open hole below the casing. The wells were tubed to bottom and scale growth in the open hole stuck the tubing. A relatively expensive wash-over job was required to free the tubing.

The first attempts to remove the scale deposition (in the middle 1950's) were with converter treatments (sodium bicarbonate). Two of these treatments were performed and chemical analyses of the well fluid indicated that significant quantities of calcium sulfate had been dissolved with the treating solution. This was very encouraging, but the treatment failed to increase production substantially and free the tubing string which was stuck in the open hole. Before additional converter treatments were performed, several wells were fraced, which resulted in large increases in production. It was decided that fracture treatments were a better investment and the converter treatments were abandoned.

Formation fracture treatments were effective for a few months and then the production began to decline rapidly. The tubing was stuck in the open hole and required a wash-over to free the tubing. The cost of the fracture treatment paid out, but the overall job was not as attractive as the original increase in production indicated.

In an effort to obtain the desired production increases and reduce the cost of the remedial work, converter treatments were used again. These treatments were performed by a service company using proprietary chemicals. The treatments consisted of spotting the converter in the open hole and allowing 48 hours reaction time. The converter was then pumped out of the well and another chemical spotted in the open hole and allowed to react for 48 hours. The well was pumped to remove the treating chemical and then the well was acidized with 2000 gal. of 15 per cent hydrochloric acid.

There are some interesting observations that should be made about converter treatments in general: (1) the converter treatment is usually preceded by a cleanout job which mechanically removes most of the scale growth from the open hole; (2) the converter treatment requires several days of down time with a corresponding loss in production; and (3) the quantity of acid used to clean up the hole after the treatment is several times the amount necessary to dissolve the reaction products that would be present if all the converter reacted with calcium sulfate scale. It is a fact that all of the converter does not react with the scale; therefore, a considerable volume of the acid is available to react with the formation. The obvious conclusion from a consideration of these observations, which have been proven to be fact in our operations, is that a large portion of the production increase usually attributed to the converter treatment is actually the result of the cleanout and acid job. This is not intended to imply that no benefit is derived from the converter treatment, but rather to point out the fact that other parts of the treatment can and do contribute to the overall success of the job.

Most of the information we had on scale problems in the West Welch Field had been derived from production tests and remedial work. Actually, this information proved to be of little or no value because it had led to assumptions concerning the scale deposit that were incorrect. In June of 1965 a program of diagnostic work was started that was designed to do two things: (1) to determine the location and rate of scale growth and (2) to evaluate the various remedial techniques and scale inhibitors available.

Two very useful pieces of information were obtained from this work: (1) the scale grows on and directly out from the formation face with little, if any, tendency to migrate down the well bore from the problem zone and (2) the rate of growth is such that the well bore can be bridged in as little as 21 days. It was interesting to note that even though the scale grew rapidly on the affected zone, there was no immediate effect on the well's production. Apparently the drastic reduction in production occurs when the scale bridges the hole and shuts the production off below or above the scale bridge, depending on whether the well is tubed to bottom or the tubing is bottomed above the producing zones. Also, a careful analysis of log and core data indicated that generally the scale growth occurred on the face of the most permeable zones.

Armed with the facts discussed in the preceding paragraph and having sufficient information on the scale growth in the offending wells to evaluate the effectiveness of the treating procedure, testing with organic phosphates was started. Inorganic phosphate had been used in the past and had given no indication of eliminating or minimizing the scale problem and was not considered for further testing.

As a matter of record, we were faced with two separate but related problems in this field; (1) to keep scale from growing in the wells with good production and (2) to improve production in wells that were not up to par. The use of conventional acidizing or fracture treatments to improve production has some undesirable features that should be mentioned. Experience had proved that these procedures would increase the production temporarily, but the production would decline rapidly after the initial surge. The possibility of scale depositions occurring in the fractures or channels and eventually making this type of remedial work ineffective could not be overlooked. The ideal situation would be to increase the production with a fracture treatment or an acid job and then treat the well to prevent scale deposition.

At the time this work was started, very little good information was available on organic phosphate, especially concerning their use in squeeze treatments. For this and other reasons, the first treatments were continuous treatments down the annulus preceded by 72 hours of circulation. One of these treatments inhibited scale growth for approximately eight months, but this experience could not be duplicated in the same well or in wells in the field. We have no explanation for this because all of the facts known about this scale growth does not indicate that any of the conventional in-hole treatments should be effective and, with the exception of this one short term success, none of them have been effective.

The next step in the evaluation program was to try formation squeeze treatments with several of the organic phosphates then available. These wells were squeezed with approximately three drums of inhibitor in 27 bbl of water at a rate of two bbl per minute. As a whole, these treatments were unsuccessful. One zone in a well with two scaling zones did not have scale growth for several months. This suggested that the chemical was effective when placed in the offending zone and the real difficulty was with the placement technique.

This fact was substantiated by an injectivity profile in the well that the one zone responded to treatment. At the injection rate used to squeeze inhibitor into the formation, some of the inhibitor entered the zone that responded to treatment but very little, if any, entered the zone that did not respond to treatment. This gave more impetus to our search for a satisfactory placement technique.

Immediately following the unsuccessful squeeze jobs, three wells were fraced and the treatment was spearheaded with 30 bbl of inhibited fluid. The wells were treated down the tubing at a rate of 10 bbl per minute using gelled water to carry the sand. Open-hole calipers were run in two of these wells to determine the rate of scale growth. No scale was found in either of these wells for 12 months and, even though scale began to grow in one well, there has been no significant loss in production. Both wells were squeezed with scale inhibitor about 14 months after the fracture treatment. The well that had scale growth in it when the squeeze treatment was performed still had scale growing, the one with no scale at the time of squeeze treatment still has no indication of scale growth by caliper surveys.

It was assumed from this experience with fracture treatments that the treating rate of the squeeze treatments was too slow. A series of tests was set up using a treating rate of 10 bbl per minute and produced water as the flush. These treatments were generally ineffective, proving that the treating rate alone was not the cause of the failure. Since the reason for the lack of response was still not known, squeeze treatments were performed exactly like the fracture treatments except that the sand was not used. These treatments were not effective either and we are still in the dark as to why a fracture treatment spearheaded with the scale inhibitor will give effective inhibition, but a squeeze treatment performed in exactly the same manner is ineffective.

As was stated earlier, we would like to use some method of stimulation in these wells and then be able to inhibit the scale growth by squeeze treatments. This is still our goal and we will continue working toward this end. All the information that has been obtained from these treatments is being evaluated and hopefully some treating method can be designed that will accomplish the desired results. One of the obvious difficulties in the West Welch Field is the problems attendent to treating a large section of open hole. This is further complicated by a natural fracture system in the east-west direction. It is possible that the procedures used in the Welch Field will give satisfactory results in a cased hole where the treatment can be selective.

CONCLUSIONS

Even though the scale problem in the Welch Field has not been eliminated and squeeze treatments in the open hole have not been perfected, significant progress has been made. All the information to date indicates that scale inhibition with organic phosphates is practical and the current need is for an effective placement technique for open hole completions.

We would like to make one thing clear concerning the experience with scale inhibition in the West Welch Field. The success of the treatment is based on actual bottom-hole measurement of the scale growth, not production tests. Appreciation of this one point is extremely important because this is the significant difference between the effectiveness of scale inhibition in this field and other experience in the West Texas Area. If we only considered the production before and after treatment, we could also report a number of economic successes. However, our interest is in developing an effective treating procedure that can be used with a high level of confidence. This goal requires a more critical evaluation of the effectiveness of inhibitors than that usually given to chemical treatments of this kind.