Oil Sands Breakthrough using a Novel Reverse Emulsion Breaker for SAGD Produced Water

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ABSTRACT

Steam Assisted Gravity Drainage (SAGD) processes have been shown to produce extremely stable reverse (oil-in-water) emulsions. Although Invert Emulsion Polymer (IEP) technology has proven to be cost effective, IEPs pose application challenges requiring make-down water and auxiliary equipment, incurring additional cost and logistical challenges. A novel reverse emulsion breaker (REB) has been developed and implemented successfully that offers reduced application monitoring, reduced equipment needs, improved handling and product stability over IEPs. Extensive synthesis efforts and on-site bottle test development resulted in a breakthrough chemical treatment with high demonstrable efficacy in multiple SAGD commercial plants in Northeast Alberta, Canada. The new product met and exceeded all the key performance indicators (KPI) with respect to quality of oil, water, and oil-water interface. Other benefits included a reduction in slop oil, as well as a reduction in equipment and handling requirements. This technical paper summarizes the development and the successful field trials conducted in 2006 and 2007.

INTRODUCTION

Steam Assisted Gravity Drainage (SAGD) is one of the most popular and fast-growing in-situ recovery processes to recover bitumen from oil sands deposits. Chemical application programs have been developed to resolve reverse (oil-in-water) emulsions. A SAGD facility in Northeast Alberta, Canada was producing extremely stable reverse emulsions containing especially-challenging high oil content (greater than 15%). This particular emulsion makes it more difficult to achieve acceptable water-drop in a conventional Free Water Knockout (FWKO), which is a critical performance target for optimal production throughput.

Although current technology offered technical resolution on a cost-effective basis, the customer wanted to find a solution that would alleviate specific operational challenges, including: handling large volumes of make-down water; minimizing the need for extensive off-loading procedures; and incurring additional equipment cost. A novel reverse emulsion breaker (REB) has been developed and implemented successfully that offers reduced application monitoring, reduced equipment needs, improved handling and product stability over current technology.

PROCEDURE

Extensive on-site bottle test development work revealed that none of the commercially-available reverse emulsion breakers (REB) satisfied all performance metrics. Water-drop performance in the Free Water Knockout (FWKO) vessel was extremely critical to achieve optimum operating conditions. Over the past five years, a myriad of conventional solution polymer chemical treatments were trialed and failed at this location.

A bottle test procedure was developed to closely simulate product performance at this SAGD facility. Newly-synthesized reverse emulsion breakers were then evaluated on fresh, representative, reverse emulsion samples. The final candidate was selected for field trial.

RESULTS AND DICUSSSION

Three-hour Field Trial

In a three-hour test, the main goal was to establish if the product perform regardless of treat cost. It is important to have a successful trial and not have it fail because the chemistry implementation was done improperly. A failed trial would have been a terminal setback. The pre-trial dosage of the incumbent REB product was 42 ppm. In order to ensure success of the trial, the novel REB was fed into the system at very high concentrations. Due to concerns that the chemical was not making it to the system, we increased the dosage to 120-160 ppm to ensure its introduction. These dosages were not necessary, but we required the chemical to work.

The novel REB effectively matched the water-drop performance of the incumbent product in the actual system. The smooth transition process from the incumbent to the new technology was performed strategically in four phase-in-phase-out stages to avoid upsetting the process. This process was carried out at approximately the following ratios (incumbent/novel REB concentration): 75/25, 50/50, 25/75, 0/100.

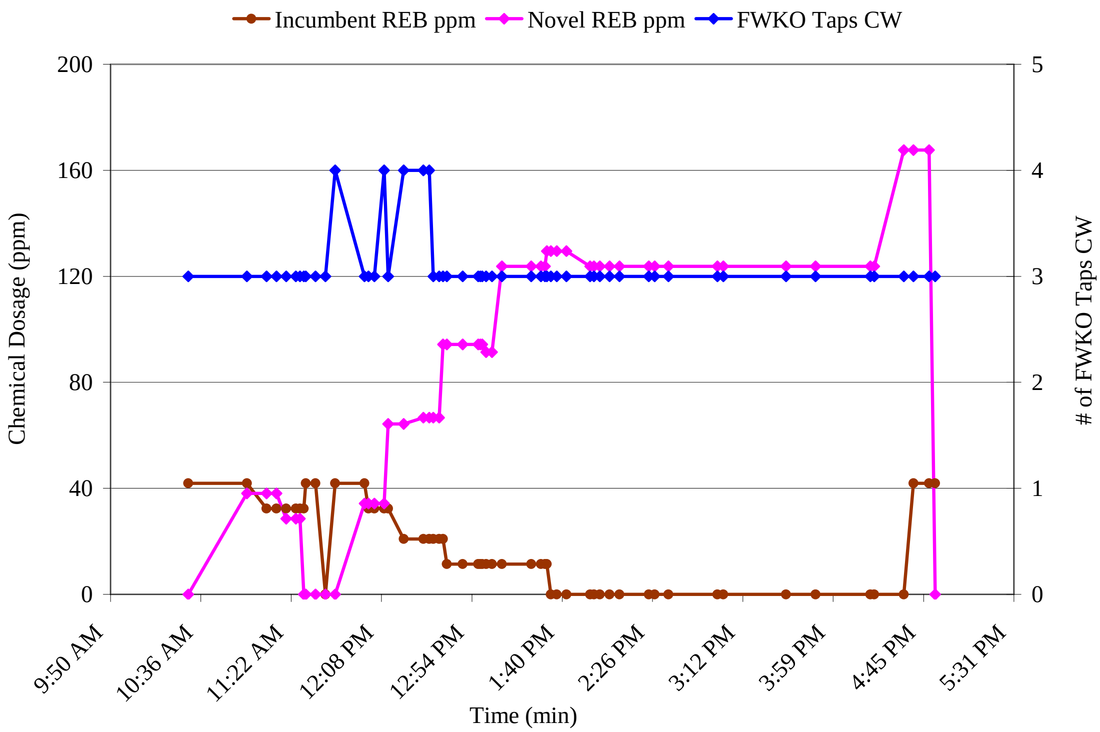
The field trial highlights are summarized below:

- The water level in the FWKO never fell below three taps of clean water.
- The FWKO oil outlet held within normal operating parameters from 14 to 19 percent BS&W.
- No change to the current chemical injection point was required to carry out the implementation of this newly developed REB.

More number of taps of clean water is not better, being able to hold the same as the incumbent is what matters. The critical KPI is to be able to hold 3-5 taps and cut as dry (or drier) than the incumbent out the oil dump.

Chart 1 illustrates the dosages of the novel REB and the incumbent REB product versus the taps of clean water in the FWKO. This graph shows the progression of the phase-in-phase-out chemistry switch strategy.

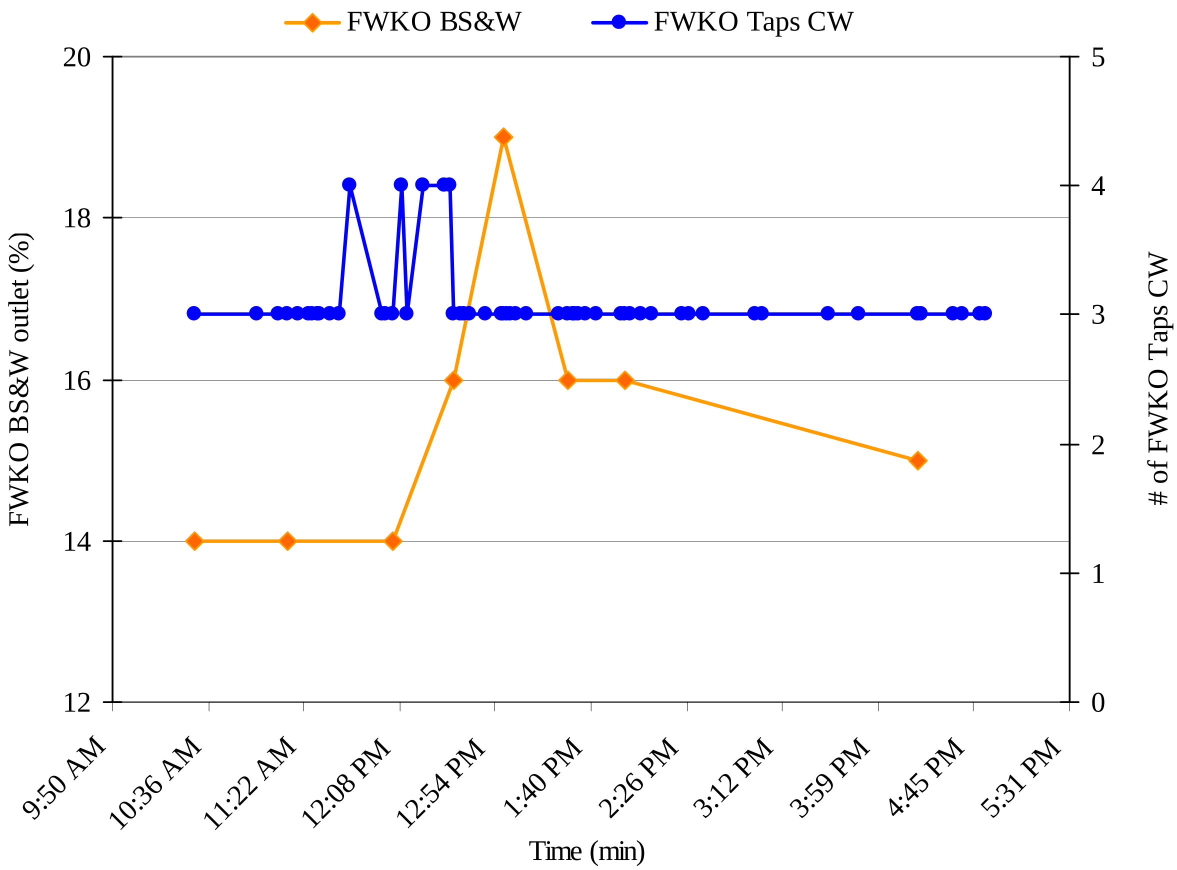
Chart 1: PPM vs. FWKO Taps of Clean Water



The system operated without incumbent product injection for approximately three hours. Note that a tap was temporarily gained (11:30 a.m. – 1:00 p.m.) due to an excess of chemical in the system. As the trial progressed, the chemistries normalized and the FWKO returned to three taps.

Chart 2 displays the relationship between the FWKO taps and the oil outlet BS&W. The BS&W content in the oil at the FWKO outlet was steady throughout the trial, except when the chemical excess caused a tap increase to four taps. This tap-level increase is likely the cause for the temporary increase in Outlet BS&W from 16 to 19 percent. Other than this spike, the BS&W held between 14 and 17 percent. Variations such as this are normal during FWKO operation with the incumbent product.

Chart 2: FWKO Taps vs. Oil Outlet BS&W



The trial data showed that the novel REB could function as a suitable replacement for the incumbent product. The primary key performance indicators (KPIs), defined as the number of FWKO taps, BS&W in oil at the FWKO outlet, and ppm oil-in-water, were all held within specifications during the trial. This led to an extended, three-day field trial in which the dosage of the novel REB was optimized, from a start-up dosage of three-times the incumbent product, down to as low as performance permits. The goal of the three-day field trial was to evaluate the effect of the novel REB on the entire system and to compare the optimal dosage and treatment cost of the novel REB with those of the incumbent product.

Three-day Field Trial

During the three-day trial, the volume of fluid processed through the process train was 30 percent above the design flow, which posed an additional degree of challenge to maintain water quality within specifications. The incumbent product applied at the FWKO inlet at 28 ppm was replaced by the novel REB for 65 hours. The transition was performed smoothly in two phase-in-phase-out stages. During the 65 hours of the trial, the water level in the FWKO never fell below two taps of clean water and the FWKO Oil outlet did not exceed 18 percent BS&W. The dosage of the novel REB was 83 ppm at the start of the trial and was optimized down to 42 ppm by the end of the trial.

It was noted that full optimization could not be achieved because of a partial plant shutdown on the final day of the trial. Further optimization is assessed to be feasible on both the novel REB and possibly on the demulsifier as well. The optimized treatment program using the novel REB offered a 15 percent cost reduction to the customer over the incumbent product.

Operation of the FWKO and treaters did not change significantly during the trial. As a precautionary measure, the demulsifier dosage was increased to about 50 ppm during the trial. Since the increase in demulsifier concentration was introduced towards the end of the trial, it was not confirmed whether or not this increase was necessary.

The three-day field trial confirmed the novel REB as a suitable replacement for the incumbent product. The field trial also demonstrated that the new product met and/or exceeded all key performance indicators (KPI), including:

- water drop (three taps of clean water in the FWKO)
- water quality (less than 500 ppm O&G in FWKO water dump)
- FWKO oil outlet (less than 19 percent BS&W)
- sales oil specification (less than 0.5 percent BS&W sales oil)
- interface quality

Chart 3 shows the dosages of the novel REB and the incumbent product versus FWKO taps of clean water. This graph shows that the new product was able to hold FWKO taps as effectively as the incumbent product. With the exception of the plant upset, the novel REB held three or more taps for the entire trial. The portion of the chart shown in green shading indicates the trial window.

Chart 3: PPM vs. FWKO Taps of Clean Water

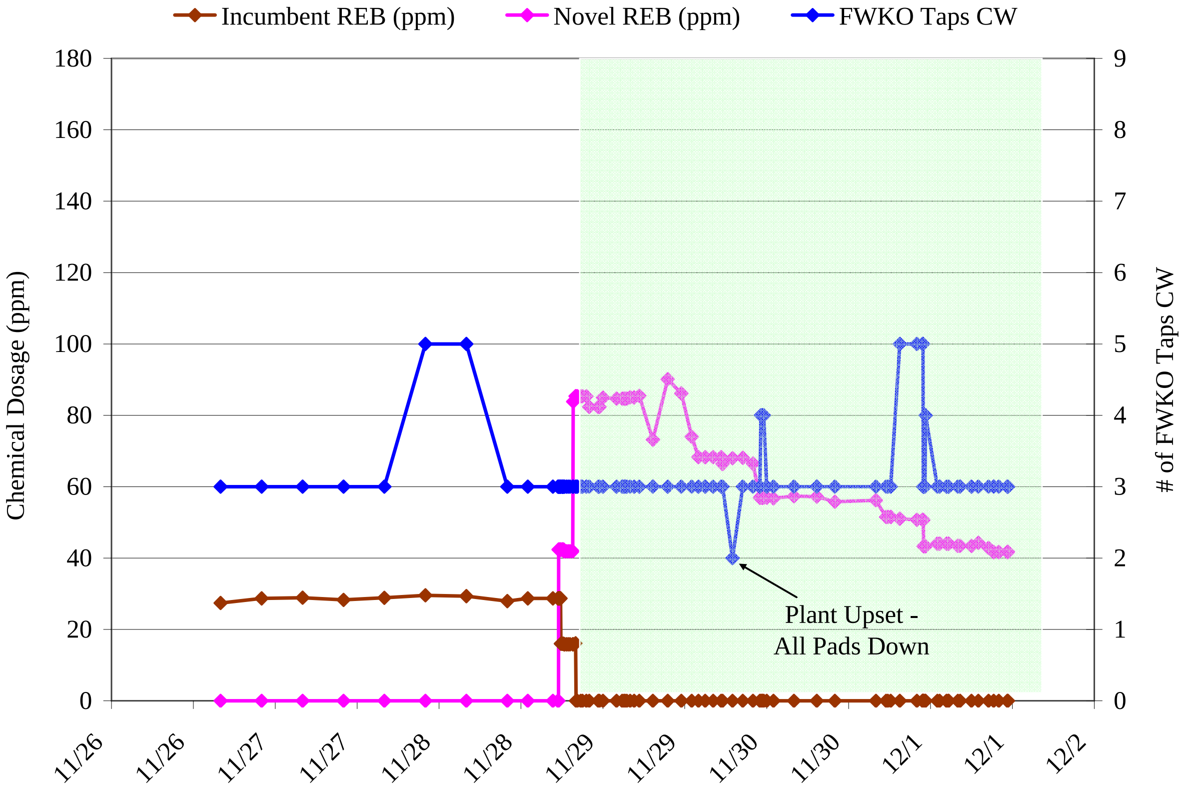
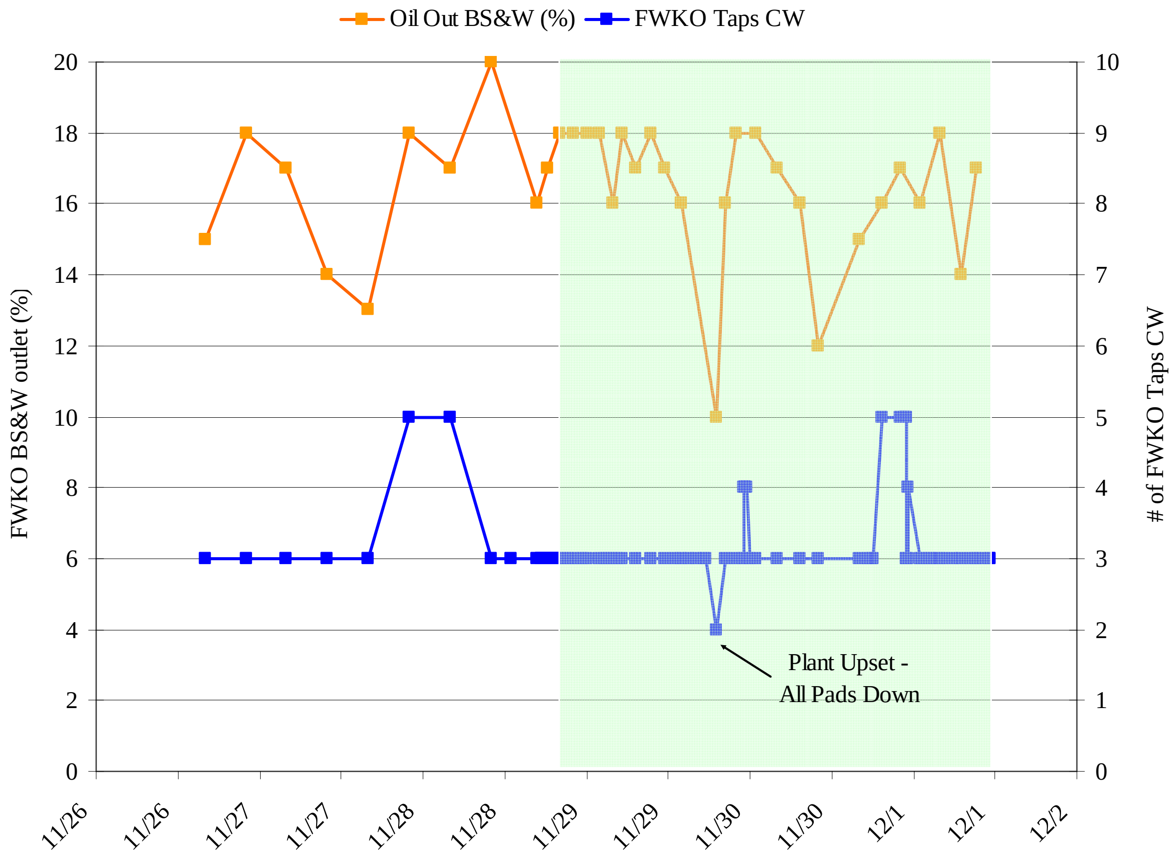


Chart 4 illustrates the relationship between the FWKO taps and the FWKO oil outlet BS&W. Note that the variability in BS&W during the trial was due to the high frequency of testing during the trial (every two hours versus every six hours, normally). The BS&W content in the oil at FWKO outlet held between 14 and 18 percent, with a couple of readings below that range. The novel REB can effectively hold the FWKO within the KPIs set by the incumbent product.

Chart 4: Oil Outlet BS&W vs. FWKO Taps



Novel Reverse Emulsion Breaker Benefits

Based on the results of the field trial, the operator chose to begin using the novel REB. Since transitioning to this new technology, the operator has experienced extensive benefits with respect to handling / application, and with high demonstrable efficacy, as listed below:

- Reduction in application monitoring (process of getting the chemical from the bulk tank to the injection point), equipment and off-loading requirements. The need for filtration to remove polymer gel "balls", special pumps, suction strainers, chemical dilution water, chemical tank circulation, check valve cleaning, and expensive specialized chemical metering pumps has been eliminated. All of which need occasional flushing and cleaning.

- Improvement in product handling and product stability. The novel REB has a shelf life of six or more months and does not experience carrier fluid separation or gel ball formation.

- Elimination of required make-down water, thereby releasing boiler feed water (90 – 120 m^3/day).

- Reduction of internal and external man-hours devoted to application, monitoring, and maintenance.

- Elimination of required “rag” draw (overall plant slop generation) from the process vessels. The solids are effectively transported out of the vessels via the water dumps.

- Higher frequency of maintaining the system within specifications, thereby allowing higher and more efficient processing of fluids.

- In addition to the benefits outlined above, the new treatment program generated more than 15 percent improvement in cost performance which does not include handling costs.

If a customer was switching from an IEP to the novel REB, the reduction in handling costs is negligible. If a customer is building a treatment system and can avoid capital cost from installing dilution water with flow meters, special bulk tankage, suction strainers, circulation pumps, possibly day tanks, and special pumps, then there is a very significant cost savings. Also, if a customer is currently using a REB chemical program that is not performing satisfactorily, and by switching to the novel REB they can avoid using an IEP, they will save significantly as well.

Photograph 1: The novel REB was specifically developed to treat production where a significant amount of the oil produced is carried by the produced water as a reverse emulsion. This particular type of emulsion occurs where high oil production is coupled with high water production, as in SAGD and other high-flow, primary-production fields around the world.

CONCLUSIONS

The novel reverse emulsion breaker replicates the performance of the incumbent product, in a high flow environment, more cost effectively.

A novel REB has been developed and implemented successfully that offers reduced application monitoring, reduced equipment needs, and improved handling and product stability over the incumbent REB product.

Extensive synthesis efforts and on-site bottle test development resulted in a breakthrough chemical treatment, with high-demonstrable efficacy in multiple SAGD commercial plants in Northeast Alberta, Canada. The new product met and exceeded all the key performance indicators (KPI).

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