March, 2002

Analysis Report of Crude Oil Recovery Enhancement Using Apollo Greenzyme®

Guangxi Tiandong Petrochemical Complex,
Tiandong Oilfield, Oil well Lun 2-25
Guangxi, China.

(Production data and results updated to July 3, 2002)

Effectiveness and application analysis using Apollo Greenzyme®

Apollo Greenzyme® is a new type of highly effective oil well unclogging agent developed by Apollo Separation Technologies Inc in United States. It is a protein based non-living catalyst, with a very high capability to release hydrocarbon compounds (oil) from solid surfaces.

In recent years, Greenzyme® has been used quite successfully in oilfields in America, Venezuela, Indonesia and other nations with good results. Last July in a single well stimulation work done for Shengli Oilfield, Yung 8-52 well, Greenzyme® has demonstrated a very satisfactory result. During the month of December 2001, our company in co-operation with Apollo Separation Technologies Inc, decided to use Greenzyme® on our Lun 2-25 oil well. The following data reports the application results of using Greenzyme® on this oil well.

1) Basic data for this oil well

Completion Depth	PBTD	Cement Top	Casing size
890 m	874.68 m	364 m	139x7.72

Perforation Interval	Pay Zone Thickness	Kelly Bushing Compensation	Date First Production
809.2 – 814.4 m	5.2 M	3 m	Feb 1, 1996.

Oil Viscosity	Oil Density	Oil Freezing Temperature
19.2 mPa.s	0.8472 (500 C)	300 C

2) Oil well production history

Perforation holes of this well were shot on November 17, 1995, followed by installing the pump jack for initial oil testing and production.

On February 1, 1996, the date trial oil production started. Production schedule was as followed: diameter of pump 44 mm, depth of pump: 713.42 m, pump length: 2.1 m, strokes: 6 times per minute, daily production time: 12 hours.

On November 1997, water flow started. Pre-production daily target for this well was as follow: daily total fluid: 6.0 tons, daily oil production : 2.7 tons, water content : 55%.

On July 12, 13 this well was hot-oiled and cleaned, no oil production was measured, we discovered about 40 m thickness of wax-conglomerates covered the piston-rod section near the mouth and vicinity section of this well, although the moving section of the pump was not frozen by the wax. The pump was lowered to 713.12 m for production. See Table 1 for monthly production data from August through December, 2001.

Table 1

Time Duration	Production Schedule	Total Fluid (tons / day)	Total Oil (tons / day)	Percent Water (%)	Remark
Aug - 2001	Φ44x2.1x6	7.5	4.1	45	
Sept- 2001	Φ44x2.1x6	6.8	3.6	47	
Oct - 2001	Φ44x2.1x6	5.9	2.8	53	
Nov -2001	Φ44x2.1x6	6.7	3.3	51	
Dec -2001	Φ44x2.1x6	6.0	2.7	55	

Greenzyme® Application

4) Basis for applying Greenzyme® for this well

The oil field surrounding on this well has an area of only 1.9 km2 , right now we have passed the mid to late development era, the oil well are densely packed over this field, with shortened distance among each other; the majority of wells have slightly over 100 m in distance from each other. If any oil well produces water over the developed eastern area, water production percentage can rise very rapidly. If one cannot control the oil water ratio among these wells, this would greatly shorten the life of these oil wells, resulting in lower oil recovery rates from these wells.

Based on the oil-releasing capability of Apollo Greenzyme®, we understand it can release hydrocarbon oil from any solid surfaces, it can unclog porosity spaces within the oil formation layers, thus increasing the oil-flow mobility in the reservoir, and it can also increase the permeability around the vicinity of bottom of a well, all these factors will produce a higher oil recovery rate.

We choose Lun 2-25 well for this unclogging application. The information from this work will have a positive feedback and long lasting effect on further development of our entire oilfield.

4) Procedures for Greenzyme® applications

December 20, 2001

8:30 AM: Uplift rod assemblies from pump jack, installed a valve from the small fourth-section of the Christmas tree.

10:18 AM: Started pumping 6 m3 of diesel into tubing-side of the well, temperature maintained at about 650 C.

10:50 AM: Finished pumping diesel.

11:15 AM: (10% Greenzyme® solution, total 8,470 liters, or 2,200 gallons.)
Use the 400-series cement truck, pumped the prepared Greenzyme® into the formation underground, keep maintaining the temperature between 650 C and 700 C.
At the beginning, the pumping pressure kept steadily rising, it reached 15 Mpa at 11:25 AM, then dropped to 10 Mpa at 11:31 AM, and kept steady.

12:10 PM Completed pumping all Apollo Greenzyme® solution.

12:15 PM: Pumped 4 m3 of diesel into underground formation, temperature was maintained between 70 to 750 C. At the beginning pumping pressure kept rising, reaching the peak at 23 Mpa, a few minutes later, pressure began to drop and kept steady at about 17 Mpa.

12:40 PM: Finished pumping diesel.

12:50 PM: Pumped 6 m3 gas-free crude oil as capping fluid, temperature was maintained at about 750 C.

13:20 PM: Completed all pumping schedules.

5) Oil well production history after Greenzyme® applications

This well was capped for 5 days after Greenzyme® applications.

- At 9:30 AM, December 25, 2001, fluid production started, till December 31, a total of 93.0 tons of fluid was produced, and water portion was 60% of total.

Table 2

Date	Time	Casing Pressure (Mpa)	Fluid Level (m)	Fluid Pressure (Mpa)	Total Fluid (ton/day)	Total Oil (ton/day)	Water Content (%)
2002.1.20	8:00	1.4	407	5.02			
2002.1.20	20:00	1.25	481	4.20	7.1	3.5	50
2002.1.21	8:00	1.3	451	4.52			
2002.1.21	20:00	1.6	482	4.53	6.1	3.2	48
2002.1.22	8:00	1.6	439	4.96			
2002.1.22	20:00	1.6	468	4.69	7.9	3.6	54

Note: Daily production time: between 8:00 – 20:00 hours.

Table 2 cont.

Between January 1 and 4, 2002, this well was closed for pressure testing works, the static wellhead pressure was 5.2 Mpa. Close pressure monitoring was recorded again for 3 more days between January 20 and 22.

- We discovered that this well had a higher dynamic liquid level in the tubing side, even after 12 hours of fluid production, the pump still had an immersion depth of over 200 m, with plentiful fluid supply.

- For this reason, on January 22, 2002, we readjusted the pumping speed to 9 strokes per minute to increase fluid production rate.

    - Original was 6 strokes per minute

Table 3

Fluid production data between January through March of 2002,

Year & Month	Production Schedule	Total Fluid (t / d)	Total Oil (t / d)	Water Content (%)	Remark
2002.1	Φ44x2.1x6	8.9	4.0	55	Change to 9 strokes / min on January 22nd.
2002.2	Φ44x2.1x9	12.4	4.9	60	Starting on Feb 7th, raise production time to 16 hours per day. From Feb 7th – 22nd, used tank trucking.
2002.3	Φ44x2.1x9	13.6	5.7	58	Normal and steady daily production.
2002.4 - July 3rd	Φ44x2.1x9	About 13.6+	About 6.0+	About 55-60	Normal and steady daily production.

Table 4

Before and after using Greenzyme® comparison of this well, showing total daily fluid production, daily oil production, changes of dynamic liquid levels and conditions.

Year & Month	Total Fluid (t / d)	Total Oil (t / d)	Water Content (%)	Fluid Level (m)	Remark
2001.8	7.5	4.1	45	551	
2001.9	6.8	3.6	47	510	
2001.10	5.9	2.8	53	531	
2001.11	6.7	3.3	51	576	
2001.12	6.0	2.7	55	551	
2002.1	8.9	4.0	55	468	
2002.2	12.4	5.0	60	528	
2002.3	13.6	5.7	58	516	
2002.4 - July 3rd	About 13.6+	About 6.0+	About 55-60	Around 516 range	Routine random check

Note: Dynamic fluid level checked after 6 hours of production

Table 2, 3 & 4 cont.

- From February 7 through 21, 2002, our whole plant was closed for Chinese New Year holidays; since we still needed to monitor production on this well, we arranged daily fluid production pickup using insulated tank trucks,

- Daily production was 16 hours per day.

Conclusion

1) After application of Apollo Greenzyme®, total daily fluid production showed significant increase, from last December's 6.0 t/d to this March's 13.6 t/d.

2) There is little change in water cut, this is because the oil viscosity in this well is low, only 19.2 mPa.s, this value reduces the other characteristics of Apollo Greenzyme®, namely reduction of oil viscosity.

- After application of Apollo Greenzyme® on this well, oil viscosity drops to 16.9 mPa.s, this is why water content percentage showed no difference as before.

- But we also observed the fact when total daily fluid output has increased two-fold, the water content can still maintain below 60% level, this clearly demonstrates the effectiveness of Apollo Greenzyme®, not only to maintain a higher daily oil production, and at the same time to control water cut percentage.

3) After Apollo Greenzyme® application, the dynamic level in this well shows a significant rise inside the tubing side, it supplies plenty of fluid production.

- This fact clearly proves that, after Greenzyme® application, the geological formation near the bottom hole and vicinity areas showed significant improvement in fluid flow mobility, allow the bottom hole formation of this well to greatly supply fluid production.

4) This is the first time our company works with a foreign company and achieve complete success, this will lay a good foundation for further future co-operations. This success will lead to a new method for the development of mid and latter stage oilfields.

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