FLOW IMPROVER SQUEEZE TREATMENT IN WELLS TO MITIGATE WAX DEPOSITION IN TUBING

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ABSTRACT

The deposition of paraffin in the tubing of wells producing high wax crude oil has been a perennial problem for Oil India Limited. The problem is mitigated primarily by mechanical scraping of the tubing. Though the method is adequate to tackle the problem, it is manpower intensive and frequently fishing of scraping tool occurs, recovery of which at times requires costly workover operation. Therefore, in the past, numbers of attempts were made to tackle the problem through chemical treatments. While all these methods gave encouraging results, the flow improver squeezing technique appeared to hold better promise. Crude oil samples from a number of wells having daily scraping problems were analysed for their amenability to flow improver chemical regularly used in OIL. Based on the laboratory results, flow improver squeeze treatment jobs were carried out using the flow improver chemical in wells NHK A and NHK B to mitigate the scraping problem.

The result of this treatment was very encouraging. The well NHK A was free from any deposition for 47 days and there after there was a mild deposition for about 2 months with substantial reduction in scraping time. In NHK B, the well was not completely free from deposition but there was a substantial reduction in scraping time. Moreover, both the wells showed increase in production with time. In NHK A, after the job, the production rate remained more or less same initially but increased later and reached around 35% higher production rate within 1½ years time before decreasing again. In well NHK B, the production rate gradually increased to 25% higher level within a year of treatment.

Key words: Wax, Deposition, Flow Improver (FI), squeezing, Low wax crude oil (LWC)

INTRODUCTION:

The crude oil produced from OIL’s fields are generally paraffinic in nature and it creates deposition problem when the reservoir equilibrium conditions get disturbed. In some wells this problem is very severe and well has to be scraped daily by using mechanical means. Mechanical scraping is a time
consuming, laborious operation. Moreover, if the tools get stuck in the tubing it may create production problem and sometime to recover them the well may require workover operation which is a costly affair. So, to overcome this problem, laboratory experiments were carried out to develop a suitable chemical treatment method. In recent past some chemical treatment methods like placement of flow improver mixed crude oil in the annulus, placement of insulating gelled oil in the annulus and squeezing flow improver and/or asphaltene dispersant treated oil in the formation were tried. Among these it was found that flow improver squeezing into the formation is more effective. Moreover OIL’s crude oils are highly amenable to flow improver treatment. Therefore, a continuous injection of flow improver chemical in the tubing below the point of wax deposition can mitigate the problem to a large extent. But creating such facilities in widely distributed OIL’s field and remote wells is not considered to be practical.

Recently, detailed laboratory evaluation of flow improver chemical regularly used for pipeline transportation in OIL was carried out for reducing paraffin deposition in oil wells. Based on the lab evaluation results, field trial was carried out in well NHK A and NHK B using flow improver chemical and it was found to be highly effective in reducing the paraffin deposition in the tubing.

This paper gives the details of laboratory evaluation as well as field trial carried out in the well NHK A and NHK B.

**LABORATORY STUDIES**

To find out the effectiveness of the flow improver chemical in OIL’s waxy crude oils following laboratory experiments were carried out with crude oil sample from a number of wells requiring daily scraping.

i) Rheology and Pour point measurement

ii) Cold Finger wax Deposition Test.

The result of these tests is given in Table-1 and plotted in Fig.-1A & Fig.-1B for wells NHK A and NHK B respectively. The result shows that flow improver is effective in reducing the pour point as well as wax deposition. At 300 ppm dosage, the pour point of the crude oil of NHK-A was reduced to <9 °C from 30 °C and wax deposition at 20 °C reduced to 0.95 g from 18 g of the blank. In NHK-B, at 500ppm FI+ 100ppm de-emulsifier dosage, pour point reduced to <9 °C from 33 °C and wax deposition at 20 °C reduced to 1.69 g from 21 g of the blank. In NHK-B, 100ppm de-emulsifier was used as this well had 10% water cut and FI alone was not very effective in reducing viscosity and pour point. Considering the effectiveness of FI, it was decided to carry out a squeeze treatment job in both wells.
JOB DESIGN

No standard job design criteria are available for batch squeeze treatment jobs. Different companies use different job design criteria depending on crude oil and chemical properties and response of formation of treatment. Usually, the amount of chemical is calculated based on effective dosage and number of effective days desired. For example, for a chemical working at 400 ppm, to treat a 50 klpd well for 90 effective days, the quantity of chemical required will be 1800 kg. The chemical is then diluted with diesel, kerosene or lease oil in a ratio 1:3 to 1:10 and squeezed. The most critical design criterion is probably the distance to which the treated chemical slug is displaced. This will mainly depend on how the chemical is adsorbed on the formation and then released during production. Chemicals adsorbing strongly is likely to get released slowly and treatment effectiveness will last longer. For one company's product, a 2 meter treatment is stated to last for 90 days while for another a 3.5 meter treatment may last for 200 days. Therefore, the chemical slug is placed into the reservoir at such distances by over displacing with 2-5 kl per meter of perforation with diesel or lease oil.

Another company assumes that treatment effectiveness lasts till 10 cycles of treatment volume is produced. Hence, the treatment volume can be calculated for desired number of days. Such calculation for NHK A and NHK B wells are shown in Table-2 and Fig.-2. The quantity of chemical used in the treatment volume is 20 times the effective dosage of the product which is presumably based on their experience. Further if the treatment volume is very high, 50% or 25% of the calculated treatment volume but containing chemical for entire treatment volume can be squeezed to get effectiveness for same number of days for 100% treatment volume. But this need to be optimized based on field experience. It can be seen from Fig-2 that for 120 days treatment, treatment volume for NHK A is 180 kls. As OIL's flow improver is effective at 300 ppm dosage, the amount of flow improver required to be 1080 kg. As 180 kl treatment volume considered to be high for squeezing, it was decided to use 25% of the volume i.e. 45 kls but containing the entire amount of FI and over displace with 30 kls of LWC to get a reservoir penetration of around 5 meter. Similarly, for NHK B, for 120 days, treatment volume was reduced 50%. In this well chemical concentration was also reduced as the chemical concentration was at higher side during the initial days in NHK A.

FIELD TRIAL

The well NHK A is producing from 2938 m Barail 2nd sand through perforation in the range 2953.0 – 2955.5 m, with gas lift. Before the job, well was producing @ 14 klpd (13klpd oil + 1 klpd water) on GL (FB) and the well required daily scraping with light scraping and encountered heavy to medium restriction from 315 to 510 m to maintain the production. During the scraping operation, 54mm, 55mm & 57 mm gauge cutters are used and the operation takes about 4-5 hours daily.
For this FI squeezing job, the well was scrapped thoroughly and then 3 kl diesel was pumped into the well bore for overnight soaking. Next day, around 45 kl flow improver treated LWC was pumped into the well followed by 28 kls LWC as after flush. The well was kept shut in for 24 hours. This job was carried out in June’05

After 24 hours the well was put on production but it was observed that there was no flow in the well. After some enlivening efforts, the well started producing @ 10 klpd and after few days, it got back its original production rate i.e. 14 klpd. The production rate before and after the treatment is plotted in Fig.3. The scraping behavior of the well was regularly monitored and the details of production and scraping behavior of the well before and after the treatment are given in Fig.4. During this monitoring period, the rheology, pour point and wax deposition characteristics of the produced fluid were also measured at required interval and these data are plotted in Fig.-4.

Considering the performance of this first FI squeezing job, a repeat job was carried out in May’07 and the production behaviour of this is also plotted in fig.3. During the repeat job the squeeze volume of the FI treated LWC was increased to 63 kl to increase the number of days of effectiveness.

The well NHK-B, is producing through the perforation range 3120.54 - 3125.11 m with gas lift. During the job, the well was producing at 28 klpd rate. The treatment procedure was same with NHK A. The job was done in April’06 by squeezing 138 kls of FI treated LWC. After overnight shut in, the well was open and started to produce. Within a week the well got back its original production rate and it showed gradual increase in production which rose to 37 klpd. The viscosity, pour point and wax deposition data of produced oil and scraping interval are plotted in Fig.5. The production rate behaviour of the well is given in the Fig.-6.

In this well also a repeat job was carried out in the 1st week of May’07 by squeezing 155 kls but the well is still waiting for production test as the well is facing some functional problem with the gas lift valve.

RESULTS AND DISCUSSION

Scraping behaviour:

Before the treatment the well NHK A was scraped daily with 54mm, 55 mm & 57 mm gauge cutter and it was taking around 4-5 hours time. After the treatment the well was free from any deposition for 47 days. During this period, scraping frequency was reduced to alternate day and then to once in three days. Thereafter, slight restriction was felt and hence scraping was carried out in one day gap and there was a significant reduction in scraping time to 30-45 minutes. This behaviour continued for 17 months (Nov’06) and thereafter, the well has gone back to its original form and it required daily scraping. This behaviour of
the well very clearly demonstrates that the FI treatment has been highly successful in eliminating/minimizing wax deposition in the tubing.

Well NHK B, was also scraped daily with 57 mm gauge cutter and it required 2.5-3 hrs for scraping. After the treatment also the well was not completely free from deposition but the amount of deposition and the scraping time reduced considerably. The well was free from deposition only for 10 days and after that the well stated showing deposition. But the deposition was soft as the scraping time reduced to 1-1.5 hrs. from 2.5-3 hrs. of the pre job condition.

**Rheology and wax deposition:**

In NHK-A, rheology, pour point and wax deposition characteristics improved significantly after the treatment. It can be seen from Fig.4 that pour point of the fluid was below 9°C for about 45 days and during this period the well produced around 516 kls. Which is around 8 cycles of the squeezed treated oil volume. During this period, as can be seen from fig.-1, the flow improver concentration in the oil was above 1000ppm. After that, the pour point rose to 24°C and remained there for 10 days and then it reached its pre job value of 30°C. The FI concentration during this period was around 100ppm. The volume produced during this 10 days period was 147 kls. This volume is around 2 cycles of the squeezed volume. Thus the design volume was able to give excellent to good effectiveness till 9 cycles of actually squeezed volume and for 59 days as against 24 cycles and 120 days of production as designed. This indicate that the chemical came out at higher concentration then the required dosage. Moreover, it is possible that some chemical trapped in area which is not coming in contact with the reservoir fluid being produced and hence can be considered lost.

In the repeat job in last week of May'07, the well, after the job was free from deposition for about 45 days and there after it started to show deposition but it is much lower than the pre-job condition. Before the treatment, there was a deposition of 9 g but after 65 days of treatment it is only 2.2g which is 75% less than the pre-job condition. Moreover the scraping time is also reduced considerably from 2-2½ hrs before the job to around 30 minutes after the job.

In well NHK B, though the rheological properties improved compared to the blank, the well failed to maintain deposition free condition for longer period. From fig.-4, it is clear that the well was completely free from deposition only for 10 days and after it started to deposit. Though the well showed deposition, the amount of deposition was low compared to blank and it was soft and scraping time reduced substantially. The pour point was below <9°C for only 10 days and after that it rose to its original value 33°C. In this well the production rate gradually increased to 25% higher level within a year of treatment.
Production Behaviour:

As mentioned earlier, before the job, well NHK A was producing at a rate of 14 klpd. After the job well produced 11-14 klpd rate for about 1½ years and the declining production trend was arrested. Considering the trend line production, the well has produced additional 400kls. The production rate declined to 6-7 klpd by March’07 when repeat job was carried out. After the repeat job, the well is producing at 10 klpd rate for the last 3 months thus showing 40% increase in production rate.

NHK B was producing at 28 klpd rate. It can be seen from Fig.6, that after the job the production rate gradually increased and reached 37 klpd in March’07. This well thus produced a significant volume of 1564 kls of additional oil during 12 months of treatment.

CONCLUSIONS AND RECOMMENDATIONS

Based on above studies, the following conclusions and recommendations are made

i) Flow improver squeeze treatment in well NHK A was successful in reducing wax deposition as well as improving the production rate and credited 35% higher production in 1½ years. In the repeat job also same behaviour is observed as the first one.

ii) In NHK-B, though the well was not completely free from deposition it was able to reduce the deposition hence improving the scraping behaviour i.e reducing the scraping time. This well showed 25% increase in production during 1 year time. Thus the flow improver squeeze treatment has been highly effective in reducing the wax deposition and improving the production pattern.

iii) This squeezing method also effective in maintaining or increasing the production from the wells.

iv) The method does not have any adverse effect on reservoir productivity.

References

1) Recommendation for PEC Treatment by M/S Tex Chem Group International, L. L.C, USA
3) R&D Note No.16 “Report on Field Trial of Dispersant HFA 704A at Kathaloni #26 &20” by H. Dubey and Ibha Kalita
4) Communication from M/S Haliburton Offshore services Inc., April 28, 1998
5) Communication from M/S Nalco India Limited, Sept 18, 2005

**TABLE-1**

Results of Pour Point and cold finger Test with FI

<table>
<thead>
<tr>
<th>Well No</th>
<th>Treatment (ppm)</th>
<th>Viscosity, Cp at 25 sec⁻¹ at 25°C</th>
<th>Viscosity, Cp at 25 sec⁻¹ at 24°C</th>
<th>Viscosity, Cp at 25 sec⁻¹ at 21°C</th>
<th>Viscosity, Cp at 25 sec⁻¹ at 18°C</th>
<th>Pour point in °C</th>
<th>Deposition C in gm</th>
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<tr>
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**TABLE-2**

Job Design Calculation

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<th>Treat Radius,m</th>
<th>NHK-A</th>
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Fig. 1A: Effect on FI Maxdip on viscosity of NHK-A crude oil

Fig. 1B: Effect on FI Maxdip on viscosity of NHK-B crude oil

Fig. 2: Treatment volume vs effective days

Fig. 3: Production profile of NHK-A

Fig. 4: Rheology, wax deposition and scraping behaviour of NHK-A

Fig. 5: Rheology, wax deposition and scraping behaviour of NHK-B
Fig. 6- Production profile of NHK-B