

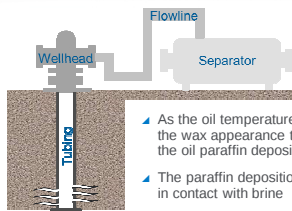
Dynamic Paraffin Deposition Cell

A novel test method to screen
paraffin chemistries in presence of brine

Saugata Gon, PhD
05/25/2017



Paraffin deposition zones in the field



- As the oil temperature goes down below the wax appearance temperature (WAT) of the oil paraffin deposition can occur
- The paraffin deposition zones often come in contact with brine
- Depending on available chemical injection points and field conditions paraffin treatments at above and below WAT conditions can be relevant.

It is necessary to understand the importance of brine on paraffin deposition

NALCO Champion
An Ecolab Company

2

Importance of brine in paraffin deposition

- Production fluids mostly contain brine upstream of the separator
- Water cut and salinity in a reservoir can vary over time
- Flow pattern inside a pipe dictates the characteristics of paraffin deposition in oil-water systems (Sarica, C. and Panacharoensawad, E., 2012*)
- Chemical mitigation/remediation for Paraffin deposition relies on paraffin inhibitors and dispersants.
 - The products often come in contact with brine in the field
- Field experience suggests that water cut can have an impact on chemical performance
- There is a need for a test method that can screen paraffin product line in presence of brine

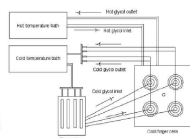
NALCO Champion
An Ecolab Company

* Sarica, C., and Panacharoensawad, E., Energy Fuels, 2012, 26, 3956-3978 ,

3

Prior art on Paraffin Deposition Testing in presence of brine

- ▲ Texaco study on wax deposition in high pressure flow loop system: Hsu, J. J. C., Santamaria, M. M., Brubaker, J. P., 1994; SPE-26480
- ▲ Tulsa University Flow loop study on oil-water system*
 - Anisoke, C. F., 2007, M. S. Thesis
 - Bruno, A., 2006, M. S. Thesis
- ▲ University of Tulsa study on effect of water cut on paraffin deposition with conventional cold finger operation with emulsified crude: Couto, G. H., Chen, H., Delecase, E., Sarica, C., Volk, M., SPE Production and Operations, 2008, 49-55



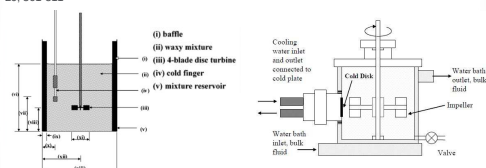
NALCO Champion
An Schlumberger

* Sarica, C., and Panacharoensawad, E., Energy Fuels, 2012, 26, 3968-3978 ,

4

Prior art on Paraffin Deposition Testing in presence of brine

- ▲ University of Calgary study on paraffin deposition from oil water mixture using a four blade disc turbine: Kasumu, A. S. and Mehrotra, A. K., Energy Fuels, 2015, 29, 501-511



- ▲ Caltech and Chevron collaborative study on paraffin crystal and deposition control study by emulsification used a cold disk wax deposition apparatus for wax deposition study under agitated hydrodynamic conditions: Ahn, S., Wang, K. S., Shuler, P. J., Creek, J. L., Tang, Y., 2005, SPE 93357

NALCO Champion
An Schlumberger

5

Background and motivation for screening paraffin products in presence of brine

- ▲ Current high throughput paraffin inhibitor screening tool is Cold Finger
 - Agitation is provided using a magnetic stirrer at the bottom of a 100 mL bottle
 - Limitation in screening products in presence of brine
 - Limitation in generating high shear
 - Limitation in maintaining same shear throughout the test time
- ▲ There is a need for a system that can provide high throughput screening of products in presence of brine
 - Generate higher shear
 - Closer to field conditions
 - Use a limited amount of oil
- ▲ Concept development for **Dynamic Paraffin Deposition Cell**

NALCO Champion
An Schlumberger

6

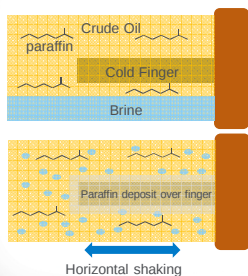
Key Objectives: Dynamic Paraffin Deposition Cell

- ▲ Develop a methodology that more closely reflects real world paraffin deposition prevention scenarios under dynamic high shear conditions in presence of brine.
- ▲ The method should be able to differentiate among various chemistries.
- ▲ Generate better correlation between field and lab data generation.

Dynamic Paraffin Deposition Cell (DPDC)

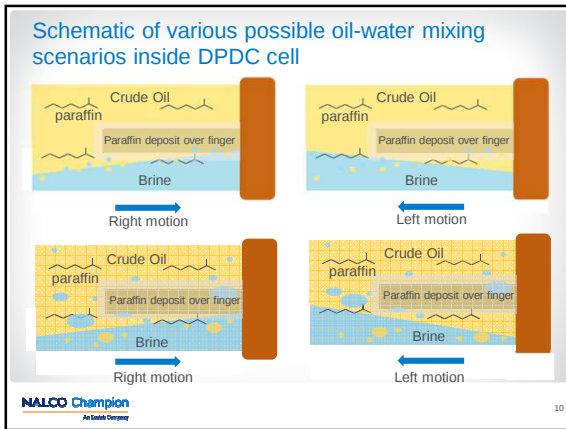


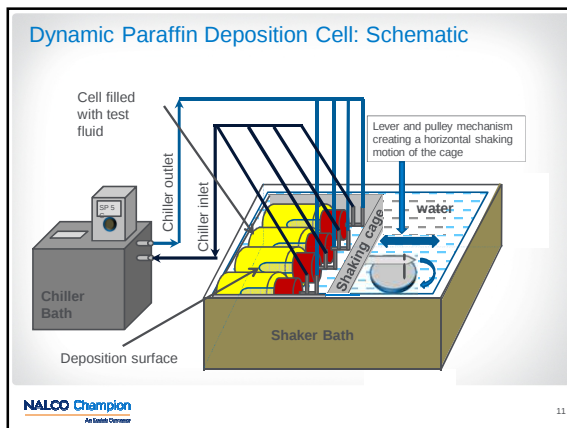
Dynamic Paraffin Deposition Cell: Concept



- Condition inside the cell
- Agitation imparted in a stagnant cell
 - Agitation provides good mixing between the oil and water phase.
 - High shear generation inside the cell
 - Product screening in oil/water system feasible

- Condition in a field line
- Flow pattern may change due to variation in production rate
 - High shear present in the pipeline
 - Multiphase flow upstream of separator







DPDC Operating Procedure

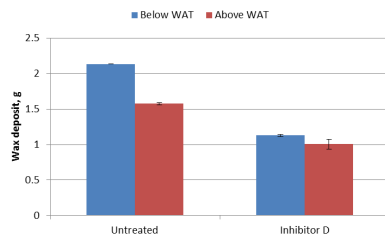
▲ Above WAT condition

- Oil conditioned at 60°C
- Chemical injected and reconditioned at 60°C for 30 minutes
- Brine injected into the cell
- The finger assembly inserted and the cell setup was placed inside the shaker bath and agitated for half an hour
- Deposition cycle is initiated

▲ Below WAT condition

- Oil conditioned at 60°C
- Brine injected into the cell
- The finger assembly inserted and the cell setup was placed inside the shaker bath and agitated for half an hour.
- As the test fluid attain target temperature chemical is injected and agitated for 15 minutes for mixing
- Deposition cycle is initiated

Data reproducibility above and below WAT: Condensate-1 with 16% synthetic brine

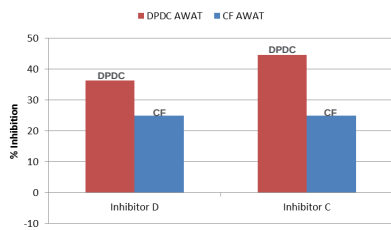


Below WAT		
Th. C	Tc. C	Run time, h
31		6

Above WAT		
Th. C	Tc. C	Run time, h
49		6

Paraffin deposit generation was possible with reasonable accuracy using two replicate cells. Effect of inhibitor was visible

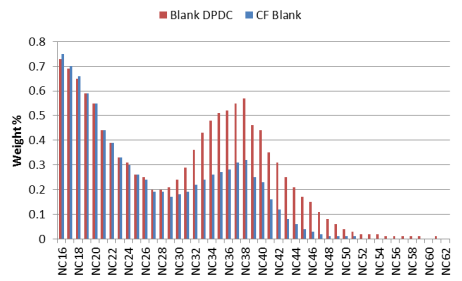
Bench Marking Study with conventional Cold Finger: Above WAT study with Condensate-1



Above WAT		
Th. C	Tc. C	Run time, h
49		6

DPDC run including 16% brine showed better performance of products and performance differentiation

Comparison of HTGC profile between conventional CF and DPDC: Above WAT condition with Condensate-1



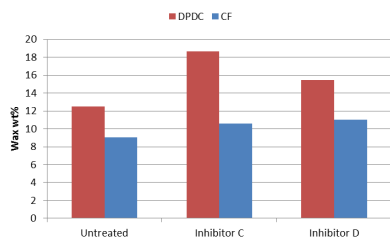
DPDC deposits show an increase in wax content compared to conventional cold finger

NALCO Champion
An Ecolab Company

16

Comparison of wax content between conventional CF and DPDC: Above WAT condition with Condensate-1

C₁₆ + components have been added from the respective HTGC profiles

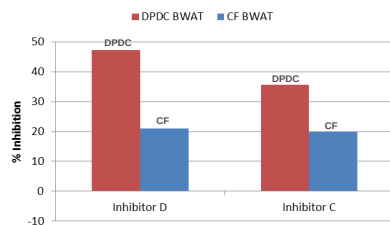


DPDC deposits show an increase in wax content compared to conventional cold finger

NALCO Champion
An Ecolab Company

17

Bench Marking Study with conventional Cold Finger: Below WAT study with Condensate-1

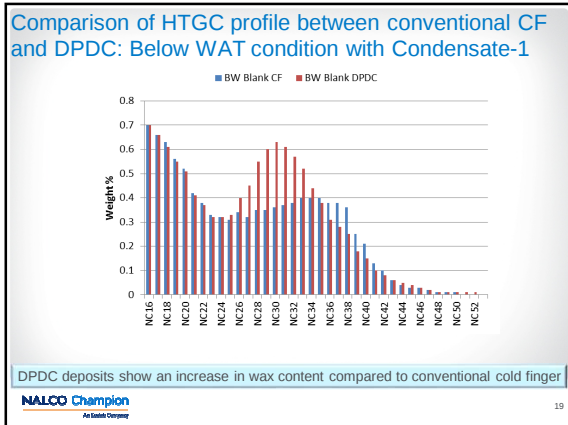


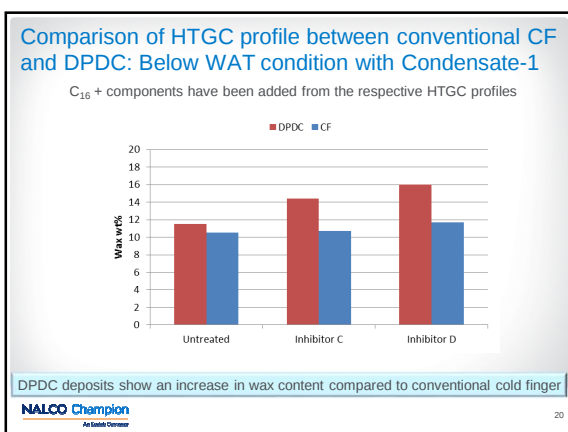
Below WAT		
Th, C	Tc, C	Run time, h
37	3	6

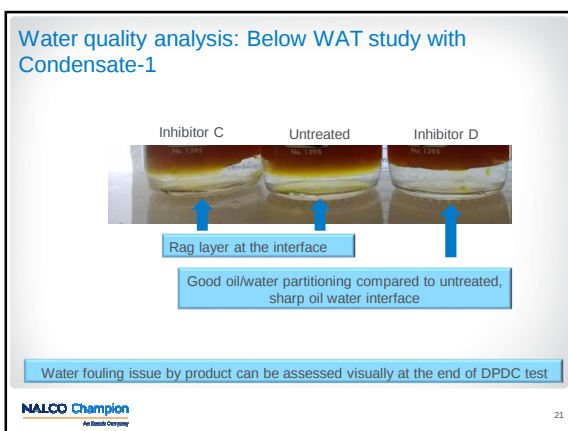
DPDC run including 16% brine showed better performance of products and performance differentiation

NALCO Champion
An Ecolab Company

18





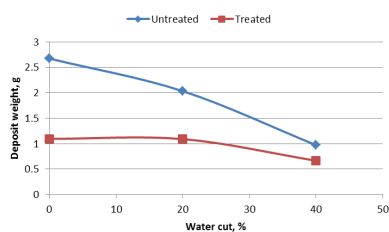


Summary of Conventional Cold Finger vs DPDC

- ▲ Better product differentiation observed with DPDC compared to conventional cold fingers
- ▲ DPDC can include brine into the test system and assess the product performance in oil-water systems.
- ▲ The paraffin deposits contained higher wax content in DPDC compared to Cold Finger.
- ▲ The water fouling tendency of paraffin product can be tested at the end of DPDC experiment adding benefit over conventional Cold Finger.

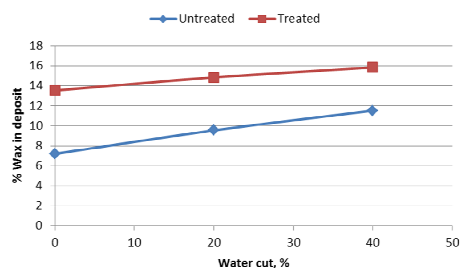
Effect of water cut on paraffin deposition

Water Cut Effect Study: Light Crude Oil-2 with Inhibitor C



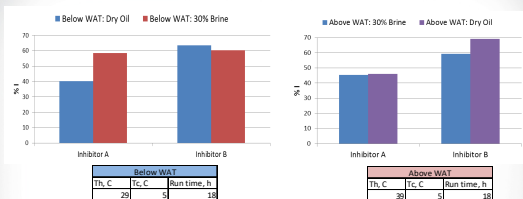
With increase in water cut amount of paraffin deposition decreased.

Water Cut Effect Study: Light Crude Oil-2



With increase in water cut wax content of paraffin deposits increased.

Above and below WAT run: Eagle Ford Condensate-2



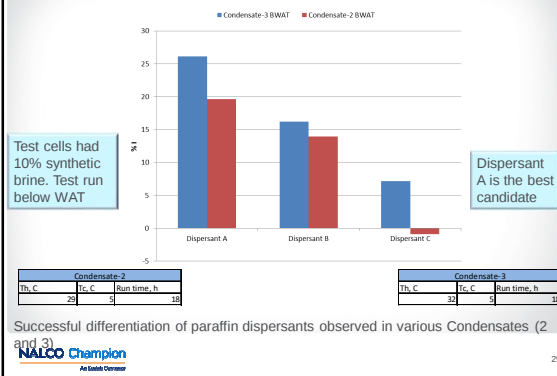
▲ Test conditions affect the influence of brine on performance of products

Dispersant screening

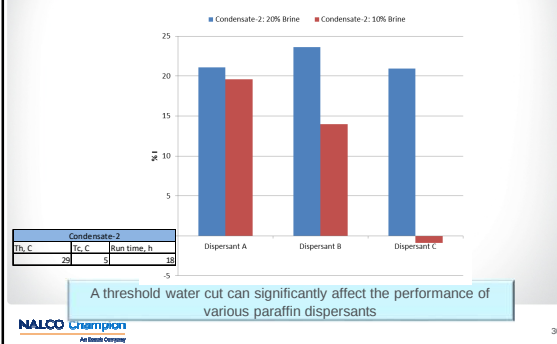
Product screening for Paraffin Dispersants

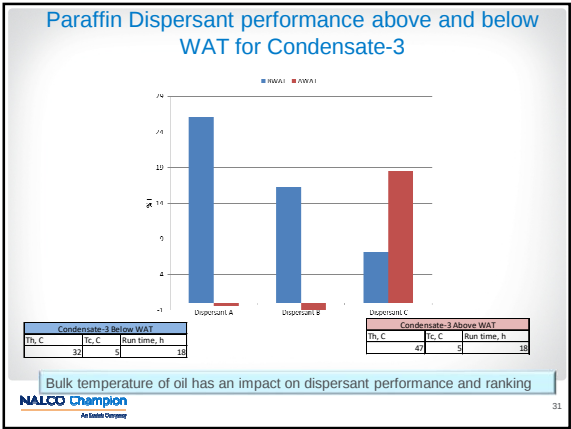
- Paraffin dispersants are often found useful for chemical treatment in the field
- It is often thought to be effective in presence of brine
- Conventional cold fingers showed limitations in detecting paraffin dispersant performance

DPDC for Paraffin Dispersant Ranking

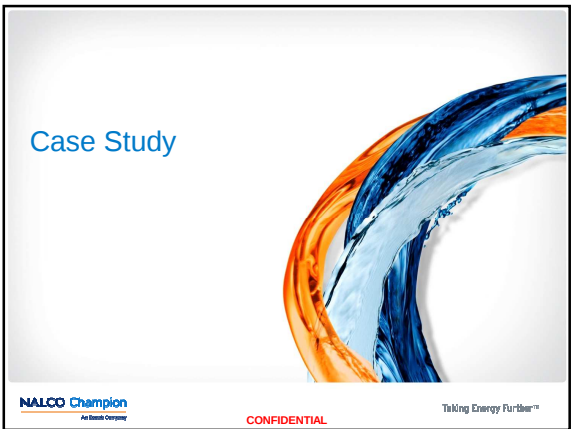


Paraffin Dispersant performance variation with water cut: Condensate-2



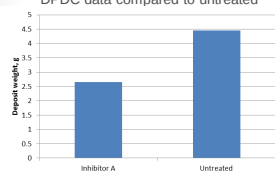


- Paraffin Dispersant Screening Summary
- ▲ DPDC can successfully rank paraffin dispersants based on paraffin deposit quantification.
 - ▲ Water cut and test conditions can affect the product performance.
 - ▲ DPDC is sensitive to test conditions' variations.
- NALCO Champion
An Ecolab Company
- 32



DPDC Case Study: Eagle Ford

DPDC data compared to untreated



Condensate-4 Below WAT		
Th, C	Tr, C	Run time, h
25	9	18

Successful field trial with improvement of paraffin deposition control



Untreated Unit spool – after the trial



Treated Unit spool – after the trial

Conclusion

- ▲ Dynamic paraffin deposition cell provides a tool to study paraffin deposition in presence of brine
- ▲ It can help screening paraffin dispersants' performance in laboratory
- ▲ Effect of water cut impact on paraffin deposition can be studied
- ▲ DPDC data showed increased wax content compared to cold finger
- ▲ DPDC is a step in the right direction for more realistic product performance testing in presence of brine
- ▲ Provisional Patent application has been filed: Application No. 62/479,063

Acknowledgement

- ▲ Nalco Champion for giving permission to present
- ▲ SPE Organizing Committee for the presentation opportunity
- ▲ Susan Garner, Jose Macias
- ▲ David Fouchard, Emily Pohl and rest of the Paraffin and Asphaltene Group in Flow Assurance Sugar Land facility
- ▲ Rogelio Banda, Ken Dorris and Wilfredis Medina Melendez
- ▲ Thank you all for listening

Thank You and Stay Safe



NALCO Champion
Air-Soluble Chemistry

37
