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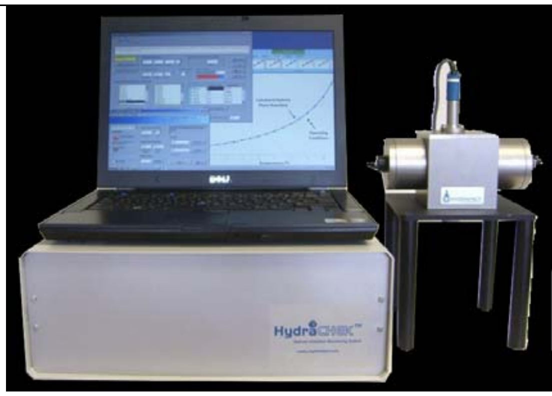
HydraCHEK: Selected Case Studies

HydraCHEK was developed based on a requested from the industry and as a result of Joint Industry Project at Heriot-Watt University. It was commercialised by Hydrafact through a Scottish Enterprise SMART R&D award. The device, which is size of a desktop computer, requires 120 ml of a produced water sample. It measures the speed of sound, electrical conductivity and temperature of the water sample. From these three measurements the concentration of hydrate inhibitor and salt can be determined within seconds, which can quickly be compared with the desired inhibitor injection rates and adjusted if necessary. Knowing the actual concentration of salt/inhibitor in the aqueous phase eliminates all uncertainties related to process parameters (e.g., water cut, pump rate, inhibitor purity and partitioning in other phases). A selection of calibration sets are available, which cover all commonly used hydrate inhibitors.

Case study-1 (below) was among the University REF submission. It also was instrumental in the Heriot-Watt winning Queen's Anniversary Prize for Higher and Further Education

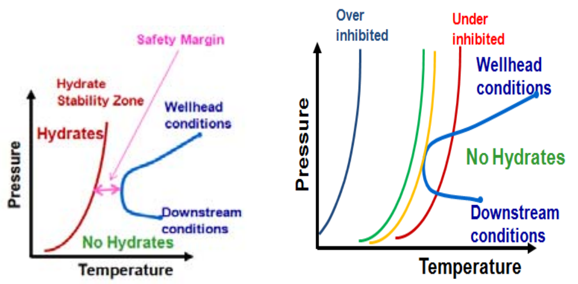


Lab-based HydraCHEK

THE QUEEN'S ANNIVERSARY PRIZES
FOR HIGHER AND FURTHER EDUCATION

(http://www.hw.ac.uk/news/oil-gas-gains-queens-anniversary-prize.htm.)

Furthermore, the measured salt and inhibitor concentrations could be used in determining the hydrate phase boundary stability zone). Superimposing the real time pipeline/system conditions (i.e., P&T) will determine the hydrate safety margin. Again the information could be used in optimising the inhibitor injection rates, saving inhibitor costs and/or avoiding hydrate problems. An online version of the system with automatic sampling, measurement, and disposal has been developed and due for field trial.



Hydrate safety margin, over/under-inhibited systems

Case Study-1

Location: North Sea

System: Lean natural gas, methanol & saline formation water

Task: Monitoring hydrate safety margin and hydrate slurry concentration

Outcome: Inhibitor dose rate was reduced to zero

Savings: Direct savings in methanol costs (millions of GBP), extended field life by 5 years, producing 3.5 MMBOE, increasing the recovery factor by 2.5%, extra income of around 175 million GBP

Indirect savings in millions of GBP due to higher hydrocarbon recovery, less contaminated product, logistic, etc.

Background

Methanol was used as a hydrate inhibitor in a North Sea development (as detailed in Case Study-1). Based on the initial design the maximum water cut was 40 Sm^3/day, but in 2010 the water cut increased to more than 100 Sm^3/d and the field was being prepared to be decommissioned. However, due to significant gains in the fields continuous production (revenue from gas sales: gas provides blending premium for CO2 rich fields that flow to the platform, and improved reserves recovery) an holistic field management strategy was developed that captured all the constraints from reservoir, to wells to flow assurance through a combination of methodology and field trials with operator buy-in to try something new.

In addition to adjusting gas flow rates from each well (to limit water production) it was decided to lower the operating pressure from 76 bar to 71 bar. However, operation below turndown means that pressure control is impossible and there are frequent excursions into the hydrate zone. It was necessary therefore to implement an early warning system so that operators could react in case there was a build-up of hydrates.

HydraCHEK deployed

After examining a number of options for early warning, it was decided to use HydraCHEK for this purpose. Hydrates exclude salts from their structures, therefore, hydrate formation would result in an increase of the salt concentration in the free water, which can be detected by HydraCHEK. The total average salt content was measured by HydraCHEK giving a typical value of ~ 4.8 mass %.

With HydraCHEK and the above methodology in place, a programme of gradual reduction of methanol was embarked upon until a Field trial was performed in August 2012 without any methanol. After gathering further information and building confidence in the methodology the trial continued and it was established that HydraCHEK could give 24 hr advanced warning of hydrate problems.

Results

The field which was planned for abandonment in 2010 continued production for another 5 years (still is producing, but periodic), producing an extra 3.5 million BOE and generating more than 175 million GBP, in addition to eliminating product contamination and methanol costs.

Further details:

Saha P, et.al. NUGGETS gas field - Pushing the operational barriers. Presented in the SPE Offshore Europe Oil and Gas Conference and Exhibition held in Aberdeen, UK, September 3-6, 2013.

Case Study-2

Location: North Sea
System: Lean natural gas, methanol & saline formation water
Task: Monitoring and optimising hydrate inhibitor injection dose rate
Outcome: Inhibitor dose rate was reduced in stages from 28 wt% (designed) to less than 5 wt%
Savings: Substantial direct savings in methanol costs, estimated at millions of GBP
Indirect savings (millions of GBP) due to higher hydrocarbon recovery, less contaminated product, logistic, etc.

Background

Methanol was used as a hydrate inhibitor in a North Sea development. Based on the initial design parameters (i.e., minimum seabed temperature, maximum system pressure and 3 °C safety margin) 28 wt% methanol was suggested for preventing gas hydrate problems.

A coulometric Karl Fischer (KF) technique was used as an indirect method of quantifying methanol, by determining the water content and assuming the remainder of the solution is methanol. The chloride content of the produced water sample was measured by the Mohr Titration. Samples are also sent onshore for ion analysis to track the water breakthrough of the field. The above techniques were time-consuming and each arriving with different time lags to the operator, hence it was difficult to use the results and optimise methanol injection rates.

HydraCHEK deployed

HydraCHEK was deployed in April 2011. After extensive lab tests and establishing the reliability of the device, it was used to adjust inhibitor injection rate. The fact that HydraCHEK gave both concentrations of salt and methanol within seconds was found very useful.

Results

Gradually with increasing confidence, the methanol injection rate was reduced in stages, resulting in significant savings in direct methanol costs, higher hydrocarbon recovery, less contaminated products, less costs associated with logistic, etc.

Furthermore, HydraCHEK measurements were much faster and there is no need for any chemicals/reagents.

Further details:

Calum MACPHERSON, TOTAL E&P UK, Philippe GLENAT, Saeid MAZLOUM, Iain YOUNG, "Successful Deployment of a Novel Hydrate Inhibition Monitoring System in a North Sea Gas Field.", Presented at the 23rd International Oil Field Chemistry Symposium, 18 – 21 March 2012, Geilo, Norway.

Case Study-3

Location: Middle East

System: Sour gas/condensate, Kinetic Hydrate Inhibitor & produced water

Task: Monitoring and optimising hydrate inhibitor dose rate

Outcome: Inhibitor dose rate was successfully monitored and optimised, avoiding potential hydrate blockage

Savings: Direct savings in chemical/staff costs, estimated at hundreds of thousands of USD

Background

Kinetic Hydrate Inhibitor (KHI) is being used as hydrate inhibitor in a Middle East sour gas/condensate development. The produced water is mainly condensed water with little salt. Previous experience with similar fields shows that under-dosage could result in rapid hydrate formation/blockage.

The dosing of KHI is linked to its efficiency for given conditions. Under-dosing could result in hydrate formation risk. Over-dosing is not desired, because it will rapidly lead to unnecessary high OPEX as the KHI efficiency reaches its plateau when its dosage is increased. The monitoring of KHI is consequently a vital control parameter to ensure that the optimum injection rate is delivered and that no under-dosing occurs. Water samples are collected from the surface facilities regularly and sent to the lab for analysis.

In the past, only chemical measurement techniques of KHI were available, including colorimetric techniques. They are usually recommended by the KHI vendors. Generally, they work fine and with good accuracy, but they are complex, require skilled chemists, and, more importantly, they are time consuming. In this specific case, the KHI vendor had recommended using a spectrophotometer to evaluate the concentration of KHI in produced water samples. The samples had to be pre-conditioned to meet the desired specification of the analytical method.

HydraCHEK deployed

HydraCHEK was deployed in 2008. The device was found fast and easy to use and the results will be ready within few seconds. After extensive comparative tests and establishing reliability and repeatability of HydraCHEK over the range of KHI concentrations (1-5 wt%) it was deployed as the primary KHI concentration measuring device.

Results

HydraCHEK has successfully replaced the time consuming colorimetric technique and it has been used continuously over the past seven years. The implementation of the C-V (Conductivity-Velocity) technique (HydraCHEK) has allowed rapid follow-up of KHI concentration in the produced waters received onshore. It offers the possibility to rapidly monitor the KHI concentration better manage inhibitor injection for optimal performance. The resulting savings in staff time and chemical inhibitor are estimated be tens of thousands of USD per year.

Further details:

Lavallie O., et.al. Successful field application of an inhibitor concentration detection system in optimising the kinetic hydrate inhibitor (KHI) injection rates and reducing the risks associated with hydrate blockage. IPTC 13765, Doha, Qatar, Dec 7-9, 2009.

Case Study-4

Location: Middle East
System: Sour gas/condensate, MEG & produced water
Task: Monitoring and optimising hydrate inhibitor dose rate
Outcome: Inhibitor dose rate was successfully monitored and optimised, avoiding potential hydrate blockage
Savings: Direct savings in chemical and staff costs

Background

Mono-Ethylene Glycol (MEG) is being used as hydrate inhibitor in a Middle East sour gas/condensate development. The produced water is a combination of formation and condensed waters.

Several methods were used for measuring MEG concentrations in the aqueous phase including densitometer, gas chromatography and a combination of the two. In general, techniques based on density measurements were not reliable at MEG concentrations less than 10 wt%, especially if combined with changes in the concentration of salts (or condensed water). Gas chromatography (GC) methods were reliable, but only if there was no salt in the system (salt can block GC columns). Obviously, knowing the salt concentration is crucial to knowing the position of the hydrate phase boundary and the amount of MEG required to avoid hydrate formation. In addition, GC and densitometer measurements were time consuming, often involving the shipping of samples to a laboratory off-site, and are relatively labour intensive/costly. None of the above methods were able to determine salt concentrations.

HydraCHEK deployed

HydraCHEK was transferred to the site in 2010 for field evaluation. Samples were taken from the inlet and outlet of a MEG regeneration unit, as well as the pipeline inlet on the offshore platform, and the outlet from a slug-catcher. The samples taken were analyzed using HydraCHEK the results compared to measurements on the same samples using gas chromatography and density measurements. The results show that HydraCHEK could accurately determine the concentration of salt and MEG. The results were reliable over a wide range of MEG concentrations. The device was found fast and easy to use. In addition to MEG concentration, HydraCHEK could also determine salt concentration, essential for evaluating the hydrate phase boundary (i.e., stability zone).

Results

HydraCHEK trail was successful and device was able to determine the concentration of MEG and salt at the inlet and outlet of the pipeline and at the MEG regeneration unit. As a result of field trial, the client ordered two HydraCHEK devices for their plant.

Further details:

Bonyad H., et.al. Field Evaluation of a Hydrate Inhibition Monitoring System. Presented at the Offshore Mediterranean Conference, Ravenna, Italy, March 23-25, 2011.

Case Study-5

Location: Central Asia
System: Sour gas condensate, MEG & produced water
Task: Monitoring and optimising hydrate inhibitor dose rate
Outcome: Inhibitor dose rate was successfully monitored and optimised, avoiding blockage
Savings: Direct savings in chemical and staff costs

Background

This is an offshore development in Central Asia. Fluids from the production header flow to the production train where the gas is separated from the condensate in the production separator. The produced untreated gas and condensate are routed via two separate 73 km pipelines (12” for condensate and 26” for gas) from offshore to the onshore Gas Treatment Plant. Mono Ethylene Glycol (MEG) is transferred from onshore unit via a 4" pipeline and injected directly into the production facilities and into the condensate and gas pipelines. Lean MEG is also manually injected upstream of Feed Gas Separator to prevent hydrate formation in the vessel as well as some critical points in the gas treatment plant for intermittent injection during start-up, transient operation, etc. In onshore facilities TEG is used for gas dehydration.

The worst operating conditions is 5 °C (during winter) and 100 barg. Based on normal design criteria a safety margin of 5 °C is considered, which results in 47 wt% MEG. The actual injected MEG is more than 50 wt% to account for MEG distribution and losses into hydrocarbon phases.

HydraCHEK deployed

In January 2013, HydraCHEK was deployed in the onshore gas processing laboratory for determining the concentration of rich MEG. The initial deployment was to have a technique for fast and reliable measurement of MEG concentration (i.e., to make sure the system is not under-inhibited). The device has since enabled significant reduction in MEG dose rate. For example, in mid-June 2013 the actual operating conditions were 11 °C and 78.3 bar. Under such conditions, only 22 wt% MEG is required to avoid hydrate formation. Considering a 3 °C safety margin, the concentration of MEG required would be 30 wt% compared to the designed dosage target of 47 wt% MEG, almost halving the MEG requirement. Furthermore, HydraCHEK is used in determining the concentration of MEG of lean and rich-MEG streams in the MEG regeneration unit, as well as concentration of TEG in gas dehydration unit.

Results

HydraCHEK was successful in not only avoiding any potential hydrate blockage (by providing warning if the system was under-inhibited), but also reducing the MEG injection rate by half. The direct savings in OPEX, assuming a water cut of 1%, is in excess of $400,000 per year, which include:

- Less MEG losses
- Less heating requirement in the MRU (MEG Regeneration Unit)
- Less pumping requirements

Furthermore, it enabled the operator to cope with higher water cuts. Another benefit is quick and reliable analysis of produced water & samples taken from different sections of the system, including MRU (enabling the operators to continuously monitor and optimise MRU operating conditions.