Standout concept of well clean-up and testing - secures long-term sustainable evo...

Education, Sustainability

Abstract

The Karachaganak field is situated within an environmentally sensitive area which includes a conservation area containing lakes, woodland and abundant wildlife. Additionally, surrounding the field there are several inhabited villages. As in other parts of the world, if well operations are not properly managed, there is the potential to directly impact this fragile environment, as a result of HC flaring with emissions containing both H2S and SO2 during the well operations.

Despite applying best-in-class environmental drilling practices in the well construction process, there remained the challenge of how to reduce emissions resulting from well clean-up activities in the field, with the eventual goal of achieving zero emissions during the well clean-up activities.

This paper outlines the transition of well clean-up and testing towards purely three phase “ zero emission”, broadly describing the evolution from conventional three phase flaring to a robust zero emissions approach.

The transition required new technologies to be implemented in stages which were all subject to; high level design reviews and rigorous HAZOP activities to, both define and guarantee the safe operational envelope at field implementation stage.

The result of this implementation are as follows:

- maximizing oil recovery at highest value within optimal cost
- putting the newly drilled wells on production in advance

- significantly reducing downtime
- with to date a significant environmental impact reduction in the region of 95%

The project anticipates deploying the last of the enabling technologies in the field in 4th Quarter 2018, which should see KPO achieve its long term aim of " zero emissions" during well clean-up operations.

Introduction

Formation damage or reservoir characteristics impairment – chronologically may happen in any time of the field development cycle: drilling, workover, completion, production, intervention and well services. Drilling long horizontal section in heterogeneous carbonate rock inadvertently causes long exposure into the drilling and completion fluid altering the relative permeability and significantly diminishing absolute formation permeability. In such wells formation undergoes a high frictional pressure drops in addition to applied high overbalance pressure during drilling resulting in a huge formation damage induced by enormous filtrate losses. Drilling long extended wells become more prevalent nowadays; having constant reservoir contact through horizontal drain indisputably increases well production bringing great sweeping efficiency with possible delay in early water-gas encroachment, if proper clean-up and production strategy has put in place. Drilling mud system that designed to keep cuttings in suspension across the long and sinuous wellbore required having a less impact to irreducible water saturation that could complicate the WBM flow back during initial clean-up. The drilling mud generally associated with creating impermeable mud cake

that minimizes filtrate losses and in addition withstands the shearing velocity of circulated fluids, cuttings and formation mechanical demolition from rotated drill pipe. Cleaning up the heterogeneous formation that invaded with mud filtrate and exposed to the various damaged may suffer from lack of sufficient drawdown to enable thorough clean-up along horizontal drain from toe to heel. Ineffective clean-up – results in the reservoir partial sweep, leaving virgin hydrocarbon unrecovered with premature water or gas breakthrough.

The extended flowback contain large volumes of invaded filtrate during clean-up scrutinized and overhauled by KPO at the root. The strategy touch upon all reservoir development cycles, tackle the problem and yields breakthroughs that qualitatively and quantitatively reduce flowback time and emission.

By following this philosophy, KPO opt for reservoir friendly ‘ inexpensive’ OBM aimed to mitigate poor well clean-up leaving unrecovered debris in the wellbore that in essence create impairment to the downhole equipment, surface testing and lately production facilities. The low-cost OBM intensive consumption is attributable to two main factors: safely collect the post-drilling contaminated Lamix without flaring into atmosphere and use the re-cycled Lamix® (base oil) that purified in plant and passed through strict QAQC on physical, chemical and solids content prior sending back to the rig.

The horizontal sections that sometimes drilled under CHCD mode to cure the high loss circulation zones, proved to be feasible from reservoir stand point

and from equipment, logistics and operational view. This application appears to be most economical solution to successfully drill targeted object. During drilling, the cuttings from beneath the bit carried to the fractures creating formation damage together with OBM and WBM that pumped down in sequential manner to manage and achieve drilling parameters. Even applying best technologies the near wellbore damage still persisted.

The completion concept deployed in the field since 2011, incorporates the openhole multi-stage fracturing completion with swelling packers for zonal isolation and ball activated sliding sleeves for selective stimulation within extended 6” horizontal drain through 4-1/2” liner. In fact that the swelling packer are OBM type (swelling process starts when in contact with oil based fluid) the circulation of the light completion fluid 1. 0 SG OBM significantly reduces the fluid column in the wellbore accelerating the clean-up gaining the advantage that outweigh concerns about severe impact of mud system and volumes of invaded mud filtrate required to flowback. This completion has proved its benefits in productivity index (PI), flow capacity (kH) and flow profile during evaluation of pre and post-treatment PLTs as well as effectiveness in water shut-off, paving to selective isolation approach rather than choke back or shut-in.

Mainly to remove the near wellbore damage caused by drilling fluids and on a way to accelerate the well clean-up, the stimulation strategy has been revised leading to the design and implementation of hydrocarbon-based stimulation, eliminating the potential large volumes of water based stimulation fluids injection. The water –based linear gel intrinsically

superseded by laboratory proved fluid, environmentally safe, compatible and cost-effective hydrocarbon-based system called ‘ slick oil’, which in advent replicated on well clean-up time and emission reduction.

The milling balls and baffles through CT conveyance originally introduced large amount of milling fluid with debris in excess. State-of-the-art technology that led and fine-tuned by KPO become worldwide unique invention, exclusively devoted and developed for inherent completion specification, which enabled milling entire horizontal section (up to 9 balls and baffles) in single tractor run without injecting aqueous fluid system in the well.

The forthcoming stimulation trial, based on chemical diversion of retarded acid called OpenPath® is still under feasibility study, however optimistically promising featured efficiency with less treatment volumes.

Applying advanced technologies, strategies to reduce the amount of lost filtrates have a one major objective is to minimize the so called ‘ geological losses’ to atmosphere, accelerate the clean-up and hook-up the newly drilled wells into to the production stock prematurely increasing cumulative recovery in compliance with HSE and facilities limitations. The evolution of the well clean-up and testing has been revised and reached the prominent progress, though still being refined to reach ‘ zero emission’ for all three phases. Over the past five years the tendency of flaring and penalties drawn by ecological authority significantly fallen down due to well-managed clean-up controlled over the well’s life without differed production.

Background

In the early stages of field development during FSU the clean-up at primitive environmentally detrimental conventional level was common practice. With sustainable field development the conventional flaring become unacceptable posing the threat to environment, preserved biodiversity and ecosystem, adjacent inhabited villages, as well as KPO personnel engaged in SIMOPS, like project management, well construction, flowline instrumentation hook-up, extensive drilling campaign nearby sites made rapid change in well clean-up performance. Therefore, it compelled the step forward towards vital smokeless combustion, where sour effluents treated with H2S scavenger prior flaring.

KPO has a high commitment to the environmental performance, in spite of significant emission volumes reduction over the years, the adherence to constant environment control is still ongoing. The monthly reports on air quality and results of studies of the field operational effect on soil, surface water and livestock continuously monitored and presented to the state council commission and each of the closest villages. Moreover, all 8 villages in the vicinity are equipped with air monitoring stations with real-time air sampling. Resettlement campaign of two villages to the district is completed that allowed to increase the sanitary-protection zone boundary of the field. It is forth mention that, contamination of the soil and groundwater is a criminal offence under the RoK Criminal Code, Article 282 – Atmospheric Pollution and Article 333- Violation of Mineral Resources Conservation and Mining Regulations and requires always keep in mind and being in compliance with,

especially during well clean-up operations when flaring byproducts potentially falling into the flare pit resulting in seepage into soil and water layers.

Beaver, the species included in the IUCN Red List

Little bustard, the rare species in the Karachaganak Field, included into the Red Book of Kazakhstan and the IUCN Red List

The common purpose of the well clean-up is to unload the well from invaded filtrates accumulated from drilling, completion and post-multi-stage acid treatment in amount of > 2000m3 followed by well testing through the surface facilities. The lack of industry reliable well test package designed to overcome engineering constraints became deterrent factor for suspending the upgrading of well clean-up philosophy/integrated approach which seriously hindered the progress.

The current well clean-up procedure is to use a HP Separator for wells that able to flow at sufficient high pressure, otherwise use standard separator diverting all produced fluids to the burn pit until the FWHP value reach the PLP so well could be diverted to the plant, or continue flare until plant acceptable water cut is achieved.

The main constraints that KPO has to overcome during clean-up and well test package design and field implementation stage:

- Limitation of KPO production facilities, particularly water volumetric and mineralogical content

- High precision to WC % (0-1%)
- High threshold for spent stimulation fluids acceptance to avoid intolerance of the system
- Flowline inlet pressure criteria threshold (85-130bar)
- Flowline temperature limit 65Cdeg
- Efficiently separate fluids (3 phase) and provide real-time high precision rate measurements
- Three –phase Flowback measurements
- measurements
- Have sufficient temporarily wellsite fluid storage capacities, in case of process equipment emergency shutdown
- Treat and dispose separated water (H2S <2ppm)
- Ensure the 24-hrs coverage of process and equipment safety and integrity screening
- Provide constant N2 blanketing for atmospheric/pressurized tanks to avoid air ingress during operation (HSE aspect).

Well clean-up and testing development in KGK field pursuing ‘ zero emission’ chronologically distributed in following sequence

Typical well clean-up and well test ramp-up procedure

Newly drilled and completed well that undergone horizontal multi-stage stimulation through RSSs carried out using ‘ slick oil’ practically expected to have limited flow back of water. It is required to separate and inject oil into production line while water will be treated and disposed of at the wellsite. The clean-up and well test package that subjected to use contains two-stage

HP separator, High pressure pump and MPFM. Well which connected to the plant may have shared RMS slot with another well that have to be shut in to avoid creating back pressure in stream line. For new well hooked-up to the production line till RMS is isolated by two ball valves (mechanical pressure barrier) against shared wells and most of the time this line till valves is empty or depressurized for re-injection spool installation. It became a normal practice to open the well directly to the RMS at its inception of clean-up to fill up this flowline with wellbore full of diesel or ‘ slick oil’ (pumped at the last displacement stage of acid treatment) till feeling up the back pressure at other side. The well has enough pressure (SIWHP> 30bar, even well in vacuum) to freely flow. Later on well will be diverted to the separator clean-up process following up the ramp-up program. Gradually increasing choke size while having critical flow the well is cleaned-up till BS&W reaches <10% followed by setting bottomhole gauges at LN prior multi-rate test and PBU. Some wells already have permanent downhole gauges installed which could be real-time monitored in the control room. Depend on FWHP the oil can re-injected via HP pump or spontaneously flow at sufficient production line inlet pressure. Wellhead parameters and rates are continuously monitored while BS&W and oil are regularly sampled at upstream and downstream choke for lab analysis. The water mineralogical content, mainly concentration of chloride (Cl-), calcium (Ca2+) and magnesium (Mg2+), as well as WC and pH are important indicators for the plant well acceptance criteria.

Very rarely well might not reach sustained flow regime. At this time coiled tubing is used as a velocity string for nitrogen lift until decent stable flowing

pressure is achieved. If the well struggles to flow due to low FWHP the HP Pump is considered to be utilised injecting oil through re-injection spool to RMS. The well ramp-up completes with PLT followed by setting long-term bottomhole gauges. During clean-up and well test all debris left after milling balls and baffles are collected in y-strainers and debris catcher. In case of foaming (separator carryover in gas/oil line) or emulsion tendency the rigorously selected and compatible with existing production facilities defoamer or demulsifier will be injected to the process line to improve separation and rate measurements.

Clean-up and well test package implementation process

Prior accepting the clean-up package and bring to bear the application undergoes through rigorous selection and compliance checks, where HSE is one of the principal drivers. Each aspect must be approved by KPO and the contractor and be available for every package and every configuration of equipment. Methodology which used to guarantee the field implementation within safe operational envelop and exceptional job in high level well clean-up and testing has proved its efficiency within these years in terms of safety, total recovered HC and consequent less emission to the environment on job basis.