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PAST AND FUTURE OF FLOW BACK TECHNOLOGY: FOUR-PHASE FRACTURING FLOWBACK SURFACE WELL TESTING EQUIPMENT INCREASES OPERATIONAL SAFETY AND EFFICIENCY BOTH ON AND OFFSHORE

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RESUMEN

Pasado y Futuro de la Tecnología de *Flow Back*: Equipo de superficie para ensayo de *flowback* de fractura en cuatro fases incrementa la seguridad operacional y la eficiencia tanto en tierra como costa afuera

Uno de los desafíos del flowback es manejar todos los fluidos en la superficie y es más importante cuando fluyen el gas y los sólidos. En este caso, el flujo se vuelve más abrasivo y es necesario un equipo especial para recibir dichos efluentes en la superficie. La solución estándar incluye un colector de conexión y un separador de arena que funcionan en conjunto con un colector de estrangulación estándar y un separador trifásico. Esta solución no puede manejar todo tipo de situaciones que se pueden encontrar en todo el mundo.

Para estos escenarios severos de flujo de retorno, se desarrolló una nueva tecnología, lo que demuestra una mejor solución que puede adaptarse a más escenarios, reduciendo la intervención humana al manipular filtros de arena. Se requiere menos personal operativo y se reduce el tiempo de funcionamiento.

El próximo desafío será utilizar este equipo para fracturar operaciones de rotato de tapones (FPDO) para reducir los riesgos de seguridad al manejar el gas en la superficie en comparación con la tecnología FPDO actual que se utiliza.

Este documento presenta los resultados del uso de esta tecnología tanto en escenarios offshore como terrestres y el futuro de tales operaciones en campos no convencionales, incluida la administración de flujo de aire para mejorar la productividad del pozo mediante la medición, el control y el análisis correctos de los datos de retorno.

INTRODUCTION

Around 2010, an operator had to clean some gas wells that could not be cleaned out with available technology. The job was to flow a heavy mud with a high concentration of solids. Three-phase separators with conventional chokes were used without success. The fluid with gaswas flowing at high velocity, eroding surface equipment, and flooding the three-phase separator which was not capable of separating such effluent.

A new class of well testing equipment was designed to address this issue, capable of handling such flow scenarios to separate and measure all four phases produced. This solution included a 15Kpsi frac flow back choke manifold and a 4-phase separator with 15Kpsi equipment such as surface safety valve with remote Emergency Shut Down system, surge tanks, surface data acquisition system, heaters, boilers, atmospheric tanks, high- and low-pressurepipes, and other accessories.

SOLUTION

The core of the solution proposed was two pieces of equipment: the frac flow back (FFB) choke manifold and a 4-phase separator. The FFB deals with the pressure and velocity to decrease erosion power from the flow and the separator to separate and measure well effluents.

4-phase Separator

The 4-phase vertical test separator is capable of safely separating and measuring flow rates of oil, gas, water, and solids produced from the reservoir, handling solid returns in a controlled and safe manner. It is two separate pieces of equipment, the vertical separator vessel and its control skid.

Inside the vessel, all phases pass through a separation process. An assisted flush pumps the solids to a tank or container and the remaining phases flow through the control skid that controls the separator and measures the flow rates using turbine meters for liquids and anorifice meter for gas.

For offshore and onshore applications, a 1440-psi separator and an 800-psi heli-lift version of the 4-phase separator was used. The heli-lift version was designed to operate in remote areas and was used in Amazon forest locations. Due to its lightweight, helicopters could transport the equipment.

Figure 1. 4-phase separator and control skid

Frac Flow Back (FFB) Choke Manifold

The FFB choke manifold controls the well by means of an adjustable choke and two fixed chokes in series on each side. The well is controlled by closing or opening adjustable chokes and the two fixed chokes decrease pressure in steps, avoiding high velocities after the choke. In a high flow rate of gas with solids, this reduces equipment erosion.

Figure 2. Frac Flow Back Choke Manifold

According to Margoto *et al.* (2017) the FFB choke manifold set a new operational standard for well testing on abrasive gas wells, using a high-resistance material and the described design helped enable formation evaluations that were previously considered dangerous. The three chokes performed a soft pressure reduction, reducing the abrasive effects of the flow on the equipment.

The study was done using field data and ANSYS® FLUENT® software (version 15.0) to perform the computational fluid dynamics (CFD) simulations for the different flow conditions in a conventional and FFB choke manifold. The discretization technique was the finite volume method. Additionally ANSYS DesignModeler™ was used during geometry creation (Margoto *et al*, 2017).

Other equipment

The frac flow back package includes 15Kpsi equipment such as flexible hoses, surface safety valve, data header and high pressure 15Kpsi surface lines to the choke manifold, and downstream

from the choke 3 Kpsi surface lines, heaters, boilers, 250 psi surge tanks, various sizes of atmospheric tanks, and other accessories, ending in an environmentally-friendly high-efficiency burner capable of 30° rotation to each side.

APPLICATIONS - PAST & PRESENT

Clean up

The first application for the system was the cleanup of several wells that were shut-inbecause no appropriate cleaning technology was available. Previous attempts to use three phase separators and standard well testing equipment to clean and test the well were unsuccessful. The standard choke manifolds eroded rapidlydue to the combined high gas rates and solids (Fig. 3-4)with the chokes and curves being damagedfirst. This caused a very hazardous situation for the test crew.

In addition, the three phase separators were not capable of separating the fluid (Fig. 5) which wascomposed of a very heavy mud with micronized solids.

For the first operations,the thickness of the pipe wallsweremonitored for damage, especially on pipe elbows, while solids flow was monitored by a sand detector integrated into the surface data acquisition equipment.

This systemcleaned several wells with gas rates of 1MM m^3/day (Table 1) and 13 ppg heavy mud (Fig. 6).The equipment safely handled solids at surface and erosion was very minimal.

Figure 3. Choke bean (new)

Figure 4. Choke bean (eroded)

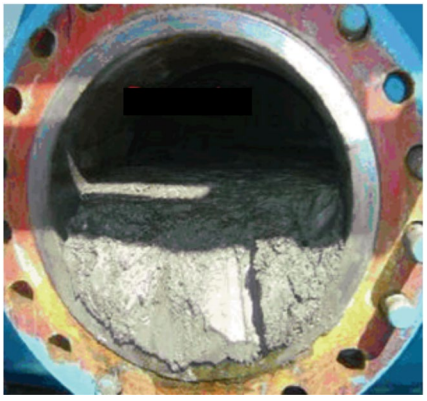

Figure 5. Three-phase separator flooded by the mud, prior to the use of 4-phase separators

Figure 6. Mud with high concentration of micronized solids

Operational Parameters	
Gas rate	1 MMm3/day
Solid rate	240 bbl/day
Oil rate	6000 - 8000 bbl/day
WHP	>10.000 psi

Table 1. Cleanup Scenario Parameters

Frac Flow Back

For flow back applications,prior technology uses sand filters or sand separators in conjunction with three phase separators and standard choke manifolds. This solution does not ensure that the well will be flowing continually, and sometimes the well should be shut-in during the cleanup because the well can only be aligned to the separator when solids stop flowing.

In the case of the new flow back package,the well can be aligned to the separator at the beginning of the cleanup period and does not need to be shut-in until the well is clean and tested. As the flow can be aligned to the separator, it is possible to measure all rates and some decisions can be made faster. Wells are cleaned in less time.

In some operations,companies test the wells to have original parameters, make the stimulation with proppants, and then open the well for a second test to evaluate the gain in the stimulation process. In conjunction with debris tolerant downhole test tools, the FFB set of equipment can allow a safer operation. Another critical situation is when premature screen-out occurs and the well needs to be cleaned.

Well Test & Fiscal Measurements

This set of equipment could also be used for well testing purposes.The 4-phase separator is a flexible piece of equipment that allows operators to use it for cleanups and flowback, and with the same set could perform well testing operations. The choke manifold configuration also allows control of the well, handlingof solids and maintaining the critical flow to provide accurate surface and downhole testing information.

Special devices were installed in the separators allowing use for fiscal measurement, a procedure obligatory by the Brazilian national petroleum agency standards to accurately measure oil and gasproduction.

APPLICATIONS - FUTURE

Frac Plug Drill Out (FPDO)

The next challenge was to apply the 4-phase separator and FFB choke manifold to design a 15 Kpsi frac plug drill out solution that provided more safety while handling gas at surface.

In unconventional fracturing, at the end of the frac operation the plugs are milled using coil tubing and a specific plant is mounted at surface to receive the flow back from this plug cutting. In some cases, a closed circuit is created to return the water to the system in order to make more gel and pump through the coil tubing again.

The standard FPDO solids control solution uses a plug catcher, standard choke manifolds with sand separator, and a tank with a gas booster at the end of the process.A shaker separates water and the finest grains of solids. Water is returned to the coil tubing by pumping through filters to clean it enough to return to the system.

With 4-phase separators and the frac flow back choke manifold, the trash catcher holds the more aggressive debris from the well which includes rubber and composite plug materials. The solids that pass through the trash catcher are managed by the choke manifold and separated by the separator, keeping gas safe during all processes and avoiding human contact with the effluent of the well from the beginning of the process to the end when the gas is burned using a vertical flare stack.

CONCLUSION

More than 300 operations were performed using this set of equipment that showed to be useful in several kinds of operations. Measuring pipe wall thickness was important in the beginning because no prior information was gathered regarding the erosion effects of flowing gas and solids in high rates up to 1 MM m^3/day, 6000-8000 bbl/day of liquids and wellhead pressures of more than 10 Kpsi.

FFB sets were used for different applications as described earlier: cleanups, frac flow backs, well testing, and fiscal measurements both on and offshore.

Heli-lift 4-phase test separators also showed to be versatile equipment.After jobs in jungle locations, it was used offshore on a specific rig where the crane was not capable to lift a standard three phase separator.The heli-lift version of the 4-phase separator was used and could handle the solids that were flowing due to a damaged screen in the well completion.

Sand detectors were also important to show when solids began to arrive and when the flow was clean of solids. Final disposal was made by conditioning the solids in drums and sent for treatment.

The frac flow back surface well test equipment is currently used for unconventionals operations to help clean wells during plug drill out. It promises to be the next standard for this kind of operation and has led to new standards for cleanup and flow backs.

NOMENCLATURE

Bbl/day – barrels per day
CFD – Computational Fluid Dynamics
ESD – Emergency Shut Down
FFB – Frac Flow Back
FPDO – Frac Plug Drill Out
MMm3/day – Millions of cubic meters per day
Psi – pounds per square inch
WHP – Well Head Pressure

REFERENCE CITED

Margotto, R., Cunha, J., Miranda, R., Ribeiro, D.C., Benedito, U.M.M., Meneguelo, A.P. 2017. Chokes in Series Provide Safe Testing Operations in Wells with Abrasive Solids. Presented at Offshore Technology Conference Brasil held in Rio de Janeiro, Brazil, 24–26 October 2017

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