Propellant-Assisted Technologies Successfully Deployed in Middle-East & South Asia to Enhance Productivity

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AGENDA

- INTRODUCTION
- SOFTWARE MODELING
- CASE HISTORIES
  - Propellants combined with Acid
  - Propellant around a perforating gun
  - Propellant inside a perforating gun
- CONCLUSIONS
**INTRODUCTION**

**Principle and Benefits of Propellants**

**Step 1:** A sleeve of propellant is placed over the conventional perforating gun and positioned across the zone of interest.

**Step 2:** As the gun detonates it in turn ignites the propellant sleeve. The pressure generated is sufficient to fracture the formation near the wellbore and open up the perforations.

**Step 3:** The propellant sleeves generate as much as 25,000 psi at the perforations. This technique has been especially successful when used in underbalanced TCP completions.

**BENEFITS**

- Enhance well productivity or injectivity
- Deliver perforation breakdown and cleanup
- Deliver near-wellbore stimulation
- Overcome formation damage created during the perforating event
- Reduce hydraulic fracture initiation pressures and improve proppant placement
INTRODUCTION

Types of Propellant Applications

- Sleeve of propellant placed over a conventional perforating gun
- Molded cylinder with propellant like oxidizing material surrounding an internal steel support tube
- Internal propellants arranged within the perforating system
Software platform for computational modeling of transient, downhole perforating events

- **Wellbore Flow Model**
  - Evolves partial differential equations for a compressible, non-equilibrium, multi-phase fluid mixture.
  - Conservative finite differences
  - Includes transient propellant burn

- **Fracture Generation & Propagation**
  - Fracture initiation and propagation
  - Heat conduction, convection, radiation
  - Debris flow in fracture

- **Dynamic Perforation Modeling**
  - Guns, tubes, valves, other tools & metallic components
  - Transient elastic behavior
  - Tool failure models

- **Perforation Flow & Cleanup**
  - Dynamically tracks connection between wellbore and reservoir
  - Includes shot density and phasing
  - Dynamic clean up model

- **Reservoir Fluid Flow**
  - Evolves multi-phase Darcy flow equations
  - Constant temperature
  - Layer-cake implementation

- **Solid Object Models**
  - Fluid Motion In/Out of Perfs/Fracs, and Connecting to Reservoir

- **Possible Surface Over or Under Pressure**

- **Energized Zone**

- **Energy Source (e.g., Perf Gun)**

- **Tubing, Packers, etc.**

**Modeling Software**

2019-NAPS Propellant-assisted technologies for Middle-East and South Asia to Enhance Productivity
CASE-HISTORY

PROPELLANT COMBINED WITH ACID

- Well drilled and completed in 2016 with achieved productivity of both oil and gas as expected
- Overall productivity was reduced by > 50% over the first 12 months of production
- Customer seeking solution to restore productivity
CASE-HISTORY

PROPELLANT COMBINED WITH ACID

- Application of propellants (Stimtube) + acid treatment to rejuvenate productivity

- Spot acid against the perforated interval, and run 2” propellant tube inside the acid.

- Propellant as the driving force for acid, to induce fractures and most importantly, capitalize on the newly created fractures with the soaked acid.

- Dynamic event modeling used to design job, mitigate risk and estimate injection rates
Multiple runs to spot acid using the propellants resulted in a successful operation

Post-job analysis indicated that the overall flow rates and productivity exceeded expectations

Flawless execution of this operation in treating formation damage and stimulating the well has prompted the operator to execute similar strategy for other wells in the future
Combining Acid treatment and Propellant as a driver successfully restored production to original rates

Pre-job modelling optimized operation design and ensured successful and safe deployment

Multiple wells successfully stimulated till date with a plan to stimulate more wells in the future
An Exploratory well in South Asia was drilled to explore the formation.

Based on the integrated study of geological and geophysical data, four objects were approved for initial production testing.

All objects were in the same formation.

This sandstone formation has 12% porosity, 60% water saturation and 1-5 mD permeability, with high stress magnitude (~0.75 psi/ft).

The objective of the testing was to identify fluid type, flow rate and pressure data to build a rich reservoir model.
Overbalanced perforations with wireline were required, so as to test many objects in the same well without lowering the completion string.

Low permeability did not provide good perforation clean-up.

With conventional perforation, the expected flow could not be achieved due to the possible presence of skin factor.

The challenge was to overcome the near wellbore damage in order to connect the wellbore with uninvaded formation.

Propellant-assisted technology was recommended to penetrate near wellbore damage, reducing skin and mildly stimulating the well.
The model assumed an initial positive skin of 3.8 and 5 mD permeability.

Model results estimate post treatment skin of -3, 100% perforation break down, bi-wing fractures ~4.24 m in length, fracture conductivity index of ~4mD/ft

No warnings or flags were observed.

Successful deployment of the propellant applications yielded positive results, PLT Results- 3mm bean: 7146m3/day. 4mm bean: 9536m3/day. 5mm bean: 14093m3/day.
INTERNAL PROPELLANTS WITHIN THE PERF GUN

- Combines perforating and well stimulation in one operation.

- The system integrates perforating charges with a proprietary energetic material.

- The detonation of the perforating charges initiates a complex, sequentially burning reaction of the energetic material generating high pressure gas pulse.

- This pulse cleans the tunnel and initiates fractures into the surrounding reservoir improving production/injection performance.

- Successfully run in heavy oil SAGD (steam assisted gravity drainage) wells in Canada. Injection wells showed substantial increases in productivity.

- Tight unconventional reservoirs: West Texas field studies and Woodford shale studies have shown higher inflow performance and decrease in hydraulic fracturing breakdown pressures.
INTERNAL PROPELLANTS WITHIN THE PERF GUN

- An operator in the Middle East observed minimal fluid influx from the formation, which led to their ESP’s heating up and eventually failing.

- As a solution, it was decided to explore a propellant driven application to establish proper formation connectivity.

- Propellant application deployed on Multiple wells:
  - Wireline deployed
  - 3-1/8” perforating system (5 SPF, 60 deg phasing, 21 ft.) with internal propellants
  - Formation is a sandstone, with formation pressure ranging between 2000-4000psi
INTERNAL PROPELLANTS WITHIN THE PERF GUN

- Pre-job evaluation of the system
  - A number of flow laboratory experiments were conducted to compare the influence of the propellant application on tunnel clean-up and productivity
  - System-level qualification tests were conducted to check the gun swell and survivability of the system
INTERNAL PROPELLANTS WITHIN THE PERF GUN

- Pre& post job modeling of the system
  - Reservoir-driven charges combined with internal propellants were modelled.
  - A first-order, preliminary model was developed and calibrated using gage data obtained from the field.
  - Good comparison between the gage data and the computed data

*First-ever successfully deployment of this system for the Middle East operator through careful testing/validation, pre and post job modelling and operational planning yielded positive results (increased productivity)*
QUESTIONS?
THANK YOU

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