Considering Temperature Applications In Wellbore Analysis

May, 2015
Wellbore Analysis

Purpose

• Meet your objectives!

Differentiators

• Service Provider should be objective oriented.
• Should be measured by your success understanding wellbore dynamics.
• Must understand the ability and limitations of downhole equipment:
  – Is the equipment engineered for wellbore diameters and environments – Temperatures, Pressures, and Chemicals that may be present.

Logging Services

It is critical to:

• Define the test objective
• Develop logging procedure
• Prepare necessary equipment
• Conduct pre-deployment meeting with team
• Perform site specific and job safety analysis

Once the job is complete, timely log presentation with the analysis and interpretation is important.
Typical Wellbore Analysis Applications

- Locate leaks in tubing, casing, or packers
- Find cross flow between zones
- Locate channeling behind pipe
- Quantify production or injection rates of each interval
- Locate water entry and determine if it is coming from the pay zone or channeling from above or below
- Find non-performing perforations
- Evaluate gas-lift performance
- Locate storage of injection or fracture fluids
Example of Log Analysis Provided to Oil Producers

Typical data and analysis from a production log. Both spinner (flow velocity) and density (fluid weight) have serious limitations and yet these are used to determine production rates. The industry to this day uses physical measurements to calculate chemical composition.

Reasonable accuracy difficult in multiphase flow.
Production Logging Analysis Has Been Considered Unreliable

• Unfortunately, a number of service providers have too often delivered unreliable service with no benefit to their customers.

• There are a number of reasons why:
  – Lack of understanding of the measurement equipment they are using;
  – Insufficient sensor resolution to properly analyze wellbore;
  – Use of uncorrected density or velocity measurements;
  – Use of canned programs with standard models;
  – A desire to get onto remedial workovers;
  – Etc...

To add value Service provider must meet your objectives!
Misinterpretation of Data is Prevalent in the Industry

• Unfortunately, personnel are trained to input data and receive answers from canned programs. This is the extent of the analysis.

• A good analysis depends on two critical measurements:
  • Velocity - from Spinner revolutions per second (RPS);
  • Density – from differential pressure or radioactive density

• Both parameters are readily measured, but often misinterpreted.
Example of Typical Mistakes - Velocity

Average Fluid Velocity is Estimated and Annotated as Vapp or APPARENT velocity

Correction Factor .5

This changes at each entry or exit point

Correction Factor ? You Guess

Service provider must understand these limitations and factor them into the analysis to eliminate errors
Example of Typical Mistakes - Density

Sound knowledge of fluid flow dynamics increases the analysis accuracy in wells below critical flow
Consider Using Temperature to Confirm Our Analysis

- Temperature is always faithful
- Accurately measured under all well conditions
- When fluid moves temperature moves with it
- Slope of temperature identifies changes in fluid movement

All analysis should be reconciled to temperature response
Temperature Sensor Should Have

• VERY HIGH RESOLUTION
  – Small changes quickly identified

• VERY FAST RESPONSE TIME
  – Logging speeds not too critical

• VERY ACCURATE
  – PVT cooling or heating easily determined

High quality temperature capability provides unique insight of wellbore conditions that lesser ones can not achieve
Temperature Sensor Sensitive Enough to Identify the Lithology in Thermally Stabilized Wells

Joint Research between SMU Geology and Mobil Research

With high resolution, fast response sensor correlation with the gamma ray log possible – identifying the lithology
An Example of Using Temperature for a Complete Analysis

- A good clean example JT heating and cooling and PVT cooling

- Water Source was determined in this survey because the wellbore was completed below perforations far enough for logging tool to measure.
Problem

• A 1.7 Mcf/day gas well began to produce water and the hydrostatic pressure caused the well to top flowing

Objective

• Locate water source

Procedure

• Keep well shut in until able to log
• Run base pass with well shut in
• Swab well until it flows
• Run flowing passes until water source defined

Discovery

• Water source discovered at 6,080 ft. channeling backside of casing and entering borehole at bottom of perfs 5,968 ft.
• Gas from zone entering at 5,933 ft. and 5,953 ft.

Remedial action

• Cement squeeze

Result

• Well initially produced gas and water (water that had cross flowed from below)
• Water gradually dropped off until only gas was being produced

Benefit to customer

• Gas production was restored to 1.7 Mcf/day with no water production
Application: Injection Profile

Problem
- Injection pressure of the well suddenly dropped with no change in injection rate

Objective
- Locate where injection fluid is leaving borehole and where it is stored

Procedure
- Make passes while injecting fluid
- Shut injection off
- Make passes as temperature decays back toward gradient

Discovery
- Spinner indicated injection water leaving the borehole at top of upper perforations
- Temperature indicates injected fluid moving up behind casing to zone at 1,530 ft.

Remedial action
- Cement squeeze upper perforations

Result
- Injected fluids revert back to intended zones

Benefit to customer
- Water flood contributing to pressure zone
Injection Well Channel Up
Injection Well Scaled

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- Top of Channel
- Packer
- Perfs
- Water Exiting Well Bore
- Storage Indicated from Previous Injection

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NeoTek Confidential – No disclosure without prior written permission
Application: After Frac & Cross Flow

Objective

- Evaluate extent of frac treatment

Procedure

- Run base temperature log after cementing
- Frac was pumped approximately 1 month later
- Run shut-in temperature logs at intervals of 3 hours, 4 hours, 5 hours, and 6 hours after pumping frac

Discovery

- Identified the extent of frac treatment with both Gamma Ray (GR) and temperature decay
- Cross flow within the frac zone and communication above zone which could lead to channeling once the zone depletes

Benefit to customer

- Better understanding of well performance will improve decision making on future completions in the field

Extent of frac is identified by RA tag seen on post-frac GR and cool temperature signature where frac fluids have been pumped to the formation
It is Critical to Have a Thorough Understanding of All Measurements to Provide an Accurate Analysis

- Your service provider should understand your objective and have a game plan before they start
- They should have the expertise with their measurement systems to eliminate common mistakes
- They need to reliably meet your objective to add value

Service provider must measures itself by your success!
Our Production Logging Tools Are Differentiated by Very High Temp / High Pressure Operation

Gamma Ray Detector
Type: Scintillation

Pressure Sensor
Type: Quartz Crystal
Accuracy: ± 0.03% F.S.
Resolution: 0.01 psi
Ranges: 10k, 16k, 20k
Make: Quartzdyne

Collar Locator
Type: Coil / Rare Earth Magnet

Temperature (Borehole)
Rating: 285/ 450 /650 F
Type: Platinum RTD
Accuracy: ± 1 Deg. C.
Resolution: 0.001 Deg. C.
Response: 0 - 100 Deg. C (4 seconds)

Temperature (Compensation)
Accuracy: ± 1 Deg. C.
Resolution: 0.01 Deg. C.

Capacitance (Fluid I.D.)
Determine water presence in well bore fluids.

Flow Meter (Spinner)
Type: Continuous
Sensors: Reed Switch / Magnetic
Resolution: 0.25 rps or 0.08 rps
Data Status: Velocity / Direction / Diagnostics

The Modular Design Makes Adding Our Chemical Sensing Capability a Straight-Forward Development Project
Water Channeling From Above Zone