

The Application and Benefits of the StimWatch® Stimulation Monitoring Service

a report by

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Stimulation Monitoring Objective

Historically, it has been extremely difficult to evaluate the placement of stimulation fluids in realtime during a multi-zone treatment. As a result, the zonal volumetric of injected fluid is based purely on the interpretation of geological data. Pre-job fluid placement simulators provide a theoretical prediction of the injection profile with prediction performance based on the quality of the model inputs. However, during stimulation treatments unknown or unpredictable downhole events could have a significant impact on the results of the treatment.

In order to achieve successful stimulation treatments, it is important to monitor the following conditions throughout the job:

- the injection profile – which zones are and are not being treated;
- the effectiveness of the diversion process;
- pre-defined rules for adjusting the job based on the realtime injection and diversion response; and
- the status of squeezed zones and the location of natural fractures.

Halliburton's StimWatch® monitoring service offers an economical solution to the problem of realtime fluid tracking and provides the necessary information for optimising treatment design, as well as the insights needed to improve future treatment strategies.

Service Description

The StimWatch® service allows a stimulation treatment to be 'watched' as it progresses downhole. The service uses a fibre optic Distributed Temperature Sensing (DTS) system to monitor wellbore temperature profiles during the stimulation treatment.

Changes in wellbore temperature are caused by the injection process. This temperature information is processed in realtime and converted into downhole injection profiles that provide the operator with a qualitative indication of fluid distribution across the pay interval(s). This is achieved without the need for shut-in periods or extensive pre-conditioning of the wellbore.

The DTS optical fibre cable assembly can be deployed in either a permanent or retrievable configuration, whichever is the better application for the particular situation. The cable assembly can be strapped to the completion casing or production tubing as a permanent installation. For retrievable scenarios in horizontal wells, coiled tubing can be used to position the fibre cable assembly across the perforated interval.

Monitoring Benefits

Fluid placement is critical to the success of any stimulation treatment. It is therefore important for the operator to have access to information that supports realtime monitoring and optimisation of stimulation treatments. The StimWatch® service provides this type of information.

Analysis of the complete wellbore temperature profiles can also provide a quantitative assessment of downhole flow rates, thereby indicating treatment fluid distribution across the intervals. Stimulation treatment designs can be modified to improve zonal coverage and monitor the effectiveness of diversion processes as the job progresses.

With the StimWatch® service, complete wellbore temperature profiles can be analysed in order to determine which perforations are being treated during a multi-zone stimulation treatment. DTS data visualisation and analysis software displays realtime temperature profiles as well as animated playback of historical data in order that the user can visualise and interpret downhole events as the job progresses.

The StimWatch® service provides:

- qualitative and quantitative knowledge of injected fluid distribution in realtime, allowing optimisation of stimulation treatment performance;
- feedback, allowing modification of pump rates, diverter stage sequencing and stage lengths in realtime;
- critical information for optimising fluid usage from a health, safety and environmental perspective; and
- a resource for evaluating treatments and improving future job design.

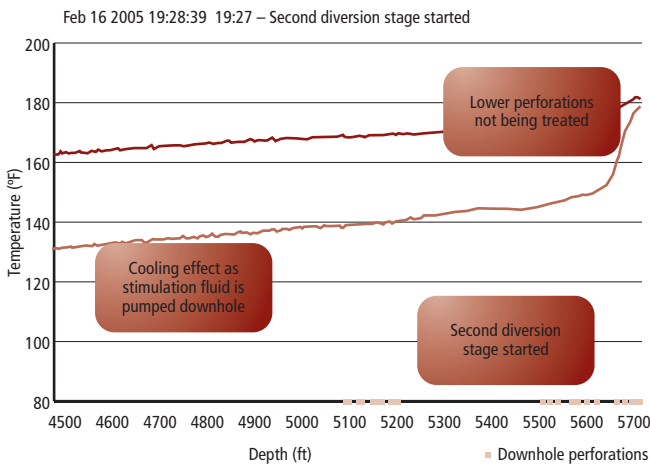
Commercial Applications

The StimWatch® service is well suited to the following multi-zone applications:

Dan Gualtieri, MBA, MSEE, PMP, is currently a Senior Product Champion for Halliburton in its Production Enhancement group. He has spent 15 years with Halliburton in various aspects of product, system and software development. He has over 14 years of product management experience, managing a wide range of engineering, systems and networking projects from concept to final delivery. In addition, he has co-ordinated international projects in the US, Thailand, Mexico and South America. Mr Gualtieri has an MSEE and MBA from Oklahoma State University – Stillwater and a BSEE and BS Physics from the University of Missouri – Rolla. He is an active member of the Society of Petroleum Engineers (SPE), the Instrument Society of America (ISA) and the Houston chapter of the Project Management Institute (PMI) and is a certified Project Management Professional (PMP).

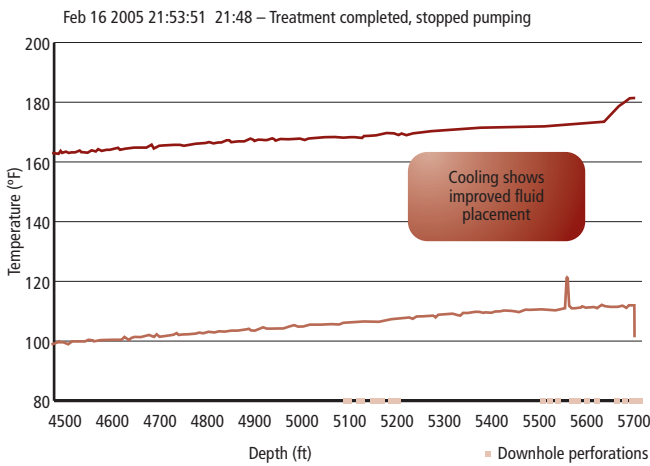
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Figure 1: Realtime Visualisation



Provided during stimulation activities. A second diversion stage was initiated based on the bottomhole temperature profiles.

Figure 2: Improved Fluid Placement



Verified when the second diversion attempt is successful.

- near-wellbore matrix acidising;
- determining well inflow performance prior to stimulation activities;
- identifying the amount of fluid or proppant flow-back;
- injection identification related to steamfloods, waterfloods or CO₂ floods;
- minfrac, acid fracturing and hydraulic fracturing treatments;
- squeeze treatments, conformance fluids, sand control chemicals, etc.;
- fracturing height identification; and
- pre- and post-stimulation well performance evaluation via flow profile analysis techniques.

Impact on the Industry

Collecting complete wellbore temperature profiles during the placement of stimulation and diversion fluids has opened a new window to understanding and modifying matrix stimulation treatments, as well as fracturing and conformance treatments. Rapidly collected temperature profiles can identify precisely where fluids are entering the formation, allowing realtime optimisation of the treatment via on-the-fly modification of the planned programme. This information is required in order to improve stimulation fluid placement across the entire treatment interval.

The StimWatch® service identifies stimulation fluid placement based on changes in fluid properties, which introduce variations in temperature gradients as fluid moves in the wellbore. This type of analysis provides a detailed understanding of the quality of treatment applied to the treatment intervals.

Case Study

A Californian operator planned a stimulation treatment for a well perforated in multiple sand and shale horizons. The upper formation was partially depleted; the lower, newly perforated formation was still at original reservoir pressure. A multi-stage sandstone acid treatment with diverter was designed, executed and monitored with a retrievable DTS. The StimWatch® monitoring service allowed the operator to view the placement of the acid treatment in realtime, providing justification for instantaneous changes in the stage sequencing, size and pump rates.

Figures 1 and 2 represent chronological temperature profiles throughout the stimulation treatment. Wellbore temperature is plotted as a function of depth along the entire wellbore. The initial temperature profile is shown by the top curve of each graph, while the bottom curves represent the active wellbore temperature profile at the specified time during the treatment. Figure 1 shows wellbore cooling after the first diversion stage has been pumped downhole. As demonstrated by the hot spot at the bottom of the wellbore, the lowest set of perforations was not treated. A change in the diversion strategy was initiated based on this observed result. The second diversion stage was successful and diverted treatment fluid to the lower interval. This was evident due to monitoring the cooling in that region, as seen in the final temperature profile shown in Figure 2.

The StimWatch® service provides the operator with the ability to visualise job-specific and unique aspects of the stimulation treatment. In one case, it was observed that acid was being placed out of zone behind a leaking gas lift mandrel. Another job identified stimulation treatments being placed inside natural fractures. Without this type of monitoring capability, the intended pay intervals would not have been treated and stimulation fluids would therefore have been wasted. In many cases, monitoring surface pressure changes is not adequate and these events would be unknown to the operator. The efforts placed on monitoring and optimising fluid placement could go a long way towards improving long-term well performance. ■